LTE-A Base Station Performance Tests According to TS 36.141 Rel. 14

Application Note

Products:

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

3GPP TS36.141 defines conformance tests for E-UTRA base stations (eNodeB). Release 14 (LTE-Advanced Pro) added several tests, such as those for enhanced Licensed Assisted Access (eLAA).

This application note describes how all required performance tests (TS36.141 Chapter 8) can be performed quickly and easily by using vector signal generators from Rohde & Schwarz.

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

The LTE base station transmitter (Tx) tests (TS36.141 Chapter 6) are described in Application Note 1MA154.

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

Application Note
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ROHDE&SCHWARZ

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The following abbreviations are used in this Application Note for Rohde & Schwarz test equipment:

- The R&S®SMW200A vector signal generator is referred to as the SMW.
- The software R&S®TSrun is referred to as the TSrun.

Note:

Please find the most up-to-date document on our homepage

http://www.rohde-schwarz.com/appnote/1MA162.

This document is complemented by software. The software may be updated even if the version of the document remains unchanged

1 Introduction

Long Term Evolution (LTE) networks or Evolved Universal Terrestrial Radio Access (E-UTRA) (from Releases 8 and 9) have long since been introduced into daily usage. As a next step, 3GPP has added several extensions in Release 12, known as LTE-Advanced (LTE-A). These include a contiguous and non-contiguous multicarrier and/or carrier aggregation (CA) option, changes to MIMO (up to 8x8 in the downlink and introduction of MIMO in the uplink). Release 13 (now called LTE advanced pro) introduces a 3GPP solution for the Internet of Things, called NB-IoT as a new physical layer and enhanced MTC. In Release 14, the new innovations are the enhanced Licensed Assisted Access (eLAA) in Unlicensed Spectrum, the support for Vehicle-to-Everything (V2x) services as well as 4-band and inter-band Carrier Aggregation (CA).

An overview of the technology behind LTE and LTE-Advanced is provided in Application Note 1MA111, 1MA232 and 1MA252. The white papers 1MA166 and the application note 1MA296 handle NB-IoT.

The LTE-A conformance tests for base stations (eNodeB) are defined in 3GPP TS 36.141 Release 12 [1] and include transmitter (Tx), receiver (Rx) and performance (Px) tests. T&M instruments from Rohde & Schwarz can be used to perform all tests easily and conveniently.

This application note describes the performance tests in line with TS36.141 Chapter 8. It explains the necessary steps in manual operation for vector signal generators. A free remote-operation software program is additionally provided. With this software, users can remotely control and demo tests on base stations quickly and easily. It also provides the SCPI commands required to implement each test in user-defined test programs.

The transmitter (Tx) tests (TS36.141 Chapter 6) are described in Application Note 1MA154 and the receiver (Rx) tests (TS36.141 Chapter 7) are covered in Application Note 1MA195.

Table 1-1 gives an overview of the performance tests defined in line with Chapter 8 of TS36.141. All tests can be carried out using instruments from Rohde & Schwarz. These tests are individually described in this application note. Please note that one test will be implemented in the SMW firmware later (marked in yellow).

Note

Performance Requirement (Chapter 8)		
Chapter (TS36.141)		**Test**
8.2 Performance requirements for PUSCH		
	8.2.1	Performance requirements of PUSCH in multipath fading propagation conditions transmission on single antenna port
	8.2.1A	Performance requirements of PUSCH in multipath fading propagation conditions transmission on two antenna ports
	8.2.2	Performance requirements for UL timing adjustment
	8.2.3	Performance requirements for HARQ-ACK multiplexed on PUSCH
	8.2.4	Performance requirements for High Speed Train conditions
	8.2.5	Performance requirements for PUSCH with TTI bundling and enhanced HARQ pattern
	8.2.6	Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with synchronous interference
	8.2.6A	Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with asynchronous interference
	8.2.7	Performance requirements of PUSCH in multipath fading propagation conditions transmission on single antenna port for coverage enhancement
	8.2.8	Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with asynchronous interference
8.3 Performance requirements for PUCCH		
	8.3.1	ACK missed detection for single user PUCCH format 1a transmission on single antenna port
	8.3.2	CQI performance requirements for PUCCH format 2 transmission on single antenna port
	8.3.3	ACK missed detection for multi user PUCCH format 1a
	8.3.4	ACK missed detection for PUCCH format 1b with Channel Selection
	8.3.5	ACK missed detection for PUCCH format 3
	8.3.6	NAK to ACK detection for PUCCH format 3
	8.3.7	ACK missed detection for PUCCH format 1a transmission on two antenna ports
	8.3.8	CQI performance requirements for PUCCH format 2 transmission on two antenna ports
	8.3.9	CQI performance requirements for PUCCH format 2 with DTX detection
	8.3.10	ACK missed detection for PUCCH format 1a transmission on single antenna port for coverage enhancement
	8.3.11	CQI performance requirements for PUCCH format 2 transmission on single antenna port for coverage enhancement
	8.3.12	ACK missed detection for PUCCH format 4
	8.3.13	ACK missed detection for PUCCH format 5
8.4 Performance requirements for PRACH		
	8.4.1	PRACH false alarm probability and missed detection
8.5 Performance requirements for Narrowband IoT		
	8.5.1	Performance requirements for NPUSCH format 1
	8.5.2	ACK missed detection for NPUSCH format 2
	8.5.3	Performance requirements for NPRACH

Table 1-1: Covered Tests, yellow is not implemented yet.

Ready for RED?

The new radio equipment directive RED 2014/53/EU adopted by the European Union replaces the previous directive RTTED 1999/5/EC, better known as R&TTE. With RED, not only radio transmitters, but also radio receivers have to meet minimum regulatory performance requirements and need to be tested. Article 3.2 contains fundamental technical requirements.

The Harmonised European Standard **ETSI EN 301 908 Part 14** covers essential requirements of article 3.2 for E-UTRA Base Stations. The tests refer to **ETSI TS 136 141**, which is the same as **3GPP TS36.141**.

The Harmonised European Standard **ETSI EN 301 908** covers essential requirements of article 3.2 for Mobile Communication On Board Aircraft (MCOBA) systems. Chapter 4.2. defines tests for E-UTRA-OBTS (Onboard Base Transceiver Station), which refer to **ETSI TS 136 141**, which is the same as **3GPP TS36.141**.

2 General Performance Tests

2.1 Note

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

2.2 Performance Test setup

Fig. 2-1 shows the general test setup for performance tests. A SMW is used to perform the test. Some tests are for four or eight Rx antennas. One SMW with additional RF sources like the SGS can generate the necessary signals for four Rx antennas. To generate signals for eight Rx antennas, one SMW with additional six RF sources like SGS and SGT are needed. Some tests require special MIMO combining setups; these are described in the respective sections.

Note:

Tests with four Rx antennas can also be handled by two SMW. This is not described in this application note.

Tests with eight Rx antennas can also be handled by four SMW. This is not described in this application note.

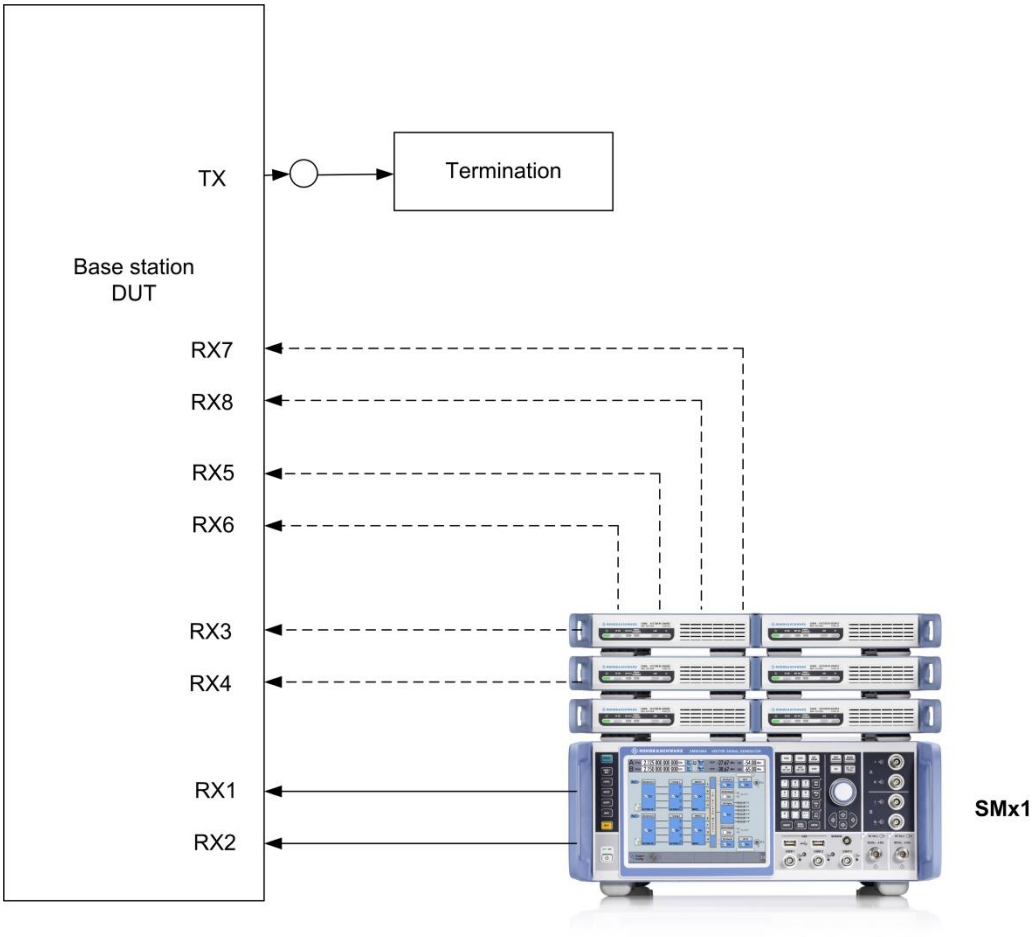


Fig. 2-1: Px Test Setup; To generate signals for four Rx antennas, one SMW plus two SGS are necessary. To generate signals for eight Rx antennas, one SMW plus six SGx are necessary.

2.3 Instruments and Software options

The SMW vector signal generator can be used for the tests described here.

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

- SMW-K55 EUTRA/LTE (for four paths)
- SMW-K84 EUTRA/LTE Release 9 (for four paths)
- SMW-K85 EUTRA/LTE Release 10 (for four paths)
- SMW-K115 Cellular IoT
- SMW-K119 EUTRA/LTE Release 13/14

The instruments need following options:

- SMW-B14 Fading
- SMW-K71 Dynamic Fading
- SMW-K74 MIMO
- SMW-K62 AWGN
- SMW-K69 LTE Closed Loop BS Tests

A couple of tests require four RF paths and/or four LTE signals. This can be handled with one SMW plus two external RF generators (e.g. SGS).

- 1 x SMW + 2 x SGS
- SMW-K16 Analog IQ

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

- 1 x SMW + 2 x SGS + 4 x SGT
- SMW-K18 Dig IQ

In the following sections, only the used SMW is mentioned again without stating the number of external RF generators. The generators are still needed, though.

Fig. 2-2 gives an overview of the required instruments and options.

Number	Measurement	Instruments and options										
		2 antennas							4 Antennas		8 Antennas	
		SMx	AWGN (K62)	Fading (B14)	MIMO (K74)	LTE (K55,K85, K119)	Cellular IoT (K115)	HARQ (K69)	SGS	Analog IQ (K16)	SGS + SGT	Dig IQ (K18)
8	***Performance requirements***											
8.2	**Performance requirements for PUSCH**											
8.2.1	PUSCH in multipath fading propagation conditions transmission (single antenna port)	☑	☑	2	-	1		☑	2	☑	2 + 4	☑
8.2.1A	PUSCH in multipath fading propagation conditions transmission (two antenna ports)	☑	☑	2	☑	2		☑	2	☑	2 + 4	☑
8.2.2	UL timing adjustment	☑	☑	2	☑	2		☑	- - -			
8.2.3	HARQ-ACK multiplexed on PUSCH	☑	☑	2	-	1			- - -			
8.2.4	High Speed Train conditions	☑	☑	2	-	1		☑	- - -			
8.2.5	PUSCH with TTI Bundling and enhanced HARQ pattern	not implemented										
8.2.6	Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with synchronous interference	not implemented										
8.2.6A	Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with asynchronous interference	not implemented										
8.2.7	Performance requirements of PUSCH in multipath fading propagation conditions transmission on single antenna port for coverage enhancment	☑	☑	2		1	1	☑	- - -			

Number	Measurement	Instruments and options										
		2 antennas							4 Antennas		8 Antennas	
		SMx	AWGN (K62)	Fading (B14)	MIMO (K74)	LTE (K55,K85, K119)	Cellular IoT (K115)	HARQ (K69)	SGS	Analog IQ (K16)	SGS + SGT	Dig IQ (K18)
8	***Performance requirements***											
8.3	**Performance requirements for PUCCH**											
8.3.1	ACK missed detection for single user PUCCH format 1a (single antenna port)	☑	☑	2	-	1			2	☑	2 + 4	☑
8.3.2	CQI performance for PUCCH format 2 (single antenna port)	☑	☑	2	-	1			- - -			
8.3.3	ACK missed detection for multi user PUCCH format 1a	☑	☑	2	☑	2			2	☑	2 + 4	☑
8.3.4	ACK missed detection for PUCCH format 1b with Channel Selection	☑	☑	2	-	1			2	☑	2 + 4	☑
8.3.5	ACK missed detection for PUCCH format 3	☑	☑	2	-	1			2	☑	2 + 4	☑
8.3.6	NAK to ACK detection for PUCCH format 3	☑	☑	2	-	1			2	☑	2 + 4	☑
8.3.7	ACK missed detection for PUCCH format 1a (two antenna ports)	☑	☑	2	☑	1			2	☑	2 + 4	☑
8.3.8	CQI performance requirements for PUCCH format 2 (two antenna ports)	☑	☑	2	☑	1			- - -			
8.3.9	CQI performance requirements for PUCCH format 2 with DTX	☑	☑	2	☑	1			- - -			
8.3.10	ACK missed detection for PUCCH format 1a transmission on single antenna port for coverage enhancement	☑	☑	2	☑	1	1		- - -			
8.3.11	CQI performance requirements for PUCCH format 2 transmission on single antenna port for coverage enhancement	☑	☑	2	☑	1	1		- - -			
8.3.12	ACK missed detection for PUCCH format 4	☑	☑	2	☑	1			2	☑	2 + 4	☑
8.3.13	ACK missed detection for PUCCH format 5	☑	☑	2	☑	1			2	☑	2 + 4	☑
8.4	**Performance requirements for PRACH**											
8.4.1	PRACH false alarm probability and missed detection	☑	☑	2	-	1			2	☑	2 + 4	☑
8.5	**Performance requirements for Narrowband IoT**											
8.5.1	Performance requirements for NPUSCH format 1	☑	☑	2	☑	1	1		- - -			
8.5.2	ACK missed detection for NPUSCH format 2	☑	☑	2	☑	1	1		- - -			
8.5.3	Performance requirements for NPRACH	☑	☑	2	☑	1	1		- - -			

☑ needed for the measurement (exact this one)

--- not used

Fig. 2-2: Overview needed instruments and options

3 Performance Tests (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 signal (PUCCH and PRACH) under multipath channel conditions.

Fixed Reference Channels (FRC)

For the performance tests, Fixed Reference Channels (FRC) are defined. They contain LTE channel parameters as modulation, code rate and allocated resource blocks etc. They are named according to [1], annex A and split in different subsets:

FRC A3: A3-1…A3-7 (QPSK for performance requirements)

FRC A4: A4-1…A4-8 (16QAM for performance requirements)

FRC A5: A5-1…A5-7 (64QAM for performance requirements)

FRC A7: A7-1…A7-6 (16QAM for UL timing adjustment)

FRC A8: A8-1…A8-6 (QPSK for UL timing adjustment)

FRC A12: A12-1…A12-6 (QPSK for performance requirements type A)

FRC A13: A13-1…A13-6 (16QAM for performance requirements type A)

FRC A16: A16-1…A16-5 (NB-IoT NPUSCH F1 performance requirements)

FRC A17: A17-1…A17-6 (256QAM for performance requirements)

FRC A18: A18-1…A18-6 (16QAM for PUSCH transmission)

FRC A19: A19-1…A19-6 (256QAM for PUSCH transmission)

For more details refer to [1], annex A.

All FRCs are implemented as predefined settings for FDD and TDD in the signal generator family SMW.

Channels

According to [1] the channels to be tested are at the bottom (B), in the middle (M) and at the top (T) of the supported frequency range of the base station.

3.1 Basic operation

For most of the following measurements, the first operating steps are the same. They are described only once.

The SMW simulates one or more LTE-UE's and the channel with fading and noise (if applicable). In the single tests, special settings are added. Before starting with the described steps, perform a preset of the device (green button in left upper corner). In principle, four main parts are necessary:

- Signal routing / MIMO settings
- LTE settings for one or more UE's in the baseband block(s)
- Channel simulation / Fading
- AWGN / SNR

3.1.1 Signal routing / MIMO settings

The test setups require a routing of the UE signals to the Rx antennas of the base station under test.

The SMW is able to handle up to four independent basebands and (with additional RF generators) up to eight RF paths. Routing is done via System configuration (simple settings can be done via routing in the baseband block).

Table 3-1 shows the routing settings for the different tests.

Heading			
Test	**2 RX Antennas**	**4 RX Antennas**	**8 RX Antennas**
8.2.1	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.2.1A	1 x 2 x 2	1 x 2 x 4	1 x 2 x 8
8.2.2	2 x 1 x 2	---	---
8.2.3	1 x 1 x 1 1 x 1 x 2	---	---
8.2.4	1 x 1 x 2	---	---
8.2.5	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.2.6(A)	---	---	---
8.2.7	1 x 1 x 2	---	---
8.3.1	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.3.2	1 x 4 x 2	---	---
8.3.3	1 x 1 x 2	---	---
8.3.4	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.3.5	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.3.6	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.3.7	1 x 2 x 2	1 x 2 x 4	1 x 2 x 8
8.3.8	1 x 2 x 2	---	---
8.3.9	1 x 1 x 2 1 x 2 x 2	---	---
8.3.10	1 x 1 x 2	---	---
8.3.11	1 x 1 x 2	---	---
8.3.12	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.3.13	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.4.1	1 x 1 x 2	1 x 1 x 4	1 x 1 x 8
8.5.1	1 x 1 x 2	---	---
8.5.2	1 x 1 x 2	---	---
8.5.3	1 x 1 x 2	---	---

Table 3-1: Signal routing / MIMO settings

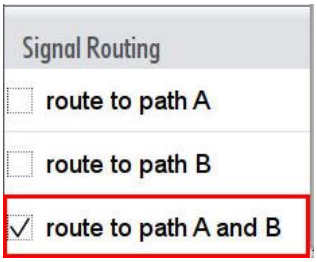


Fig. 3-1: Simple baseband routing

System Configuration SMW

You can reach the **System Configuration** via the soft button in the lower left area or by a click on *Fading*.

1. Set **Mode** to **Advanced.**
2. Set the wanted configuration according to Table 3-1.

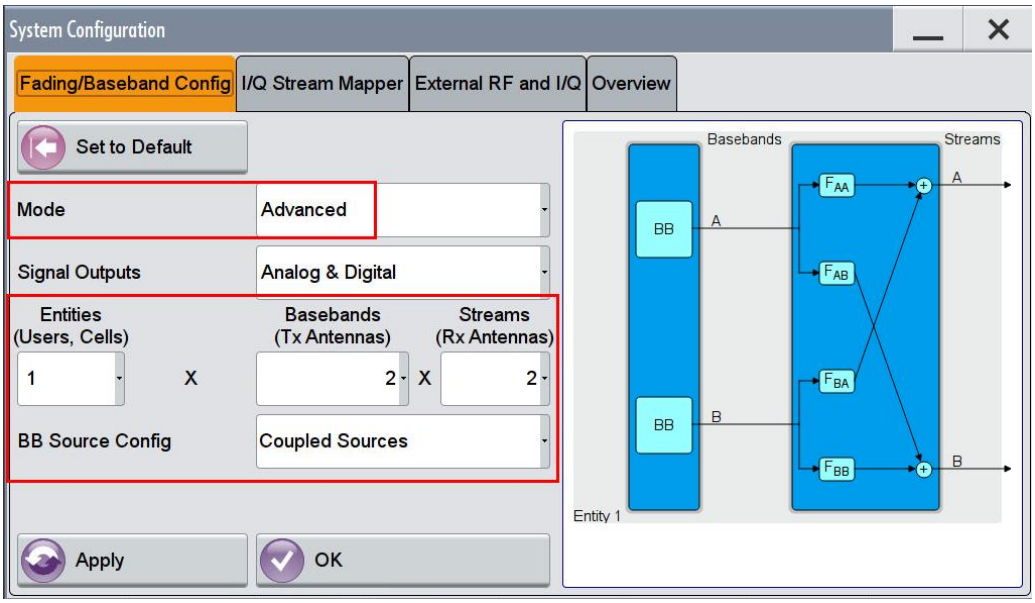


Fig. 3-2: System Configuration in the SMW

3.1.2 General Uplink LTE settings

3. In the block diagram, click the **Baseband** block (typically A). Select **EUTRA/LTE…**

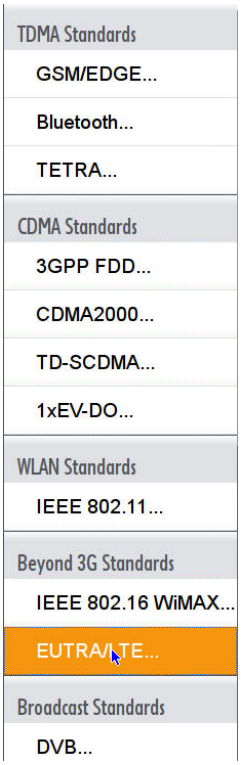


Fig. 3-3: Setting of LTE in the baseband

The EUTRA/LTE A dialog opens (Fig. 3-4)

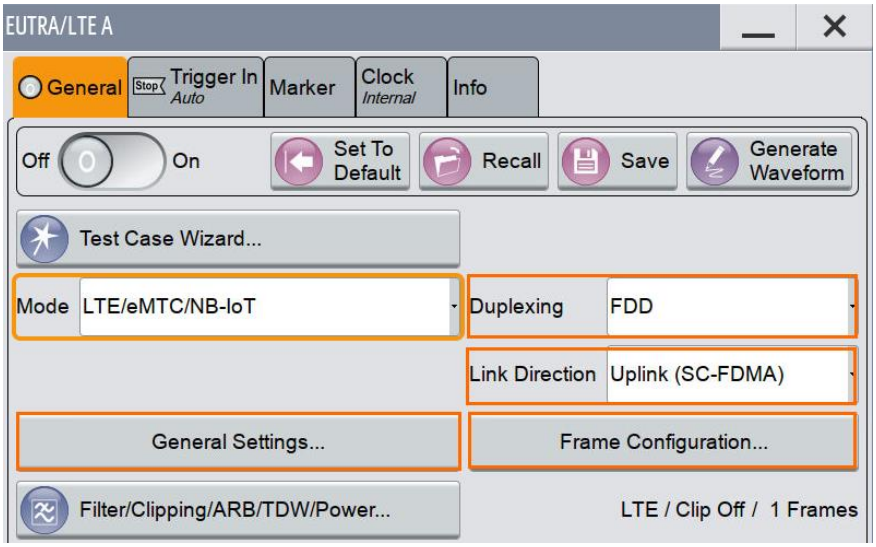


Fig. 3-4: EUTRA/LTE main dialog. Set Link Direction to Uplink.

4. Set **Link Direction** to **Uplink (SC-FDMA)**. Select the **Duplexing** (**FDD** or **TDD)** (example: FDD).

5. When using **TDD** click **General UL Settings...** and set the **TDD UL/DL Configuration** and the **Special Subframe Config**.

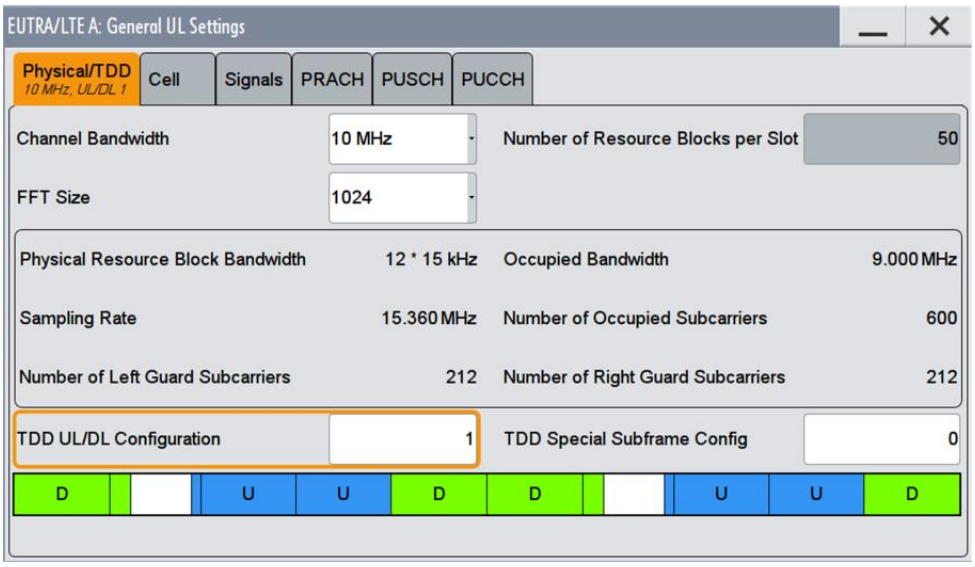


Fig. 3-5: Setting the TDD UL/DL Configuration in duplexing mode TDD (example: 1)

The 3GPP specification [3] defines seven different uplink-downlink configurations, i.e. the allowed combination of downlink, uplink and special slots. These seven configurations are shown in Table 3-2, with "D" denoting a subframe reserved for downlink, "U" for uplink, and "S" for the special subframe.

TDD Uplink / Downlink configurations

UL/DL configuration	Subframe number										Second configurable subframe number
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
0	D	S	U	U	U	D	S	U	U	U	3
1	D	S	U	U	D	D	S	U	U	D	3
2	D	S	U	D	D	D	S	U	D	D	7
3	D	S	U	U	U	D	D	D	D	D	3
4	D	S	U	U	D	D	D	D	D	D	3
5	D	S	U	D	D	D	D	D	D	D	2 (in second **frame**)
6	D	S	U	U	U	D	S	U	U	D	3

Table 3-2: Uplink-downlink configurations. Downlink in green, Uplink in blue

The SMW simplifies settings with the parameter **configurable subframes.** You just have to setup the needed subframes only. The SMW copies the settings to the other subframes automatically. In a couple of tests only every second subframe is used (e.g. to transmit certain patterns). Please note that in TDD mode the second uplink

subframe depends on the UL/DL configuration. Thus, the subframe number to set differs. The first subframe to set is number 2. The second subframe to set is mentioned in Table 3-2.

Cyclic Prefix

6. In the tab **Cell,** set the **Cyclic Prefix** (example: **Normal)**.

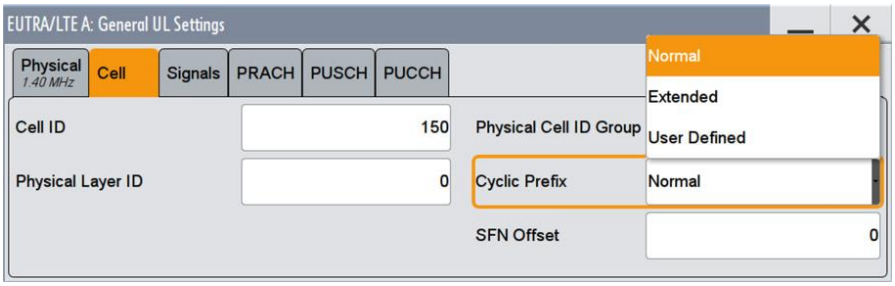


Fig. 3-6: Setting the Cyclic Prefix

Filter/Clipping/ARB/TDW/Power settings

7. The SMW supports different filters, see Fig. 3-7.

Best ACP focusses an excellent ACP performance. **Narrow** additionally features a smoother shape in the frequency domain. **Best EVM** focusses an excellent EVM performance. **No upsampling** additionally features a small output waveform file size.

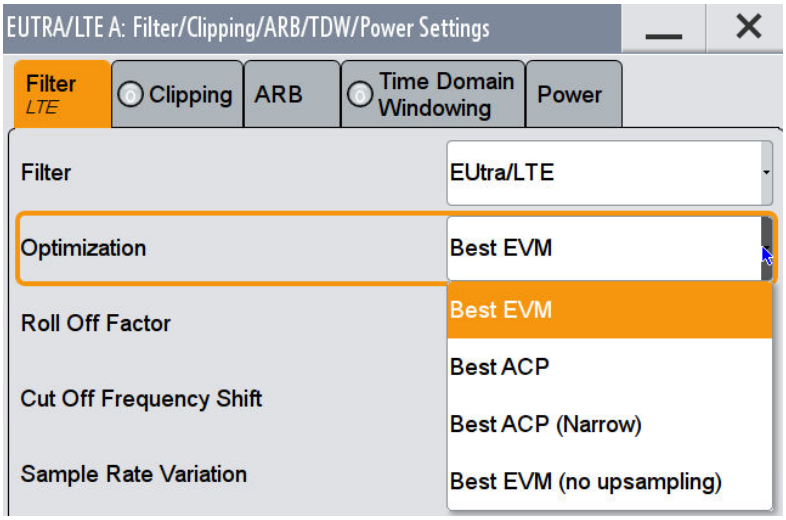


Fig. 3-7: LTE Filter Settings

Power Settings

8. In the main dialog, select **Filter/Clipping ….** Select the **Power** tab and **set** the **Power Reference** to **UE Burst RMS Power.**

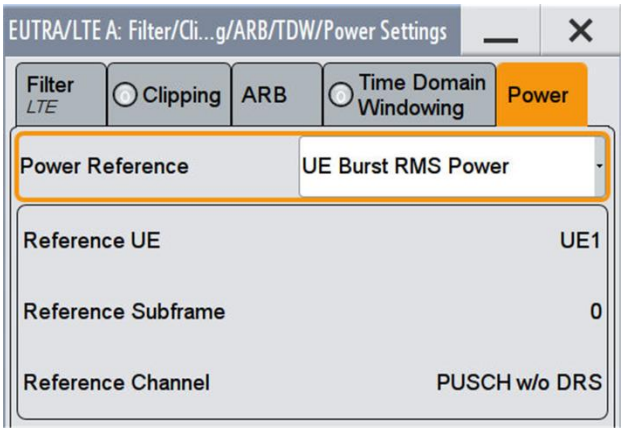


Fig. 3-8: LTE Power Settings

It defines the reference of the **Level** display in the SMW status bar. It is the power reference for all tests. In this mode, the RMS and PEP in the SMW status bar are displayed during a single subframe of the **Reference UE**. **UE Burst RMS Power** is required for setting the AWGN correctly (e.g. according to TS36.141), in case not every possible subframe is used by the simulated UE.

Trigger

In default mode, the SMW starts the LTE signal immediately.

9. To align the start of the LTE signal to the base station under test, set **Trigger In Mode** to **Armed Auto**. (Fig. 3-9)

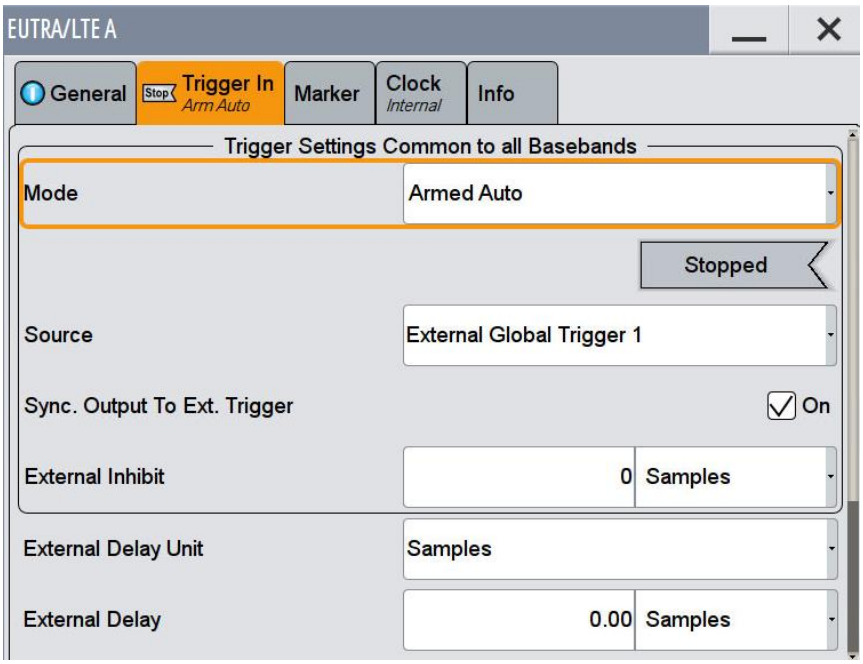


Fig. 3-9: Trigger In settings. The SMW waits for an external trigger signal to align the LTE signal.

NB-IoT standalone

A couple of tests are for NB-IoT. In the performance tests, only the standalone mode is used.

1. To generate standalone NB-IoT signals, set the **Channel Bandwidth** to *200 kHz*. Thus, the SMW automatically uses standalone mode.

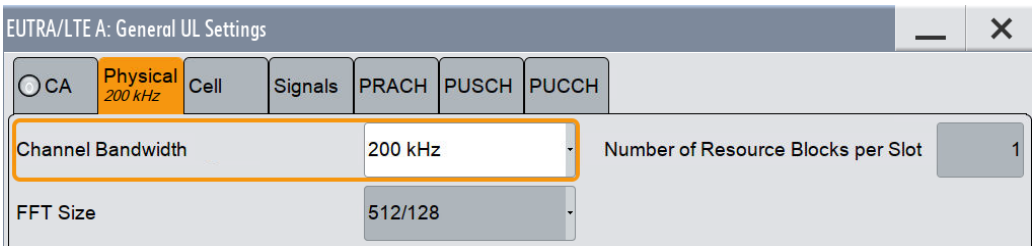


Fig. 3-10: NB-IoT standalone mode uses 200 kHz bandwidth

2. Click on UE1 to open further settings

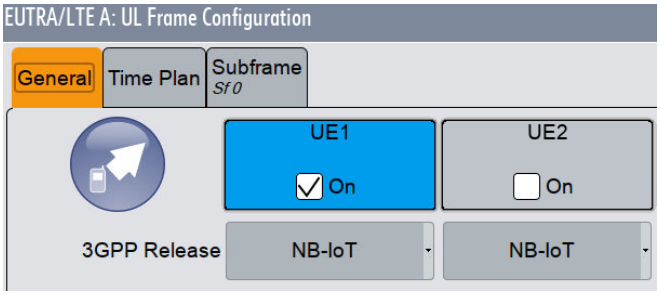


Fig. 3-11: UE1 transmits an NB-IoT signal

3. In the tab **FRC** choose the wanted **FRC** (A14….A15) and switch **on** the **FRC State**.

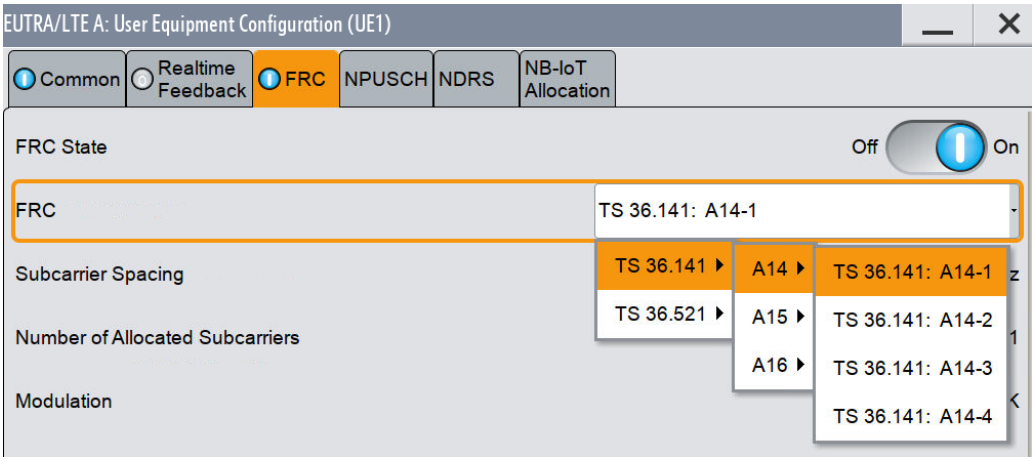


Fig. 3-12: FRCs for NB-IoT

4. The SMW automatically sets the parameters according to the wanted FRC. Click **Adjust Length** if the Current **ARB Sequence Length** differs from the Suggested length.

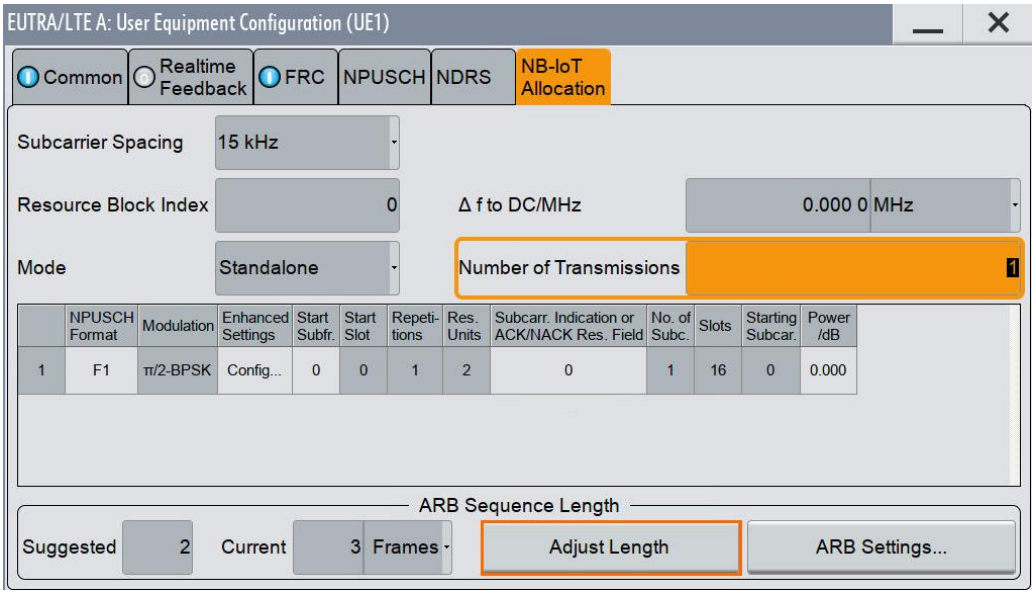


Fig. 3-13: Detailed FRC settings

3.1.3 General Fading settings

The SMW provides channels simulators in the baseband via the block **Fading**. It allows the fast and easy configuration with predefined settings according to the different mobile radio specifications (e.g. in LTE EVA 5 Hz). Additionally individual fading settings can be applied.

1. Click on the block **Fading** and **Fading Settings (**Fig. 3-14)

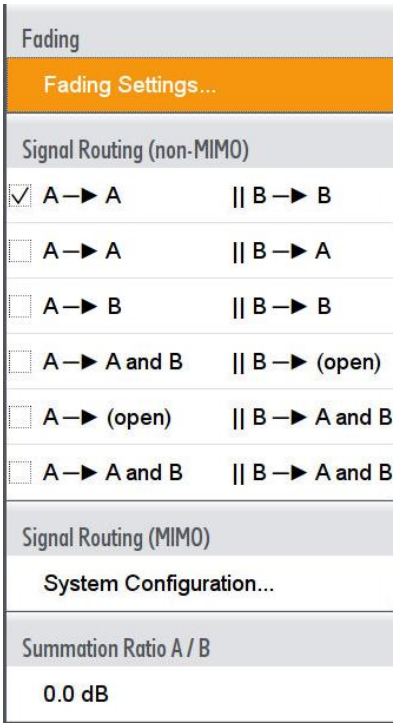


Fig. 3-14: Fading Settings

2. Select a profile via **Standard** (e.g. EVA 5 Hz Low) (Fig. 3-15 and Fig. 3-16)
3. Switch the fading block **On**. (Fig. 3-15)

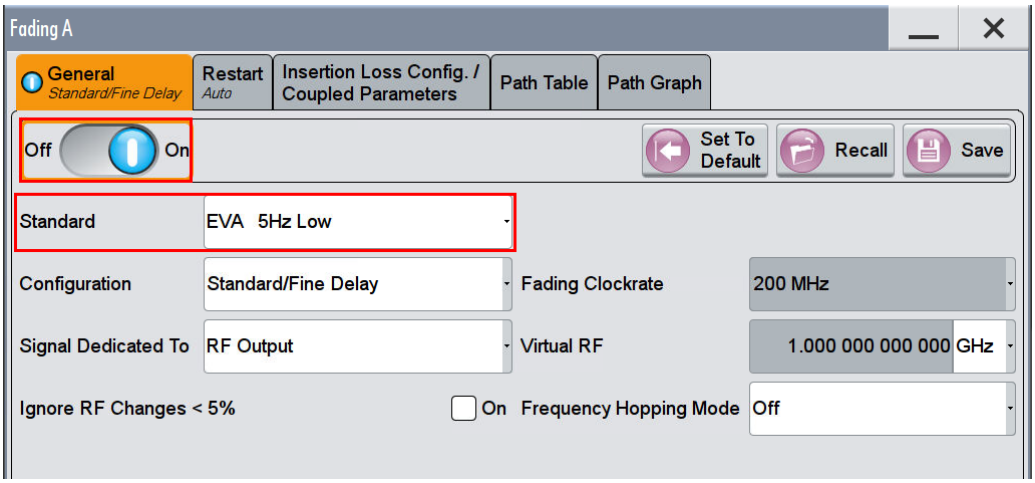


Fig. 3-15: Overview General Fading settings. Select a predefined settings in Standard

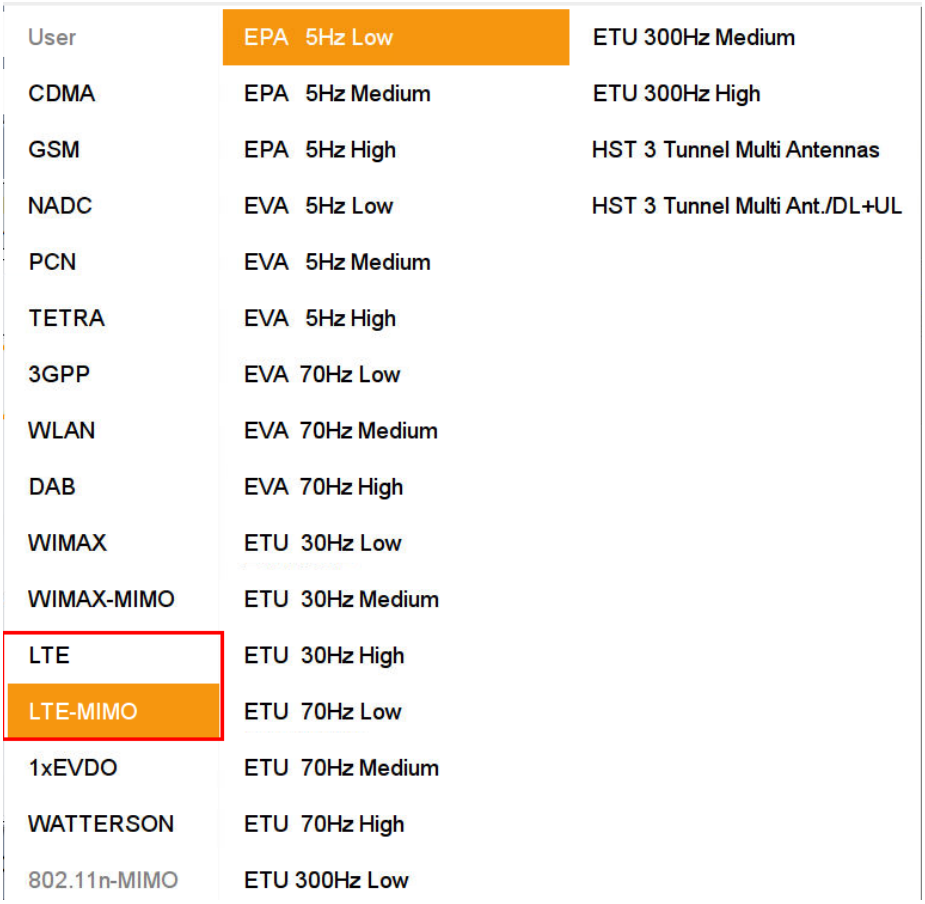


Fig. 3-16: Predefined Fading profiles for LTE-MIMO

4. Repeat the settings in other paths. If special MIMO modes are used, this is done automatically
5. The path settings are shown as a table and as graph. Individual settings can be handled in the tables. (Fig. 3-17 and Fig. 3-18)

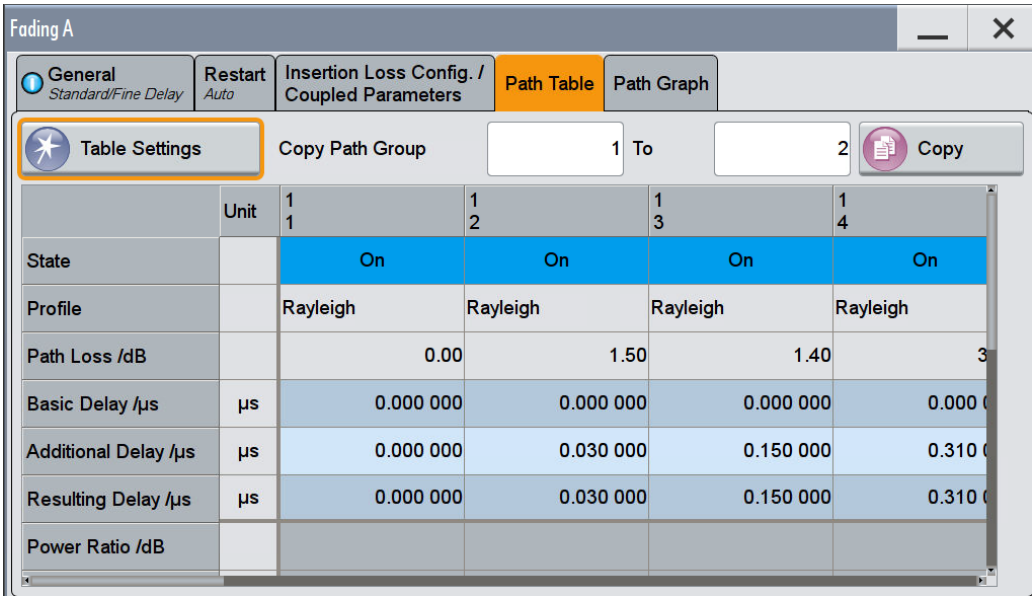


Fig. 3-17: Fading Path table

Fig. 3-18: Fading Path graph

3.1.4 General AWGN settings

The SMW provides noise via the block AWGN. The power levels in [1] are always set via a noise power and a relative signal-to-noise (SNR) requirement. The noise bandwidth to set always refers to the system (occupied) bandwidth:

Occupied Bandwidths							
Channel-Bandwidth [MHz]	**0.2**	**1.4**	**3**	**5**	**10**	**15**	**20**
Occupied Bandwidth [MHz]	0.180	1.08	2.7	4.5	9	13.5	18

Table 3-3: Occupied Bandwidth (System Bandwidth)

1. Click on the block **AWGN**
2. Switch the state **ON** and set the **Mode** to **Additive Noise**.(Fig. 3-19, Fig. 3-20)
3. Set the **System Bandwidth** according to Table 3-3 (e.g. $BW_{channel}$ = 10 MHz -> BW_{system} = 9 MHz) (Fig. 3-19).
4. Set the **Ratio** to **1.5** (Fig. 3-19).

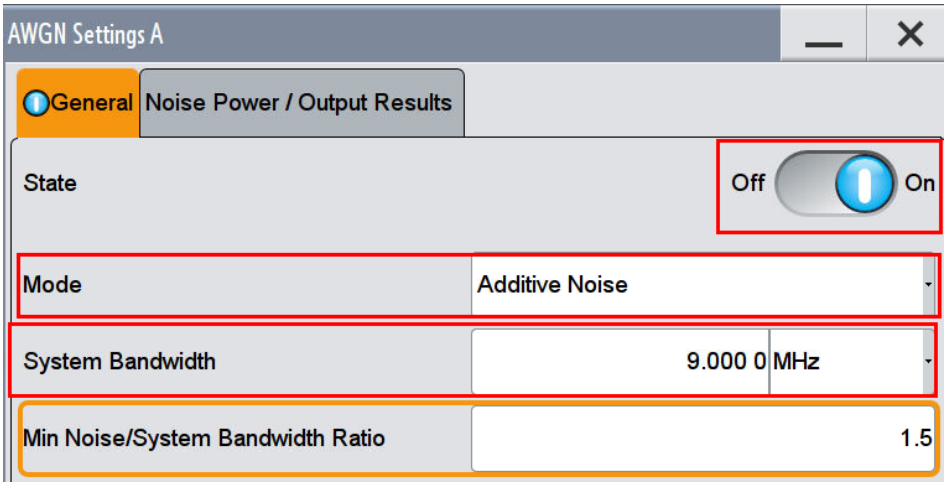


Fig. 3-19: General AWGN settings. The system bandwidth depends on the LTE channel bandwidth.

5. Set the **Reference Mode** to **Noise**.
6. Set the **Noise Power** and the **Carrier to Noise Ratio** (SNR) (e.g. power = -80.5 dB, SNR = - 4 dB) (Fig. 3-20). Please note that for certain test cases an additional SNR correction factor applies.
7. For the SMW the referenced RF port has to be set (e.g. RF A)

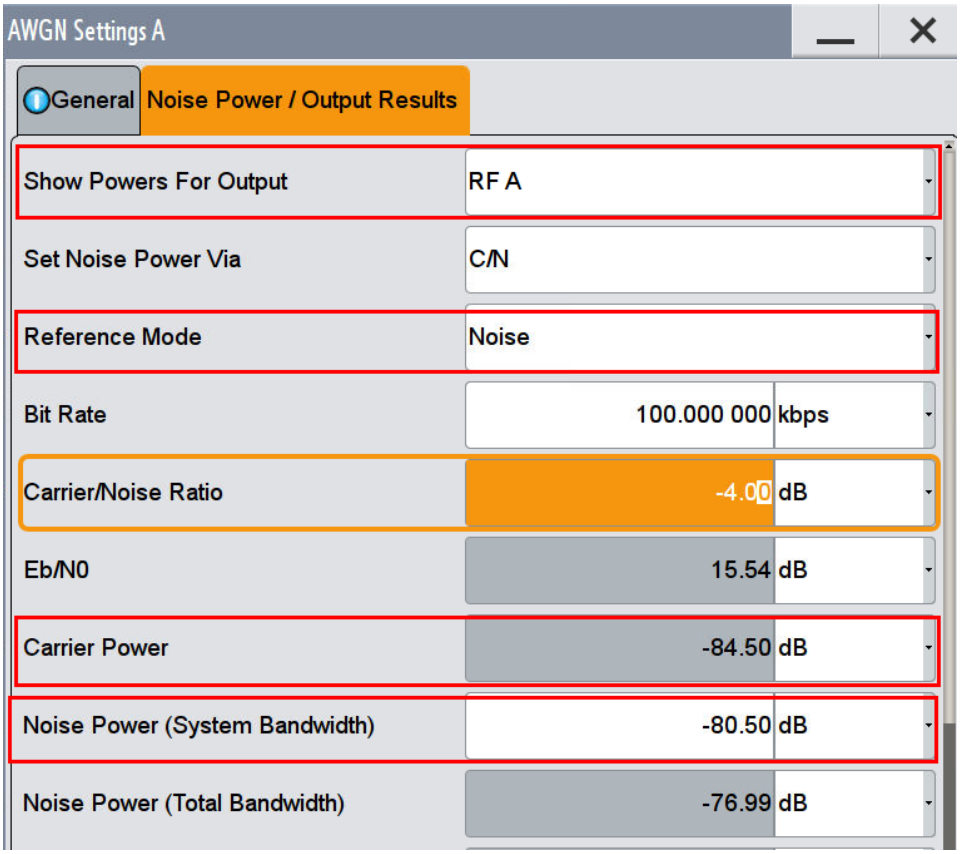


Fig. 3-20: AWGN settings. Set the noise power and the SNR. The effective Carrier Power is shown.

3.1.5 SMW: extension to four or eight RF paths

The SMW is able to generate up to eight baseband signals. It supports two RF paths directly inside one instrument. To support four or eight RF channels, additional instruments like the SGS and the SGT can be connected via IQ to the SMW. The SMW then controls those external instruments and acts like one instrument with four or eight channels.

An example with a SGS connected via IQ OUT1 to the SMW is used to explain the settings.

1. Open the **System Configuration** (e.g. click on **I/Q Stream mapper**) and click on the tab **External RF and IQ**
2. Click in the row External Instrument in line I/Q OUT 1. (Fig. 3-21)

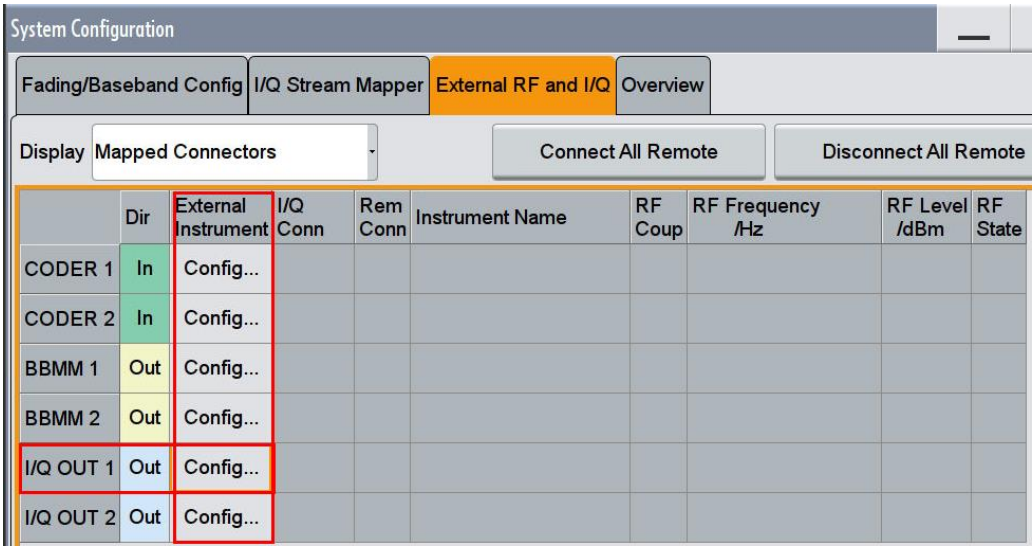


Fig. 3-21: Configuring external instrument at IQ1 Out

3. Click on the button **SCAN**. The SMW searches for available instruments on the LAN.

4. Select the wanted instrument under **External Instrument**. Check the shown settings and click **Apply and Connect**. The reference path is RF A. (Fig. 3-22)

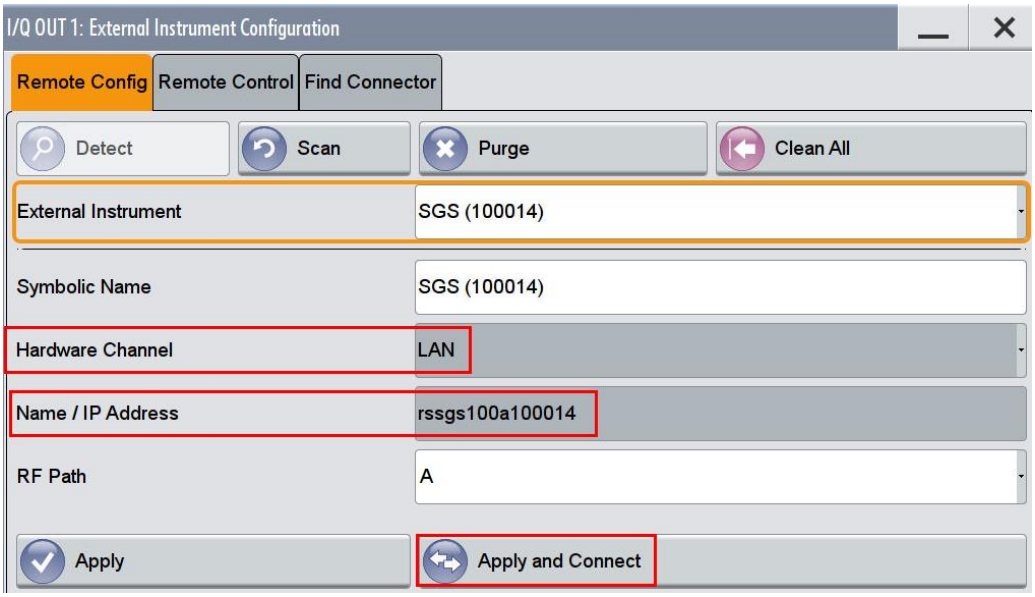


Fig. 3-22: Choose an external instrument

5. If **RF Coup** is marked, the instrument uses the same frequency, level and RF state like the SMW (e.g. RF A). Offsets can be entered relatively to the reference path. (Fig. 3-23)

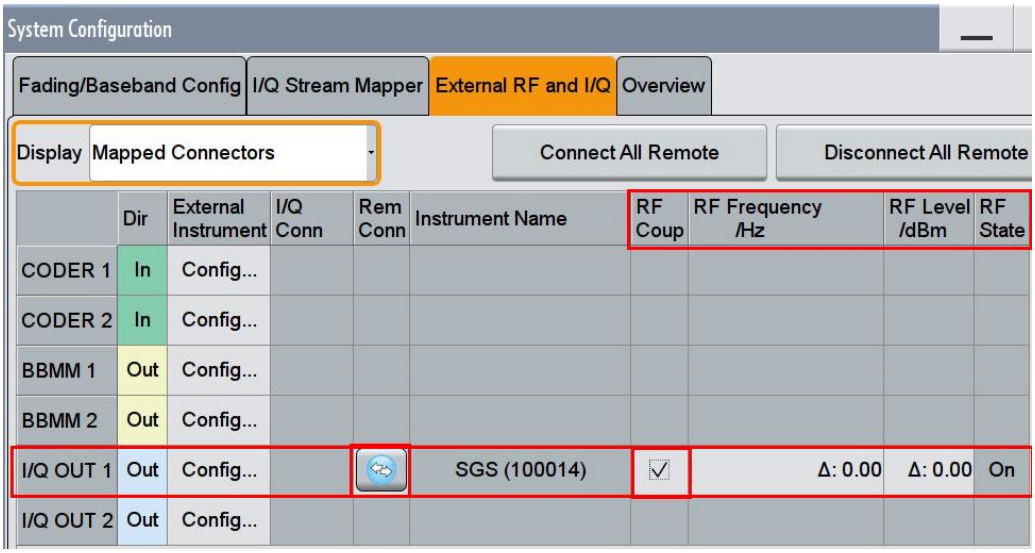


Fig. 3-23: External instrument is RF coupled to RF A. It uses the same frequency, level and RF state like RF A.

6. Switch **On** the used IQ Modulators.

The SGT can be connected the same way as the SGS to the SMW. The SGT uses DIG IQ connections e.g. via FADERx.

3.1.6 Demo Program R&S TSrun

This Application Note comes with a demonstration program module called **LTE BS Performance Tests** for the software TSrun, which is free of charge. The module covers all required tests (with the exceptions in Table 1-1).

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

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

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

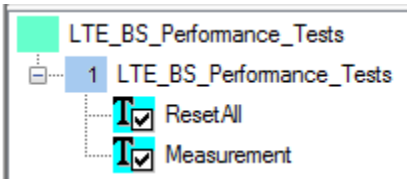
Following SCPI resources are needed:

- SMx

Getting started

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

The test consists of two independent test cases:



- The test case **ResetAll** resets all instruments (SMx).
- The test case **Measurement** is the main part.

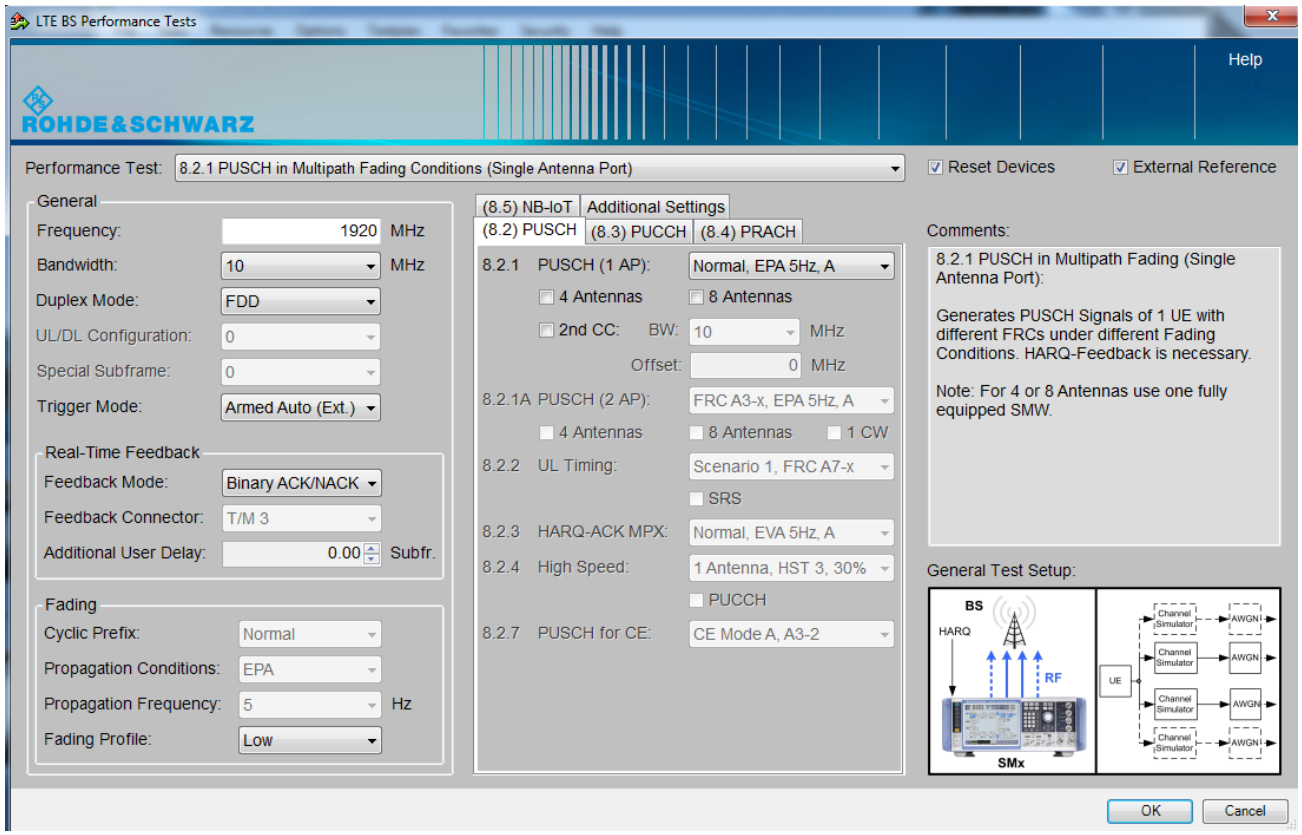


Fig. 3-24: Full overview: setting parameters for the LTE BS Performance tests.

General settings

The basic parameters are set at the top right:

- **Reset Devices**: Sends a reset command to all connected instruments
- **External Reference**.

The tabulator **Addittional Settings** is used to enter compensations for external path attenuations.

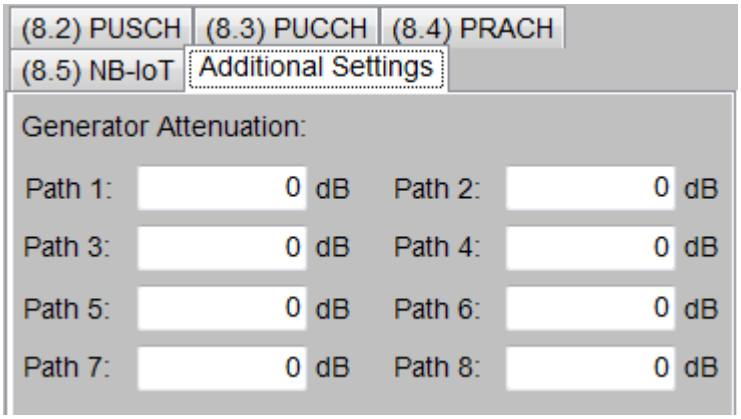


Fig. 3-25: Attenuation settings.

Test cases

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

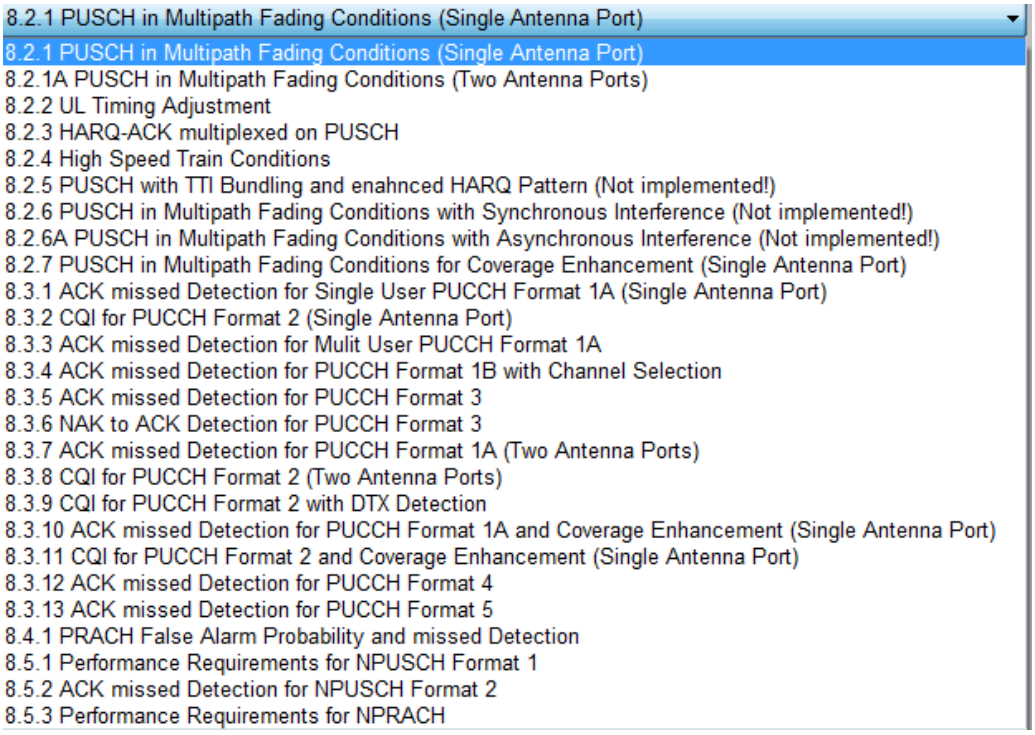


Fig. 3-26: Available test cases.

Based on the selected test case, helpful hints are provided in the Comments section and an illustration of the basic test setup is displayed.

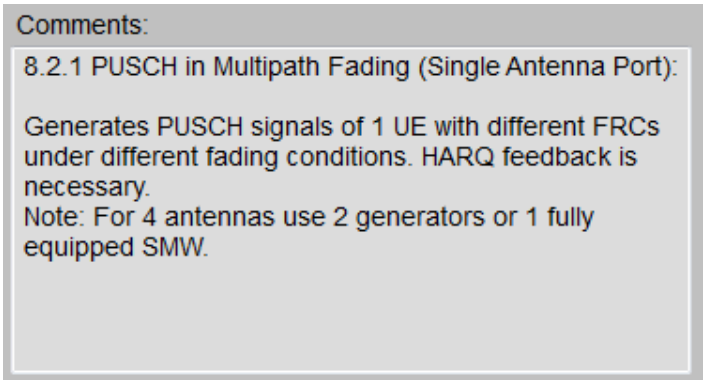


Fig. 3-27: Brief notes are provided in the Comments **section (top right) based on the selected test case.**

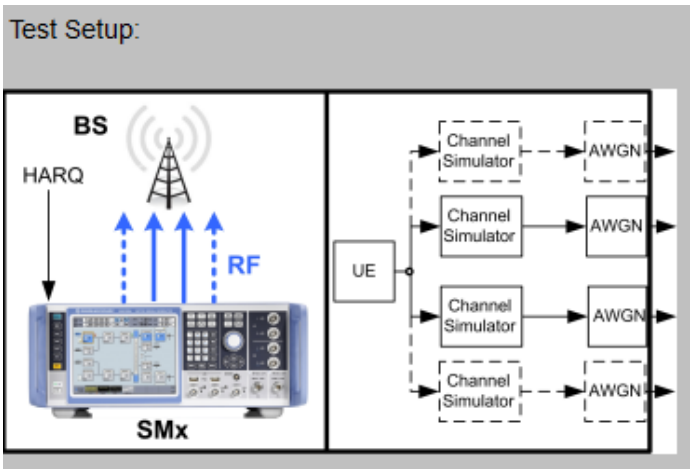


Fig. 3-28: The Test Setup **section (bottom right) displays a basic setup for the selected test case.**

General settings for the signal

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

- **Frequency** for the center frequency
- **Bandwidth:** channel bandwidth
- **Duplex Mode**
  - For **TDD: UL/DL Configuration** and **Special Subframe**
- **Trigger Mode:** typically External trigger provided by the base station under test
- The section **Feedback** defines the real time feedback handling for certain PUSCH tests
- The section **Fading** shows the fading settings

More advanced settings for specific tests cases are described in the corresponding sections below.

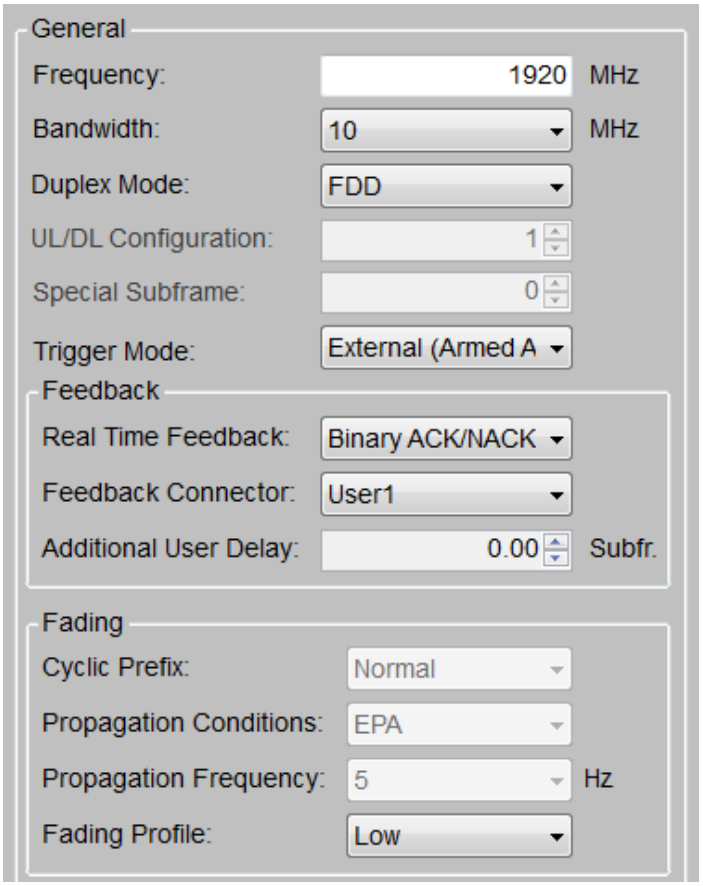


Fig. 3-29: Main parameter settings.

3.2 Performance requirements for PUSCH (Clause 8.2)

The physical uplink shared channels (PUSCH) carries user data, it 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 3-4.

AWGN power level for PUSCH tests	
Channel bandwidth [MHz]	**AWGN power level**
1.4	-92.7dBm / 1.08MHz
3	-88.7dBm / 2.7MHz
5	-86.5dBm / 4.5MHz
10	-83.5dBm / 9MHz
15	-81.7dBm / 13.5MHz
20	-80.4dBm / 18MHz

Table 3-4: AWGN power level for PUSCH tests

Hybrid Automatic Repeat Request (HARQ)-Feedback

Some PUSCH tests require a feedback signal from the base station under test to provide feedback for HARQ and/or uplink timing control information. The signal generator automatically adjusts the transmitted signal based on the feedback. Software option SMW-K69 Closed Loop BS Tests is needed to perform tests with base station feedback.

The Realtime Feedback Configuration is enabled only for UE1 in instruments. It supports three different modes (Fig. 3-30). You can find the settings under **Frame Configuration** in **UE1**.

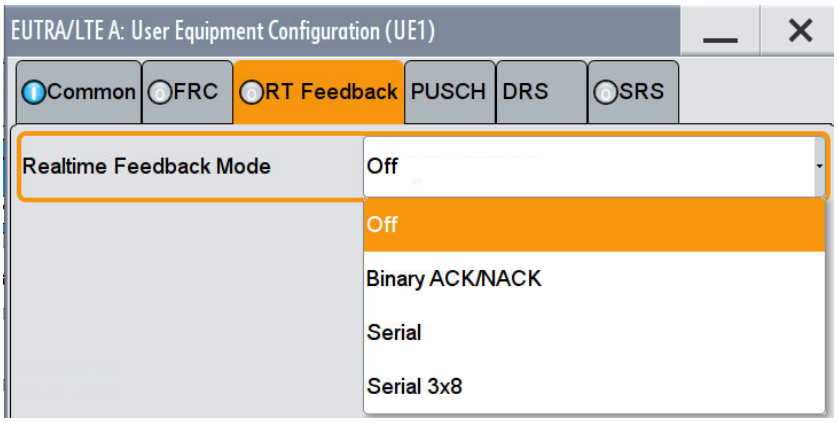


Fig. 3-30: The three supported mode in option SMW-K69

Please note that for NB-IoT and eMTC only the serial modes are available.

Select the supported Realtime Feedback Mode (example: Binary ACK/NACK). The default parameter of Redundancy Version Sequence and the Max. Number of Transmissions fits to the needed settings already (Fig. 3-31).

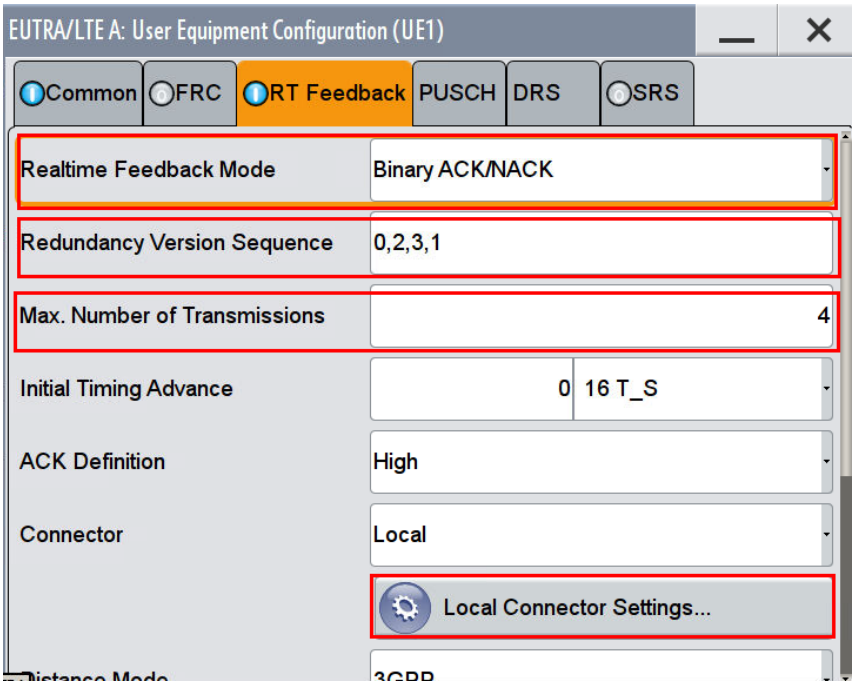


Fig. 3-31: Setting RT Feedback

You can configure the feedback line as required with the button **Local Connector Settings** (example: set **Connector T/M 3 Direction** to **Input** and **Connector T/M 3 Signal** to **Feedback**).

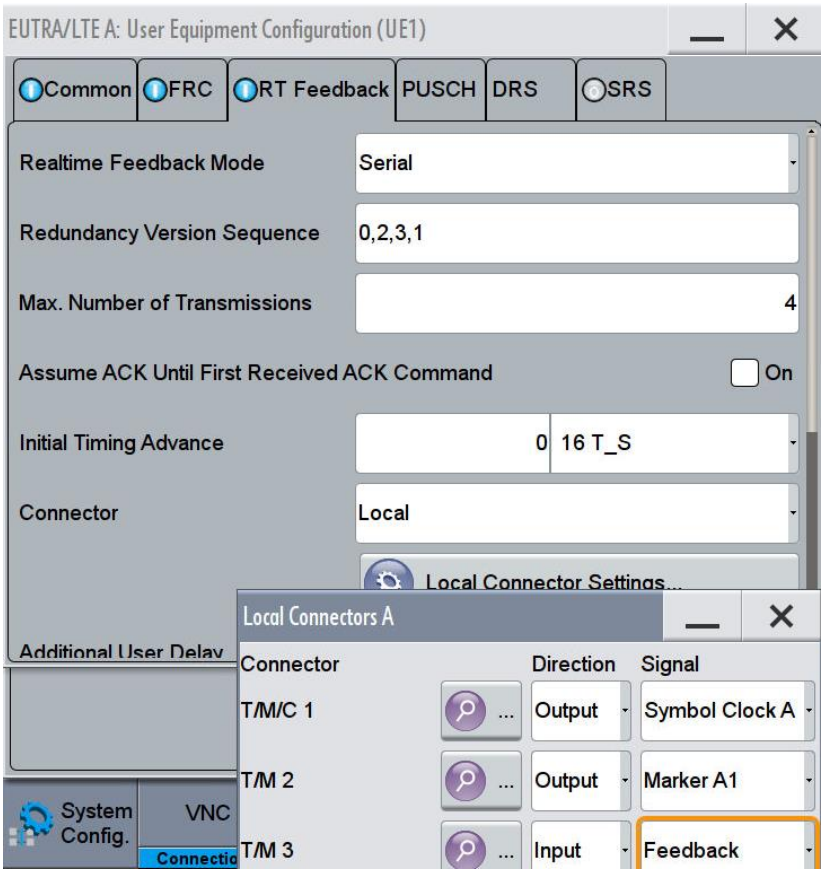


Fig. 3-32: Settings for using a serial feedback line from the BS to SMW. The HARQ-feedback line from the BS is connected with Local Connector T/M3 at the SMW rear panel.

Signals and connectors for PUSCH tests		
Signal	**HARQ feedback (from BS)**	**Frame Trigger (DL timing from BS)**
Connector @ SMW	TM3 (rear panel)	USER3 (front panel)

Table 3-5: Feedback and trigger inputs

SNR Correction Factor

For FRC's with not all RB's allocated (A3-1, A4-1, A4-2 and A5-1) a special SNR correction factor has to be applied by the user.

SNRΔ = 10 log (allocated RB's / full possible RB's per slot)

Example: For FRC A4-1 in 5 MHz bandwidth only one RB is allocated. 25 RBs per slot can be allocated acc. to [2]. Thus SNRΔ = 10 log (1 / 25) = -13.98 dB.
This factor depends on the bandwidth, see Table 3-6.

SNR Correction factor PUSCH	
Bandwidth in MHz	**Factor in dB**
1.4	-7.78
3	-11.76
5	-13.98
10	-16.99
15	- 18.75
20	- 20.00

Table 3-6: SNR correction factor for PUSCH tests with 1RB allocated.

3.2.1 Performance requirements of PUSCH in multipath fading propagation conditions transmission on single antenna port (Clause 8.2.1)

The test 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 FRC's. HARQ re-transmission is assumed.

Test parameters 8.2.1	
Parameter	**Value**
Maximum number of HARQ transmissions	4
Redundancy version (RV) sequence	0, 2, 3, 1, 0, 2, 3, 1
Uplink-downlink allocation for TDD	Configuration 1 (2 DL:2 UL)

Table 3-7: Parameters for PUSCH test 8.2.1

Carrier Aggregation

This test is applicable for Carrier Aggregation if the tested BS supports it. Only the CC combination with the largest aggregated bandwidth and the largest number of CCs has to be tested. For this CC combination, the tests using full PRB allocation FRC are conducted on per CC basis and measured by the required SNR levels corresponding to the bandwidths used on the different CCs.

CA can be tested by using a further baseband. The bandwidth then is limited to the bandwidth of the I/Q block. Further limitation may appear if for the other baseband a frequency shall be used which is too far off from the other used frequencies or where no resource is available. Also, see application note 1MA166 and 1GP92.

Base station categories

This test is applicable for all categories of BS. Tests with the fading profiles ETU 70Hz Low and ETU 300Hz Low are not applicable for Local Area and Home Area BS (marked yellow in the tables below).

Test requirements

The following tables show the test requirements for all bandwidths and all applicable number of RX antennas (2, 4 and 8). They include AWGN, SNR, SNR correction factor and the resulting carrier power level. For the given parameters, the fraction of the maximum throughput has to be achieved. All tables are in [1] section 8.2.1.

Test requirements 8.2.1, 1.4 MHz Bandwidth, 2 RX antennas, AWGN -92.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	Add. SNR Corr. Factor -7,78 [dB]	Offset VRB	Resulting LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-2	30%	-3.5			-96.2
			70%	0.7			-92.0
		A4-3	70%	11.2			-81.5
		A5-2	70%	18.3			-74.4
		A17-1	70%	22.0			-70.7
		A18-1	70%	8.0			-84.7
		A19-1	70%	18.7			-74.0
	EVA 5Hz	A3-1	30%	-2.1	X	2	-102.58
			70%	2.4	X	2	-98.08
		A4-1	30%	5.0	X	2	-95.48
			70%	11.9	X	2	-88.58
		A5-1	70%	19.2	X	2	-81.28
	EVA 70Hz	A3-2	30%	-3.3			-96
			70%	1.3			-91.4
		A4-3	30%	4.6			-88.1
			70%	12.5			-80.2
	ETU 70Hz	A3-1	30%	-1.8	X	2	-102.28
			70%	3.0	X	2	-97.48
	ETU 300Hz	A3-1	30%	-1.6	X	2	-102.08
			70%	3.5	X	2	-96.98
Extended	ETU 70Hz	A4-2	30%	5.4	X	2	-95.08
			70%	14.1	X	2	-86.38
Note: Not applicable for Local Area and Home Area BS.							

Table 3-8: Test requirements for test 8.2.1, 1.4MHz Bandwidth, 2RX antennas, AWGN -92.7dBm

Test requirements 8.2.1, 1.4 MHz Bandwidth, 4 RX antennas, AWGN -92.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Corr. Factor -7,78 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-2	30%	-6.0			-98.7
			70%	-2.5			-95.2
		A4-3	70%	7.7			-85
		A5-2	70%	15.0			-77.7
		A17-1	70%	18.8			-73.9
		A18-1	70%	4.7			-88.0
		A19-1	70%	15.3			-77.4
	EVA 5Hz	A3-1	30%	-4.4	X	2	-104.88
			70%	-0.7	X	2	-101.18
		A4-1	30%	1.9	X	2	-98.58
			70%	8.4	X	2	-92.08
		A5-1	70%	16.0	X	2	-84.48
	EVA 70Hz	A3-2	30%	-5.7			-98.4
			70%	-2.1			-94.8
		A4-3	30%	1.4			-91.3
			70%	8.9			-83.8
	ETU 70Hz	A3-1	30%	-4.2	X	2	-104.68
			70%	-0.4	X	2	-100.88
	ETU 300Hz	A3-1	30%	-4.0	X	2	-104.48
			70%	0.0	X	2	-100.48
	ETU 600Hz	A13-1	30%	-0.3			-93.0
			70%	6.7			-86.0
Extended	ETU 70Hz	A4-2	30%	2.2	X	2	-98.28
			70%	10.5	X	2	-89.98
Note: Not applicable for Local Area and Home Area BS.							

Table 3-9: Test requirements for test 8.2.1, 1.4 MHz Bandwidth, 4 RX antennas, AWGN-92.7dBm

Test requirements 8.2.1, 1.4 MHz Bandwidth, 8 RX antennas, AWGN -92.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Corr. Factor -7,78 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-2	30%	-8.8			-101.5
			70%	-5.8			-98.5
		A4-3	70%	4.6			-88.1
		A5-2	70%	11.5			-81.2
		A17-1	70%	15.7			-77.0
		A18-1	70%	1.7			-91.0
		A19-1	70%	12.2			-80.5
	EVA 5Hz	A3-1	30%	-6.6	X	2	-107.08
			70%	-3.2	X	2	-103.68
		A4-1	30%	-1.1	X	2	-101.58
			70%	5.2	X	2	-95.28
		A5-1	70%	12.3	X	2	-88.18
	EVA 70Hz	A3-2	30%	-8.4			-101.1
			70%	-5.2			-97.9
		A4-3	30%	-1.9			-94.6
			70%	5.4			-87.3
	ETU 70Hz	A3-1	30%	-6.2	X	2	-106.68
			70%	-3.0	X	2	-103.48
	ETU 300Hz	A3-1	30%	-6.1	X	2	-106.58
			70%	-2.7	X	2	-103.18
Extended	ETU 70Hz	A4-2	30%	-0.5	X	2	-100.98
			70%	7.0	X	2	-93.48
Note: Not applicable for Local Area and Home Area BS.							

Table 3-10: Test requirements for test 8.2.1, 1.4 MHz Bandwidth, 8 RX antennas, AWGN-92.7dBm

Test requirements 8.2.1, 3 MHz Bandwidth, 2 RX antennas, AWGN -88.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -11,76 [dB]	Offset VRB	LTE Carrier Power Level [dBm]
Normal	EPA 5Hz	A3-3	30%	-3.5			-92.2
			70%	0.7			-88.0
		A4-4	70%	11.5			-77.2
		A5-3	70%	18.7			-70.0
		A17-2	70%	22.6			-66.1
		A18-2	70%	8.0			-80.7
		A19-2	70%	18.5			-70.2
	EVA 5Hz	A3-1	30%	-2.2	X	7	-102.66
			70%	2.4	X	7	-98.06
		A4-1	30%	4.9	X	7	-95.56
			70%	12.1	X	7	-88.36
		A5-1	70%	19.4	X	7	-81.06
	EVA 70Hz	A3-3	30%	-3.4			-92.1
			70%	1.2			-87.5
		A4-4	30%	5.3			-83.4
			70%	13.1			-75.6
	ETU 70Hz	A3-1	30%	-1.9	X	7	-102.36
			70%	3.0	X	7	-97.46
	ETU 300Hz	A3-1	30%	-1.6	X	7	-102.06
			70%	3.5	X	7	-96.96
Extended	ETU 70Hz	A4-2	30%	5.3	X	7	-95.16
			70%	14.1	X	7	-86.36
Note: Not applicable for Local Area and Home Area BS.							

Table 3-11: Test requirements for test 8.2.1, 3 MHz Bandwidth, 2 RX antennas, AWGN-88.7dBm

Test requirements 8.2.1, 3 MHz Bandwidth, 4 RX antennas, AWGN -88.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -11,76 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-3	30%	-6.2			-94.9
			70%	-2.8			-91.5
		A4-4	70%	8.3			-80.4
		A5-3	70%	15.0			-73.7
		A17-2	70%	19.3			-69.4
		A18-2	70%	4.6			-84.1
		A19-2	70%	14.6			-74.1
	EVA 5Hz	A3-1	30%	-4.4	X	7	-104.86
			70%	-0.7	X	7	-101.16
		A4-1	30%	1.8	X	7	-98.66
			70%	8.4	X	7	-92.06
		A5-1	70%	16.0	X	7	-84.46
	EVA 70Hz	A3-3	30%	-5.9			-94.6
			70%	-2.3			-91.0
		A4-4	30%	2.2			-86.5
			70%	9.3			-79.4
	ETU 70Hz	A3-1	30%	-4.2	X	7	-104.66
			70%	-0.3	X	7	-100.76
	ETU 300Hz	A3-1	30%	-4.0	X	7	-104.46
			70%	0.0	X	7	-100.46
	ETU 600Hz	A13-2	30%	-0.5			-89.2
			70%	6.4			-82.3
Extended	ETU 70Hz	A4-2	30%	2.1	X	7	-98.36
			70%	10.5	X	7	-89.96
Note: Not applicable for Local Area and Home Area BS.							

Table 3-12: Test requirements for test 8.2.1, 3 MHz Bandwidth, 4 RX antennas, AWGN-88.7dBm

Test requirements 8.2.1, 3 MHz Bandwidth, 8 RX antennas, AWGN -88.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -11,76 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-3	30%	-9.0			-97.7
			70%	-6.0			-94.7
		A4-4	70%	4.7			-84.0
		A5-3	70%	11.7			-77
		A17-2	70%	16.2			-72.5
		A18-2	70%	1.9			-86.8
		A19-2	70%	11.6			-77.1
	EVA 5Hz	A3-1	30%	-6.5	X	7	-106.96
			70%	-3.4	X	7	-103.86
		A4-1	30%	-1.0	X	7	-101.46
			70%	5.0	X	7	-95.46
		A5-1	70%	12.3	X	7	-88.16
	EVA 70Hz	A3-3	30%	-8.7			-97.4
			70%	-5.3			-94.0
		A4-4	30%	-2.2			-90.9
			70%	5.4			-83.3
	ETU 70Hz	A3-1	30%	-6.4	X	7	-106.86
			70%	-3.1	X	7	-103.56
	ETU 300Hz	A3-1	30%	-6.2	X	7	-106.66
			70%	-2.7	X	7	-103.16
Extended	ETU 70Hz	A4-2	30%	-0.6	X	7	-101.06
			70%	7.1	X	7	-93.36
Note: Not applicable for Local Area and Home Area BS.							

Table 3-13: Test requirements for test 8.2.1, 3 MHz Bandwidth, 8 RX antennas, AWGN -88.7dBm

Test requirements 8.2.1, 5 MHz Bandwidth, 2 RX antennas, AWGN -86.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -13.98 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-4	30%	-4.1			-90.60
			70%	-0.1			-86.60
		A4-5	70%	11.0			-75.50
		A5-4	70%	18.6			-67.90
		A17-3	70%	22.5			-64.0
		A18-3	70%	8.9			-77.6
		A19-3	70%	20.0			-66.5
	EVA 5Hz	A3-1	30%	-2.1	X	12	-102.58
			70%	2.4	X	12	-98.08
		A4-1	30%	4.9	X	12	-95.58
			70%	12.1	X	12	-88.38
		A5-1	70%	19.2	X	12	-81.28
	EVA 70Hz	A3-4	30%	-3.9			-90.40
			70%	0.5			-86.00
		A4-5	30%	4.9			-81.60
			70%	12.9			-73.60
	ETU 70Hz	A3-1	30%	-1.9	X	12	-102.38
			70%	3.0	X	12	-97.48
	ETU 300Hz	A3-1	30%	-1.6	X	12	-102.08
			70%	3.5	X	12	-96.98
Extended	ETU 70Hz	A4-2	30%	5.4	X	12	-95.08
			70%	14.1	X	12	-86.38
Note: Not applicable for Local Area and Home Area BS.							

Table 3-14: Test requirements for test 8.2.1, 5 MHz Bandwidth, 2 RX antennas, AWGN-86.5dBm

Test requirements 8.2.1, 5 MHz Bandwidth, 4 RX antennas, AWGN -86.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. through-put	SNR [dB]	add SNR Correct. Factor -13.98 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-4	30%	-6.5			-93.00
			70%	-3.2			-89.70
		A4-5	70%	8.2			-78.30
		A5-4	70%	15.0			-71.50
		A17-3	70%	19.1			-67.40
		A18-3	70%	5.7			-80.80
		A19-3	70%	16.4			-70.10
	EVA 5Hz	A3-1	30%	-4.5	X	12	-104.98
			70%	-0.8	X	12	-101.28
		A4-1	30%	1.8	X	12	-98.68
			70%	8.5	X	12	-91.98
		A5-1	70%	16.1	X	12	-84.38
	EVA 70Hz	A3-4	30%	-6.3			-92.80
			70%	-2.7			-89.20
		A4-5	30%	1.8			-84.70
			70%	8.9			-77.60
	ETU 70Hz	A3-1	30%	-4.2	X	12	-104.68
			70%	-0.3	X	12	-100.78
	ETU 300Hz	A3-1	30%	-4.0	X	12	-104.48
			70%	0.0	X	12	-100.48
	ETU 600Hz	A13-3	30%	-0.3			-86.8
			70%	6.7			-79.8
Extended	ETU 70Hz	A4-2	30%	2.2	X	12	-98.28
			70%	10.5	X	12	-89.98
Note: Not applicable for Local Area and Home Area BS.							

Table 3-15: Test requirements for test 8.2.1, 5 MHz Bandwidth, 4 RX antennas, AWGN -86.5 dBm

Test requirements 8.2.1, 5 MHz Bandwidth, 8 RX antennas, AWGN -86.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. through-put	SNR [dB]	add SNR Correct. Factor -13.98 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-4	30%	-9.5			-96.0
			70%	-6.6			-93.1
		A4-5	70%	4.9			-81.6
		A5-4	70%	11.9			-74.6
		A17-3	70%	15.9			-70.6
		A18-3	70%	2.6			-83.9
		A19-3	70%	13.1			73.4
	EVA 5Hz	A3-1	30%	-6.5	X	12	-106.98
			70%	-3.3	X	12	-103.78
		A4-1	30%	-1.3	X	12	-101.78
			70%	5.0	X	12	-95.48
		A5-1	70%	12.3	X	12	-88.18
	EVA 70Hz	A3-4	30%	-9.3			-95.8
			70%	-6.1			-92.6
		A4-5	30%	-1.9			-88.4
			70%	5.2			-81.3
	ETU 70Hz	A3-1	30%	-6.3	X	12	-106.78
			70%	-2.8	X	12	-103.28
	ETU 300Hz	A3-1	30%	-6.3	X	12	-106.78
			70%	-2.7	X	12	-103.18
Extended	ETU 70Hz	A4-2	30%	-0.6	X	12	-101.08
			70%	7.0	X	12	-93.48
Note: Not applicable for Local Area and Home Area BS.							

Table 3-16: Test requirements for test 8.2.1, 5 MHz Bandwidth, 8 RX antennas, AWGN -86.5 dBm

Test requirements 8.2.1, 10 MHz Bandwidth, 2 RX antennas, AWGN -83.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -16.99 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-5	30%	-3.6			-87.10
			70%	0.2			-83.30
		A4-6	70%	11.4			-72.10
		A5-5	70%	18.9			-64.60
		A17-4	70%	23.2			-60.3
		A18-4	70%	9.1			-74.4
		A19-4	70%	20.1			-63.4
	EVA 5Hz	A3-1	30%	-2.1	X	24	-102.59
			70%	2.5	X	24	-97.99
		A4-1	30%	4.9	X	24	-95.59
			70%	12.0	X	24	-88.49
		A5-1	70%	19.4	X	24	-81.09
	EVA 70Hz	A3-5	30%	-3.5			-87.00
			70%	0.7			-82.80
		A4-6	30%	5.1			-78.40
			70%	13.2			-70.30
	ETU 70Hz	A3-1	30%	-1.9	X	24	-102.39
			70%	3.0	X	24	-97.49
	ETU 300Hz	A3-1	30%	-1.6	X	24	-102.09
			70%	3.5	X	24	-96.99
Extended	ETU 70Hz	A4-2	30%	5.4	X	24	-95.09
			70%	14.2	X	24	-86.29
Note: Not applicable for Local Area and Home Area BS.							

Table 3-17: Test requirements for test 8.2.1, 10 MHz Bandwidth, 2 RX antennas, AWGN -83.5 dBm

Test requirements 8.2.1, 10 MHz Bandwidth, 4 RX antennas, AWGN -83.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -16.99 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-5	30%	-6.2			-89.70
			70%	-2.9			-86.40
		A4-6	70%	8.1			-75.40
		A5-5	70%	15.3			-68.20
		A17-4	70%	19.8			-63.7
		A18-4	70%	5.9			-77.6
		A19-4	70%	16.4			-67.1
	EVA 5Hz	A3-1	30%	-4.4	X	24	-104.89
			70%	-0.6	X	24	-101.09
		A4-1	30%	1.8	X	24	-98.69
			70%	8.5	X	24	-91.99
		A5-1	70%	16.1	X	24	-84.39
	EVA 70Hz	A3-5	30%	-6.1			-89.60
			70%	-2.3			-85.80
		A4-6	30%	1.3			-82.20
			70%	8.6			-74.90
	ETU 70Hz	A3-1	30%	-4.2	X	24	-104.69
			70%	-0.3	X	24	-100.79
	ETU 300Hz	A3-1	30%	-4.0	X	24	-104.49
			70%	0.0	X	24	-100.49
	ETU 600Hz	A13-4	30%	-0.4			-83.10
			70%	6.8			-76.7
Extended	ETU 70Hz	A4-2	30%	2.3	X	24	-98.19
			70%	10.9	X	24	-89.59
Note: Not applicable for Local Area and Home Area BS.							

Table 3-18: Test requirements for test 8.2.1, 10 MHz Bandwidth, 4 RX antennas, AWGN -83.5 dBm

Test requirements 8.2.1, 10 MHz Bandwidth, 8 RX antennas, AWGN -83.5 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -16.99 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-5	30%	-9.2			-92.7
			70%	-6.1			-89.6
		A4-6	70%	4.8			-78.7
		A5-5	70%	12.1			-71.4
		A17-4	70%	19.8			-63.7
		A18-4	70%	2.7			-80.8
		A19-4	70%	13.1			-70.4
	EVA 5Hz	A3-1	30%	-6.3	X	24	-106.79
			70%	-3.2	X	24	-103.69
		A4-1	30%	-1.1	X	24	-101.59
			70%	5.1	X	24	-95.39
		A5-1	70%	12.5	X	24	-87.99
	EVA 70Hz	A3-5	30%	-9.1			-92.6
			70%	-5.6			-89.1
		A4-6	30%	-2.0			-85.5
			70%	5.3			-78.2
	ETU 70Hz	A3-1	30%	-6.2	X	24	-106.69
			70%	-3.0	X	24	-103.49
	ETU 300Hz	A3-1	30%	-6.2	X	24	-106.69
			70%	-2.7	X	24	-103.19
Extended	ETU 70Hz	A4-2	30%	-0.5	X	24	-100.99
			70%	7.1	X	24	-93.39
Note: Not applicable for Local Area and Home Area BS.							

Table 3-19: Test requirements for test 8.2.1, 10 MHz Bandwidth, 8 RX antennas, AWGN -83.5 dBm

Test requirements 8.2.1, 15 MHz Bandwidth, 2 RX antennas, AWGN -81.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -18.75 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-6	30%	-3.9			-85.60
			70%	-0.2			-81.90
		A4-7	70%	11.9			-69.80
		A5-6	70%	19.4			-62.30
		A17-5	70%	23.4			-58.3
		A18-5	70%	10.0			-71.7
		A19-5	70%	22.0			-59.7
	EVA 5Hz	A3-1	30%	-2.2	X	37	-102.65
			70%	2.4	X	37	-98.05
		A4-1	30%	4.8	X	37	-95.65
			70%	12.0	X	37	-88.45
		A5-1	70%	19.3	X	37	-81.15
	EVA 70Hz	A3-6	30%	-3.9			-85.60
			70%	0.3			-81.40
		A4-7	30%	4.8			-76.90
			70%	13.5			-68.20
	ETU 70Hz	A3-1	30%	-1.9	X	37	-102.35
			70%	3.0	X	37	-97.45
	ETU 300Hz	A3-1	30%	-1.6	X	37	-102.05
			70%	3.5	X	37	-96.95
Extended	ETU 70Hz	A4-2	30%	5.5	X	37	-94.95
			70%	14.2	X	37	-86.25
Note: Not applicable for Local Area and Home Area BS.							

Table 3-20: Test requirements for test 8.2.1, 15 MHz Bandwidth, 2 RX antennas, AWGN -81.7 dBm

Test requirements 8.2.1, 15 MHz Bandwidth, 4 RX antennas, AWGN -81.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -18.75 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-6	30%	-6.6			-88.30
			70%	-3.2			-84.90
		A4-7	70%	8.2			-73.50
		A5-6	70%	15.6			-66.10
		A17-5	70%	19.5			-62.20
		A18-5	70%	6.5			-75.20
		A19-5	70%	17.7			-64.00
	EVA 5Hz	A3-1	30%	-4.4	X	37	-104.85
			70%	-0.6	X	37	-101.05
		A4-1	30%	1.8	X	37	-98.65
			70%	8.5	X	37	-91.95
		A5-1	70%	16.3	X	37	-84.15
	EVA 70Hz	A3-6	30%	-6.4			-88.10
			70%	-2.7			-84.40
		A4-7	30%	1.3			-80.40
			70%	9.1			-72.60
	ETU 70Hz	A3-1	30%	-4.2	X	37	-104.65
			70%	-0.4	X	37	-100.85
	ETU 300Hz	A3-1	30%	-4.0	X	37	-104.45
			70%	0.0	X	37	-100.45
	ETU 600Hz	A13-5	30%	-0.3			
			70%	7.0			
Extended	ETU 70Hz	A4-2	30%	2.2	X	37	-98.25
			70%	10.7	X	37	-89.75
Note: Not applicable for Local Area and Home Area BS.							

Table 3-21: Test requirements for test 8.2.1, 15 MHz Bandwidth, 4 RX antennas, AWGN -81.7 dBm

Test requirements 8.2.1, 15 MHz Bandwidth, 8 RX antennas, AWGN -81.7 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -18.75 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-6	30%	-9.8			-91.5
			70%	-6.7			-88.4
		A4-7	70%	5.0			-76.7
		A5-6	70%	12.4			-69.3
		A17-5	70%	16.1			-65.6
		A18-5	70%	3.4			-78.3
		A19-5	70%	14.4			-67.3
	EVA 5Hz	A3-1	30%	-6.5	X	37	-106.95
			70%	-3.4	X	37	-103.85
		A4-1	30%	-1.1	X	37	-101.55
			70%	5.0	X	37	-95.45
		A5-1	70%	12.3	X	37	-88.15
	EVA 70Hz	A3-6	30%	-9.5			-91.2
			70%	-6.2			-87.9
		A4-7	30%	-1.9			-83.6
			70%	5.6			-76.1
	ETU 70Hz	A3-1	30%	-6.4	X	37	-106.85
			70%	-3.0	X	37	-103.45
	ETU 300Hz	A3-1	30%	-6.3	X	37	-106.75
			70%	-2.7	X	37	-103.15
Extended	ETU 70Hz	A4-2	30%	-0.5	X	37	-100.95
			70%	7.3	X	37	-93.15
Note: Not applicable for Local Area and Home Area BS.							

Table 3-22: Test requirements for test 8.2.1, 15 MHz Bandwidth, 8 RX antennas, AWGN -81.7 dBm

Test requirements 8.2.1, 20 MHz Bandwidth, 2 RX antennas, AWGN -80.4 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -20 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-7	30%	-3.6			-84.00
			70%	0.2			-80.20
		A4-8	70%	12.1			-68.30
		A5-7	70%	20.3			-60.10
		A17-6	70%	24.3			-56.10
		A18-6	70%	9.9			-70.50
		A19-6	70%	21.6			-58.80
	EVA 5Hz	A3-1	30%	-2.1	X	49	-102.50
			70%	2.4	X	49	-98.00
		A4-1	30%	4.9	X	49	-95.50
			70%	12.1	X	49	-88.30
		A5-1	70%	19.3	X	49	-81.10
	EVA 70Hz	A3-7	30%	-3.5			-83.90
			70%	0.8			-79.60
		A4-8	30%	4.8			-75.60
			70%	13.6			-66.80
	ETU 70Hz	A3-1	30%	-1.8	X	49	-102.20
			70%	3.0	X	49	-97.40
	ETU 300Hz	A3-1	30%	-1.5	X	49	-101.90
			70%	3.5	X	49	-96.90
Extended	ETU 70Hz	A4-2	30%	5.3	X	49	-95.10
			70%	14.2	X	49	-86.20
Note: Not applicable for Local Area and Home Area BS.							

Table 3-23: Test requirements for test 8.2.1, 20 MHz Bandwidth, 2 RX antennas, AWGN -80.4 dBm

Test requirements 8.2.1, 20 MHz Bandwidth, 4 RX antennas, AWGN -80.4 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -20 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-7	30%	-6.2			-86.60
			70%	-2.9			-83.30
		A4-8	70%	8.1			-72.30
		A5-7	70%	16.5			-63.90
		A17-6	70%	20.4			-60.00
		A18-6	70%	6.3			-74.10
		A19-6	70%	17.3			-63.10
	EVA 5Hz	A3-1	30%	-4.5	X	49	-104.90
			70%	-0.7	X	49	-101.10
		A4-1	30%	1.8	X	49	-98.60
			70%	8.5	X	49	-91.90
		A5-1	70%	16.2	X	49	-84.20
	EVA 70Hz	A3-7	30%	-6.1			-86.50
			70%	-2.3			-82.70
		A4-8	30%	1.3			-79.10
			70%	9.2			-71.20
	ETU 70Hz	A3-1	30%	-3.8	X	49	-104.20
			70%	-0.3	X	49	-100.70
	ETU 300Hz	A3-1	30%	-4.0	X	49	-104.40
			70%	-0.1	X	49	-100.50
	ETU 600Hz	A13-6	30%	-0.3			-80.7
			70%	7.0			-73.4
Extended	ETU 70Hz	A4-2	30%	2.2	X	49	-98.20
			70%	10.6	X	49	-89.80
Note: Not applicable for Local Area and Home Area BS.							

Table 3-24: Test requirements for test 8.2.1, 20 MHz Bandwidth, 4 RX antennas, AWGN -80.4 dBm

Test requirements 8.2.1, 20 MHz Bandwidth, 8 RX antennas, AWGN -80.4 dBm							
Cyclic prefix	Propagation conditions	FRC	Fraction of max. throughput	SNR [dB]	add SNR Correct. Factor -20 [dB]	Offset VRB	LTE Carrier Level [dBm]
Normal	EPA 5Hz	A3-7	30%	-9.1			-89.5
			70%	-6.1			-86.5
		A4-8	70%	4.9			-75.5
		A5-7	70%	13.1			-67.3
		A17-6	70%	16.9			-63.5
		A18-6	70%	3.2			-77.2
		A19-6	70%	13.8			-66.6
	EVA 5Hz	A3-1	30%	-6.4	X	49	-106.8
			70%	-3.3	X	49	-103.7
		A4-1	30%	-1.1	X	49	-101.5
			70%	5.2	X	49	-95.2
		A5-1	70%	12.6	X	49	-87.8
	EVA 70Hz	A3-7	30%	-9.1			-89.5
			70%	-5.5			-85.9
		A4-8	30%	-1.6			-82.0
			70%	5.5			-74.9
	ETU 70Hz	A3-1	30%	-6.3	X	49	-106.7
			70%	-2.9	X	49	-103.3
	ETU 300Hz	A3-1	30%	-6.2	X	49	-106.6
			70%	-2.7	X	49	-103.1
Extended	ETU 70Hz	A4-2	30%	-0.6	X	49	-81.0
			70%	7.1	X	49	-73.3
Note: Not applicable for Local Area and Home Area BS.							

Table 3-25: Test requirements for test 8.2.1, 20 MHz Bandwidth, 8 RX antennas, AWGN -80.4 dBm

Test setup

Fig. 3-33 to Fig. 3-35 show the test setup.

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 (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3. A HARQ-Feedback signal from the base station is required.

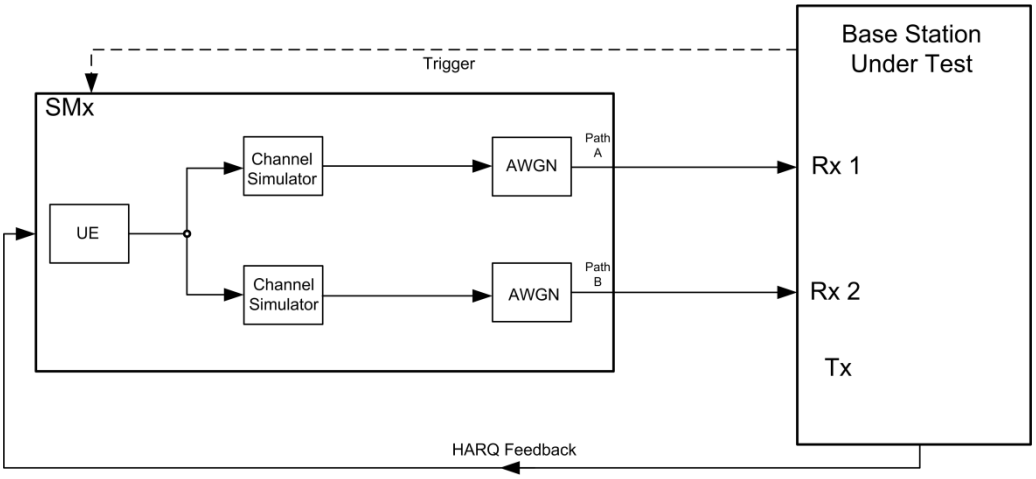


Fig. 3-33: Test setup for PUSCH test 8.2.1 for 2 antennas

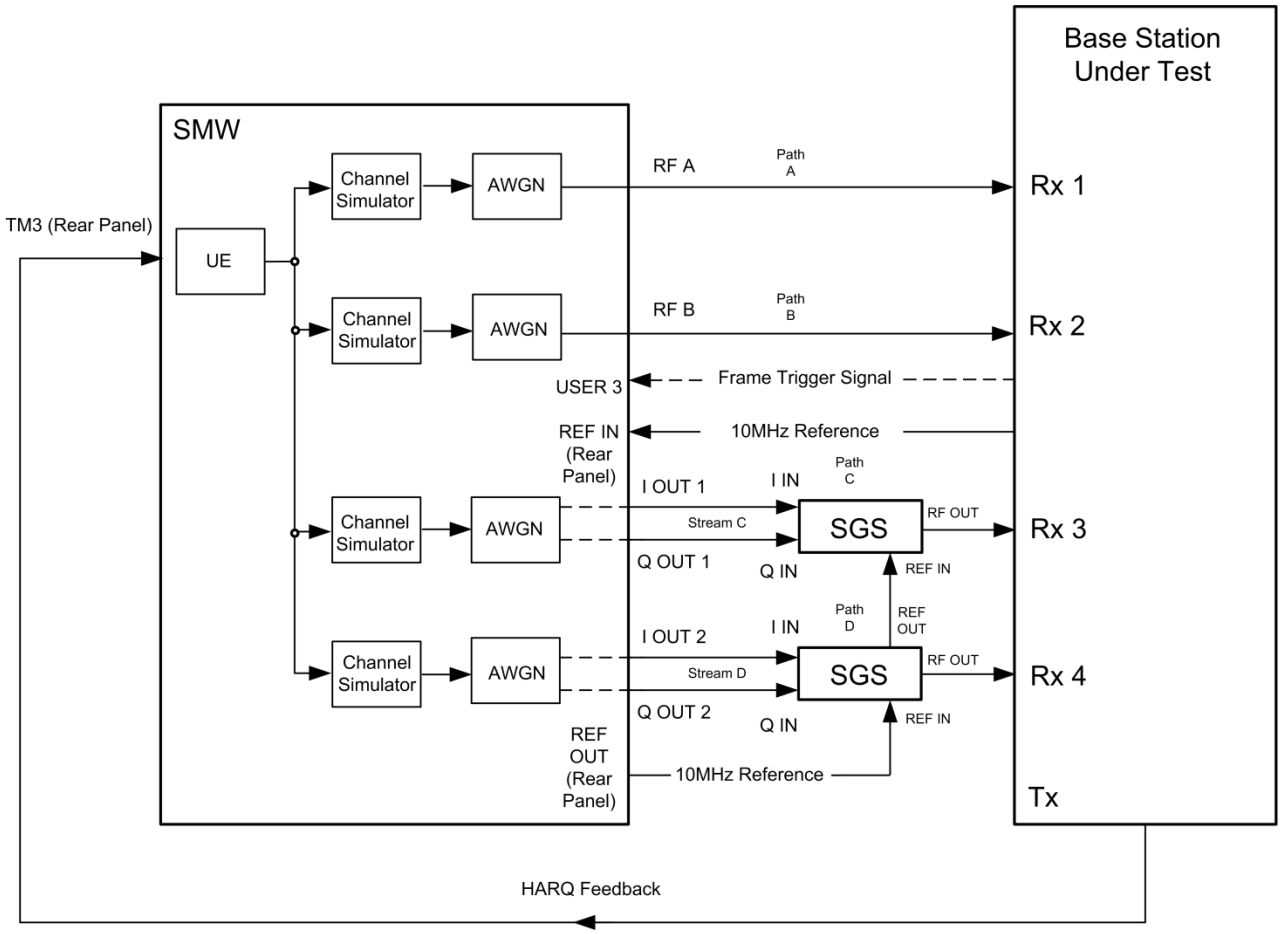


Fig. 3-34: Test setup for PUSCH test 8.2.1 for 4 antennas with one SMW

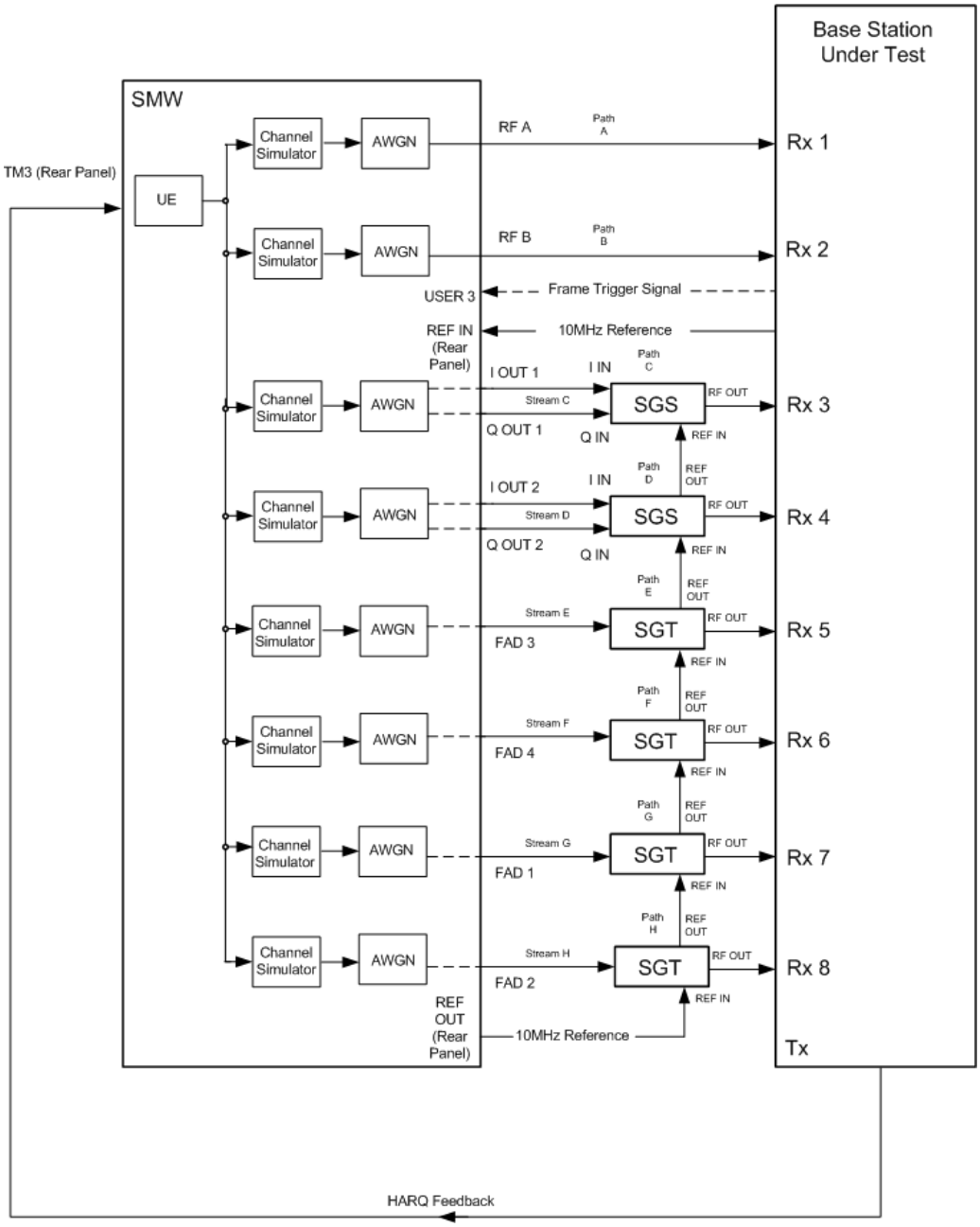


Fig. 3-35: Test setup for PUSCH test 8.2.1 for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EVA 5 Hz, 10 MHz, FRC A3-1 and fraction 30% throughput are shown. The PUSCH is transmitted continuously in every subframe.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.

3. Click **Frame Configuration.**
4. Set **No of PUSCH Config** to 1 (Fig. 3-36). In this case, only one subframe has to be configured. The configuration is automatically copied to all other subframes.

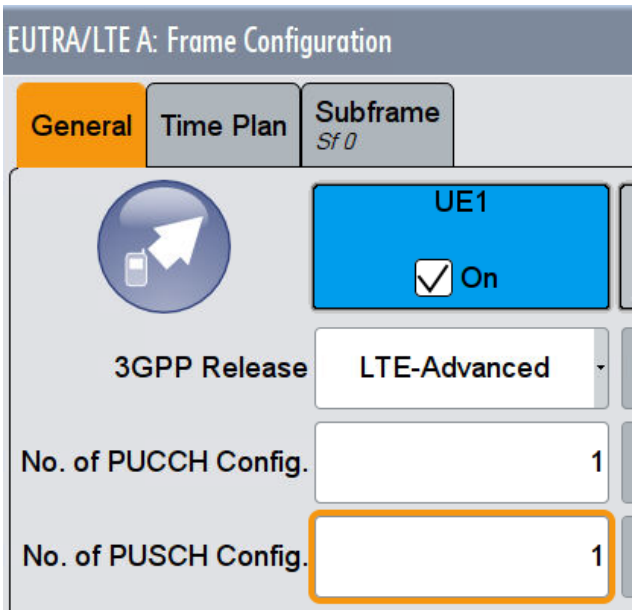


Fig. 3-36: Set one configurable PUSCH subframe. The SMW copies the setting to the other subframes automatically.

5. Open the **User Equipment Configuration (UE1)** dialog by double clicking **UE1.**
6. In the tab **FRC,** activate **FRCState.** Set the FRC according to the test requirements tables (Table 3-8 to Table 3-25, example: FRC A3-1). With the FRC automatically all FRC parameters (e.g. the allocated RBs) are set.

FRCs with one RB only

The FRCs A3-1, A4-1, A4-2 and A5-1 use one resource block only. For these FRCs, the RB in the middle of the channel bandwidth shall be used. In case the number of resource blocks in the channel bandwidth are even, the one in the middle with lower number is to be used for testing. To perform this adjustment, shift the used RBs by setting **Offset VRB** according to the tables (example: 24) as shown in Fig. 3-37.

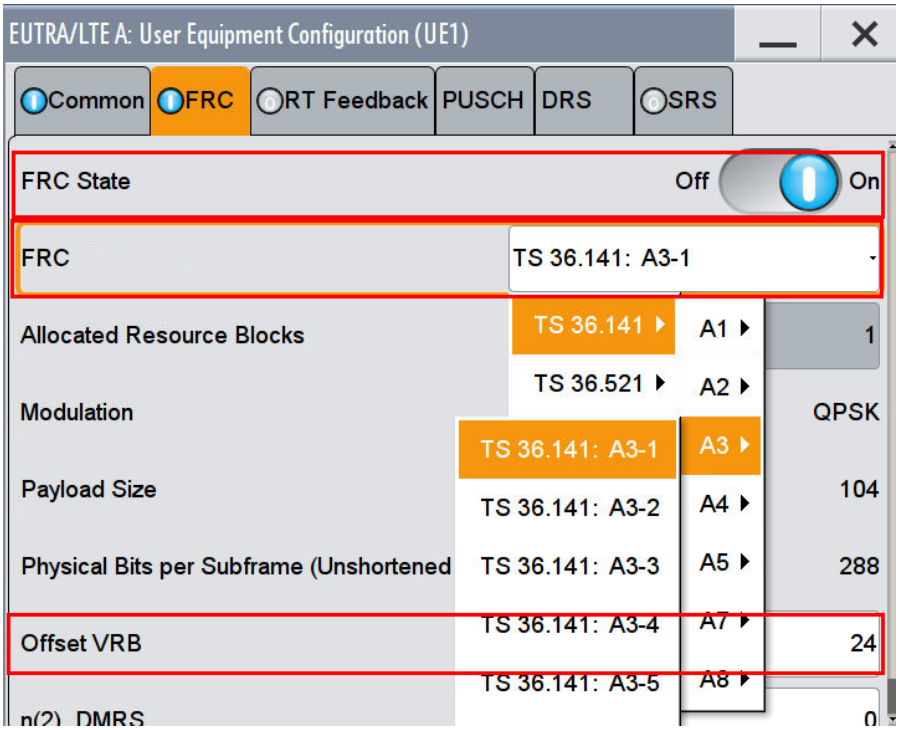


Fig. 3-37: Setting the FRC and the Offset VRB for UE1.

HARQ-Feedback

7. Set the needed **Feedback Mode**. Set the **Redundancy Version Sequence** to **0,2,3,1** and the **Max. Number of Transmissions** to **4** (Fig. 3-31).

AWGN and Fading

8. Set **Fading** according to Table 3-8 to Table 3-25 (see 3.1.3) (example EVA 5 Hz Low)
9. Set **noise power** and **SNR.** For FRC's with one RB only, take in account the **SNR correction factor** (see 3.1.4)(example: Noise = -83.5 dBm; SNR = SNR + Correction = -2.1 dB -16.99 dB = -19.09 dB)

Demo Program

Fig. 3-38 shows the parameters of the test. You can select the test in the section **8.2 PUSCH.** Select one test under **8.2.1 Multipath Fading**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. For FRC's using 1 resource block the RB in the middle of the channel bandwidth is used and the special SNR correction factor is applied. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas. To simulate Carrier Aggregation, enable **2nd CC** and the corresponding parameters. Please note that this is handled via a second carrier inside the same baseband of the SMW.

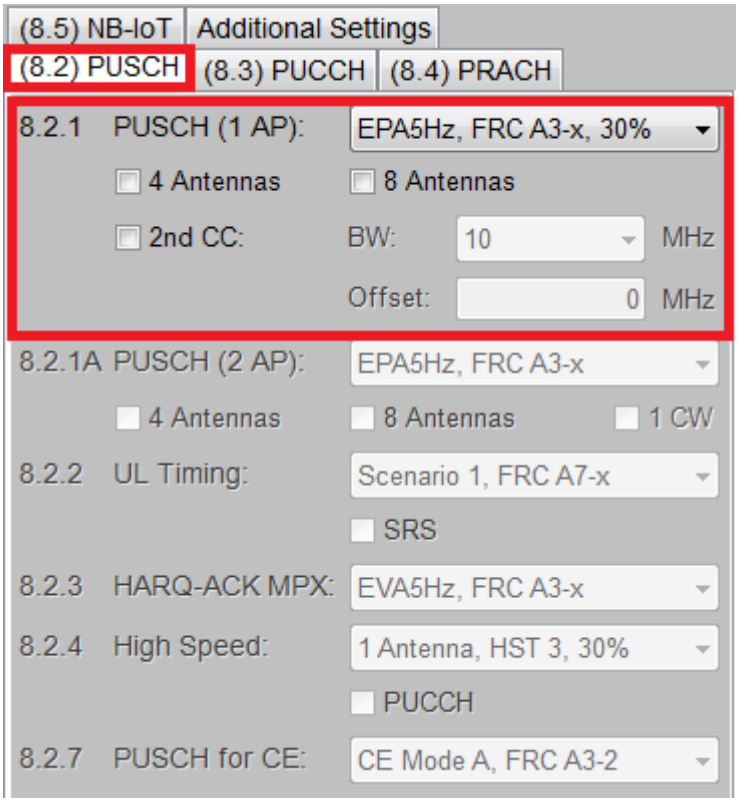


Fig. 3-38: Parameter for PUSCH test 8.2.1

Fig. 3-39 shows the report.

```
******* Performance Tests *******

8.2.1 PUSCH in Multipath Fading (Single Antenna Port)
with 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
FRC: A35
AWGN: -83.5 dBm
SNR: -3.6 dB
Finished!
```

Fig. 3-39: Report 8.2.1

3.2.2 Performance requirements of PUSCH in multipath fading propagation conditions transmission on two antenna ports (Clause 8.2.1A)

The test 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 FRC's. HARQ re-transmission is assumed.

The test is similar to the test 8.2.1 (see 3.2.1) but uses two antenna ports (UL-MIMO with ports 200 and 201). The test is done with two code words (CW).

Please note that at the moment HARQ feedback via K69 is not supported for this test.

Test parameters 8.2.1A	
Parameter	**Value**
Maximum number of HARQ transmissions	4
Redundancy version (RV) sequence	0, 2, 3, 1, 0, 2, 3, 1
Uplink-downlink allocation for TDD	Configuration 1 (2 DL:2 UL)

Table 3-26: Parameters for PUSCH test 8.2.1A

Test requirements

The following tables show the test requirements for all bandwidths and all applicable number of RX antennas (2, 4 and 8). They include AWGN, SNR and the resulting carrier power level. For the given parameters, the fraction of the maximum throughput has to be achieved. A3-x represents FRC's with QPSK modulation, A4-x with 16QAM modulation.

Test requirements 8.2.1A, 2 RX antennas									
Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions	Fraction of max. throughput	Channel Bandwidth [MHz]	AWGN [dBm]	FRC	SNR [dB]	Resulting LTE Carrier Level [dBm]
2	2	Normal	EPA 5Hz low	70%	1.4	-92.7	A3-2	5.4	-87.3
							A4-3	18.5	-74.2
					3	-88.7	A3-3	5.2	-83.5
							A4-4	18.4	-70.3
					5	-86.5	A3-4	4.5	-82.0
							A4-5	19.0	-67.5
					10	-83.5	A3-5	5.0	-78.5
							A4-6	19.4	-64.1
					15	-81.7	A3-6	4.5	-77.2
							A4-7	20.2	-61.5
					20	-80.4	A3-7	5.2	-75.2
							A4-8	20.5	-59.9

Table 3-27: Test requirements for test 8.2.1A, 2 RX antennas

Test requirements 8.2.1A, 4 RX antennas									
Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions	Fraction of max. throughput	Channel Bandwidth [MHz]	AWGN [dBm]	FRC	SNR [dB]	Resulting LTE Carrier Level [dBm]
2	4	Normal	EPA 5Hz low	70%	1.4	-92.7	A3-2	0.7	-92.0
							A4-3	12.7	-80.0
					3	-88.7	A3-3	1.1	-87.6
							A4-4	12.6	-76.1
					5	-86.5	A3-4	0.3	-86.2
							A4-5	12.7	-73.8
					10	-83.5	A3-5	1.0	-82.5
							A4-6	12.8	-70.7
					15	-81.7	A3-6	0.6	-81.1
							A4-7	13.5	-68.2
					20	-80.4	A3-7	1.3	-79.1
							A4-8	13.5	-66.9

Table 3-28: Test requirements for test 8.2.1A, 4 RX antennas

Test requirements 8.2.1A, 8 RX antennas									
Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions	Fraction of max. throughput	Channel Bandwidth [MHz]	AWGN [dBm]	FRC	SNR [dB]	Resulting LTE Carrier Level [dBm]
2	8	Normal	EPA 5Hz low	70%	1.4	-92.7	A3-2	-2.2	-94.9
							A4-3	8.3	-84.4
					3	-88.7	A3-3	-2.3	-91.0
							A4-4	8.4	-80.3
					5	-86.5	A3-4	-3.1	-89.6
							A4-5	8.4	-78.1
					10	-83.5	A3-5	-2.5	-86.0
							A4-6	8.7	-74.8
					15	-81.7	A3-6	-3.0	-84.7
							A4-7	9.1	-72.6
					20	-80.4	A3-7	-2.6	-83.0
							A4-8	9.1	-71.3

Table 3-29: Test requirements for test 8.2.1A, 8 RX antennas

Test setup

Fig. 3-40 to Fig. 3-42 show the test setup.

The wanted signal generated by SMW basebands A and B uses a 2x2 MIMO configuration. Multipath fading is simulated in the channel simulators, AWGN is added.

For four RX antennas the test can be done with just one SMW (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3. A HARQ-Feedback signal from the base station is required.

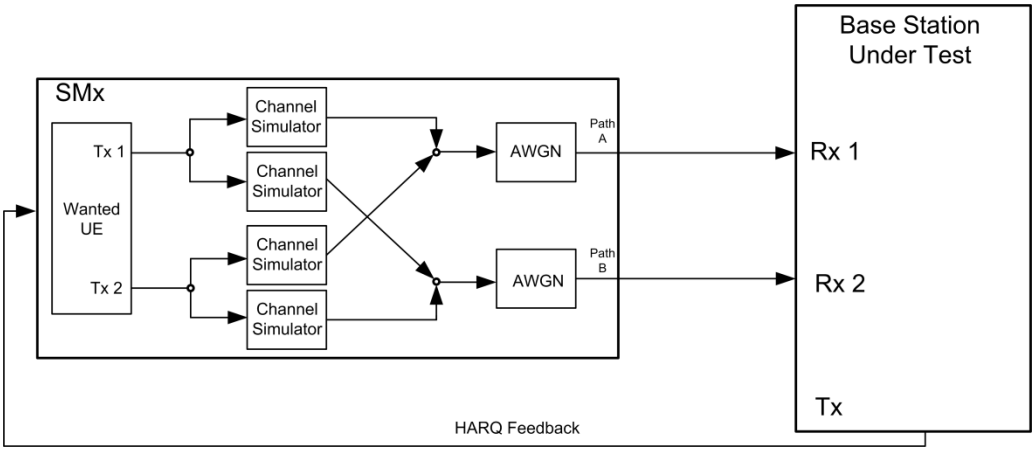


Fig. 3-40: Test setup for PUSCH test 8.2.1A for 2 antennas

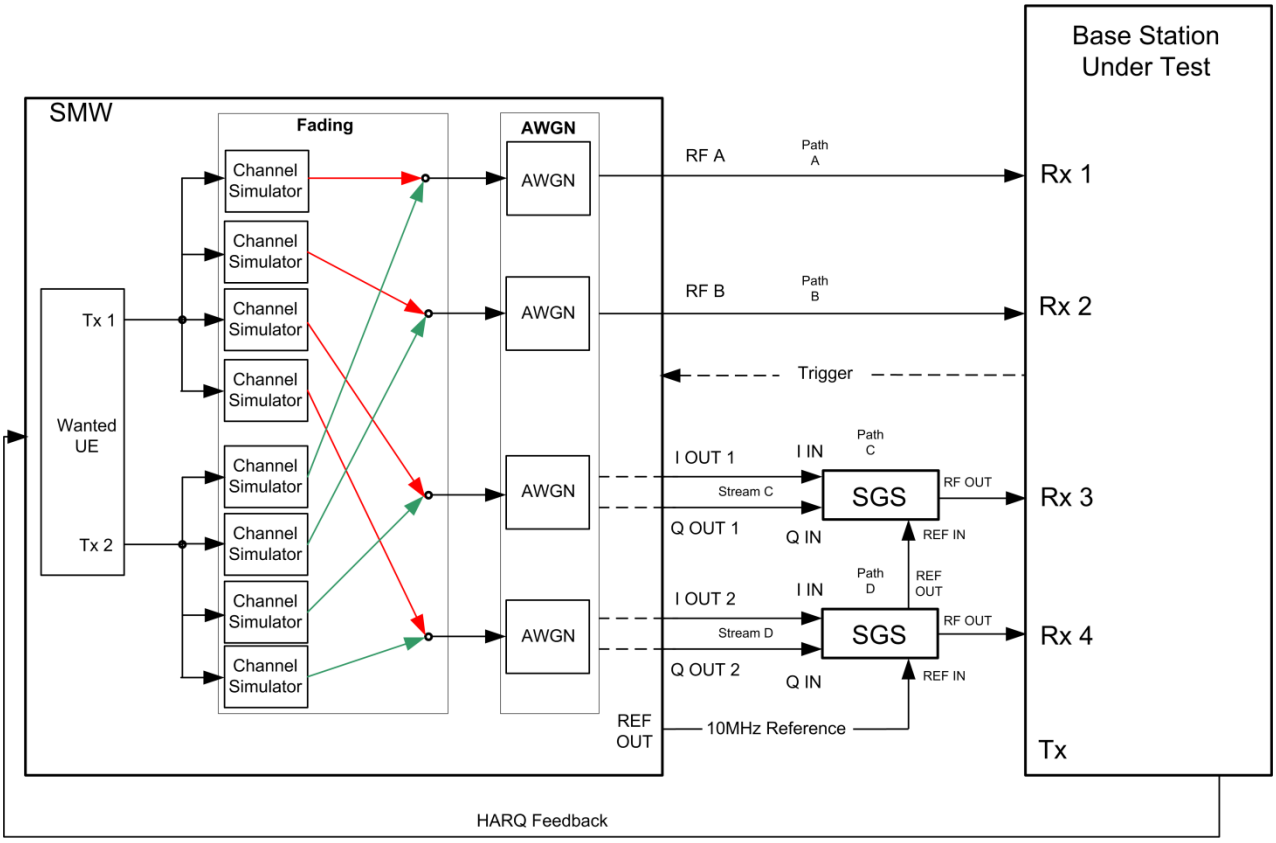


Fig. 3-41: Test setup for PUSCH test 8.2.1A for 4 antennas with one SMW

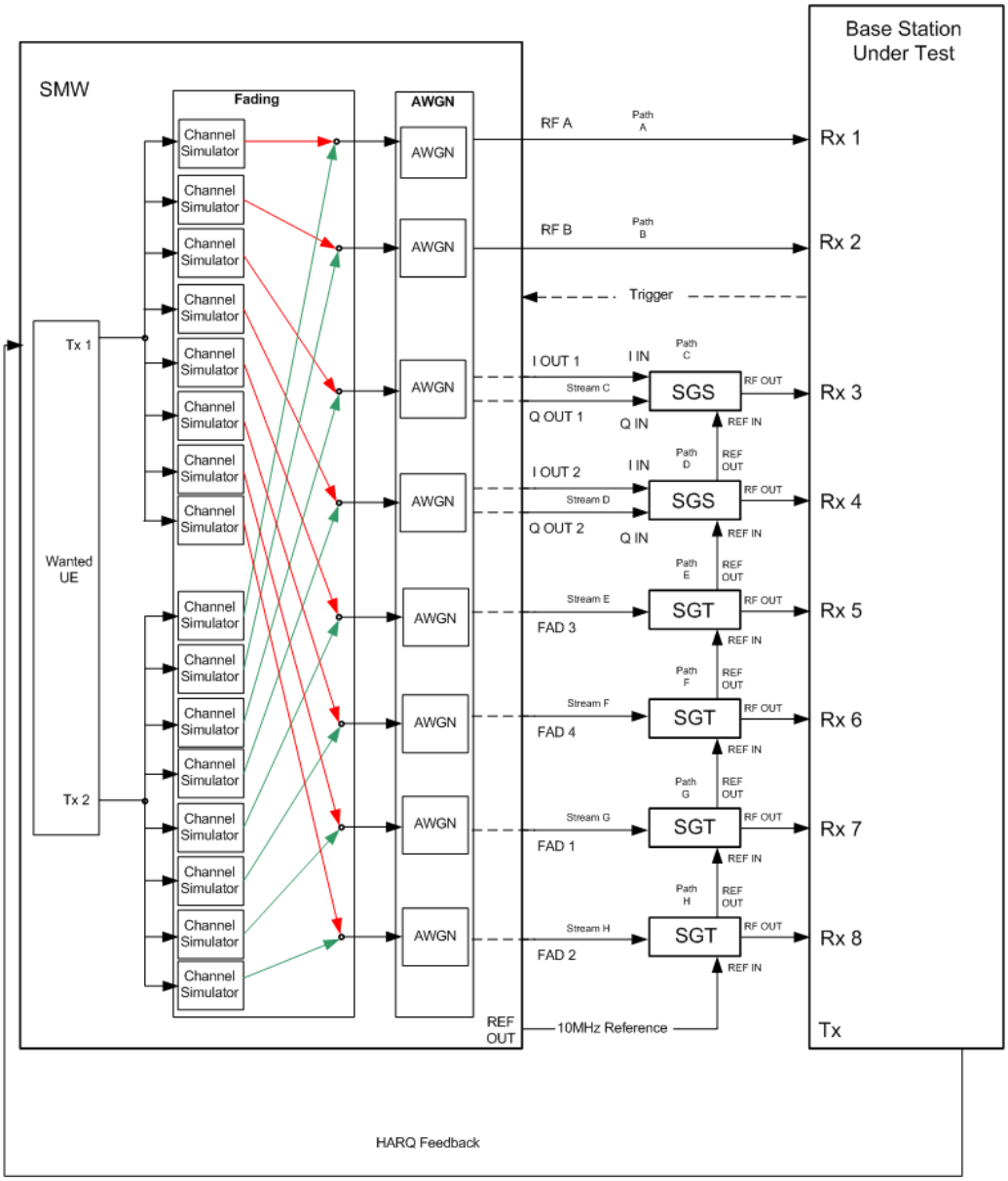


Fig. 3-42: Test setup for PUSCH test 8.2.1A for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz, 10 MHz, FRC A3-5 and two code words are shown. The PUSCH is transmitted continuously in every subframe.

1. Set the **routing** to 1x2x2 (see 3.1.1), thus two baseband blocks are routed to two paths (2x2 MIMO).
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **No of PUSCH Config** to 1 (Fig. 3-36). In this case only one subframe has to be configured. The configuration is automatically copied to all other subframes.

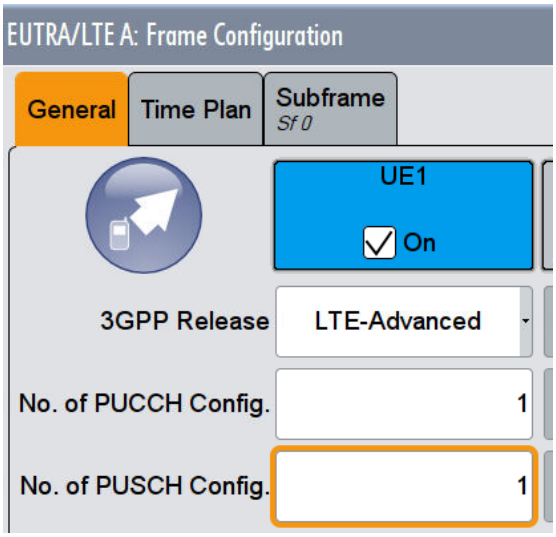


Fig. 3-43: Set one configurable PUSCH subframe. The SMW copies the setting to the other subframes automatically.

5. Open the **User Equipment Configuration (UE1)** dialog by double clicking **UE1.**

6. In the tab **FRC,** activate **FRCState.** Set the FRC according to the test requirements tables (Table 3-8 to Table 3-25, example: FRC A3-4). With the FRC automatically all FRC parameters (e.g. the allocated RBs) are set.

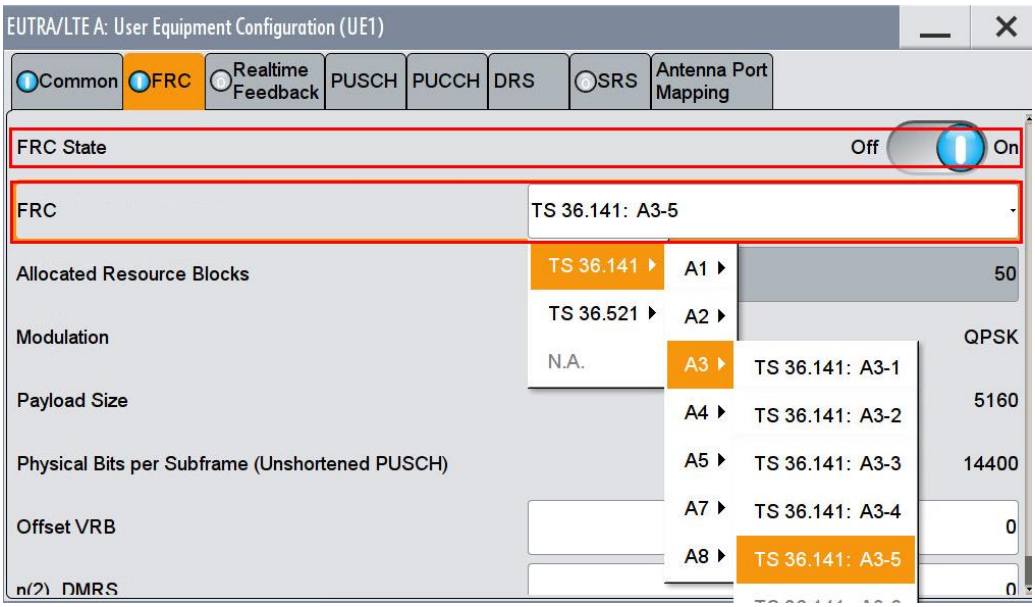


Fig. 3-44: Setting the FRC for UE1.

7. Set in tab **PUSCH** the **Transmission Mode** to **2** (TM2) and the **Number of Antenna Ports** to **2**.

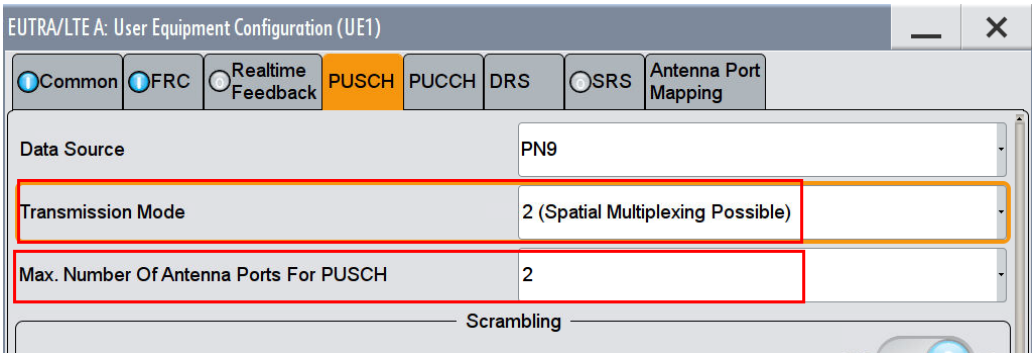


Fig. 3-45: Transmission mode (TM2) and number of antenna ports

8. Check the **Antenna Port Mapping**

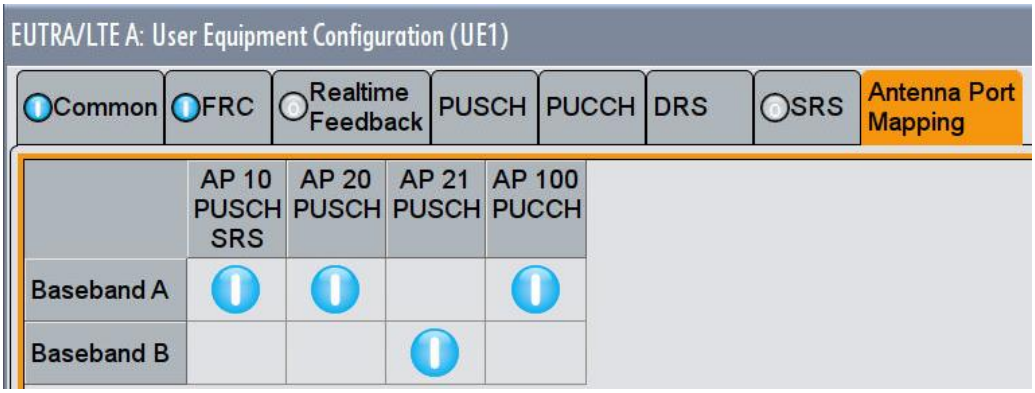


Fig. 3-46: Antenna port mapping for PUSCH 8.2.1A

9. Set two codewords (**CW**). All settings can be checked under **Config. Enhanced settings**.

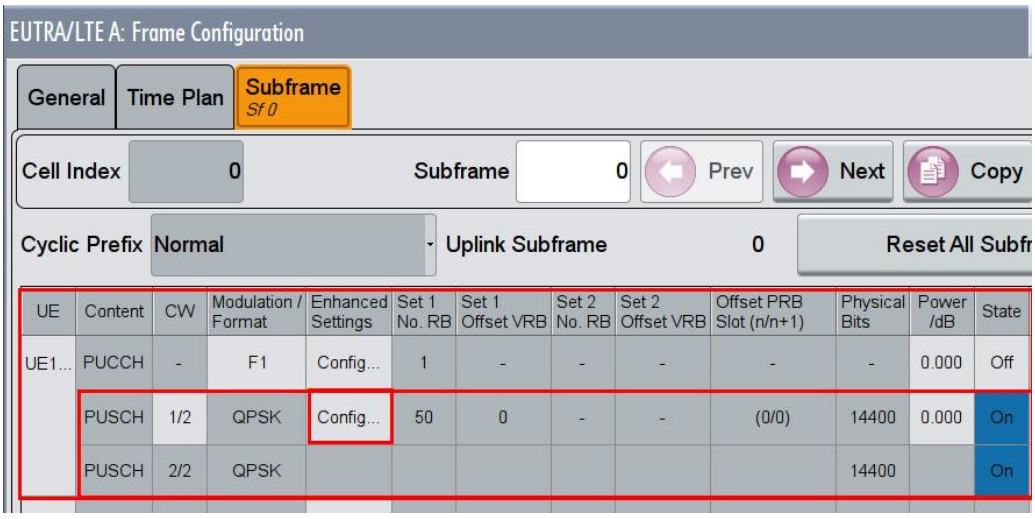


Fig. 3-47: Two codewords for PUSCH 8.2.1A

HARQ-Feedback

Please note that at the moment HARQ feedback via K69 is not supported for this test.

AWGN and Fading

10. Set **Fading** according to Table 3-8 to Table 3-25 (see 3.1.3) (example EPA 5 Hz Low)
11. Set **noise power** and **SNR**(see 3.1.4)(example: Noise = -83.5 dBm; SNR = 5.0 dB)

Demo Program

Fig. 3-38 shows the parameters of the test. You can select the test in the section **8.2 PUSCH.** Select one test under **8.2.1A PUSCH (2 AP)**. The tests are listed by the different FRC. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the channel bandwidth. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

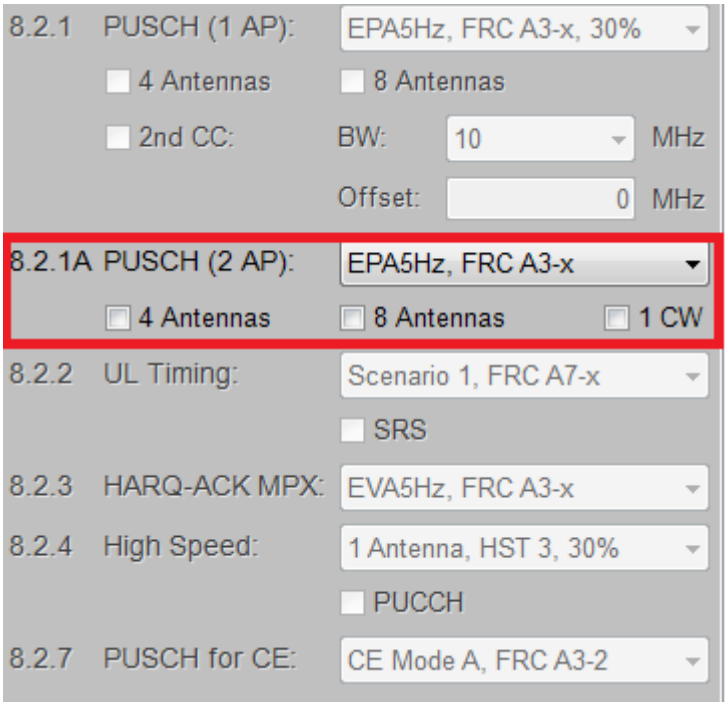


Fig. 3-48: Parameter for PUSCH test 8.2.1

Fig. 3-39 shows the report.

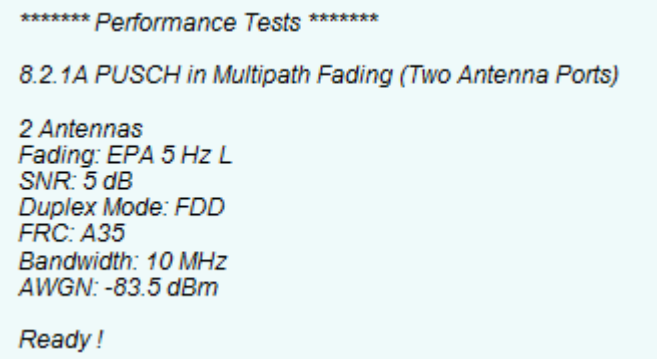


Fig. 3-49: Report 8.2.1

3.2.3 Performance requirements for UL timing adjustment (Clause 8.2.2)

The test verifies the achieved throughput of a moving UE under multipath fading conditions at a given SNR. Two signals are transmitted, one simulates a moving UE and the second simulates a stationary UE. The throughput is measured by the base station under test. The required throughput is expressed as 70% of maximum throughput for the FRCs. HARQ re-transmission is assumed. The transmission of sounding reference signal (SRS) is optional. Two moving propagation scenarios are specified. Tests with scenario 2 are optional.

This test is not applicable for local area and home area BS.

Test parameters 8.2.2		
Parameter	**Value**	
Maximum number of HARQ transmissions	4	
RV sequence	0, 2, 3, 1, 0, 2, 3, 1	
Uplink-downlink allocation for TDD	Configuration 1 (2 DL:2 UL)	
PUSCH transmitted in subframes #	FDD 0,2,4,6,8	TDD 2,3,7,8
SRS transmitted in subframes #	FDD 1	TDD UpPTS

Table 3-30: Parameters for testing PUSCH 8.2.2.

Table 3-31 shows the test requirements. The test is done with two RX antennas and normal cyclic prefix. The FRC and the SNR differs for the other bandwidths. The parameters for the moving propagation scenarios 1 and 2 are described in [1] section B.4.

Test requirements 8.2.2								
Number of RX antennas	**Cyclic prefix**	**Channel Bandwidth [MHz]**	**Moving propagation conditions**	**FRC**	**SNR [dB]**	**SNR correction** [dB]	**Resulting SNR with UE combining + 3.01 dB** [dB]	**LTE Carrier Power level [dBm]**
2	Normal	1.4	Scenario 1	A7-1	13.7	-3.01	13.7	-79
			Scenario 2	A8-1	-1.6		-1.6	-94.3
		3	Scenario 1	A7-2	14.0	-3.98	13.03	-75.67
			Scenario 2	A8-2	-1.2		-2.17	-90.87
		5	Scenario 1	A7-3	13.8	-3.19	13.62	-72.88
			Scenario 2	A8-3	-1.3		- 1.48	-87.98
		10	Scenario 1	A7-4	14.4	-3,01	14.4	-69.1
			Scenario 2	A8-4	-1.5		-1.5	-85
		15	Scenario 1	A7-5	14.6	-4.77	12.84	-86.86
			Scenario 2	A8-5	-1.5		- 3.26	-84.96
		20	Scenario 1	A7-6	14.5	-6.02	11.49	-68.91
			Scenario 2	A8-6	-1.5		- 4.51	-84.91

Table 3-31: Test requirements for test 8.2.2

SNR Correction Factor

All FRC's in this test case do not allocate all possible RB's. Thus, a special SNR correction factor is applied which depends on the bandwidth (see Table 3-32).

SNR Correction factor 8.2.2	
Bandwidth in MHz	**Factor in dB**
1.4	-3.01
3	-3.98
5	-3.19
10	-3.01
15	- 4.77
20	- 6.02

Table 3-32: SNR Correction Factor for test 8.2.2

Test setup

Fig. 3-50 shows the test setup for scenario 1. Baseband A generates the moving UE, baseband B the stationary UE. A combining network similar to 2x2 MIMO is used. For scenario 1, the fading for the moving UE signal multipath fading is applied by two channel simulators. Additional AWGN is applied for both paths. Only the Moving UE uses the DUTs feedback. The SMW needs an external trigger.

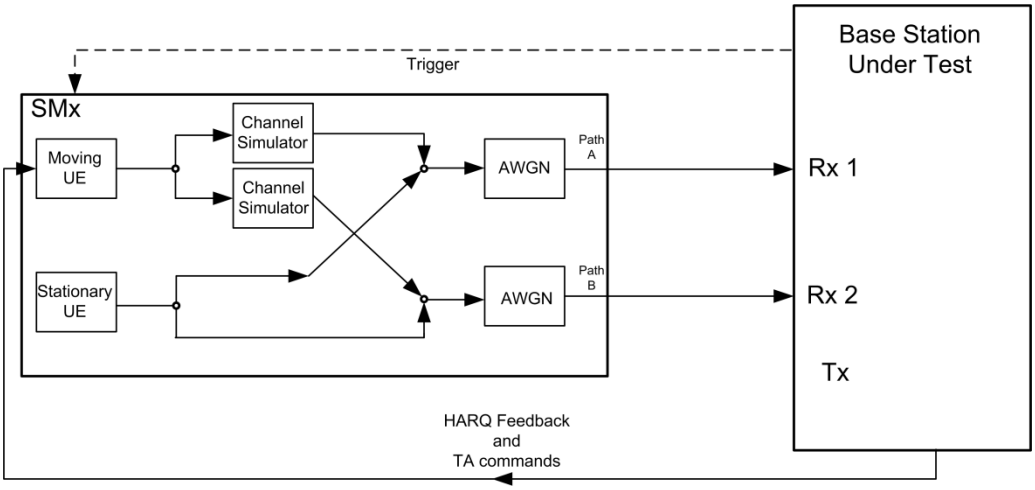


Fig. 3-50: Test setup for test 8.2.2

Test Procedure

An example shows how to perform the settings for a two antenna test setup for a channel bandwidth of 5 MHz, FRC A7-3, Scenario 1 (scenario with Doppler shift taken into account) and fading profile ETU200Hz Moving.

1. Set the routing in the SMW to **2 x 1 x 2,** thus two baseband blocks are routed to two paths with a combining network similar to 2x2 MIMO.
2. For the basic LTE steps see section 3.1.2.
3. Map the I/Q streams to the connectors as shown in Fig. 3-51 (Stream A and C are added to RF A, Stream B and D to RF B).

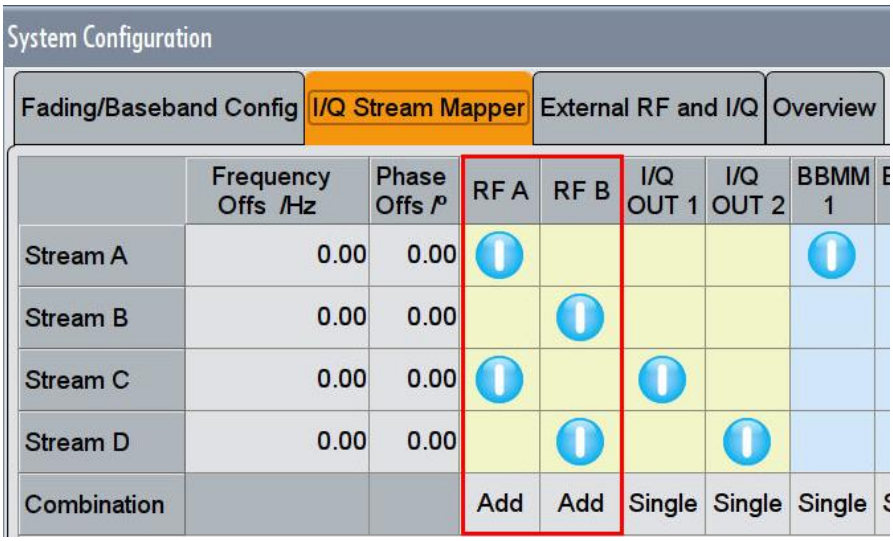


Fig. 3-51: Setting the I/Q Stream Mapper

4. Click **Frame Configuration**
5. Set **No of PUSCH Config** to 2 (Fig. 3-36), because according to Table 3-30 the PUSCH has to be transmitted in every second subframe only. With this setting,

two subframes have to be configured. The configuration is automatically copied to all other subframes.

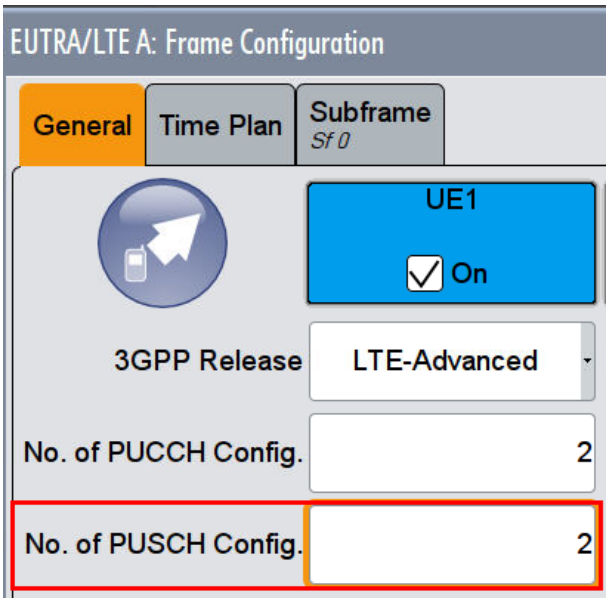


Fig. 3-52: Set two configurable PUSCH subframes

As the test requires two UE's, configure two baseband blocks:

6. Set two different UE ID/n_RNTI (example: path A: 1, path B: 2) (Fig. 3-53 and Fig. 3-54)

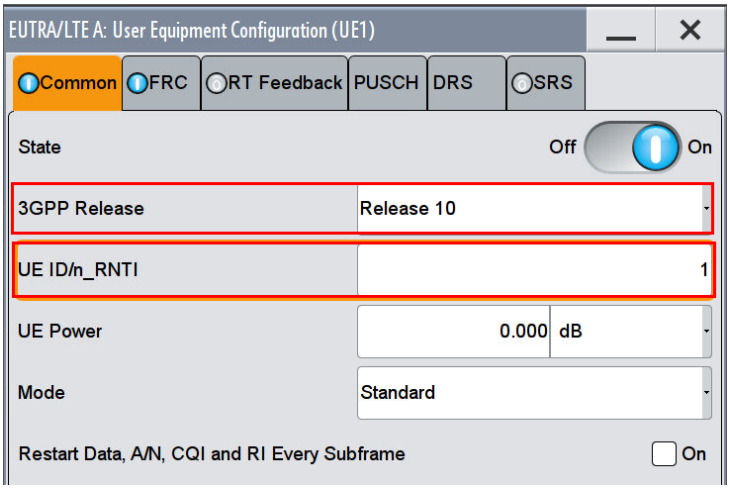


Fig. 3-53: Setting UE1 Configuration for the mobile UE (Baseband A)

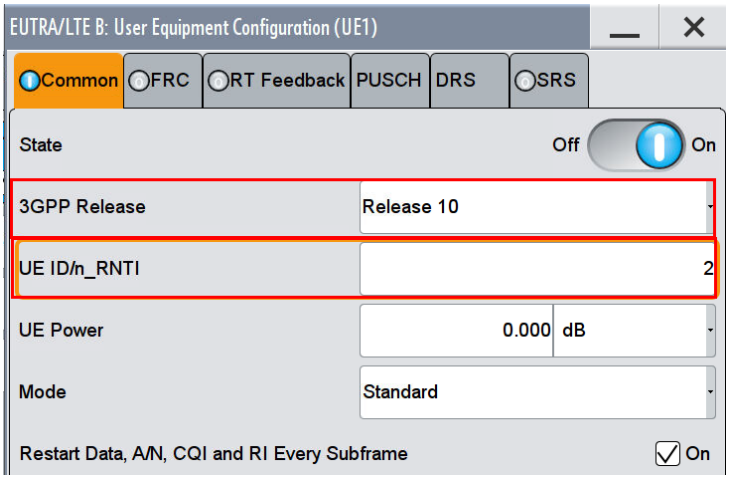


Fig. 3-54: Setting UE2 Configuration for the stationary UE (Baseband B)

7. In the tab **FRC,** activate **FRCState.** Set the FRC according to the test requirements table (Table 3-31, example: FRC A7-3). With the FRC automatically all FRC parameters (e.g. the allocated RBs) are set.

8. Both UEs shall occupy consecutive RBs in the lowest possible position. So set the **Offset VRBs** of path A and path B accordingly (example: **Offset VRB** path A: 0; **Offset VRB** path B: 12).

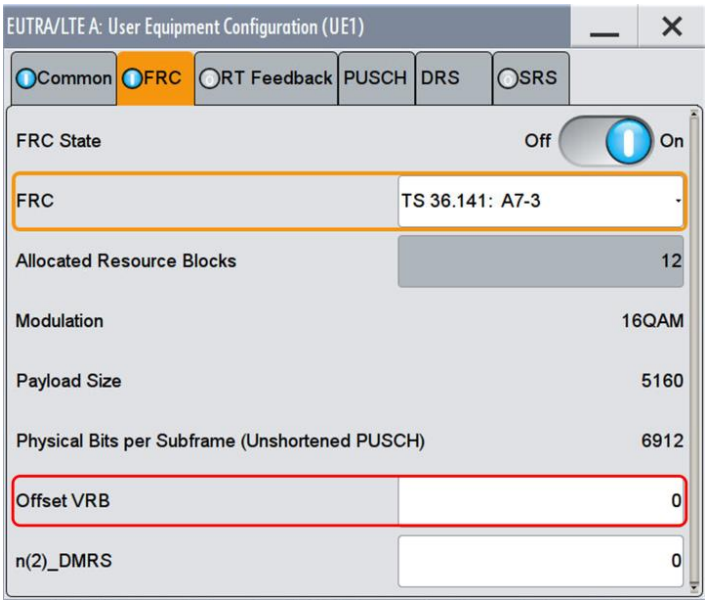


Fig. 3-55: Setting the FRC and Offset VRB (path A)

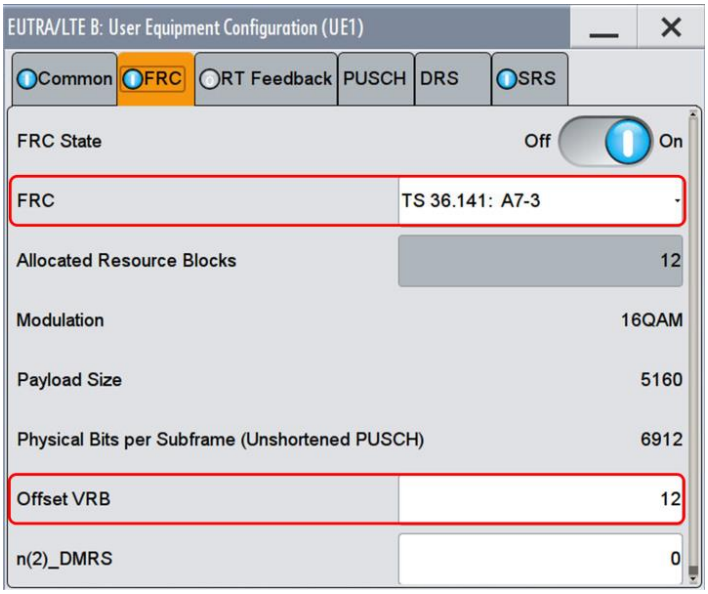


Fig. 3-56: Setting the Offset VRB of path B to ensure that the RBs are allocated consecutively.

SRS (optional)

9. In the tab **SRS,** you can enable the transmission by switching **SRS state ON**. For FDD set the **Configuration Index I_SRS** to 8, for TDD to 11. Ensure that **SRS Bandwidth B_SRS** is set to 0.

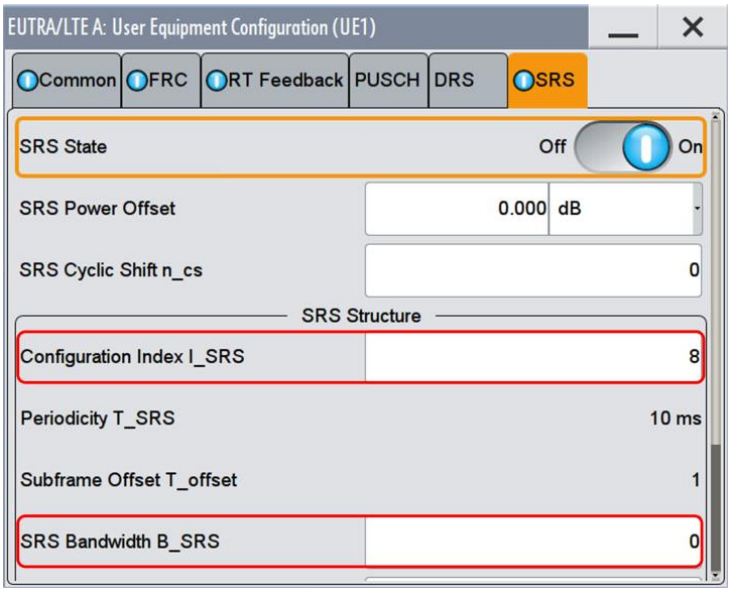


Fig. 3-57: Setting the SRS parameters in the UE

10. In the General UL Settings, **set SRS Subframe Configuration** to 10 and **SRS Bandwidth Configuration C_SRS according to** Table 3-33 (example for 5 MHz: 3) (Fig. 3-58)

SRS Bandwidth Configuration C_SRS						
Channel-Bandwith [MHz]	**1.4**	**3**	**5**	**10**	**15**	**20**
SRS Bandwidth Configuration C_SRS	7	5	3	2	5	2

Table 3-33: SRS Bandwidth Configuration C_SRS for different bandwidths

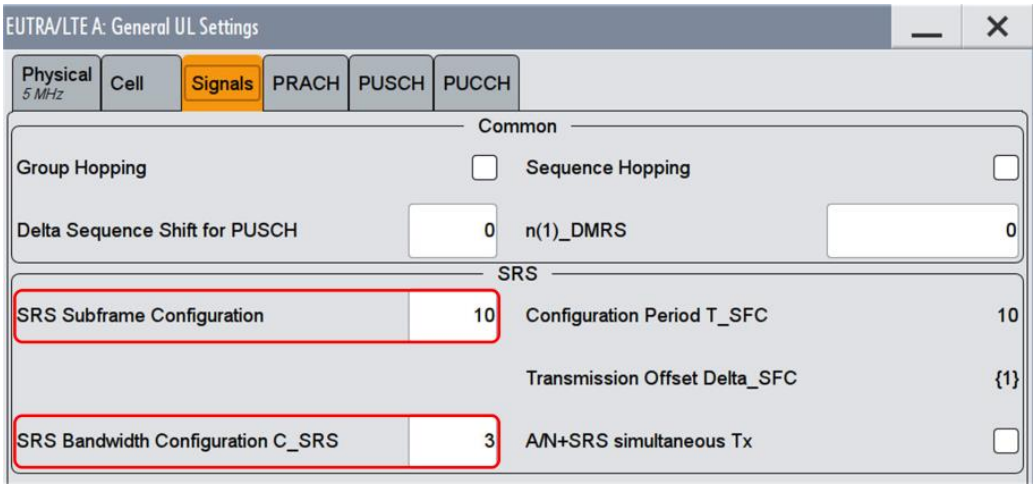


Fig. 3-58: Setting SRS basic parameters. Both parameters determine the length of the SRS sequence according to [3].

11. In the main dialog, click **Frame Configuration…**. Select the tab **Subframe**.
12. In the second subframe (example: subframe number 1), switch **State** to **Off** for PUSCH.

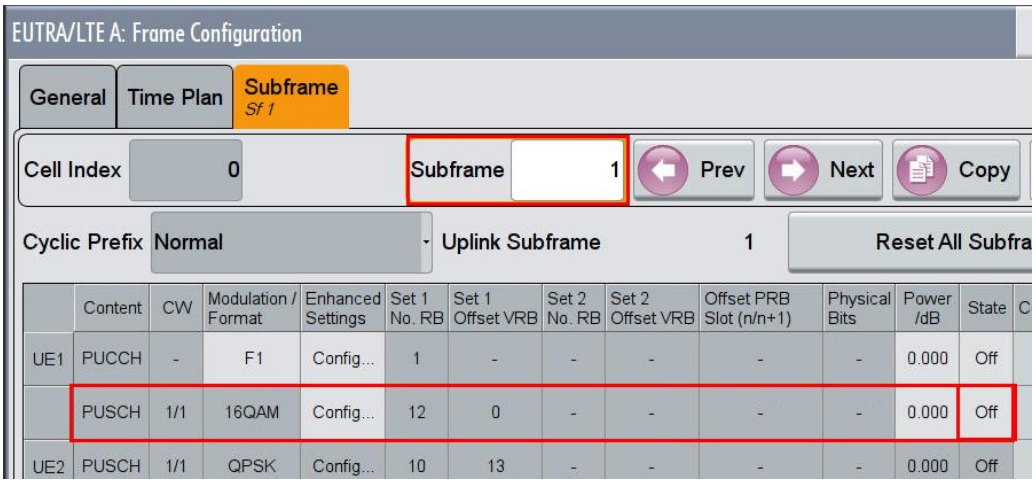


Fig. 3-59: Disable the PUSCH in the second subframe (#1)

AWGN and Fading

13. Set **Fading** according to Table 3-31 (see 3.1.3) (example: Scenario 1)
14. Set **noise power** and **SNR. T**ake in account the **SNR correction factor** (see 3.1.4) As the SMW automatically decreases the level by -3.01 dB when combing two paths, an additional correction by +3.01 dB has to be applied. This is automatically done by the demo program. (example: Noise = -83.5 dBm; SNR = SNR + Correction + CorrectionSMW = 13.8 dB -3.19 dB + 3.01 dB = 13.62 dB)

Demo program

Fig. 3-60 shows the parameters of the test. You can select the test in the section **8.2 PUSCH.** Select one scenario under **8.2.2 UL Timing**. With the checkbox SRS you can enable the optional transmission of the sounding RS. If enabled the SRS is transmitted according to Table 3-31 for FDD the Configuration Index I_SRS is set to 8, for TDD to 11. All settings are default according to the specification. The setting of the FRC and the SNR depends on the channel bandwidth. Both UE's occupy consecutive RB's in the lowest possible position.

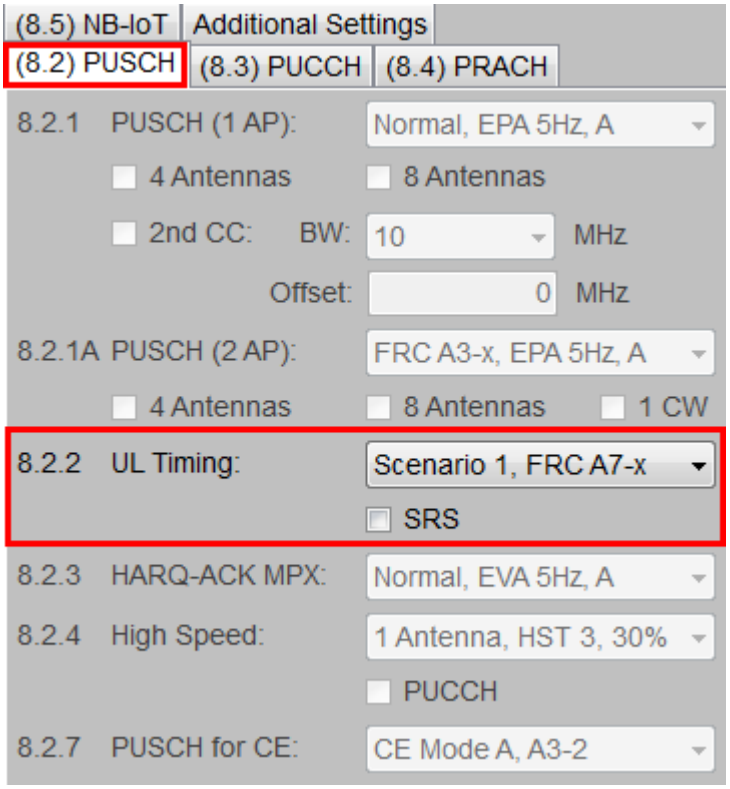


Fig. 3-60: Parameter for PUSCH test 8.2.2

Fig. 3-61 shows the report.

```
******* Performance Tests *******

8.2.2 UL Timing Adjustment

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: ETU200Hz (Scenario 1)
FRC: A74
AWGN: -83.5 dBm
SNR: 14.4 dB
SNR Correction: -3.01 dB
Finished!
```

Fig. 3-61: Report 8.2.2

3.2.4 Performance requirements for HARQ-ACK multiplexed on PUSCH (Clause 8.2.3)

The test verifies the receivers' performance at detecting HARQ-ACK under multipath fading conditions at a given SNR. The HARQ-ACK is multiplexed on PUSCH.

The probability of detection of ACK on PUSCH is defined as conditional probability of detection of the ACK when the ACK is transmitted within PUSCH allocated RE.

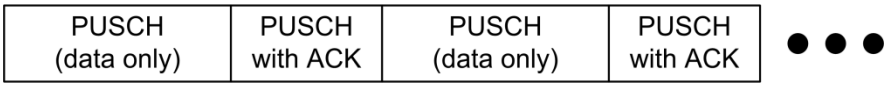


Fig. 3-62: ACK multiplexing

The test is defined for two fading profiles (for the different base station classes) and normal CP.

For wide area base stations and medium range base stations, ETU 70 Low fading profile is applicable. For home- and local area base stations the fading profile EVA 5 Low is used.

Table 3-35 shows the test requirements. The test is done with two RX antennas. The SNR, SNR correction factor and LTE Carrier Level differ with different bandwidths and FRCs.

Test requirements 8.2.3 for test with 2 Rx antennas. Wide area base stations and medium range base stations									
Cyclic Prefix	**Propagation Conditions**	**Correlation matrix**	**Channel bandwidth [MHz]**	**AWGN power level at BS input [dBm]**	**FRC**	**SNR [dB]**	**add SNR Correct. Factor [dB]**	**Index HARQ Offset**	**LTE Carrier Level [dBm]**
Normal	ETU 70	Low	1.4	-92.7	A.3-1	7.2	-7.78	8	-93.28
					A.4-3	14.4		5	-78.30
			3	-88.7	A.3-1	7.2	-11.76	8	-93.26
					A.4-4	13.5		5	-75.20
			5	-86.5	A.3-1	7.1	-13.98	8	-93.38
					A.4-5	13.1		5	-73.40
			10	-83.5	A.3-1	7.2	-16.99	8	-93.29
					A.4-6	12.9		5	-70.60
			15	-81.7	A.3-1	7.3	-18.75	8	-93.15
					A.4-7	12.7		5	-69.00
			20	-80.4	A.3-1	7.1	-20.0	8	-93.30
					A.4-8	12.6		5	-67.80

Table 3-34: Test requirements for test 8.2.3, wide area and medium range base stations

Test requirements 8.2.3 for test with 2 Rx antennas, Home and Local base stations									
Cyclic Prefix	**Propagation Conditions**	**Correlation matrix**	**Channel bandwidth [MHz]**	**AWGN power level at BS input [dBm]**	**FRC**	**SNR [dB]**	**add SNR Correct. Factor [dB]**	**Index HARQ Offset**	**LTE Carrier Level [dBm]**
Normal	EVA 5	Low	1.4	-92.7	A.3-1	7.4	-7.78	8	-93.08
					A.4-3	14.2		5	-78.50
			3	-88.7	A.3-1	7.4	-11.76	8	-93.06
					A.4-4	13.7		5	-75.00
			5	-86.5	A.3-1	7.5	-13.98	8	-92.98
					A.4-5	13.0		5	-73.50
			10	-83.5	A.3-1	7.4	-16.99	8	-93.09
					A.4-6	13.0		5	-70.50
			15	-81.7	A.3-1	7.4	-18.75	8	-93.05
					A.4-7	12.6		5	-69.10
			20	-80.4	A.3-1	7.4	-20.0	8	-93.00
					A.4-8	12.5		5	-67.90

Table 3-35: Test requirements for test 8.2.3, home and local base stations

Test setup

Fig. 3-63 shows the test setup.

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.

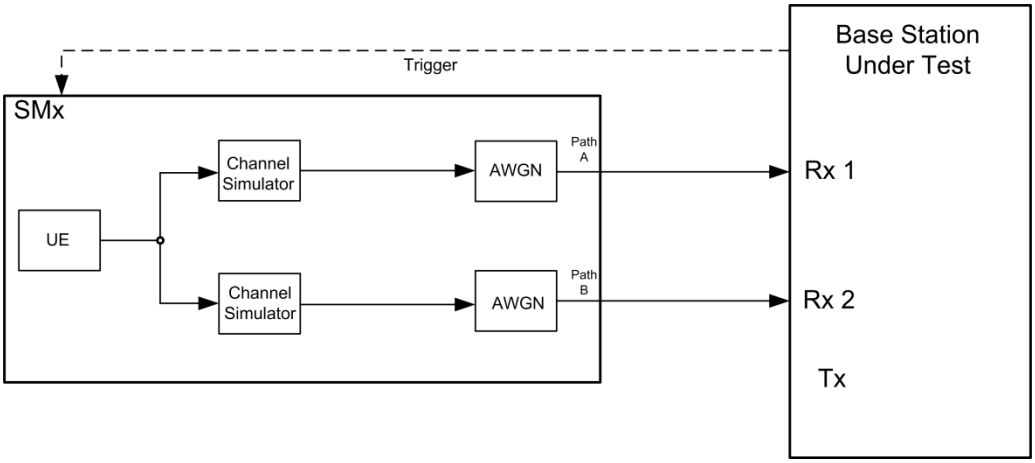


Fig. 3-63: Test setup for PUCCH test 8.2.3

Test Procedure

An example shows how to perform the settings for two RX antennas for a channel bandwidth of 10 MHz, FRC A3-1 and fading profile ETU 70 Hz (for a wide area base station). The ACK is multiplexed on every second subframe.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1).
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration.** Use **UE1.**
4. Set **No of PUSCH Config** to 2 (Fig. 3-64), because the ACK is multiplexed on the PUSCH in every second subframe only. With this setting, two subframes have to be configured. The configuration is automatically copied to all other subframes.

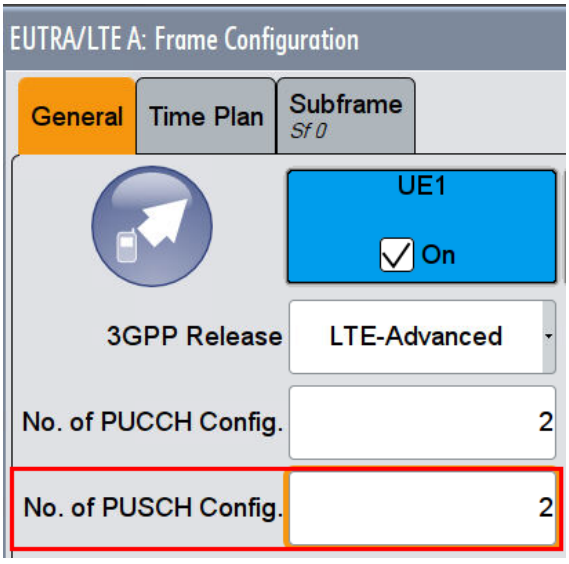


Fig. 3-64: Set two configurable PUSCH subframes

5. In the tab **FRC,** activate **FRCState.** Set the FRC according to the test requirements table (Table 3-35, example: FRC A3-1). With the FRC automatically all FRC parameters (e.g. the allocated RBs) are set.

6. For FRCs using one resource block only (A3-1), the RB in the middle of the channel bandwidth shall be used. In case the number of resource blocks in the channel bandwidth are even the one in the middle with lower number is to be used for testing. To perform this adjustment, shift the used RB by setting **Offset VRB** (example 24).

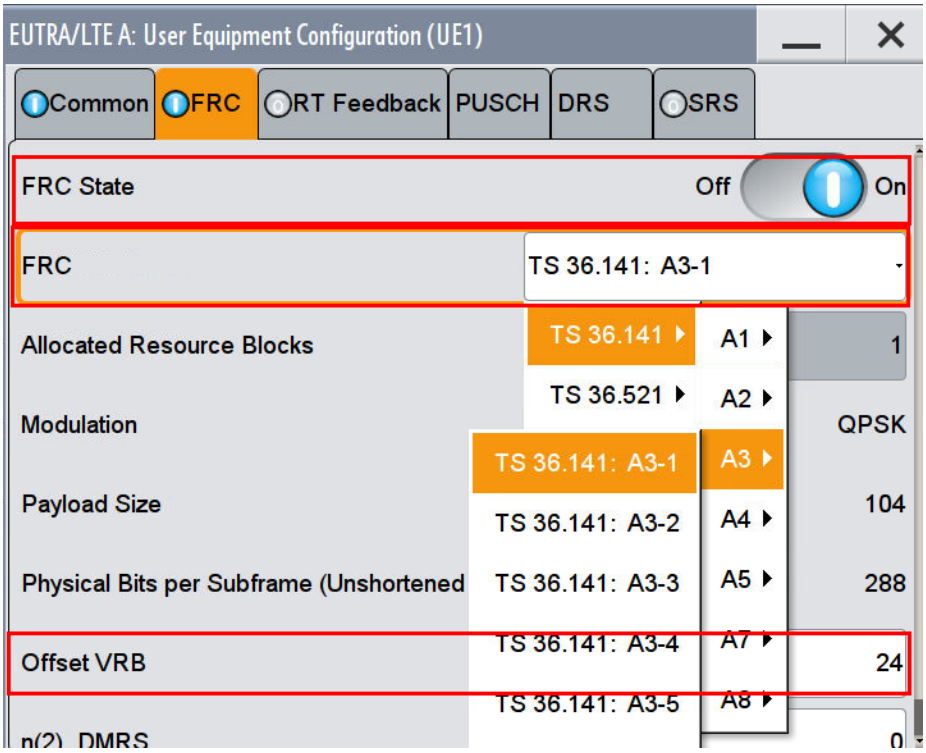


Fig. 3-65: Setting the FRC (example A3-1)

7. As **Mode** select **UCI+UL-SCH**, which enables multiplexing of the control information (UCI) and data (UL-SCH) on the PUSCH.
8. Set the **I_HARQ_offset** according to Table 3-35 (example: 8). It determines the HARQ-ACK offset index, i.e. the control information MCS offset according to [6], chapter 8.6.3.
9. Ensure that **I_RI_offset** is set to 0 and **I_CQI_offset** to 2. **I_RI_offset** determines the RI offset index for control information MCS and **I_CQI_offset** the CQI offset index for control information MCS, both according to [6], chapter 8.6.3.

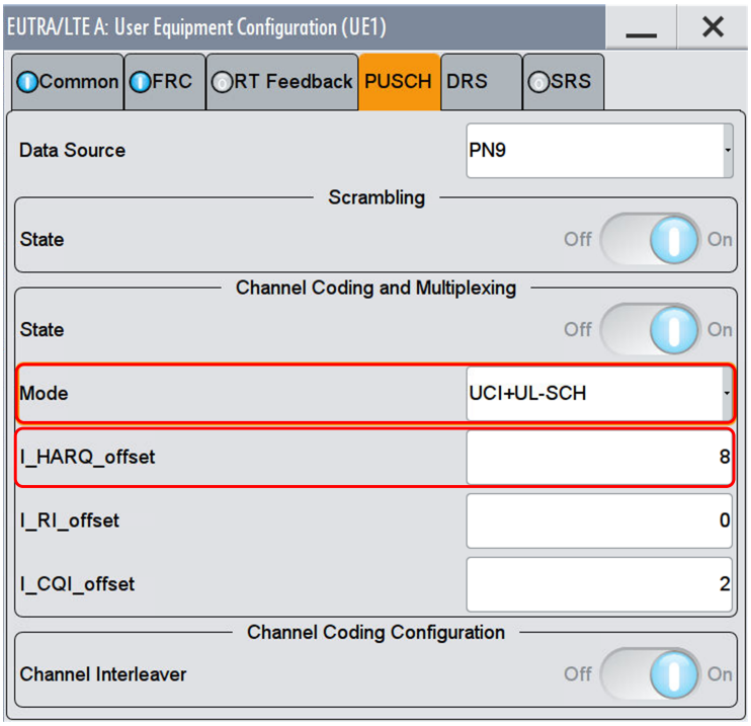


Fig. 3-66: PUSCH configuration for UE1. Data and control information is multiplexed.

10. In the main dialog, click **Frame Configuration…**. Select the tab **Subframe**.
11. In the second subframe (example: subframe #1), click **Config** in column **Enhanced Settings**.

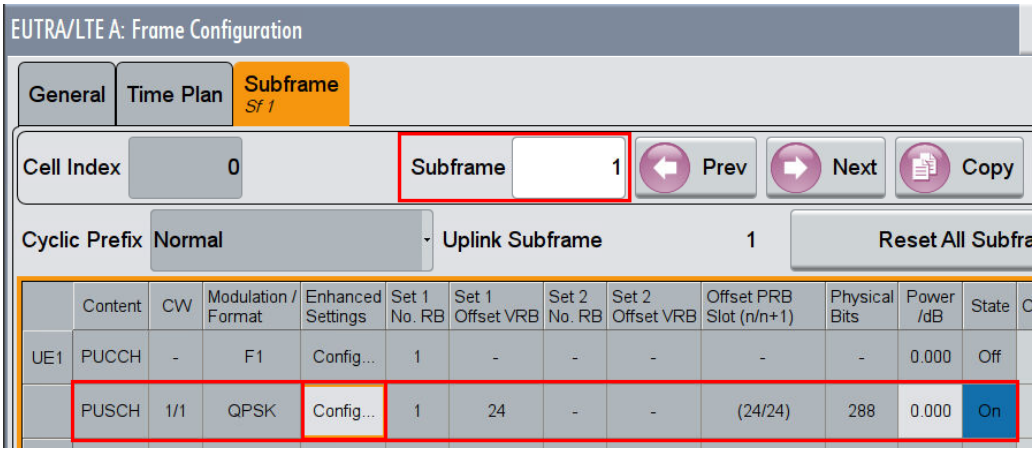


Fig. 3-67: Multiplexing settings in the second subframe (#1)

12. In tab **Channel Coding/Multiplexing,** set **Number of A/N Bits** to **1** and the **ACK/NACK pattern** (example 1). Make sure that no **Rank indication** and **CQI bits** are transmitted (set number to 0).

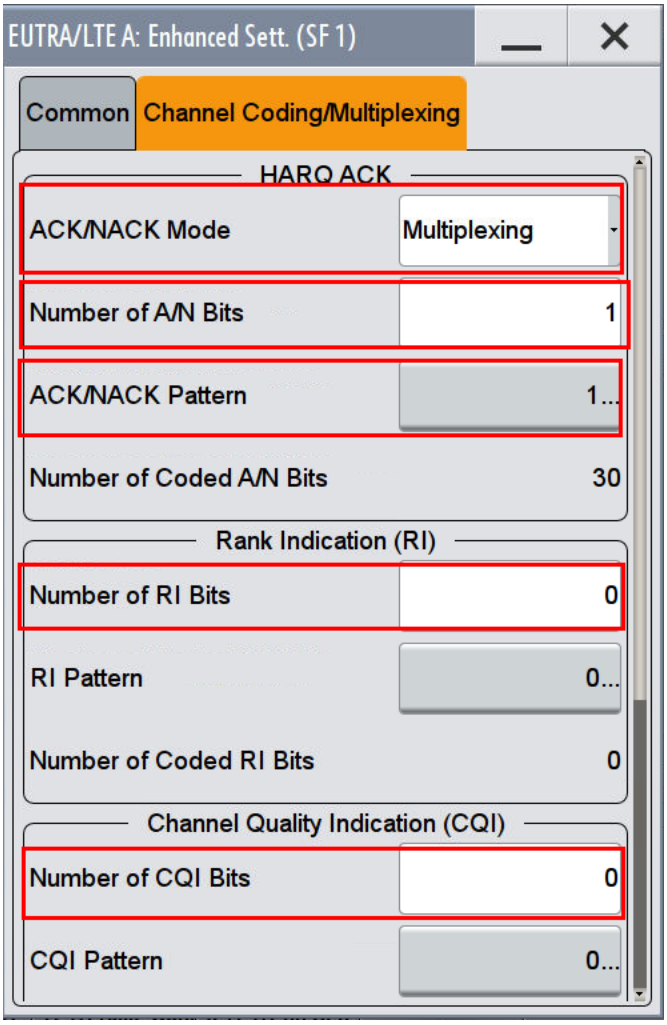


Fig. 3-68: PUSCH multiplexing settings: One ACK bit is multiplexed on the PUSCH

AWGN and Fading

13. Set **Fading** according to Table 3-35 (see 3.1.3) (example: Scenario 1)
14. Set **noise power** and **SNR. T**ake in account the **SNR correction factor** (see 3.1.4) As the SMW automatically decreases the level by -3.01 dB when combing two paths, an additional correction by +3.01 dB has to be applied. This is also automatically done by the demo program. (example: Noise = -83.5 dBm; SNR = SNR + Correction + CorrectionSMW = 14.4 dB -3.01 dB + 3.01 dB = 14.40 dB)

Demo program

Fig. 3-69 shows the parameters of the test. You can select the test in the section **8.2 PUSCH.** Select one test under **8.2.3 HARQ-ACK MPX**. The tests are listed by the fading profile. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. For FRC's using 1 resource block the RB in the middle of the channel bandwidth is used and the special SNR correction factor is applied. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default:

Low). The ACK is multiplexed in the PUSCH every second subframe starting on the subframe #1.

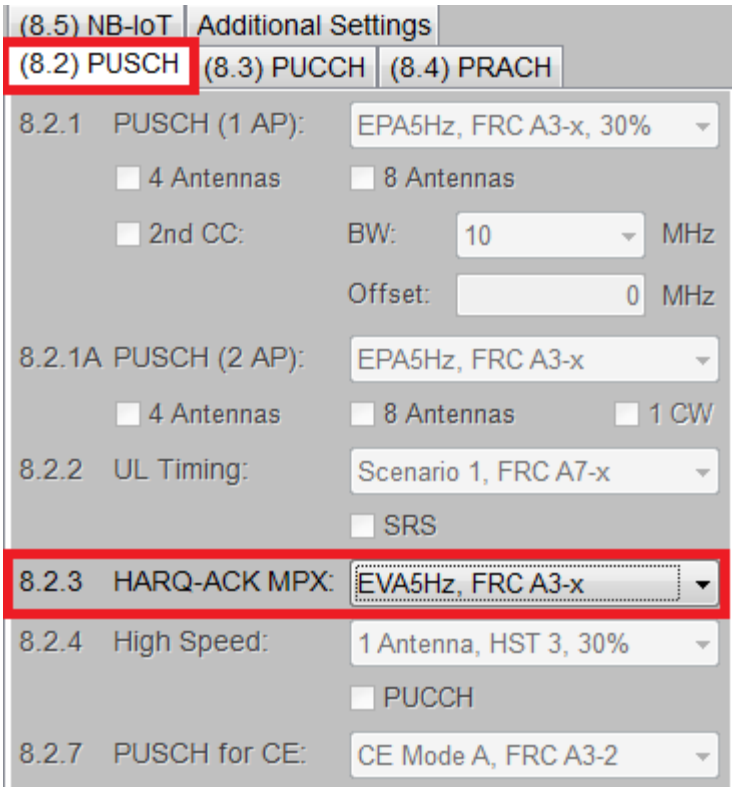


Fig. 3-69: Parameter for PUSCH test 8.2.3

Fig. 3-70 shows the report.

```
******* Performance Tests *******

8.2.3 HARQ-ACK Multiplexed on PUSCH

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EVA5Hz Low
FRC: A31
AWGN: -83.5 dBm
SNR: 7.4 dB
SNR Correction: -16.99 dB
Finished!
```

Fig. 3-70: Report 8.2.3

3.2.5 Performance requirements for High Speed Train conditions (Clause 8.2.4)

The test shall verify the receiver's ability to achieve throughput under High Speed Train conditions for a given SNR.

The performance requirement is determined by a minimum throughput for a given SNR. The required throughput is expressed as 30% and 70% of maximum throughput for the FRCs listed in Annex A.

The test is optional and applicable for Wide Area base stations and medium range BS only.

Test parameters 8.2.4	
Parameter	**Value**
Maximum number of HARQ transmissions	4
RV sequence	0, 2, 3, 1, 0, 2, 3, 1
Uplink-downlink allocation for TDD	Configuration 1 (2 DL:2 UL)
Subframes in which PUSCH is transmitted	For FDD: subframe #0 and #8 in radio frames for which SFN mod 4 = 0 subframe #6 in radio frames for which SFN mod 4 = 1 subframe #4 in radio frames for which SFN mod 4 = 2 subframe #2 in radio frames for which SFN mod 4 = 3 For TDD: Subframe #2 in each radio frames
Subframes in which PUCCH is transmitted (Note1, Note 2)	For FDD: subframe #5 in radio frames For TDD: Subframe #3 in each radio frame
Note 1. The configuration of PUCCH (format 2) is optional. Note 2. The SNR values per antenna shall be set to [-4.5 dB and -1.5 dB] for Scenario 1 and 3, respectively.	

Table 3-36: Test parameters for test 8.2.4

Table 3-37 shows the test requirements. The test is done with one or two RX antennas, normal cyclic prefix and propagation condition HST. The FRC and the SNR differs for the other bandwidths.

Test requirements 8.2.4					
Channel Bandwidth [MHz]	**FRC (Annex A)**	**Number of RX antennas**	**Propagation conditions (Annex B)**	**Fraction of maximum throughput**	**SNR [dB]**
1.4	A3-2	1	HST Scenario 3	30%	-1.2
				70%	2.2
		2	HST Scenario 1	30%	-3.6
				70%	-0.3
3	A3-3	1	HST Scenario 3	30%	-1.8
				70%	1.9
		2	HST Scenario 1	30%	-4.2
				70%	-0.7
5	A3-4	1	HST Scenario 3	30%	-2.3
				70%	1.6
		2	HST Scenario 1	30%	-4.8
				70%	-1.1
10	A3-5	1	HST Scenario 3	30%	-2.4
				70%	1.5
		2	HST Scenario 1	30%	-5.1
				70%	-1.2
15	A3-6	1	HST Scenario 3	30%	-2.4
				70%	1.5
		2	HST Scenario 1	30%	-4.9
				70%	-1.1
20	A3-7	1	HST Scenario 3	30%	-2.4
				70%	1.5
		2	HST Scenario 1	30%	-5.0
				70%	-1.1

Table 3-37: Test requirements for test 8.2.4

Test setup

Fig. 3-71 shows the test setup for 2 Rx antennas.

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.

The SMW needs an external trigger at USER3. A HARQ-Feedback signal from the base station is required.

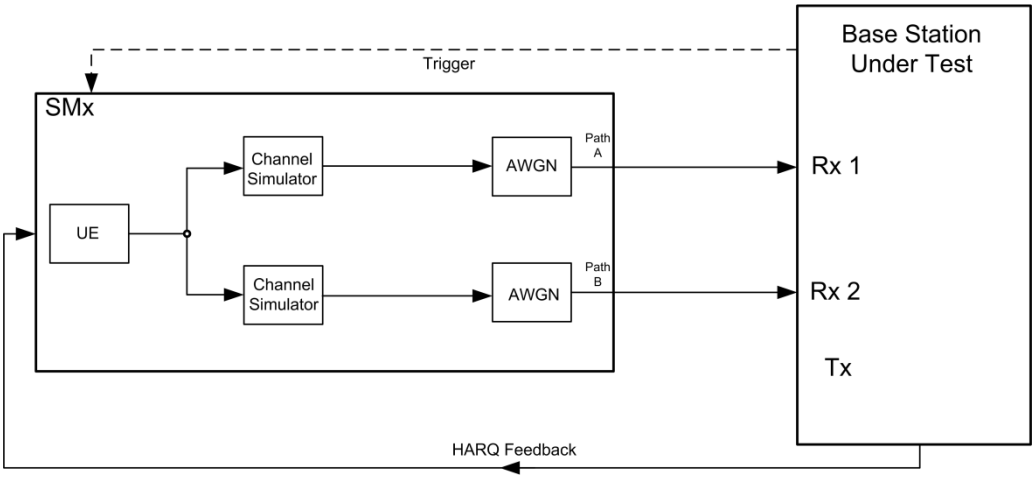


Fig. 3-71: Test setup for PUSCH test 8.2.4 for 2 antennas

Test Procedure

As an example the settings for two RX antennas, HST scenario 1, 10 MHz, FRC A3-5 and fraction 30% throughput are shown. The PUSCH is transmitted continuously in every subframe # 0 and #8. A PUCCH is transmitted in subframe #5.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **No of PUSCH Config** and **No of PUCCH Config** (example 8 and 10) (Fig. 3-36).

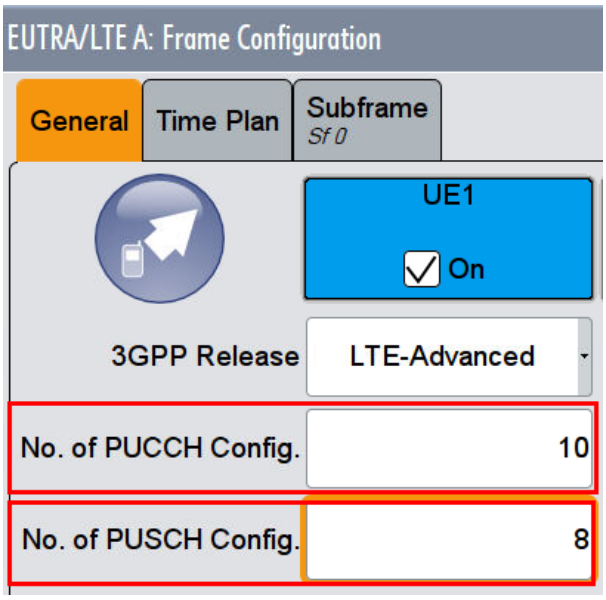


Fig. 3-72: Set configurable PUSCH and PUCCH subframes.

5. Open the **User Equipment Configuration (UE1)** dialog by double clicking **UE1.**

6. In the tab **FRC,** activate **FRCState.** Set the FRC according to the test requirements tables (Table 3-37, example: FRC A3-5). With the FRC automatically all FRC parameters (e.g. the allocated RBs) are set.

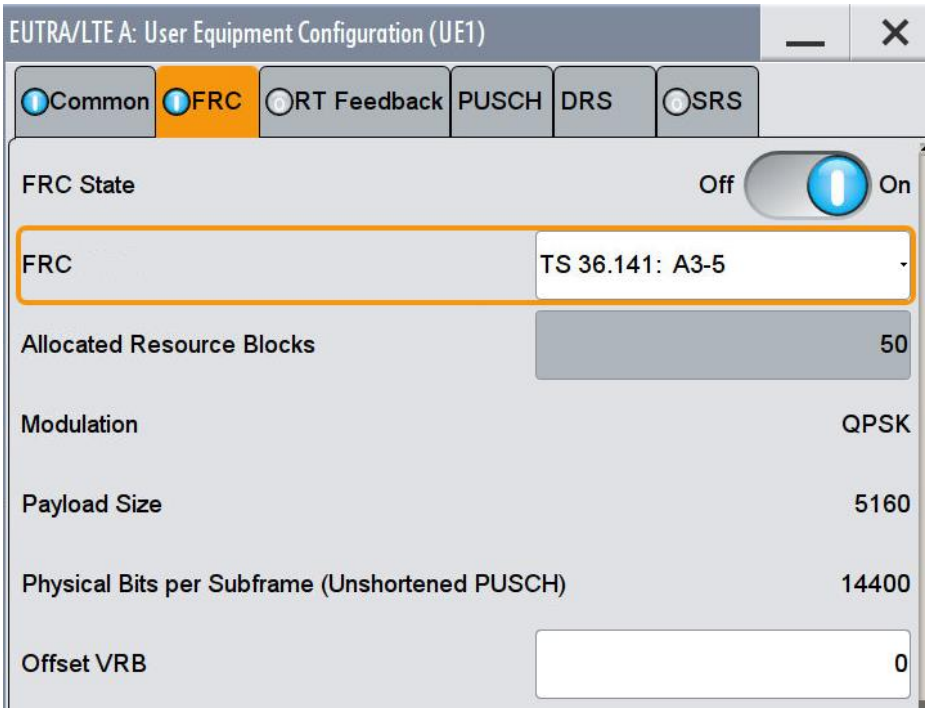


Fig. 3-73: Setting the FRC.

7. Switch **Off** the PUSCH in subframes # 1,2,3,4,5,6,7. Switch **On** the PUCCH in subframe #5. (Fig. 3-74)

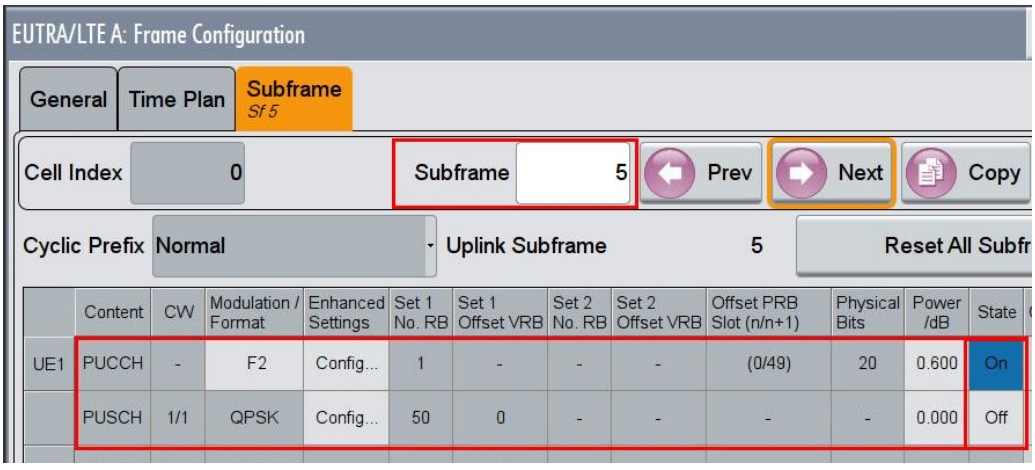


Fig. 3-74: PUCCH is On in subframe #5, PUSCH is Off

HARQ-Feedback

8. Set the needed **Feedback Mode**. Set the **Redundancy Version Sequence** to **0,2,3,1** and the **Max. Number of Transmissions** to **4** (Fig. 3-31).

AWGN and Fading

9. Set **Fading** according to Table 3-37 (see 3.1.3) (example: HST scenario 1)
10. Set **noise power** and **SNR.** For FRC's with one RB only, take in account the **SNR correction factor** (see 3.1.4)(example: Noise = -83.5 dBm; SNR = -5.1 dB)

Demo Program

Fig. 3-75 shows the parameters of the test. You can select the test in the section **8.2 PUSCH.** Select one test under **8.2.4 High Speed**. The tests are listed by their number of antennas, the fading profile and the throughput percentage. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The PUSCH is transmitted in subframes #0 and #8. The checkbox **PUCCH** enables the optional transmission of the PUCCH in subframe #5.

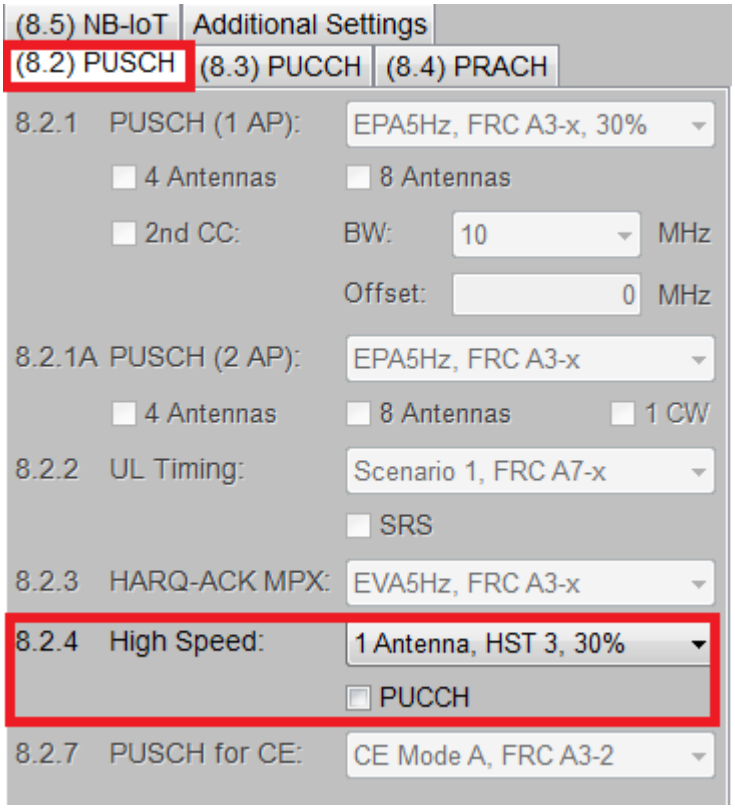


Fig. 3-75: Parameter for PUSCH test 8.2.4

Fig. 3-76 shows the report.

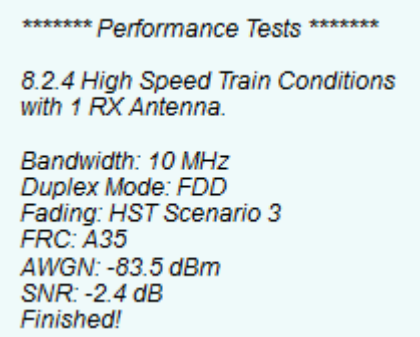


Fig. 3-76: Report 8.2.4

3.2.6 Performance requirements for PUSCH with TTI bundling and enhanced HARQ pattern (Clause 8.2.5)

Please note that this testcase is not implemented in the SMW firmware yet.

3.2.7 Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with synchronous interference (Clause 8.2.6)

Please note that this testcase is not implemented yet.

3.2.8 Enhanced performance requirements type A of PUSCH in multipath fading propagation conditions with asynchronous interference (Clause 8.2.6A)

Please note that this testcase is not implemented yet.

3.2.9 Performance requirements of PUSCH in multipath fading propagation conditions transmission on single antenna port for coverage enhancement (Clause 8.2.7)

The test shall verify the receiver's ability to achieve throughput under multipath fading conditions for a given SNR for coverage enhancement CEMode A and CEMode B.

The performance requirement is determined by a minimum throughput for a given SNR. The required throughput is expressed as 70% of maximum throughput for the FRCs listed in Annex A.

The test is applicable only for base stations supporting CEMode A respectively CEMode B.

Test parameters 8.2.7		
Parameter	**CEMode A**	**CEMode B**
Maximum number of HARQ transmissions	4	2
RV sequence	0, 2, 3, 1, 0, 2, 3, 1	FDD: 0,0,0,0, 2,2,2,2, 3,3,3,3, 1,1,1,1 TDD: 0,0,0,0,0 2,2,2,2,2, 3,3,3,3,3, 1,1,1,1,1
Number of PUSCH repetitions	8	256
Frequency hopping	On	On
Frequency hopping interval	FDD: 4 TDD: 5	FDD: 4 TDD: 5
FRC	A3-2 Modulation: QPSK RB: 6	A3-1 Modulation: QPSK RB: 1

Table 3-38: Test parameters for test 8.2.7

Table 3-39 and Table 3-40 show the test requirements. The test is done with two RX antennas. The FRC and the SNR differs for the other bandwidths.

Test requirements 8.2.7 for CEMode A					
Channel Bandwidth [MHz]	**FRC (Annex A)**	**Number of RX antennas**	**Propagation conditions (Annex B)**	**Fraction of maximum throughput**	**SNR [dB]**
3	A3-2	2	EPA 5 Hz Low	70%	-5.6
5					- 6.0
10					- 6.3
15					- 6.3
20					- 6.4

Table 3-39: Test requirements for test 8.2.7 CEMode A

Test requirements 8.2.7 for CEMode B					
Channel Bandwidth [MHz]	**FRC (Annex A)**	**Number of RX antennas**	**Propagation conditions (Annex B)**	**Fraction of maximum throughput**	**SNR [dB]**
3	A3-1	2	ETU 1 Hz Low	70%	- 14.4
5					- 14.6
10					- 14.7
15					- 14.5
20					- 14.6

Table 3-40: Test requirements for test 8.2.7 CEMode B

Test setup

Fig. 3-77 shows the test setup.

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.

The SMW needs an external trigger at USER3. A HARQ-Feedback signal from the base station is required.

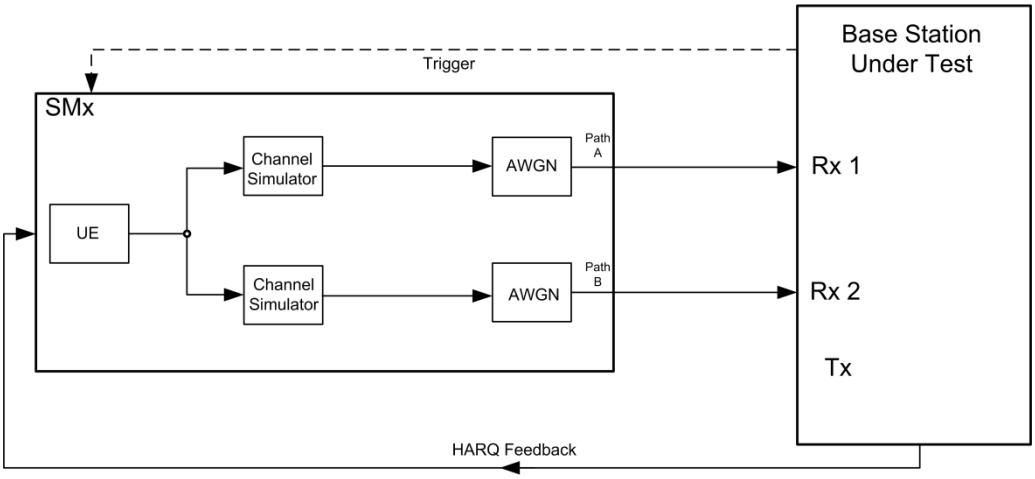


Fig. 3-77: Test setup for PUSCH test 8.2.7 for 2 antennas

Test Procedure

As an example the settings for CEMode A, EPA 5 Hz low, 10 MHz and FRC A3-2 are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Enable **UE1** for **eMTC** (Fig. 3-36).

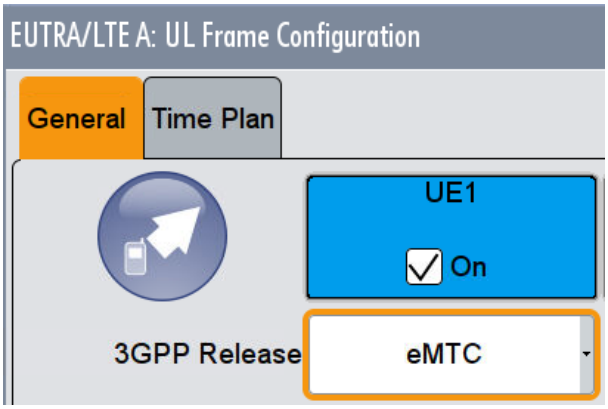
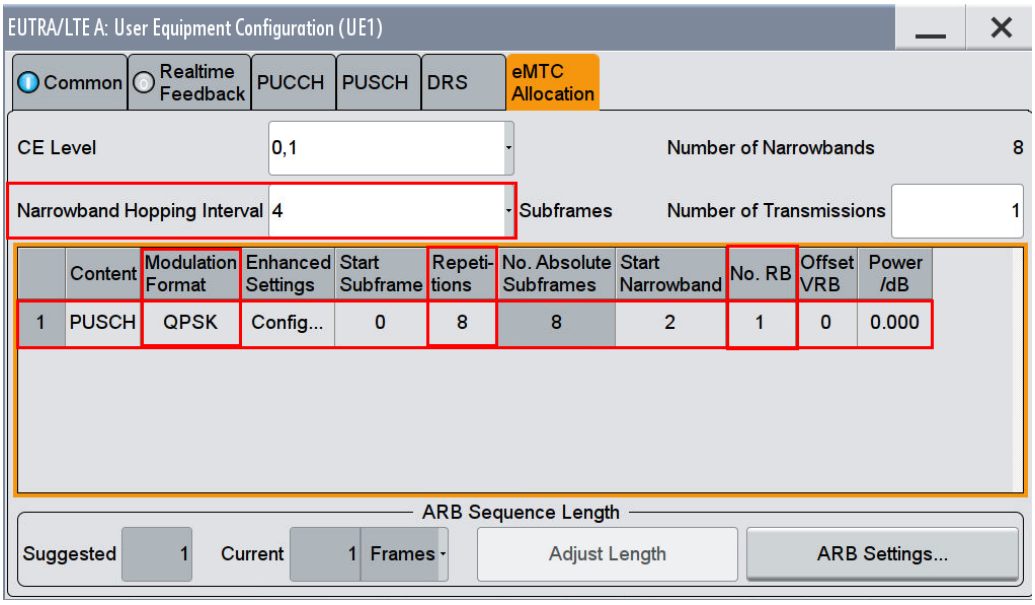


Fig. 3-78: Set UE1 to mode eMTC

5. Open the **User Equipment Configuration (UE1)** dialog by double clicking **UE1.**

Set the **Repetition, Narrowband Hopping Interval, the Modulation** and the **RB** according Table 3-38 (example: Repetition 8, Hopping 5, Modulation QPSK and 1 RB).



6. The SMW shows the number of needed Frames. Click **Adjust Length** if necessary.

HARQ-Feedback

7. Set the needed **Feedback Mode** (please note that for eMTC only serial mode are available

AWGN and Fading

8. Set **Fading** according to Table 3-39 (see 3.1.3) (example: EPA 5 Hz low)
9. Set **noise power** and **SNR. T**ake in account the **SNR correction factor** (see 3.1.4)(example: Noise = -83.5 dBm; SNR = -6.3 dB)

Demo Program

Fig. 3-79 shows the parameters of the test. You can select the test in the tabulator **8.2 PUSCH.** Select one test under **8.2.7 PUSCH for CE**. The tests are listed by the CE mode and the FRC. When selecting a particular test all settings are default according to the specification. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low).

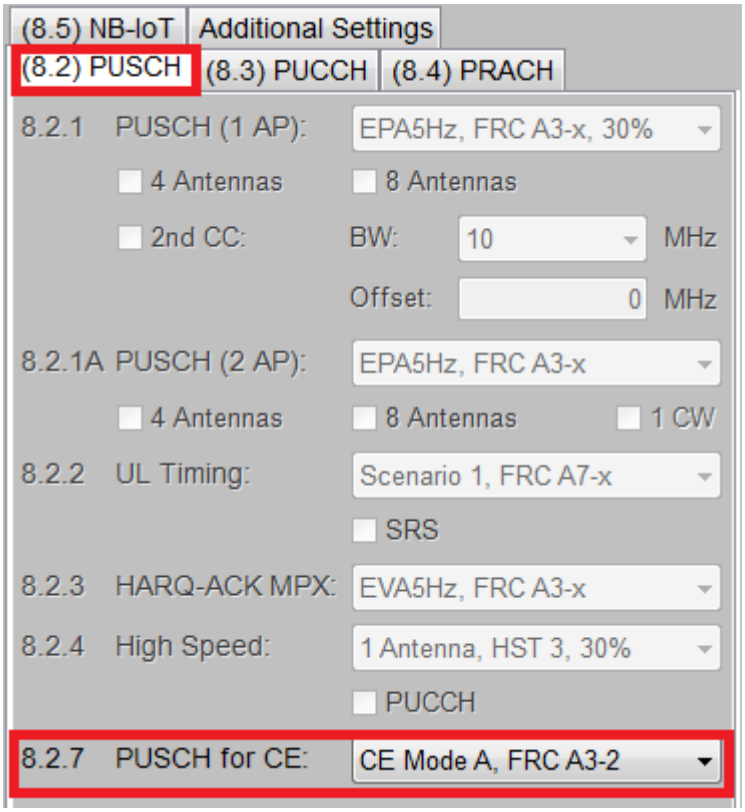


Fig. 3-79: Parameter for PUSCH test 8.2.7

Fig. 3-80 shows the report.

```
******* Performance Tests *******

8.2.7 Performance Requirements of PUSCH in Multipath Fading Propagation Conditions Transmission on Single Antenna Port for Coverage Enhancement
with CE Mode A and 8 Repetitions.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
FRC: A32
AWGN: -83.5 dBm
SNR: -6.3 dB
Finished!
```

Fig. 3-80: Report 8.2.7

3.2.10 Performance requirements of PUSCH with Frame structure type 3 (Clause 8.2.8)

Please note that this testcase is not implemented in the SMW firmware yet (FRC A.20 is needed).

3.3 Performance requirements for PUCCH (Clause 8.3)

The physical uplink control channel (PUCCH) carries control information in the uplink, like ACK/NACK or CQI information.

Special issues for single PUCCH 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 3-41.

AWGN power level for PUCCH tests	
Channel bandwidth [MHz]	**AWGN power level**
1.4	-89.7dBm / 1.08MHz
3	-85.7dBm / 2.7MHz
5	-83.5dBm / 4.5MHz
10	-80.5dBm / 9MHz
15	-78.7dBm / 13.5MHz
20	-77.4dBm / 18MHz

Table 3-41: AWGN power level for PUCCH tests

As the PUCCH only occupies one (or two RB), a special SNR correction factor is applied which depends on the bandwidth (Table 3-42).

SNR Correction factor for PUCCH tests		
Bandwidth [MHz]	1 RB Correction factor [dB]	2 RB Correction factor [dB]
1.4	-7.78	-4.77
3	-11.76	-8.75
5	-13.98	-10.97
10	-16.99	-13.98
15	- 18.75	-15.74
20	- 20.00	-16.99

Table 3-42: SNR correction factor for PUCCH tests

3.3.1 ACK missed detection for single user PUCCH format 1a transmission on single antenna port (Clause 8.3.1)

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 statistics are kept by the base station under test.

This test is applicable for all categories of BS.

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

Table 3-43, Table 3-44 and Table 3-45 show the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.1, 2 RX antennas								
Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Normal	EPA 5	Low	-1.9	-3.3	-4.2	-4.8	-4.7	-4.5
	EVA 5	Low	-3.9	-4.5	-4.5	-4.4	-4.5	-4.5
	EVA 70	Low	-4.3	-4.6	-4.6	-4.5	-4.6	-4.5
	ETU 300	Low	-4.4	-4.5	-4.3	-4.4	-4.6	-4.6
Extended	ETU 70	Low	-3.6	-3.7	-3.5	-3.7	-3.6	-3.7

Table 3-43: Test requirements PUCCH test 8.3.1 for 2 antennas, yellow marked are not applicable for Local area and Home BS

Test requirement PUCCH 8.3.1, 4 antennas								
Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Normal	EPA 5	Low	-7.3	-7.8	-8.1	-8.3	-8.3	-8.4
	EVA 5	Low	-8.2	-8.5	-8.5	-8.2	-8.3	-8.3
	EVA 70	Low	-8.3	-8.4	-8.4	-8.2	-8.4	-8.2
	ETU 300	Low	-8.1	-8.3	-8.1	-8.1	-8.3	-8.2
Extended	ETU 70	Low	-7.3	-7.5	-7.3	-7.5	-7.4	-7.4

Table 3-44: Test requirements PUCCH test 8.3.1 for 4 antennas, yellow marked are not applicable for Local area and Home BS

Test requirement PUCCH 8.3.1, 8 antennas								
Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Normal	EPA 5	Low	-10.6	-10.9	-11.6	-11.7	-11.7	-11.7
	EVA 5	Low	-11.4	-11.4	-11.5	-11.5	-11.7	-11.6
	EVA 70	Low	-11.4	-11.5	-11.6	-11.5	-11.7	-11.5
	ETU 300	Low	-11.0	-11.0	-11.0	-11.2	-11.0	-11.2
Extended	ETU 70	Low	-9.9	-10.1	-10.0	-10.1	-10.0	-10.0

Table 3-45: Test requirements PUCCH test 8.3.1 for 8 antennas, yellow marked are not applicable for Local area and Home BS

Test setup

Fig. 3-81 to Fig. 3-83 show the test setup.

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 (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3.

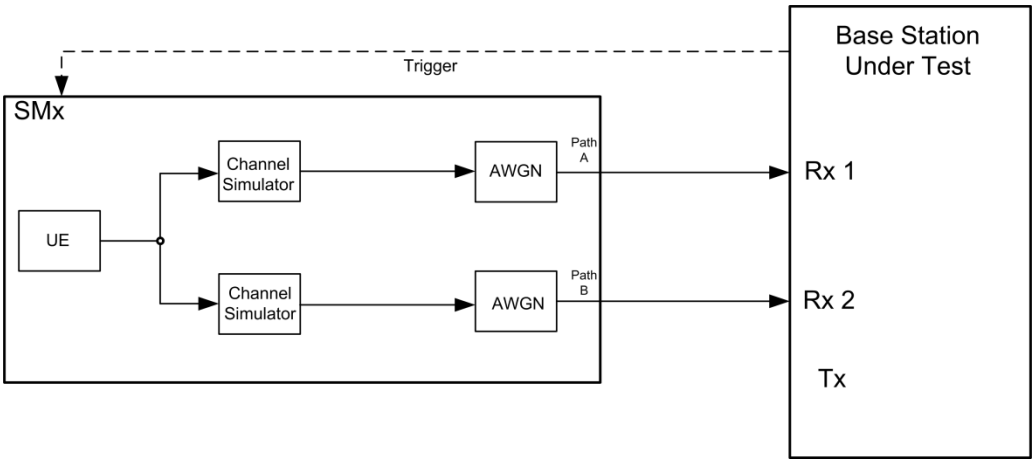


Fig. 3-81: Test setup for PUCCH test 8.3.1 for 2 antennas

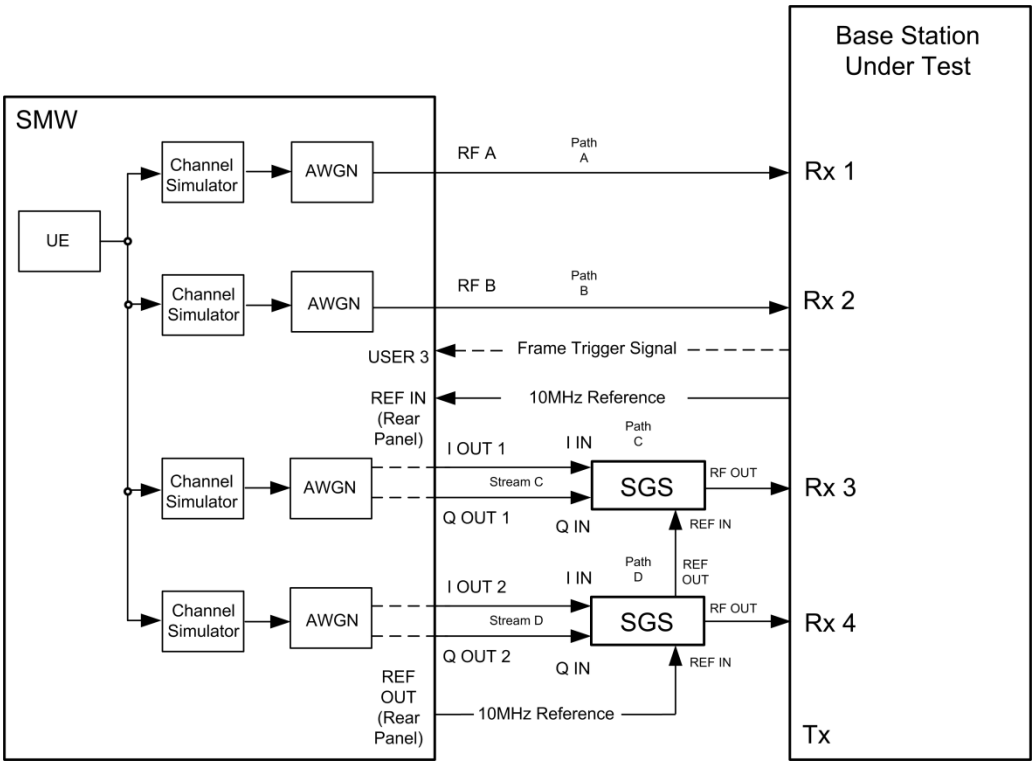


Fig. 3-82: Test setup for PUCCH test 8.3.1 for 4 antennas with one SMW

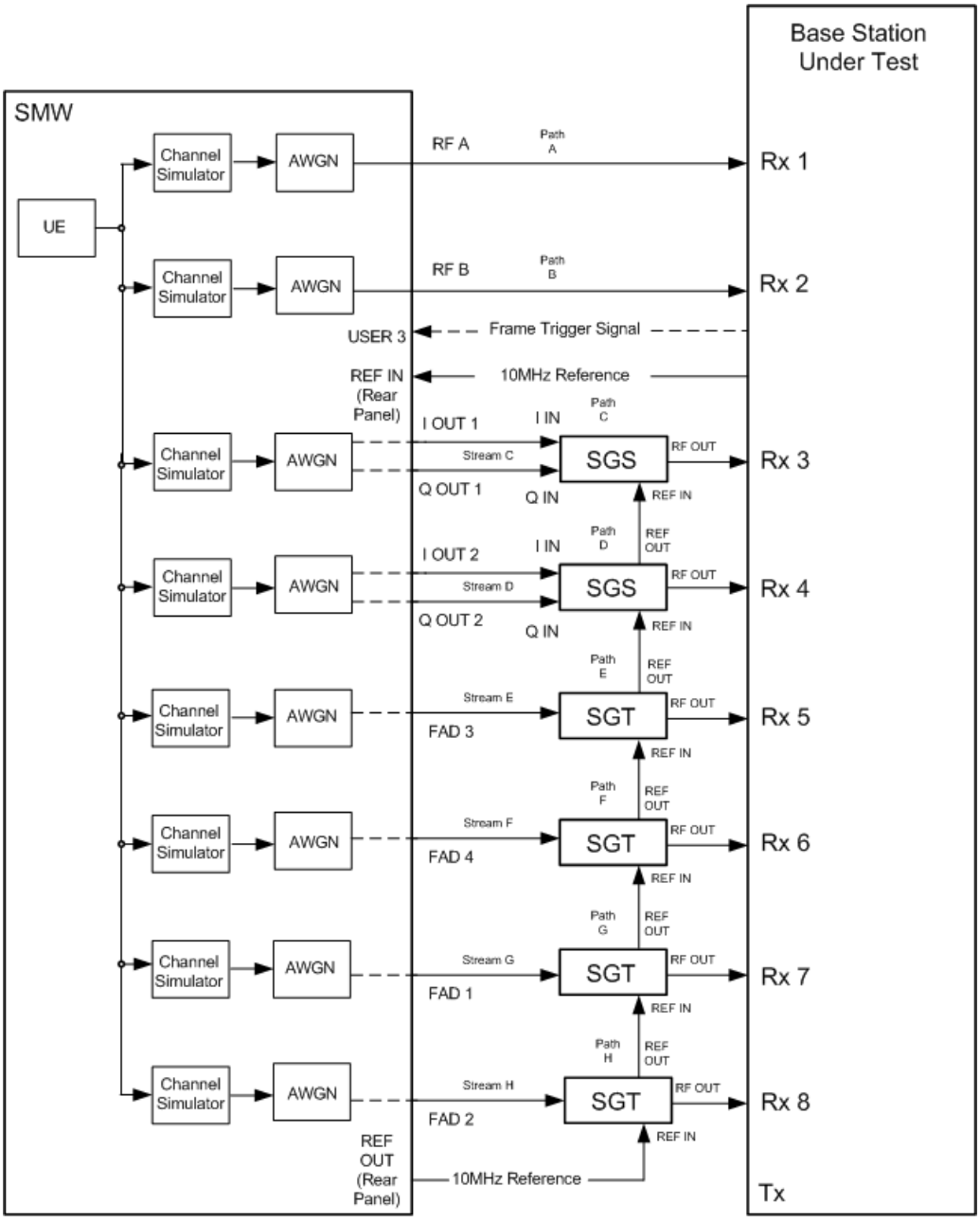


Fig. 3-83: Test setup for PUCCH test 8.3.1 for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz and 10 MHz are shown. The ACK is transmitted in every second subframe.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**

4. Set **No of PUCCH Config** to 2 (Fig. 3-84).

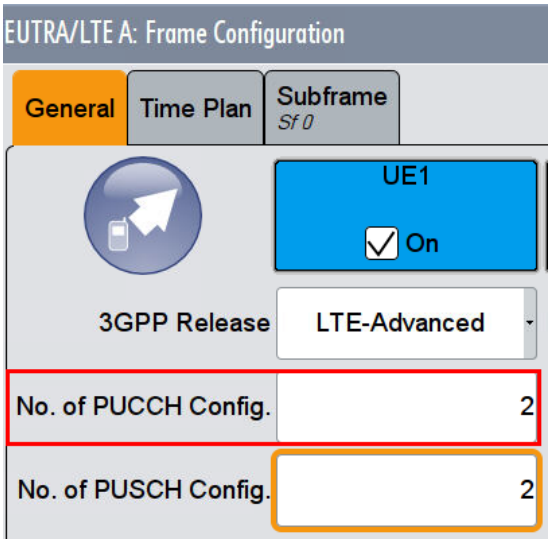


Fig. 3-84: Set two configurable PUCCH subframes

5. Click tab **Subframe**

6. Set for the PUCCH the **Format** to **F1a** and the state **On** (Fig. 3-85)

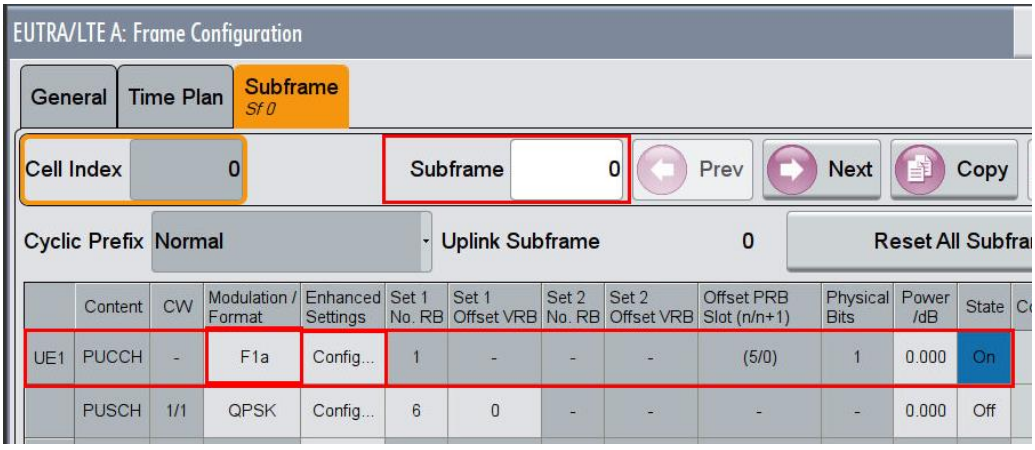


Fig. 3-85: PUCCH with format F1a in subframe 0

7. Click in column **Enhanced Settings** Config

8. Set the resource index **n_PUCCH** to 0. (Fig. 3-86)

9. Set the **ACK/NACK Pattern** (one bit) to '1' (Fig. 3-87)

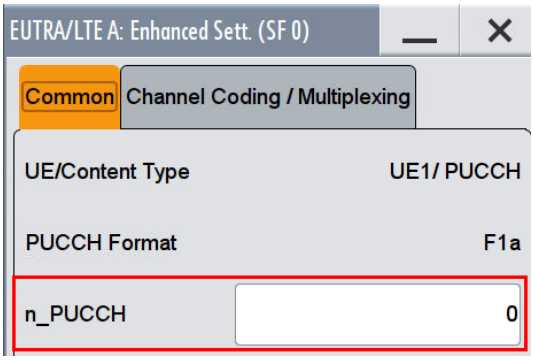


Fig. 3-86: Set the parameter n_PUCCH to 0

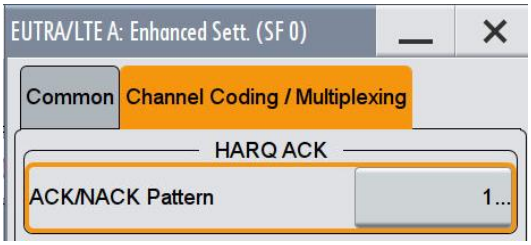


Fig. 3-87: Set one bit ACK pattern to '1' (ACK)

10. Make sure that the PUCCH in the second configurable subframe is not transmitted. (example: subframe 1 **State Off**) (Fig. 3-88)

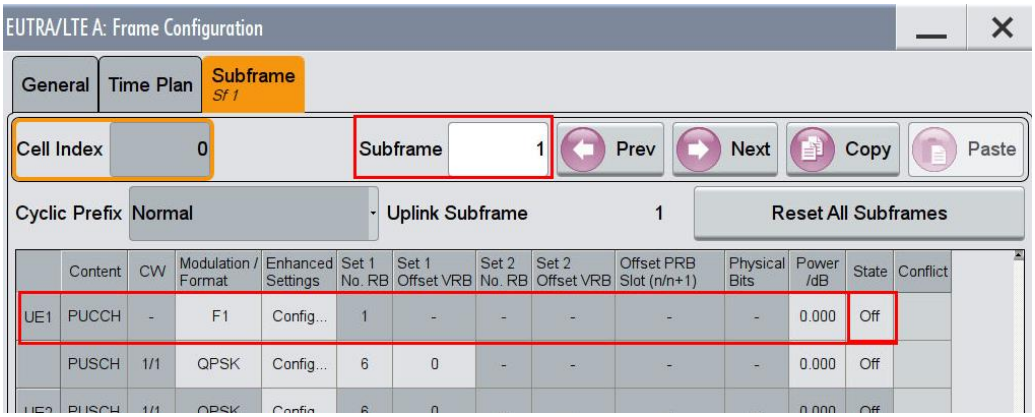


Fig. 3-88: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

11. Set **Fading** according to Table 3-43, Table 3-44 or Table 3-45 (see 3.1.3) (example EPA 5 Hz Low)

12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -4.8 dB -16.99 dB = -21.79 dB)

Demo Program

Fig. 3-89 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.1 ACK missed (1 TX)**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). The resource index n_PUCCH is set to 0. This example configures a PUCCH with ACK information in every second subframe. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

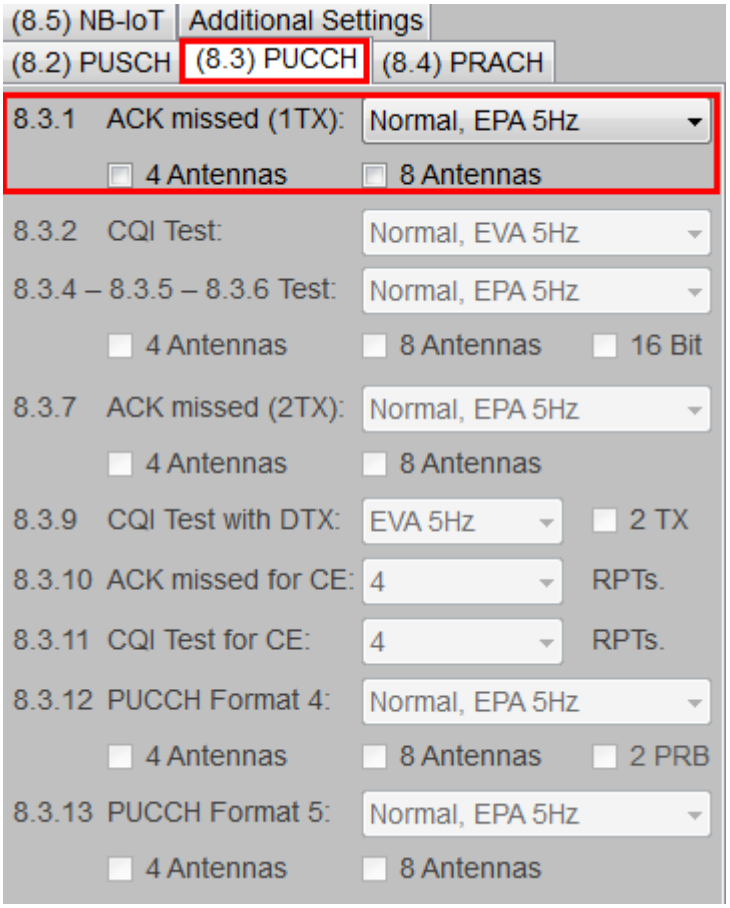


Fig. 3-89: Parameter for PUCCH test 8.3.1

Fig. 3-90 shows the report.

```
******* Performance Tests *******

8.3.1 ACK missed Detection for Single User PUCCH Format 1A (Single Antenna Port)
with 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
AWGN: -80.5 dBm
SNR: -4.8 dB
SNR Correction: -16.99 dB

ACK/NACK Pattern (One Bit): '1'
Finished!
```

Fig. 3-90: Report 8.3.1

3.3.2 CQI performance requirements for PUCCH format 2 transmission on single antenna port (Clause 8.3.2)

The test verifies the receivers' performance at CQI detection under multipath fading conditions for a given SNR. The performance is measured by the required SNR at BLER probability of detection equal to 0.99.

The fraction of falsely detected CQIs shall be less than 1% and the fraction of correctly detected CQIs shall be larger than 99%. The statistics are kept by the base station under test.

This test is applicable for all categories of BS.

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

Test requirements 8.3.2									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EVA 5	Low	-3.1	-3.5	-3.8	-3.4	-3.6	-3.6
		ETU 70	Low	-3.3	-3.8	-3.6	-3.8	-3.8	-3.8

Table 3-46: Requirements for PUCCH test 8.3.2. The yellow marked tests are applicable for Local area and Home BS, the blue for Wide Area BS and Medium Range BS.

Test setup

Fig. 3-91 shows the test setup.

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.

The SMW needs an external trigger at USER3.

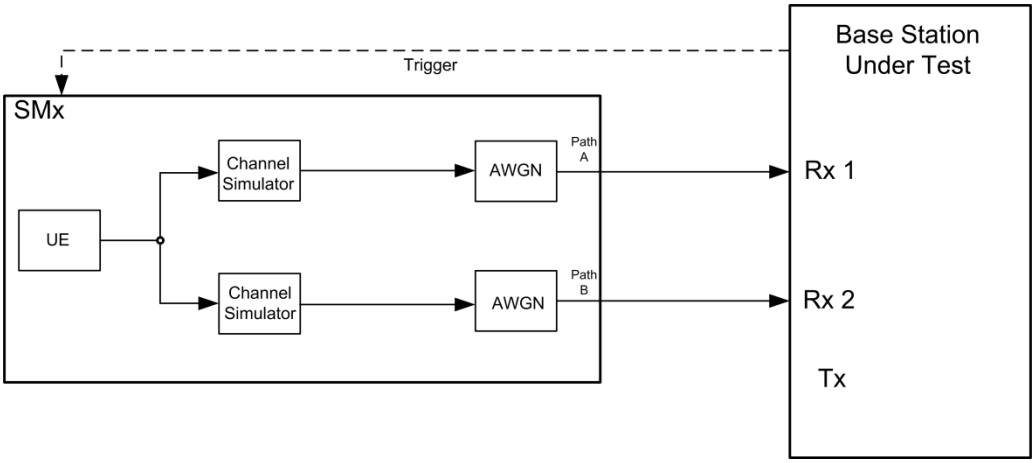


Fig. 3-91: Test setup for PUCCH test 8.3.2

Test Procedure

As an example, the settings for normal prefix, ETU 70 Hz and 10 MHz are shown. The CQI is set in every second subframe.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps, see section 3.1.2.
3. Click **Frame Configuration**
4. Set **No of PUCCH Config** to 2 (Fig. 3-92)

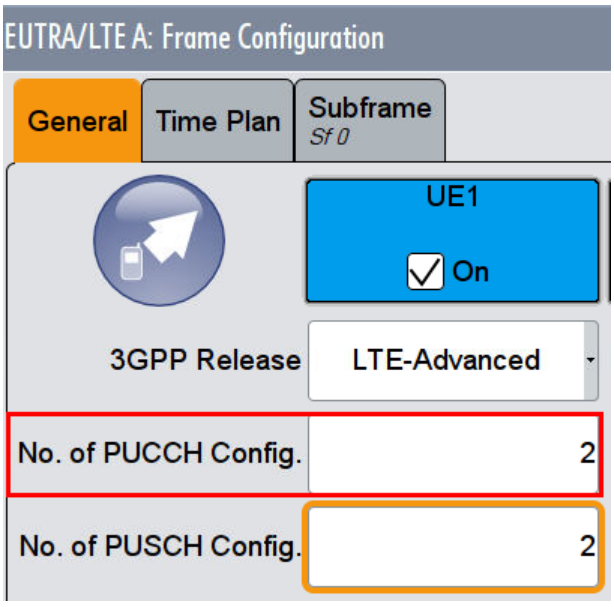


Fig. 3-92: Set two configurable PUCCH subframes

5. Click tab **Subframe**
6. Set for the PUCCH the **Format** to **F2** and the state **On** (Fig. 3-93)

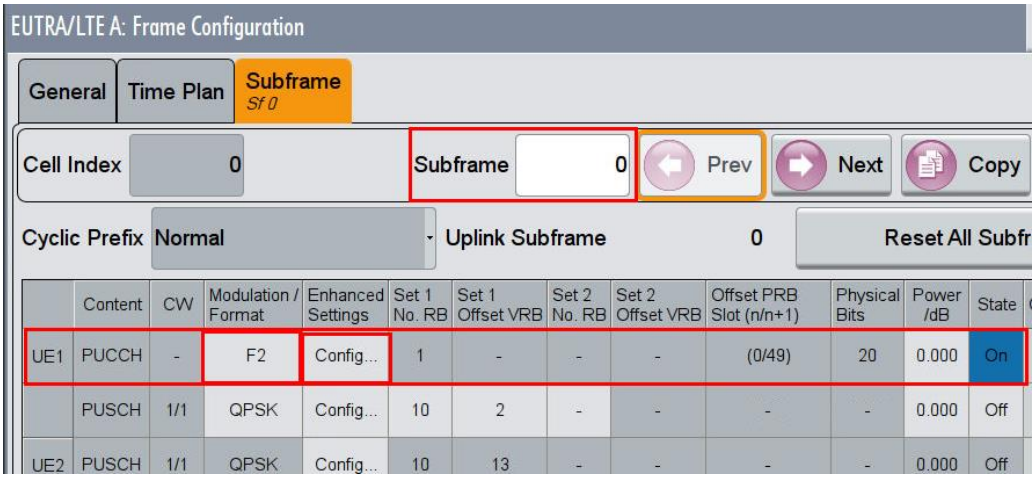


Fig. 3-93: PUCCH with format F2 in subframe 0

7. Click in column **Enhanced Settings** Config
8. Set the resource index **n_PUCCH** to 0. (Fig. 3-94)
9. Set the **Number of CQI bits to 4 and CQI Pattern** (four bits) to '1111' (Fig. 3-95)

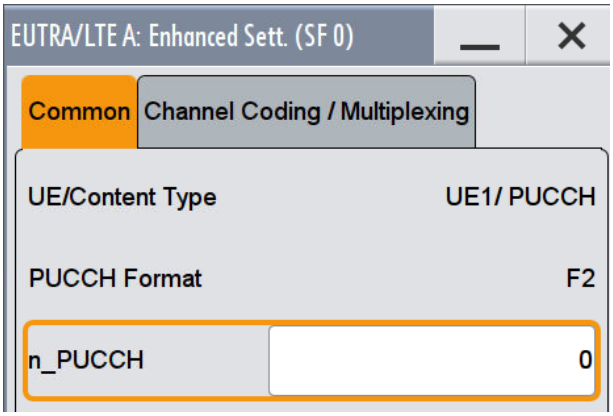


Fig. 3-94: Set the parameter n_PUCCH to 0

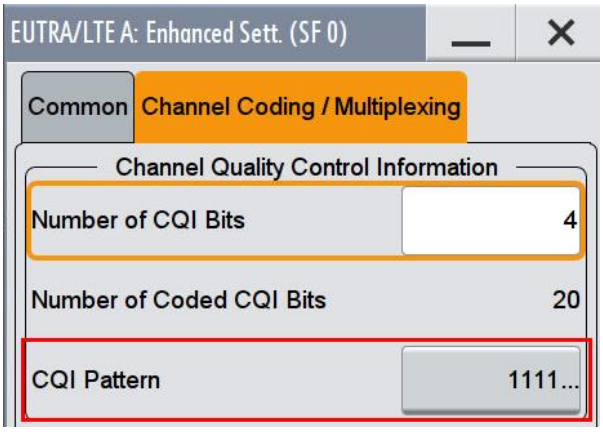


Fig. 3-95: Set four bits CQI pattern to '1111'

10. Make sure that the PUCCH in the second configurable subframe is not transmitted.(State **Off**) (Fig. 3-96)

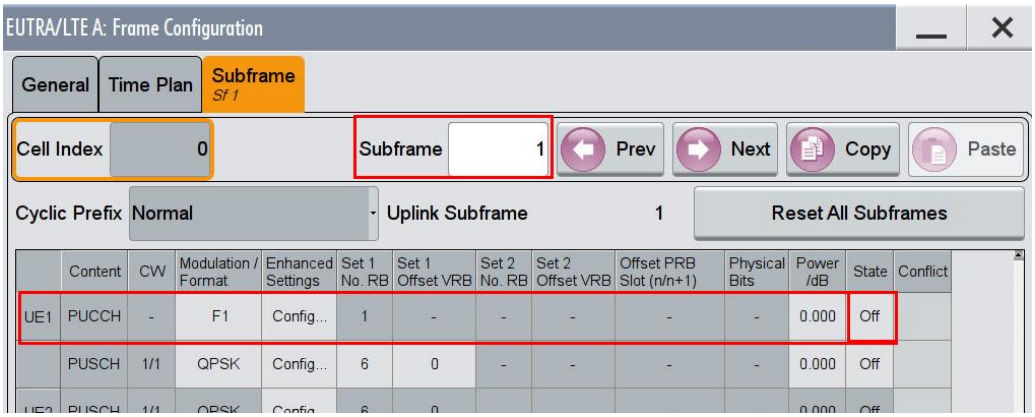


Fig. 3-96: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

11. Set **Fading** according to Table 3-46 (see 3.1.3) (example ETU 70 Hz Low)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = - 3.8 dB - 16.99 dB = -20.79 dB)

Demo Program

Fig. 3-97 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.2 CQI Test**. The tests are listed by their fading profile. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). The resource index n_PUCCH is set to 0. This example configures a PUCCH with CQI information in every second subframe.

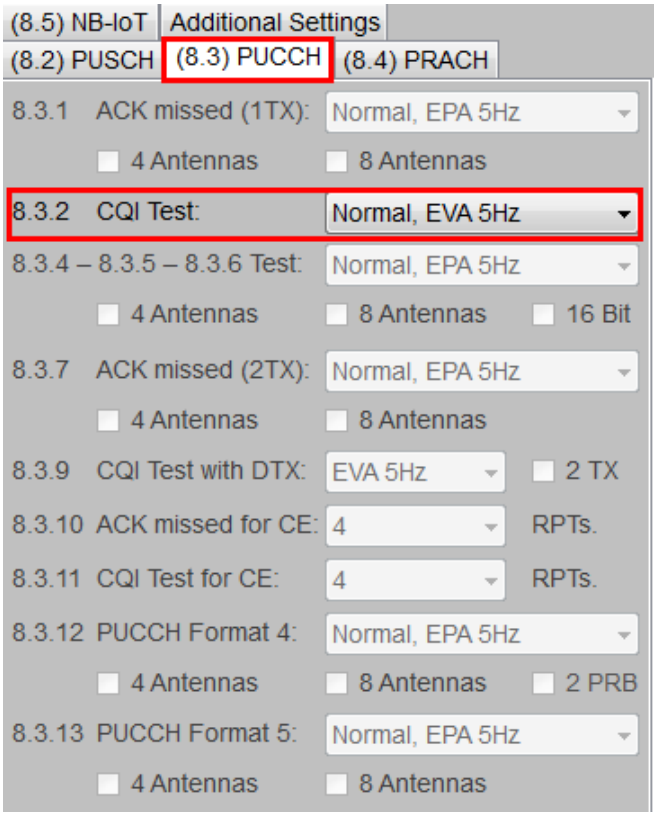


Fig. 3-97: Parameter for PUCCH test 8.3.2

Fig. 3-98 shows the report.

```
******* Performance Tests *******

8.3.2 CQI for PUCCH Format 2 (Single Antenna Port)

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EVA5Hz Low
AWGN: -80.5 dBm
SNR: -3.4 dB
SNR Correction: -16.99 dB

CQI Pattern (4 Bits): '1111'
Finished!
```

Fig. 3-98: Report for test 8.3.2

3.3.3 ACK missed detection for multi user PUCCH format 1a (Clause 8.3.3)

The test verifies the receivers' performance at detecting ACK on the wanted signal in the presence of three interfering signals under multipath fading conditions for a given SNR.

The performance is measured on the wanted signal by the required SNR at probability of detection equal to 0.99 or greater. 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 test is applicable for Wide area BS and Medium range BS only.

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

All interferers transmit one bit of information ACK (≡ '1') in the PUCCH format 1a in **all** subframes.

Requirements for PUCCH 8.3.3									
Number of RX antennas	**Cyclic Prefix**	**Propagation Conditions**	**Correlation matrix**	**Channel Bandwidth / SNR [dB]**					
				1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
2	Normal	ETU 70	Low	-3.5	-3.8	-3.8	-4.0	-4.0	-3.8

Table 3-47: Requirements for PUCCH test 8.3.3

For this test, the wanted signal and the three interferers transmit PUCCH with one bit ACK information (≡ '1') on the same resources at the same time, but with different orthogonal covers (n_PUCCH) and different relative power (see Table 3-48).

Additional test parameters multi user PUCCH 8.3.3					
	Cyclic shift index (δ =0)	**Orthogonal cover index**	**RS orthogonal cover/ ACK/NACK orthogonal cover** (n_PUCCH)	**Relative power [dB]**	**Relative timing [ns]**
Tested signal	4	0	2	-	-
Interferer 1	2	0	1	0	0
Interferer 2	3	1	7	-3	
Interferer 3	4	2	14	3	
NOTE1: Presented resource index mapping for orthogonal cover and cyclic shift indices are for the first slot of the subframe. NOTE2: All above listed signals are transmitted on the same PUCCH resources, with different PUCCH channel indices as presented above.					

Table 3-48: Additional test parameters multi user PUCCH test 8.3.3

Test setup

The test can be performed with just one SMW (with the suitable options).

Four UE's are simulated with the SMW, a combing network similar to 4x2 MIMO is added with multipath fading by the channel simulators and AWGN is applied.

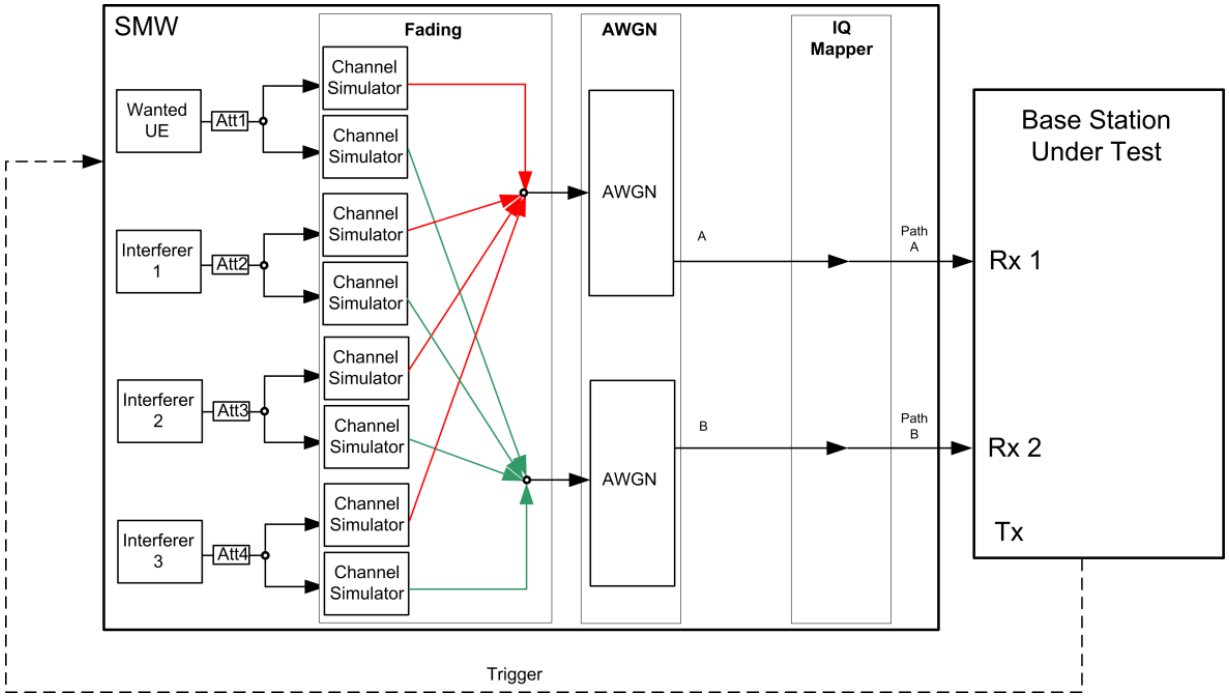


Fig. 3-99: Test setup 8.3.3. with one SMW.

Test Procedure

The SMW is able to create all four UEs in one instrument. As a combing network similar to 4x2 MIMO is needed, the **System Configuration** functionality of the SMW simplifies the settings. As an example, the settings for 10 MHz are shown. The ACK of UE1 is transmitted in every second subframe. The ACK's of the interferer is transmitted continuously in all subframes.

As in the SMW all four UE's are combined, the sum of the SNRs needs to be set.

Levels for SMW, example 10 MHz				
UE	SNR - SNR_{corr}	Relative power [dB]	SNR level [dB]	Settings
1	- 4.0 dB – 16.99 dB = -20.99 dB	0.0	- 20,99	Sum = SNR = - 14.46 dB
2		0.0	- 20,99	
3		- 3.0	- 23,99	
4		+ 3.0	- 17,99	

Table 3-49: SNR calculation example for 8.3.3 in the SMW

SMW SNR settings for PUCCH 8.3.3						
	Channel Bandwidth / SNR [dB]					
	1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
SNR	-4.75	-9.03	-11.25	-14.46	-16.22	-17.27

Table 3-50: Resulting SNR for 8.3.3 in the SMW

1. Set four independent basebands with fading and a MIMO 4x2 setting (see Fig. 3-100)

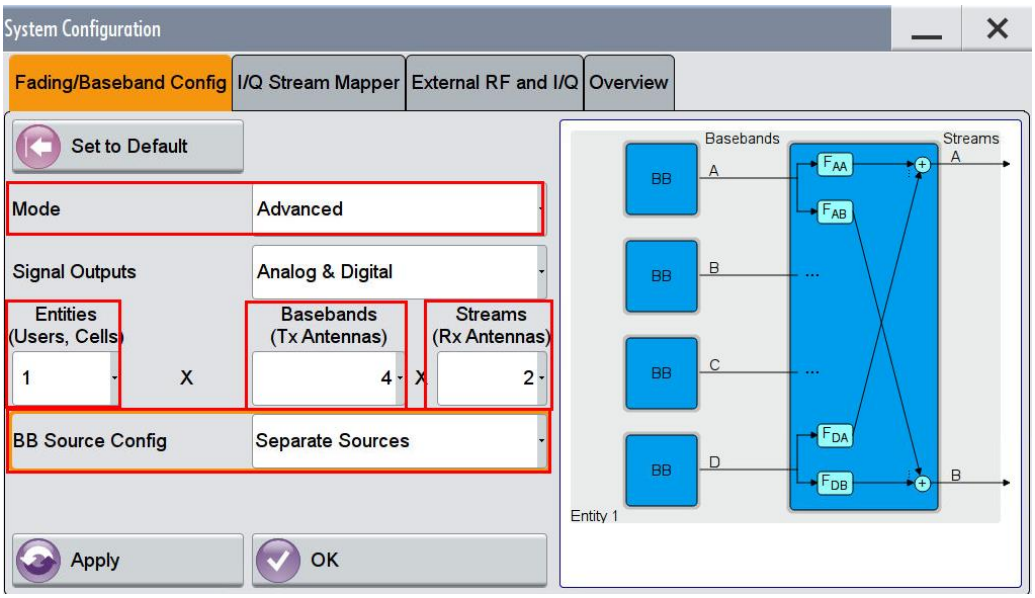


Fig. 3-100: System configuration for PUCCH 8.3.3. A network combining network similar to 4x2 MIMO is used. Baseband A simulates the wanted signal. Baseband B….D simulate the three interferers.

2. For the basic LTE steps see section 3.1.2

Setting of UE1

3. Click **Frame Configuration**
4. Set **No of PUCCH Config** to 2 (Fig. 3-101)

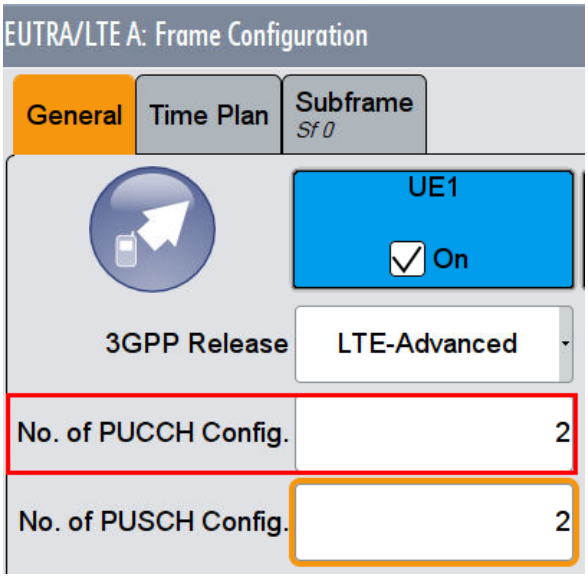


Fig. 3-101: Set two configurable PUCCH subframes

5. Click tab **Subframe**
6. Set for the PUCCH the Format to **F1a** and the state **On** (Fig. 3-102)

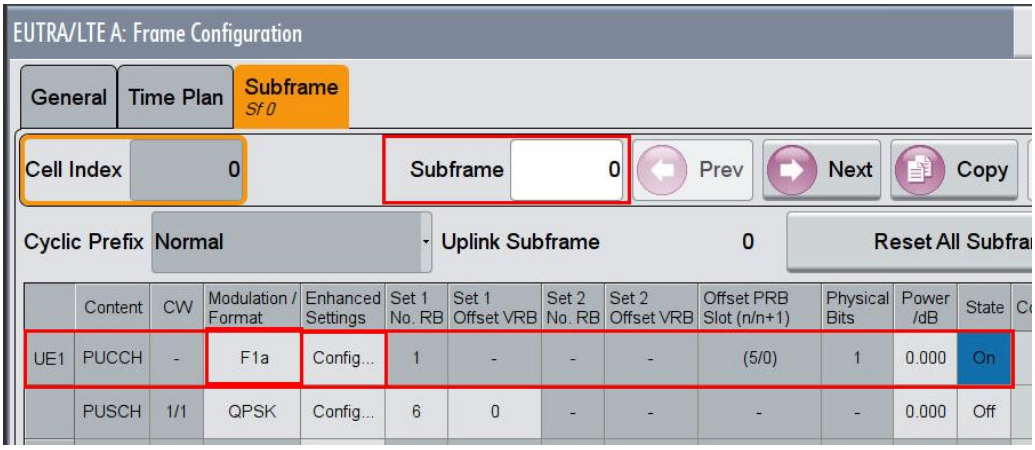


Fig. 3-102: PUCCH with format F1a in subframe 0

7. Click in column **Enhanced Settings** Config
8. Set the resource index **n_PUCCH** accordingly (**UE1: 0**). (Fig. 3-103)
9. Set the **ACK/NACK Pattern** (one bit) to '**1**' (Fig. 3-104)

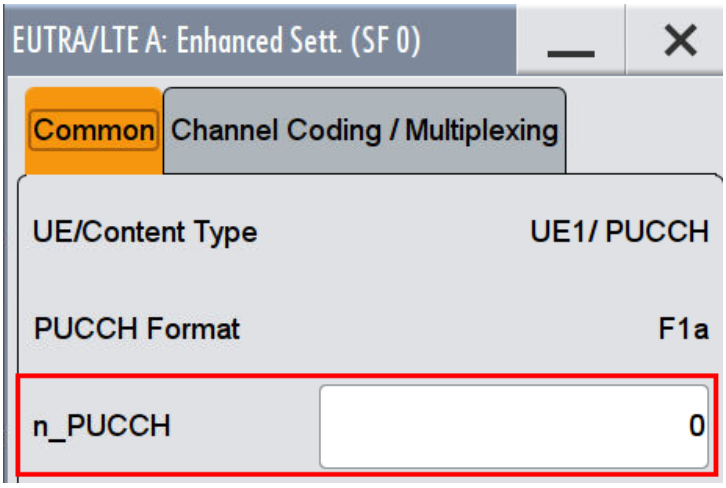


Fig. 3-103: Set the parameter n_PUCCH to 0

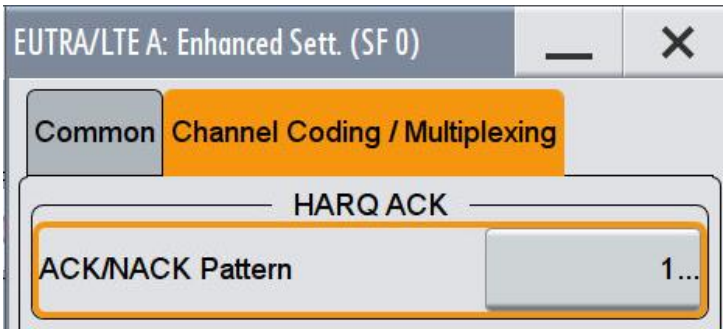


Fig. 3-104: Set one bit ACK pattern to '1' (ACK)

10. Make sure that the PUCCH in the second configurable subframe is not transmitted.(State **Off**) (Fig. 3-105)

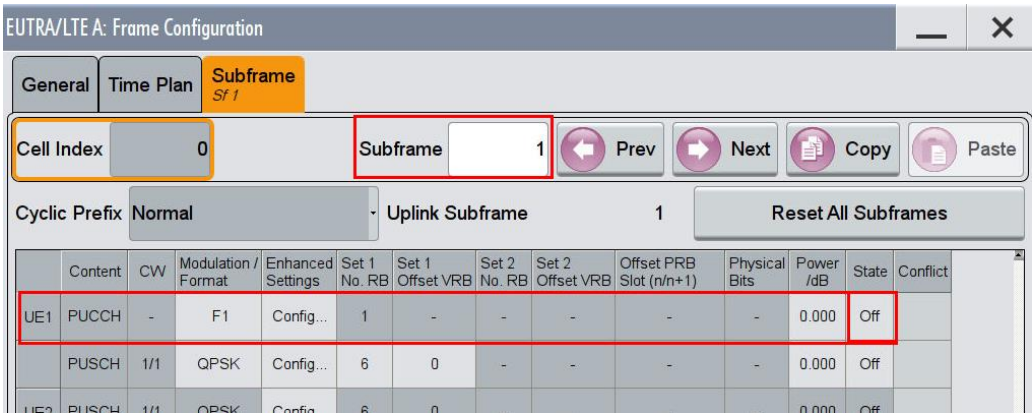


Fig. 3-105: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state off)

Setting Interferer UE's (UE2…UE4)

11. Click **Frame Configuration**
12. Set **No of PUCCH Config** to 1 (Fig. 3-106), because all interferer transmit continuously.

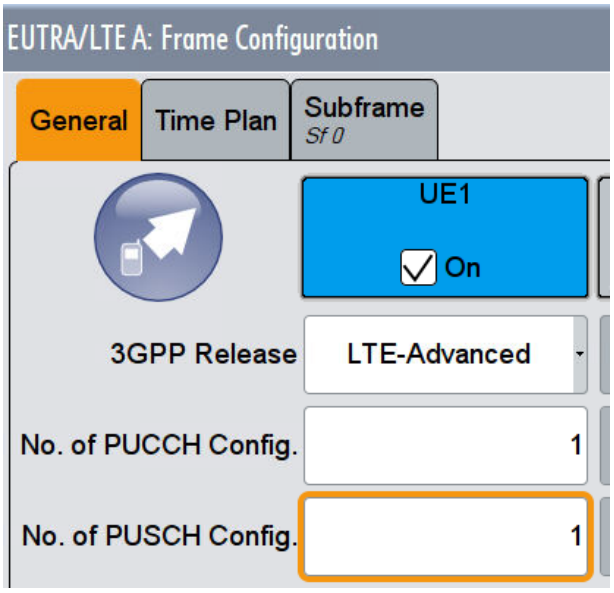


Fig. 3-106: Set one configurable PUCCH subframes for the interferers

13. Click tab **Subframe**
14. Set for the PUCCH the Format to **F1a** and the state **On** (Fig. 3-107)

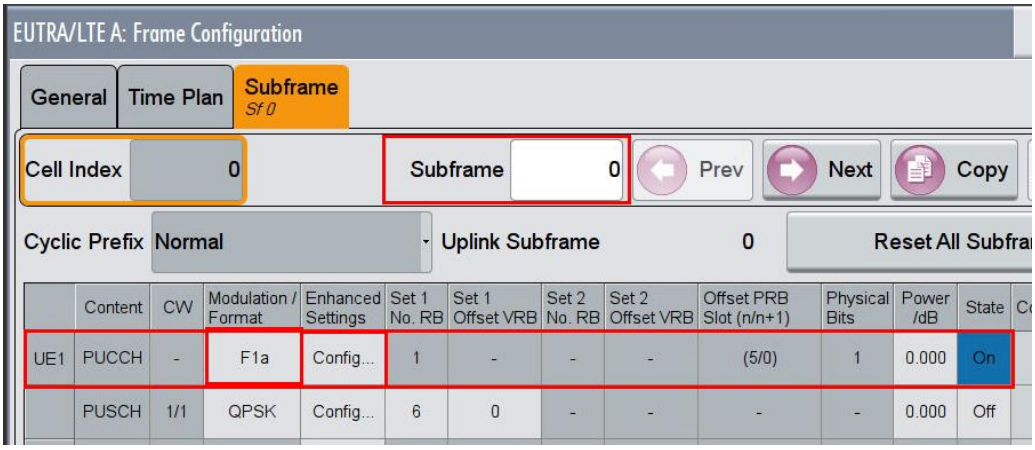


Fig. 3-107: PUCCH with format F1a in subframe 0

15. Click in column **Enhanced Settings** Config
16. Set the resource index n_**PUCCH** according to Table 3-48 (**UE2…UE4**). (Fig. 3-103) and the **ACK/NACK Pattern** (one bit) to '**1**' (Fig. 3-104)
17. Set individual relative power levels by a click on the line between the baseband and the AWGN block. In the window set the level of (Fig. 3-108 and Fig. 3-109)

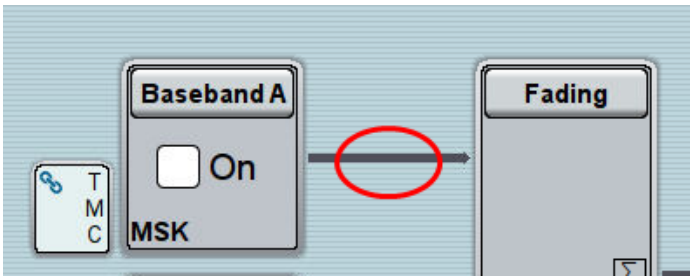


Fig. 3-108: Click here to enter baseband offsets

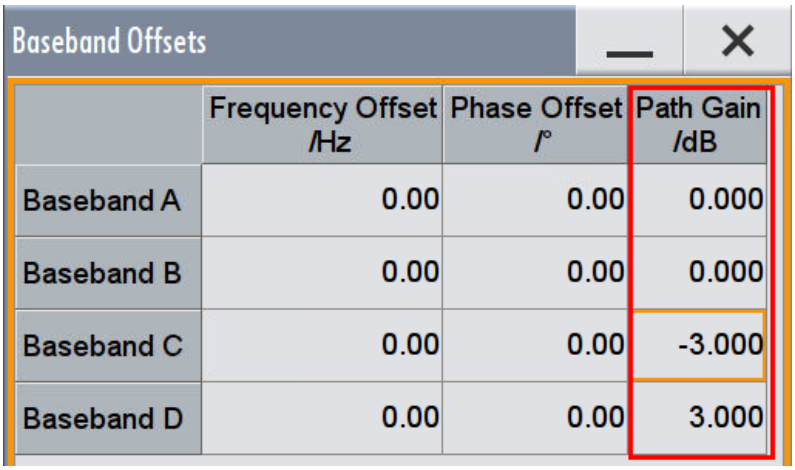


Fig. 3-109: Individual level offsets for the UE's are entered as baseband offsets

AWGN und Fading

18. Set **Fading** according to Table 3-47 (see 3.1.3) (example: ETU 70 Hz Low)
19. Set **noise power** and **SNR** according to Table 3-50 (see 3.1.4). As all UE's are summed up inside the SMW, set the SNR in the way to meet the required levels accordingly (example: Noise = -80.5 dBm; SNR = - 14.46 dB)

Demo Program

For this test, no additional parameters have to be set. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). The resource indices n_PUCCH are set to the corresponding values. This example configures an ACK information for UE1 in every second subframe.

Fig. 3-110 shows the report.

```
******* Performance Tests *******

8.3.3 ACK missed Detection for Mulit User PUCCH Format 1A

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: ETU70Hz Low
AWGN: -80.5 dBm
SNR: -4 dB
SNR Correction: -16.99 dB

ACK/NACK Pattern (One Bit): '1'
Finished!
```

Fig. 3-110: Report for test 8.3.3

3.3.4 ACK missed detection for PUCCH format 1b with Channel Selection (Clause 8.3.4)

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 statistics are kept by the base station under test.

This test is applicable for all categories of BS. Tests are specified for channel bandwidths of 10 MHz, 15 MHz and 20 MHz, only.

For the test, four bits of information ACK (≡ '1111') are transmitted in the PUCCH format 1b.

Table 3-51 shows the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.4									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	-3.9	-4.0	-4.0
		EVA 70	Low	-	-	-	-3.7	-3.9	-3.9
4	Normal	EPA 5	Low	-	-	-	-7.8	-7.9	-8.0
		EVA 70	Low	-	-	-	-7.7	-7.9	-7.9
8	Normal	EPA 5	Low	-	-	-	-11.1	-11.2	-11.2
		EVA 70	Low	-	-	-	-10.9	-11.1	-11.0

Table 3-51: Requirements for PUCCH 8.3.4

Test setup

Fig. 3-111 to Fig. 3-113 show the test setup.

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 (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3.

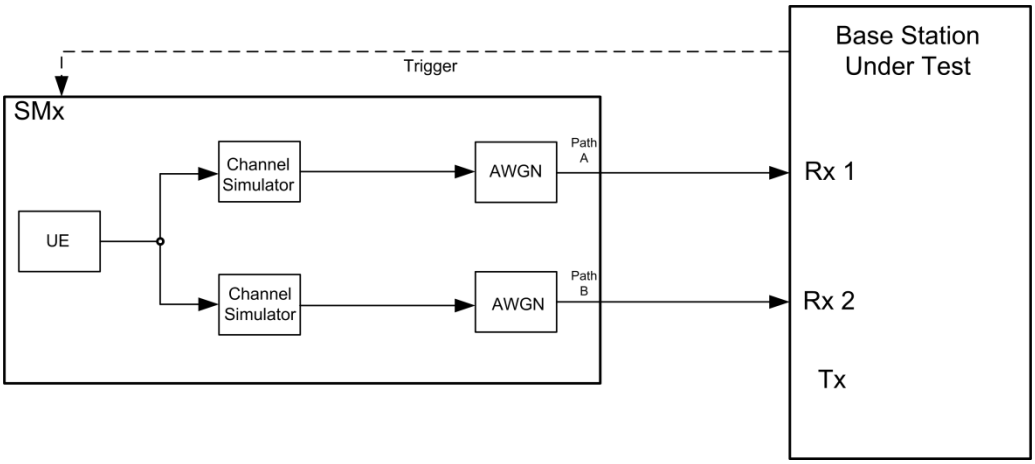


Fig. 3-111: Test setup for PUCCH test 8.3.4 for 2 antennas

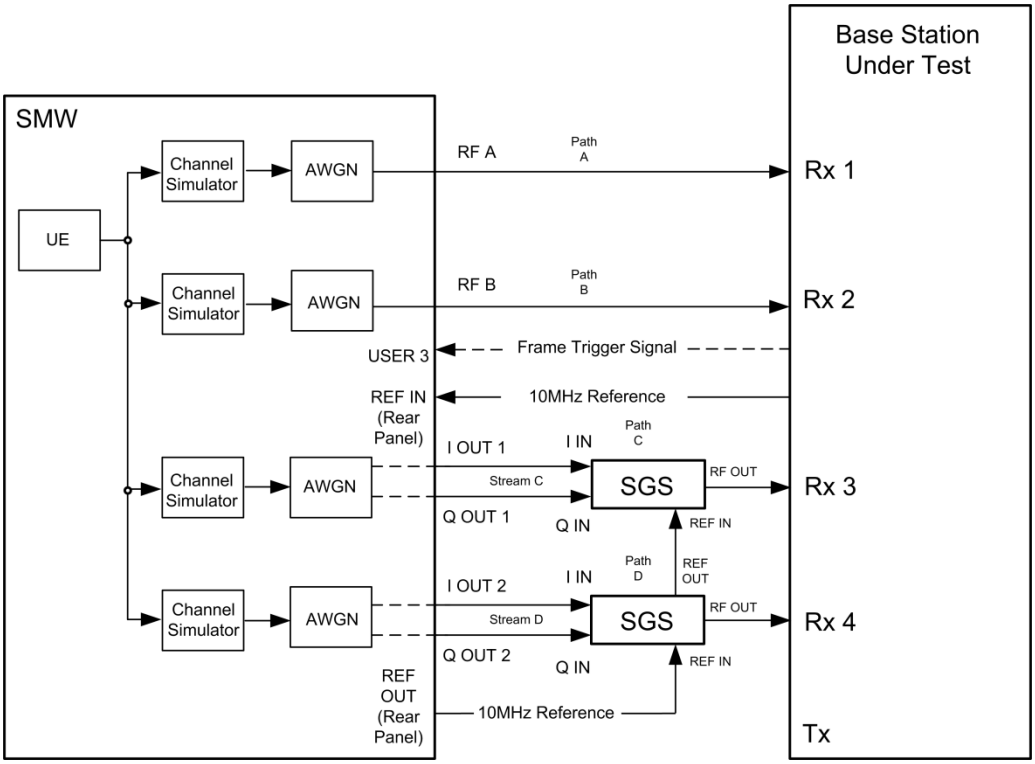


Fig. 3-112: Test setup for PUCCH test 8.3.4 for 4 antennas with one SMW

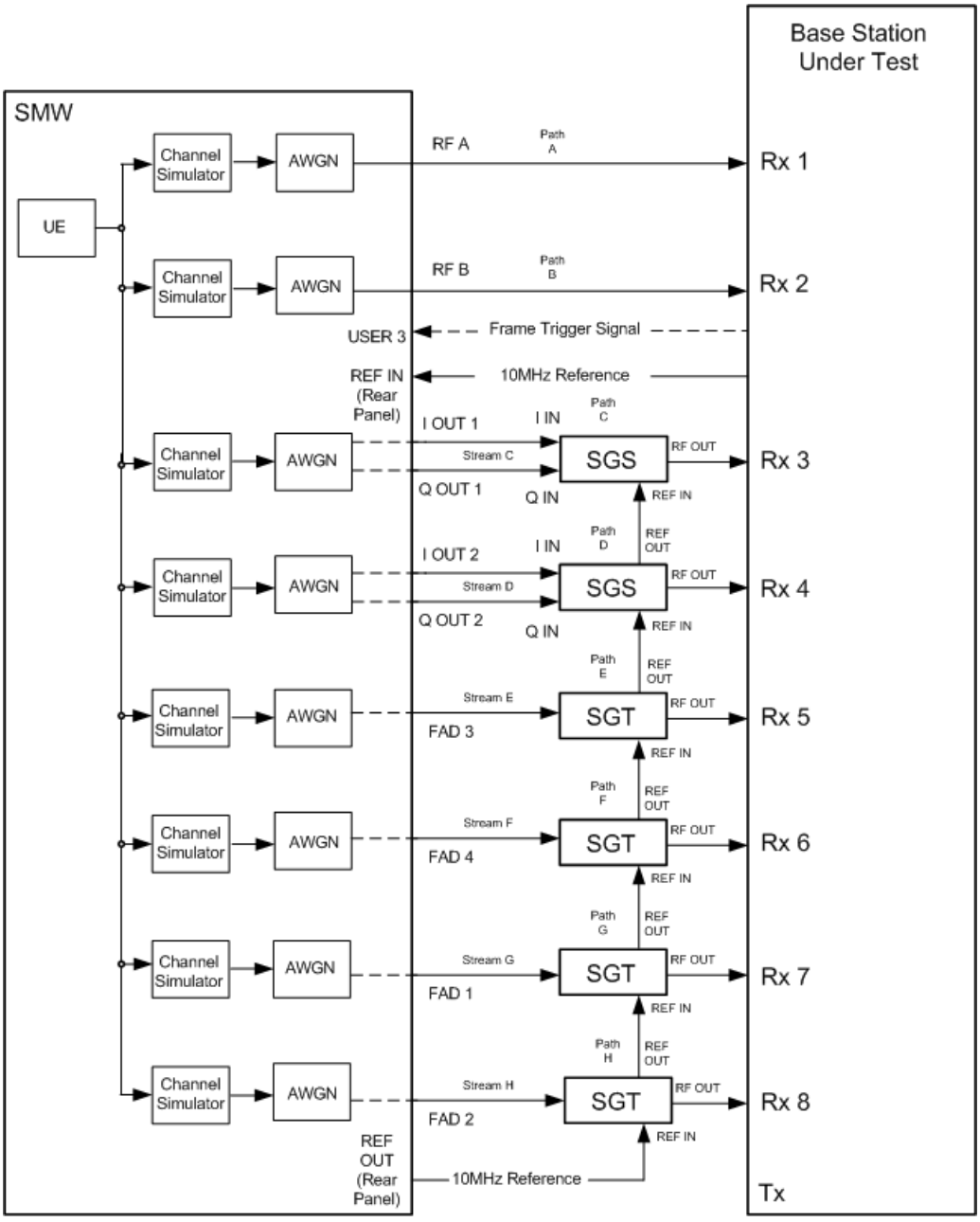


Fig. 3-113: Test setup for PUCCH test 8.3.4 for 8 antennas with one SMW

Test Procedure

As an example, the settings for 2 RX antennas, normal prefix, EVA 70 Hz and 10 MHz are shown. The ACK is sent in every second subframe.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1)
2. For the basic LTE steps see section 3.1.2
3. Click **Frame Configuration**
4. Set **No of PUCCH Config** to 2 (Fig. 3-114)

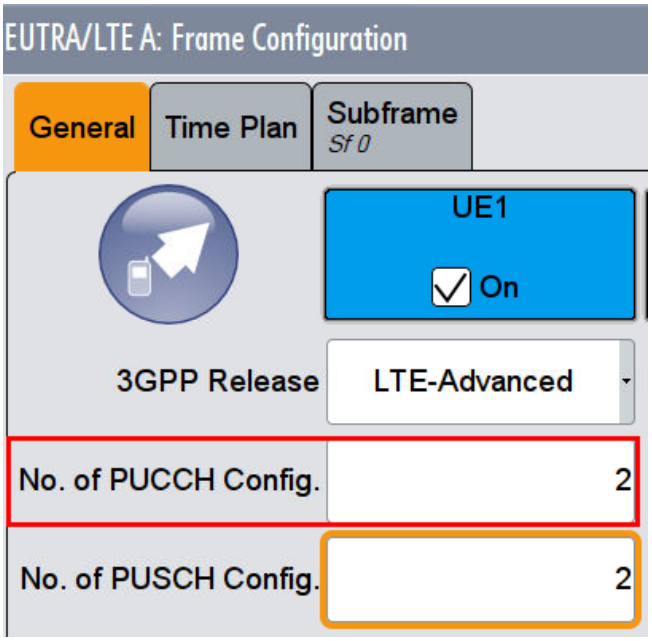


Fig. 3-114: Set two configurable PUCCH subframes

5. Click tab **Subframe**
6. Set for the PUCCH the Format to **F1b** and the state **On** (Fig. 3-115)

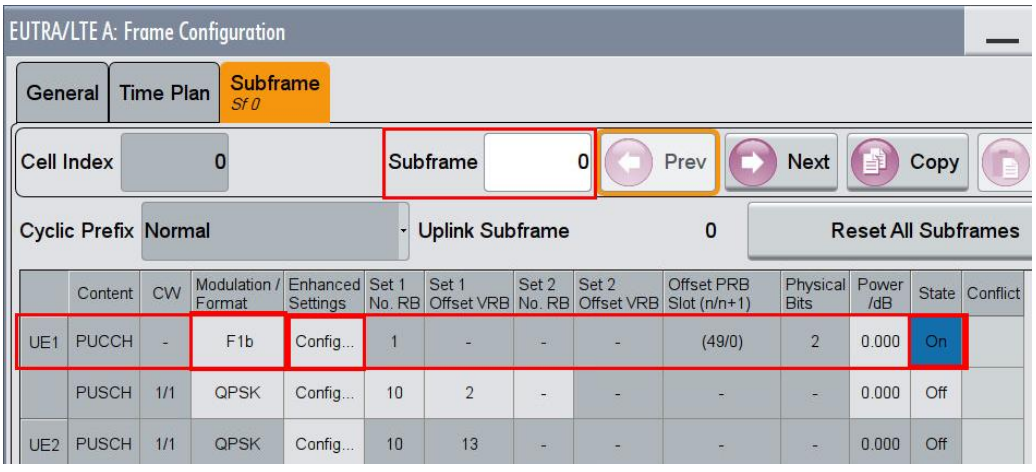


Fig. 3-115: PUCCH with format F1b in subframe 0

7. Click **Enhanced Settings** Config
8. Set the resource index **n_PUCCH** to **0**. (Fig. 3-116)
9. Set the **ACK/NACK Pattern** (two bits) to '**11**' (Fig. 3-117)

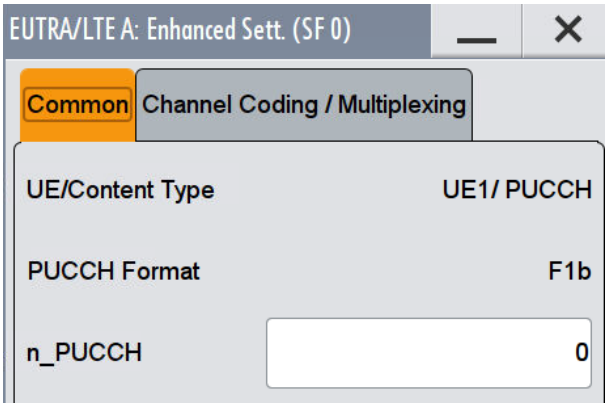


Fig. 3-116: Set the parameter n_PUCCH to 0

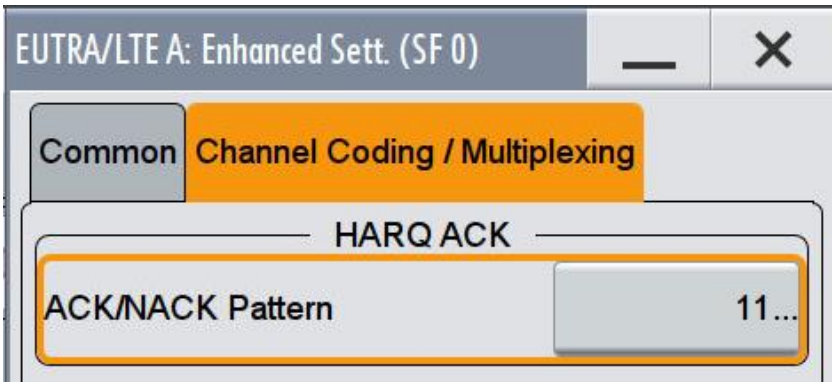


Fig. 3-117: Set two bits ACK pattern to '11'

10. Make sure that the PUCCH in the second configurable subframe is not transmitted.(State **Off**) (Fig. 3-118)

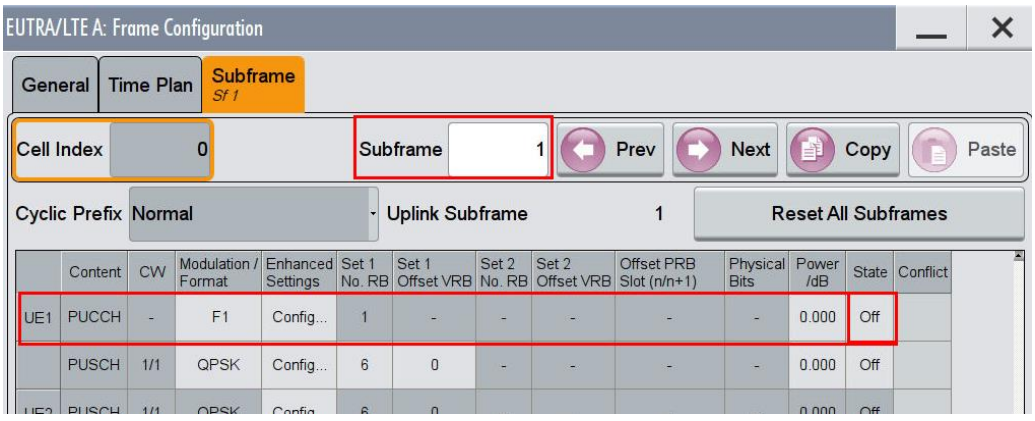


Fig. 3-118: In the second configurable subframe (subframe #1), the PUCCH is not transmitted (state Off)

AWGN and Fading

11. Set **Fading** according to Table 3-51 (see 3.1.3) (example EVA 70 Hz Low)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -3.7 dB -16.99 dB = -20.69 dB)

Demo program

Fig. 3-119 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.4 - 8.3.5 - 8.3.6 Tests**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). The resource index n_PUCCH is set to 0. This example configures a PUCCH with ACK information in every second subframe. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

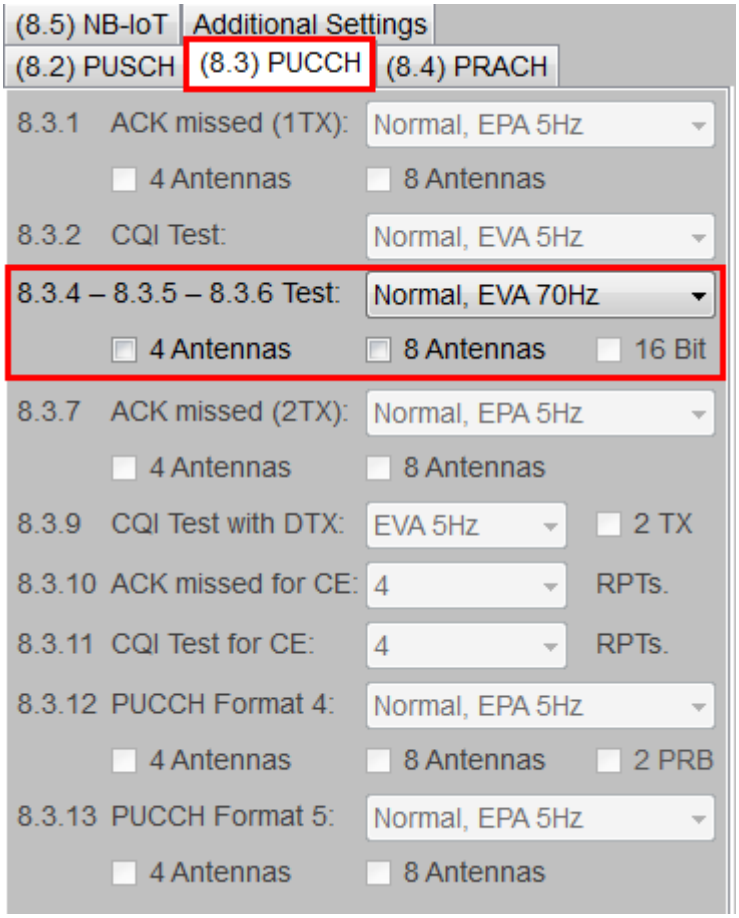


Fig. 3-119: Parameter for PUCCH test 8.3.4

Fig. 3-120 shows the report.

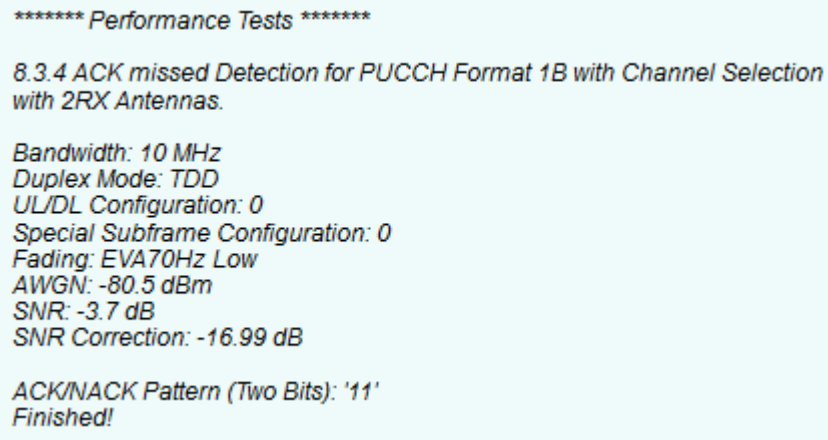


Fig. 3-120: Report 8.3.4

3.3.5 ACK missed detection for PUCCH format 3 (Clause 8.3.5)

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 statistics are kept by the base station under test.

This test is applicable for all categories of BS. Tests are specified for channel bandwidths of 10 MHz, 15 MHz and 20 MHz, only.

For the test, PUCCH format 3 is used. The number of bits are in Table 3-52. One SR bit '0' is always appended. 16 bits are for TDD only.

Ack/Nack Bits in PUCCH 8.3.5	
FDD	TDD
4 bits '1111'	4 bits '1111' +'0'
-	16 bits '1111 1111 1111 1111' +'0'

Table 3-52: AN bits in 8.3.5

Table 3-53 and Table 3-54 show the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.5, 4 AN bits									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	-3.1	-3.2	-3.2
		EVA 70	Low	-	-	-	-2.9	-3.0	-3.1
4	Normal	EPA 5	Low	-	-	-	-6.7	-6.8	-6.9
		EVA 70	Low	-	-	-	-6.6	-6.7	-6.7
8	Normal	EPA 5	Low	-	-	-	-10.5	-10.3	-10.5
		EVA 70	Low	-	-	-	-10.3	-10.4	-10.4

Table 3-53: Requirements for PUCCH 8.3.5, 4 AN bits

Test requirement PUCCH 8.3.5, 16 AN bits, TDD only									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	-0.7	-0.6	-0.6
		EVA 70	Low	-	-	-	-0.2	-0.3	-0.3
4	Normal	EPA 5	Low	-	-	-	-4.7	-4.7	-4.8
		EVA 70	Low	-	-	-	-4.4	-4.5	-4.5
8	Normal	EPA 5	Low	-	-	-	-8.2	-8.2	-8.3
		EVA 70	Low	-	-	-	-8.1	-8.2	-8.1

Table 3-54: Requirements for PUCCH 8.3.5, 16 AN bits, TDD only

Test setup

Fig. 3-121 to Fig. 3-123 show the test setup.

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 (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3.

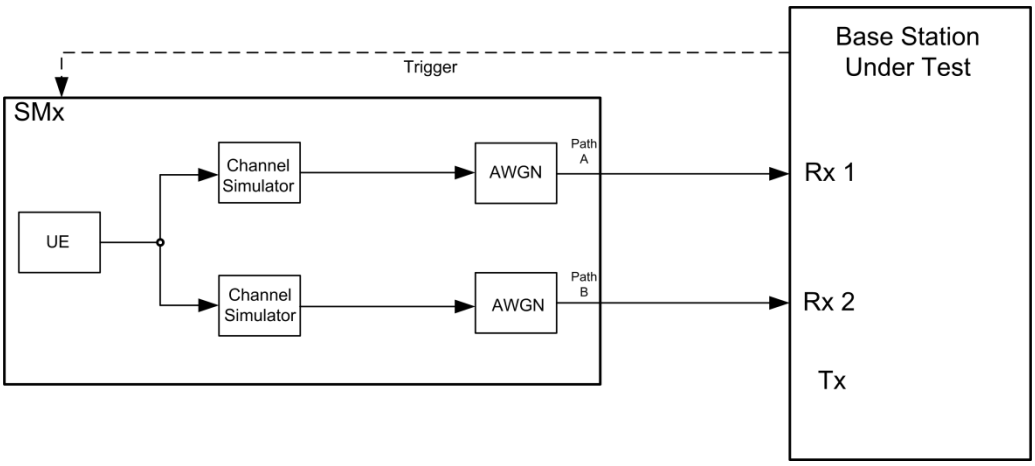


Fig. 3-121: Test setup for PUCCH test 8.3.5 for 2 antennas

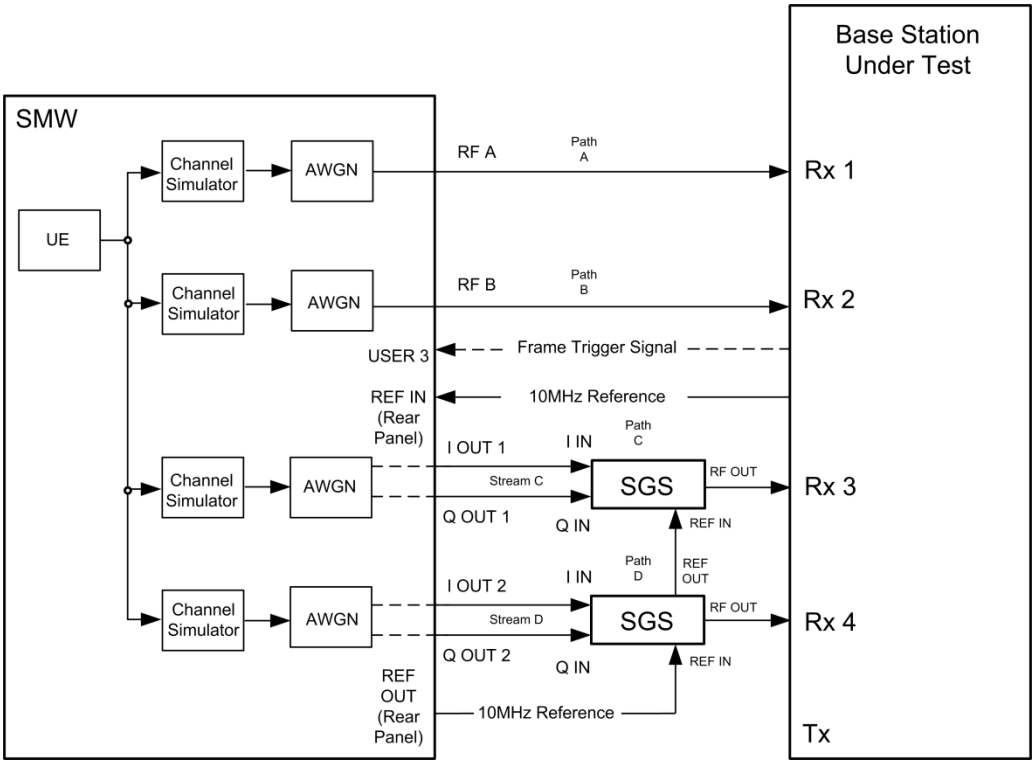


Fig. 3-122: Test setup for PUCCH test 8.3.5 for 4 antennas with one SMW

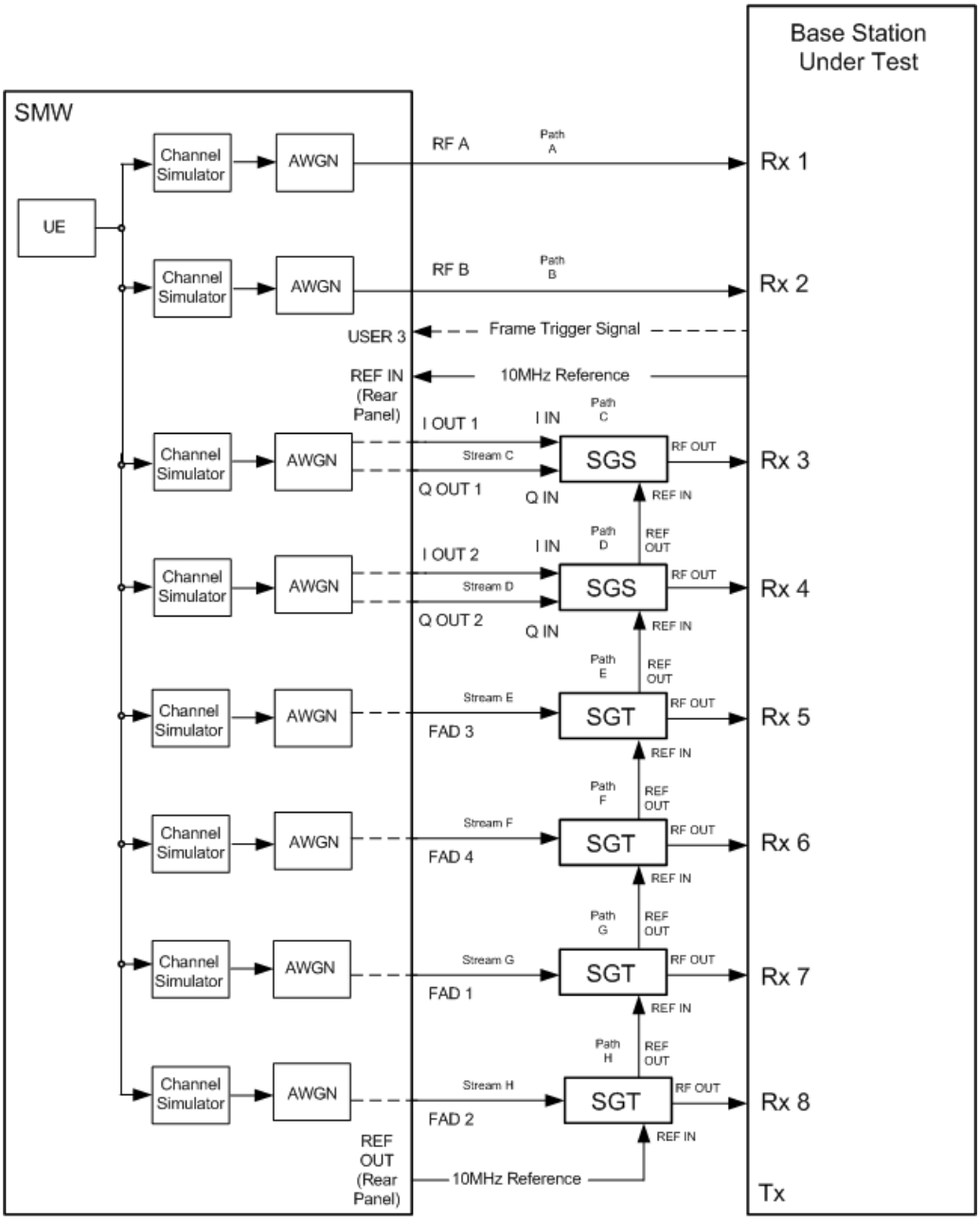


Fig. 3-123: Test setup for PUCCH test 8.3.5 for 8 antennas with one SMW

Test Procedure

As an example, the settings for 2 RX antennas, 4 AN bits, normal prefix, EVA 70 Hz and 10 MHz are shown. The ACK is set in every second subframe.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1)
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **No of PUCCH Config** to 2 (Fig. 3-124)

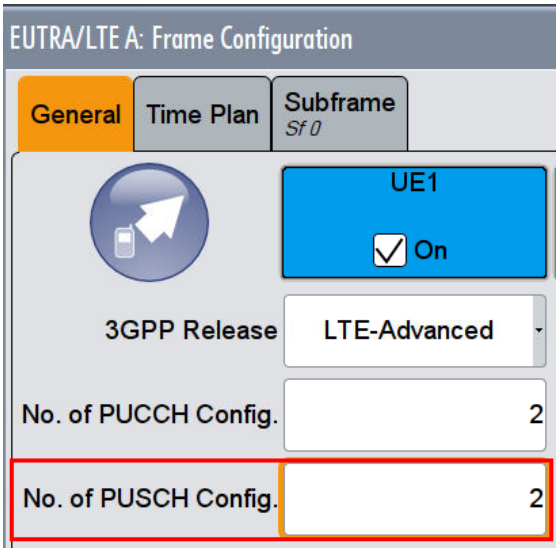


Fig. 3-124: Set two configurable PUCCH subframes

5. Click tab **Subframe**
6. Set for the PUCCH the Format to **F3** and the state **On** (Fig. 3-125)

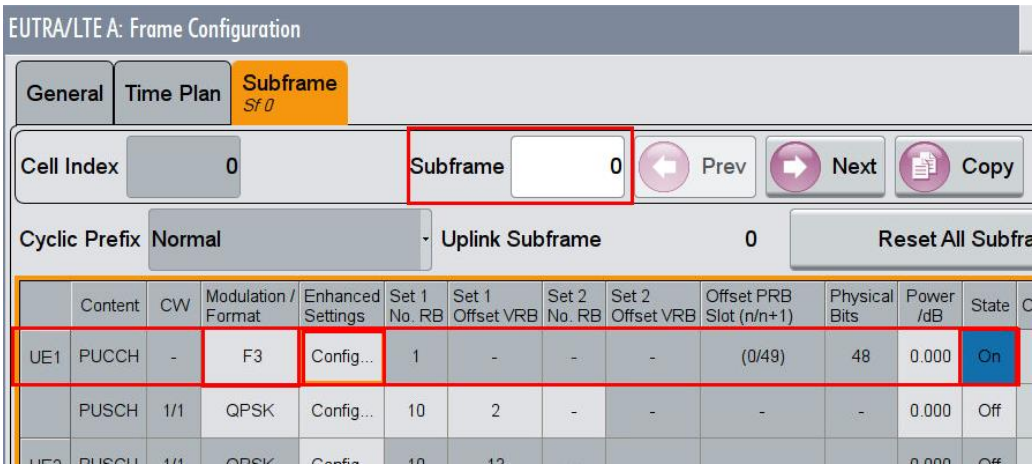


Fig. 3-125: PUCCH with format F3 in subframe 0

7. Click Enhanced Settings **Config**
8. Set the resource index **n_PUCCH** to **0**. (Fig. 3-126)
9. Set the **Number of Bits** to **5** (4 ACK + 1 SR) and the **ACK/NACK Pattern** to '**11110**' (Fig. 3-127)

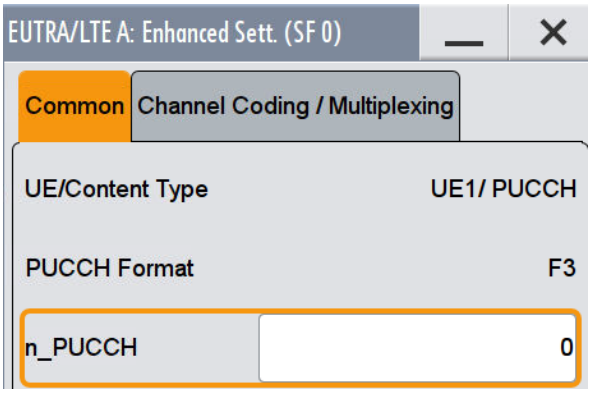


Fig. 3-126: Set the parameter n_PUCCH to 0

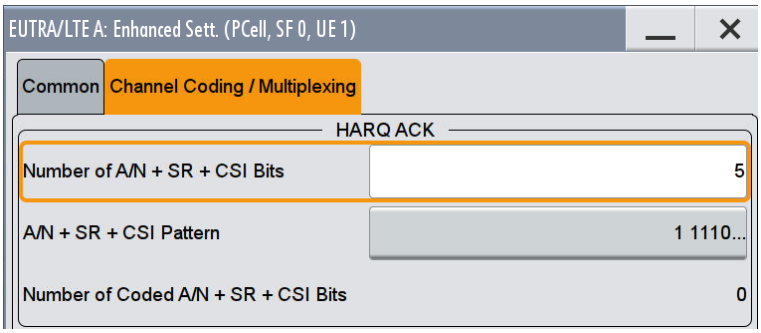


Fig. 3-127: Set five bits ACK pattern to '1111' + '0'

10. Make sure that the PUCCH in the second configurable subframe is not transmitted.(State **Off**) (Fig. 3-128)

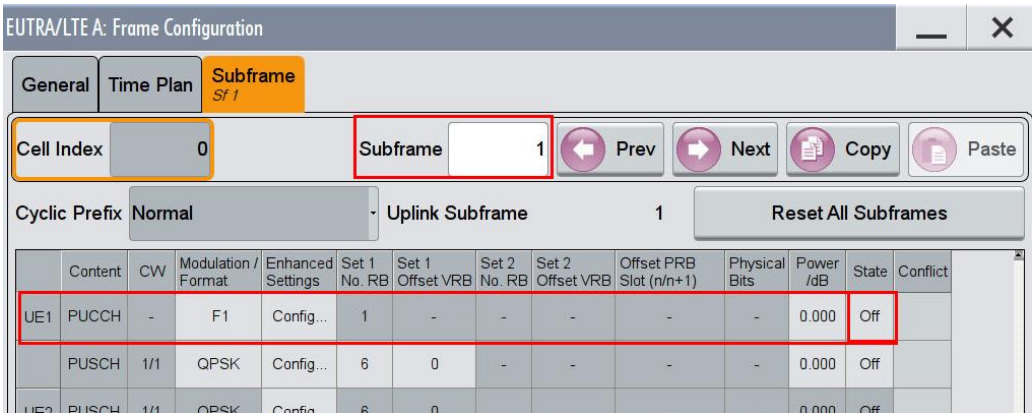


Fig. 3-128: In the second configurable subframe (subframe 1) the PUCCH is not transmitted (state on)

AWGN and Fading

11. Set **Fading** according to Table 3-52 or Table 3-53 (see 3.1.3) (example EVA 70 Hz Low)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -2.9 dB -16.99 dB = -19.99 dB)

Demo program

Fig. 3-129 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.4 - 8.3.5 - 8.3.6 Tests**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). The resource index n_PUCCH is set to 0. This example configures a PUCCH with ACK information in every second subframe. If TDD is selected, the test with 16 bit (**16 bit**) can be performed.
4 Antennas enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

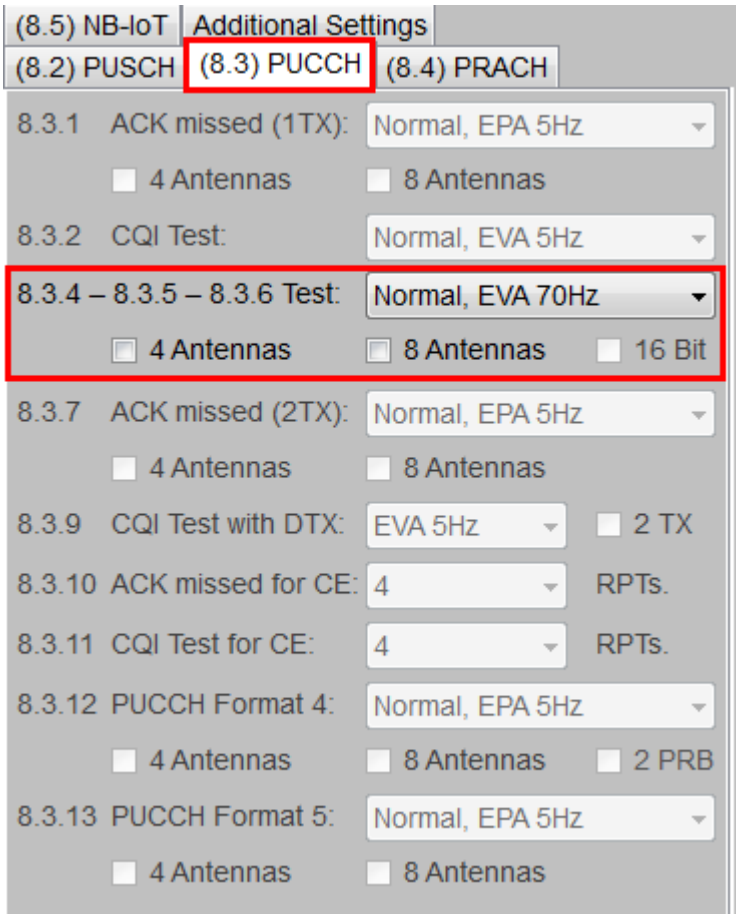


Fig. 3-129: Parameter for PUCCH test 8.3.5

Fig. 3-130 shows the report.

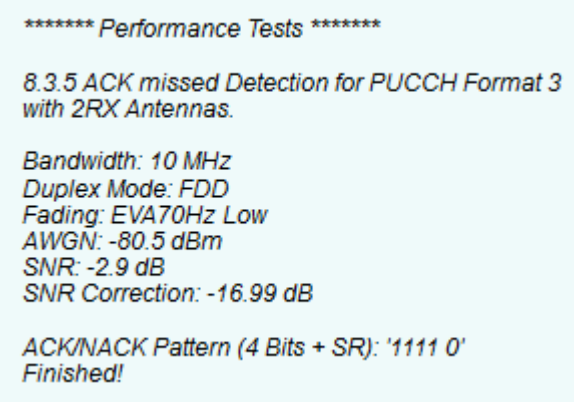


Fig. 3-130: Report 8.3.5

3.3.6 NAK to ACK detection for PUCCH format 3 (Clause 8.3.6)

The test verifies the receivers' performance at detecting NAK to ACK under multipath fading conditions for a given SNR. The probability of the NAK 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.

This test is applicable for all categories of BS. Tests are specified for channel bandwidths of 10 MHz, 15 MHz and 20 MHz, and TDD mode only.

For the test, PUCCH format 3 is used. 16 AckNack bits are transmitted with NAK always (≡ '0'). One SR bit '0' is always appended.

Test requirement PUCCH 8.3.6, 16 AN bits, TDD only									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	2.0	2.2	2.1
		EVA 70	Low	-	-	-	2.7	2.5	2.5
4	Normal	EPA 5	Low	-	-	-	-2.5	-2.7	-2.9
		EVA 70	Low	-	-	-	-2.3	-2.5	-2.6
8	Normal	EPA 5	Low	-	-	-	-6.7	-6.7	-6.7
		EVA 70	Low	-	-	-	-6.4	-6.5	-6.6

Table 3-55: Requirements for PUCCH 8.3.6, 16 AN bits, TDD only

Test setup

Fig. 3-131 to Fig. 3-132 show the test setup.

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 (suitable options required). For eight RX antennas, the test can be also done with just one SMW.

The SMW needs an external trigger at USER3.

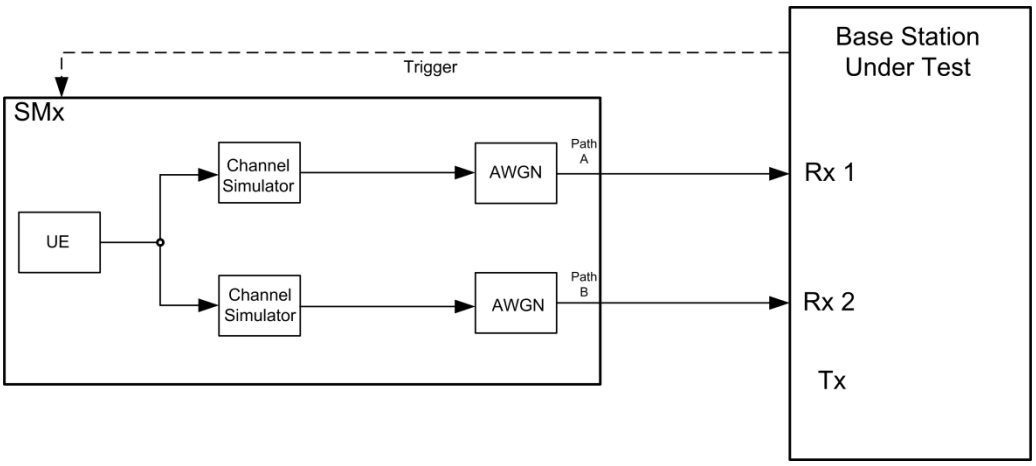


Fig. 3-131: Test setup for PUCCH test 8.3.6 for 2 antennas

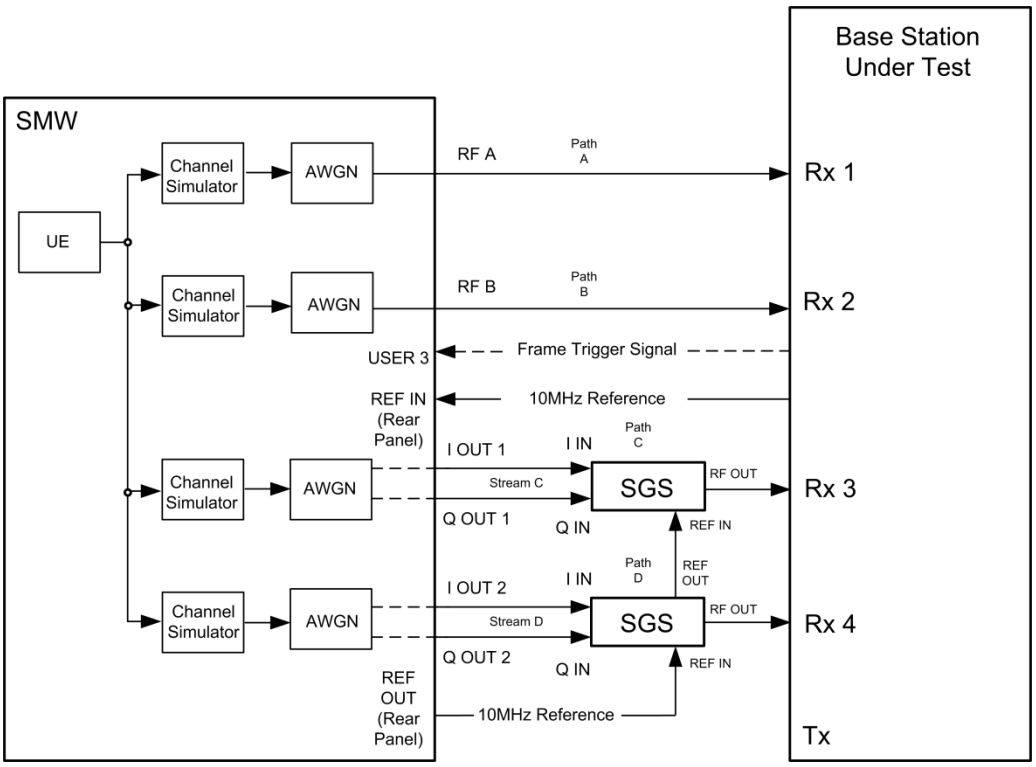


Fig. 3-132: Test setup for PUCCH test 8.3.6 for 4 antennas with one SMW

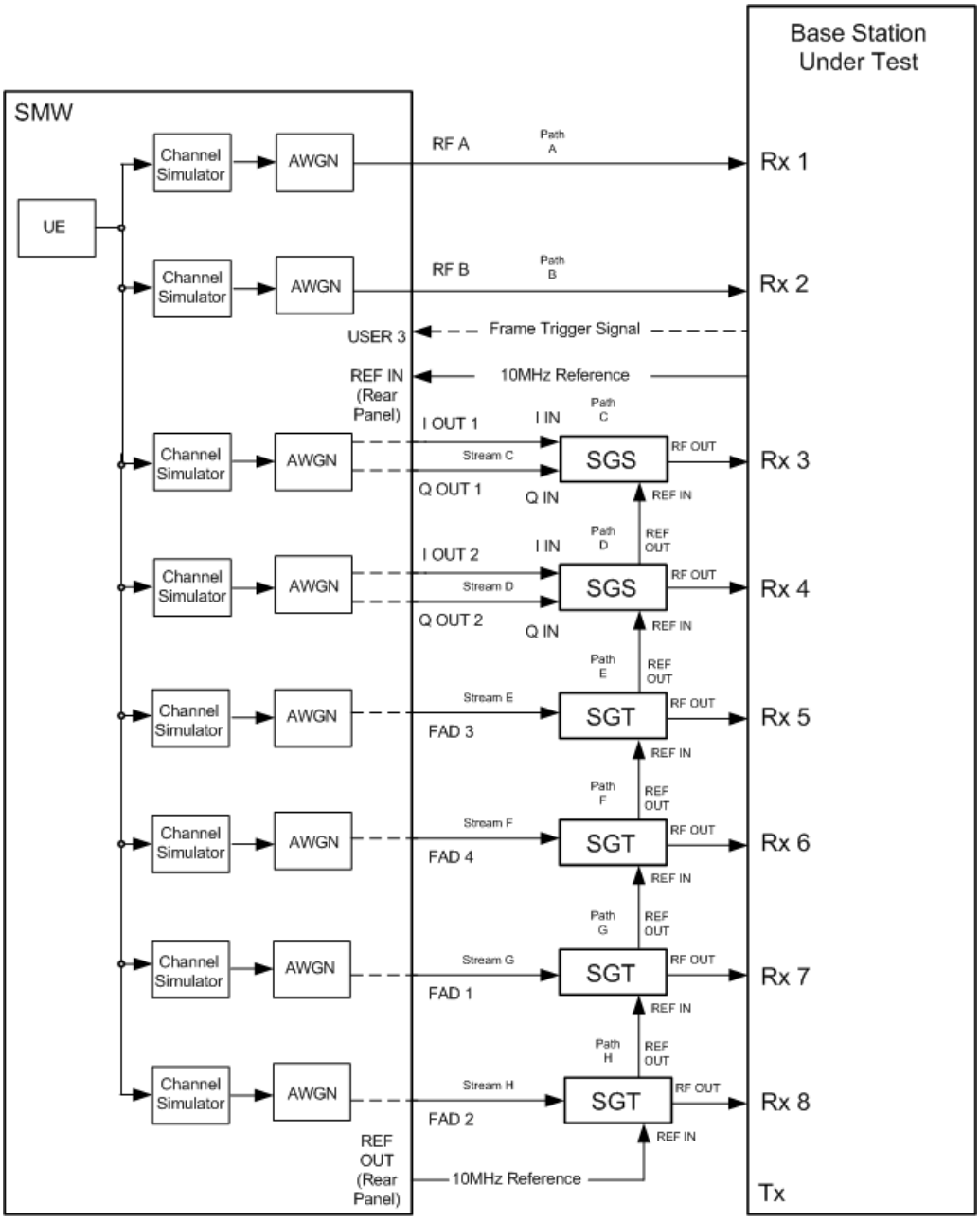


Fig. 3-133: Test setup for PUCCH test 8.3.6 for 8 antennas with one SMW

Test Procedure

As an example, the settings for 2 RX antennas, 16 AN bits, normal prefix, EVA 70 Hz and 10 MHz are shown. The ACK is set in every second subframe.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1).
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **No of PUCCH Config** to 2 (Fig. 3-134)

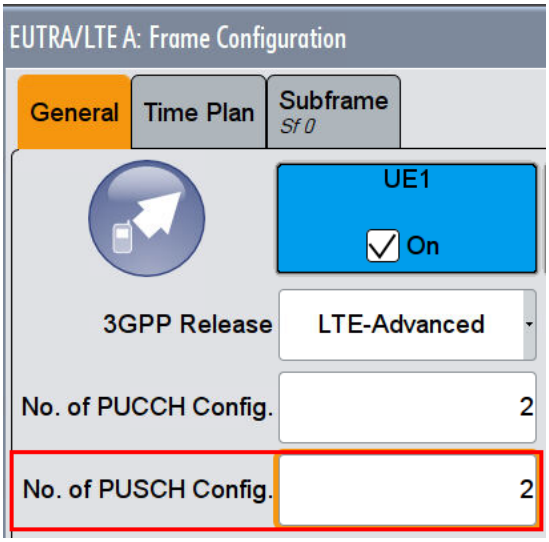


Fig. 3-134: Set two configurable PUCCH subframes

5. Click tab **Subframe**
6. Set for the PUCCH the Format to **F3** and the state **On** (Fig. 3-135)

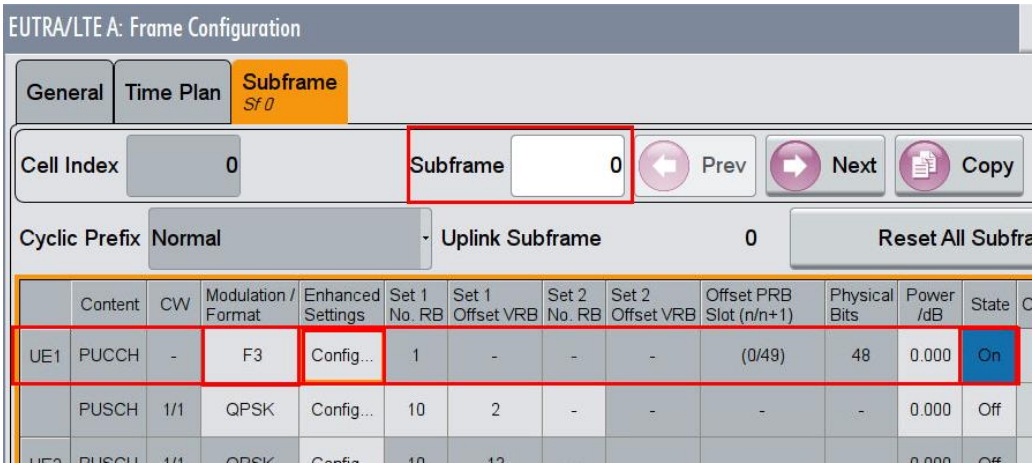


Fig. 3-135: PUCCH with format F3 in subframe 0

7. Click Enhanced Settings **Config**
8. Set the resource index **n_PUCCH** to **0**. (Fig. 3-136)
9. Set the **Number of Bits** to **17 (16 ACK + 1 SR)** and the **ACK/NACK Pattern** to '**0000 0000 0000 00000**' (Fig. 3-137)

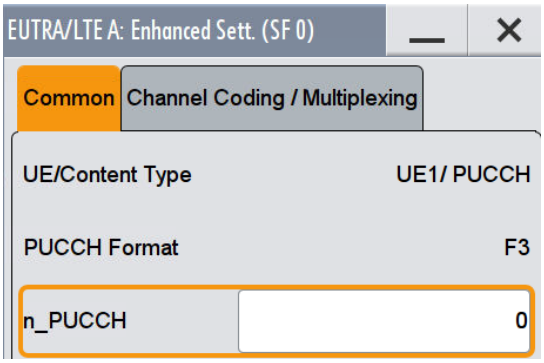


Fig. 3-136: Set the parameter n_PUCCH to 0

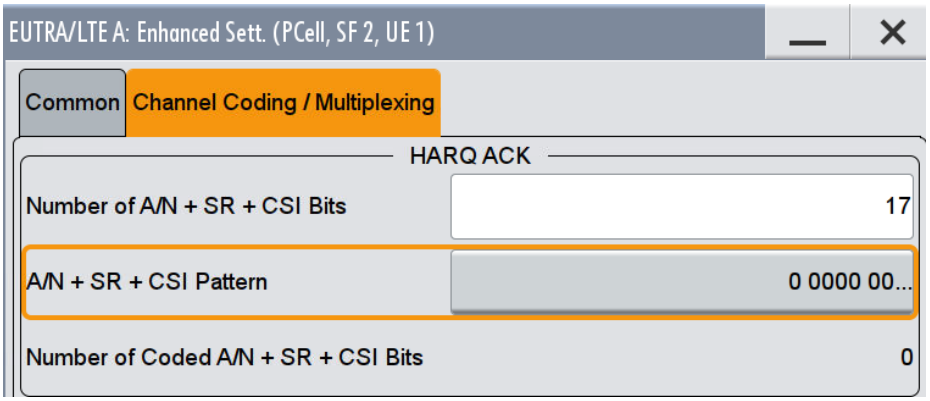


Fig. 3-137: Set 17 bits ACK pattern to '0000 0000 0000 0000' + '0'

10. Make sure that the PUCCH in the second configurable subframe is not transmitted.(State **Off**) (Fig. 3-138)

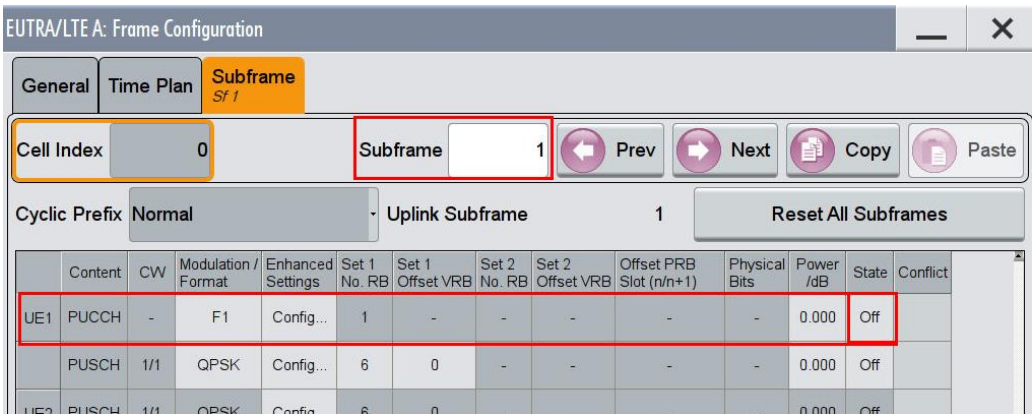


Fig. 3-138: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

11. Set **Fading** according to Table 3-55 (see 3.1.3) (example EVA 70 Hz Low)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4) (example: Noise = -80.5 dBm; SNR = SNR + Correction = 2.7 dB -16.99 dB = -14.29 dB)

Demo program

Fig. 3-139 shows the parameters of the test. When this test is selected, the Duplex mode is switched automatically to TDD. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.4 - 8.3.5 - 8.3.6 Tests**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). The resource index n_PUCCH is set to 0. This example configures a PUCCH with 16 bits of NACK information in every second subframe. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

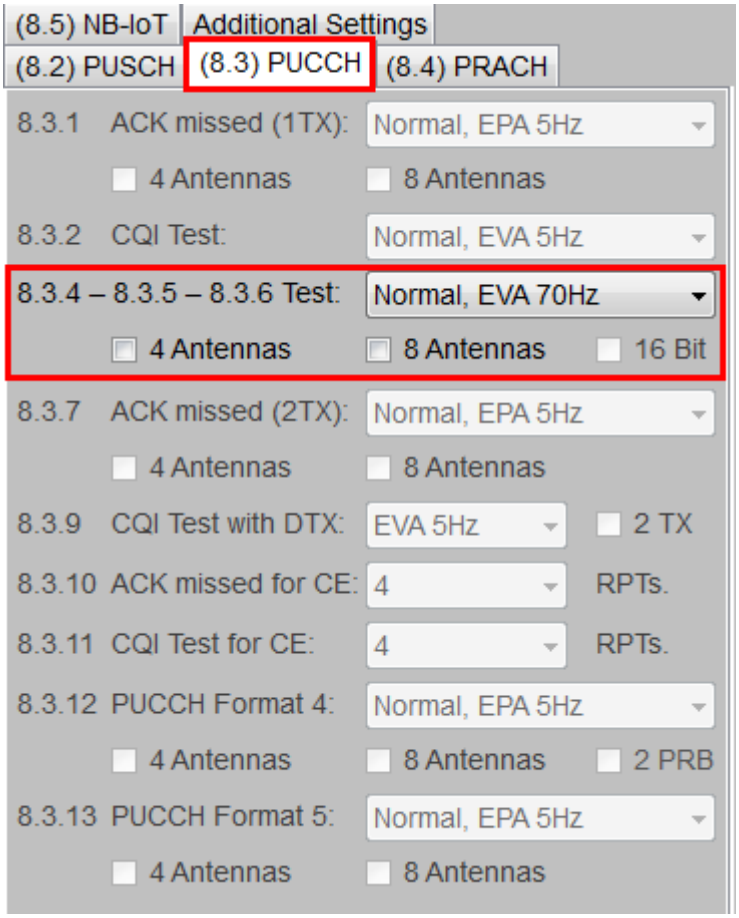


Fig. 3-139: Parameter for PUCCH test 8.3.6

Fig. 3-140 shows the report.

```
******* Performance Tests *******

8.3.6 NAK to ACK Detection for PUCCH Format 3
with 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: TDD
UL/DL Configuration: 1
Special Subframe Configuration: 0
Fading: EVA70Hz Low
AWGN: -80.5 dBm
SNR: 2.7 dB
SNR Correction: -16.99 dB

ACK/NACK Pattern (16 Bits + SR): '0000 0000 0000 0000 0'
Finished!
```

Fig. 3-140: Report 8.3.6

3.3.7 ACK missed detection for PUCCH format 1a transmission on two antenna ports (Clause 8.3.7)

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 statistics are kept by the base station under test.

This test is applicable for all categories of BS. It is similar to the test 8.3.1 (see 3.3.1) but uses two antenna ports (UL-MIMO with ports 200 and 201).

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

Table 3-56, Table 3-57 and Table 3-58 show the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.7, 2 RX antennas										
Number of TX antennas	Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
					1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	2	Normal	EPA 5	Low	-3.8	-4.1	-5.6	-5.7	-5.7	-5.9
			EVA 70	Low	-5.0	-5.1	-5.6	-5.1	-5.6	-5.6

Table 3-56: Test requirements PUCCH test 8.3.7 for 2 RX antennas

Test requirement PUCCH 8.3.7, 4 RX antennas										
Number of TX antennas	Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
					1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	4	Normal	EPA 5	Low	-7.7	-7.7	-8.5	-8.7	-8.7	-8.7
			EVA 70	Low	-8.2	-8.4	-8.5	-8.5	-8.6	-8.7

Table 3-57: Test requirements PUCCH test 8.3.7 for 4 RX antennas

Test requirement PUCCH 8.3.7, 8 RX antennas										
Number of TX antennas	Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
					1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	8	Normal	EPA 5	Low	-10.6	-10.7	-11.1	-11.2	-11.1	-11.2
			EVA 70	Low	-10.9	-11.0	-11.0	-11.0	-11.0	-11.0

Table 3-58: Test requirements PUCCH test 8.3.7 for 8 RX antennas

Test setup

Fig. 3-141 to Fig. 3-143 show the test setup.

The wanted signal generated by SMW basebands A and B uses a 2x2 MIMO configuration. Multipath fading is simulated in the channel simulators, AWGN is added.

For four RX antennas, the test can be done with just one SMW (suitable options required) .Here a 2x4 MIMO is applied. For eight RX antennas, the test can be also done with just one SMW. Here a 2x8 MIMO is applied.

The SMW needs an external trigger at USER3.

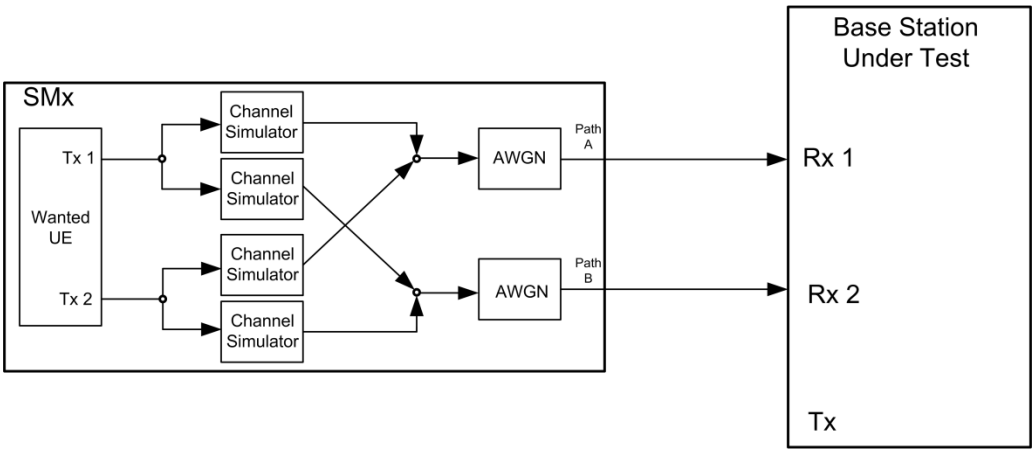


Fig. 3-141: Test setup for PUCCH test 8.3.7 for 2 antennas

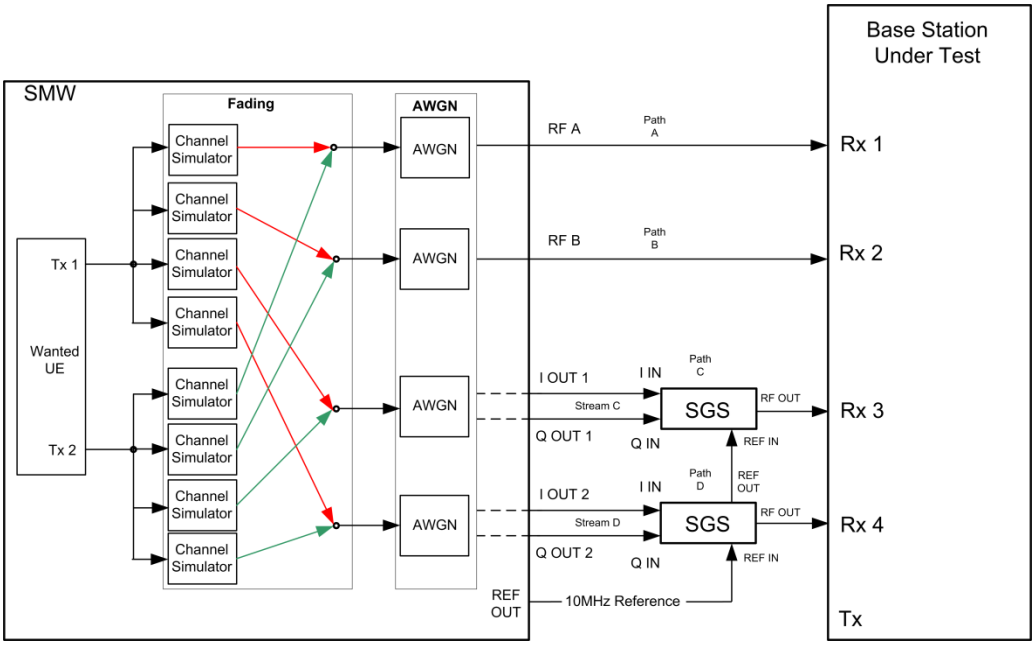


Fig. 3-142: Test setup for PUCCH test 8.3.7 for 4 antennas with one SMW

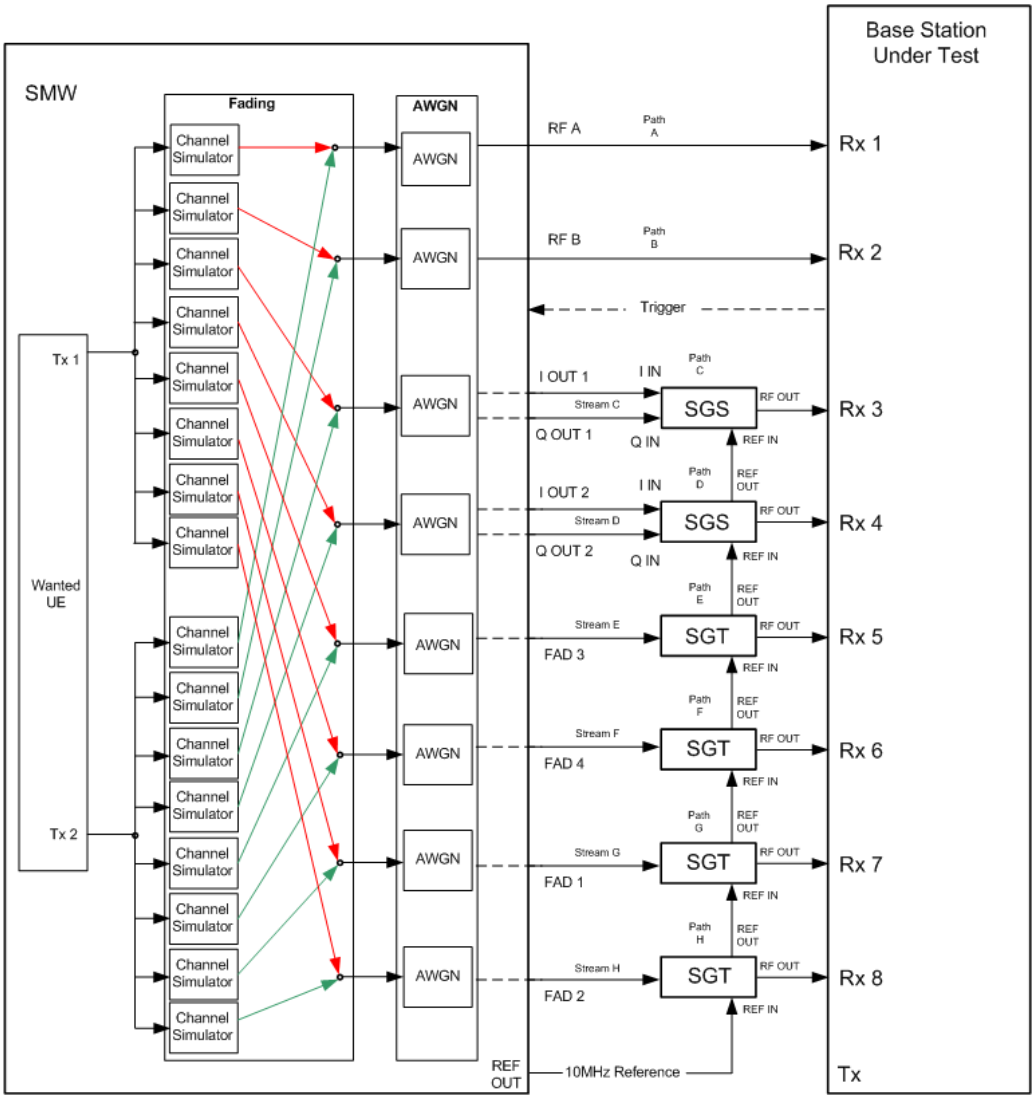


Fig. 3-143: Test setup for PUCCH test 8.3.7 for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz and 10 MHz are shown. The ACK is transmitted in every second subframe.

1. Set the **routing** to 1x2x2 (see 3.1.1), thus two baseband blocks are routed to two paths (2x2 MIMO).
2. For the basic LTE steps see section 0.
3. Click on UE1.

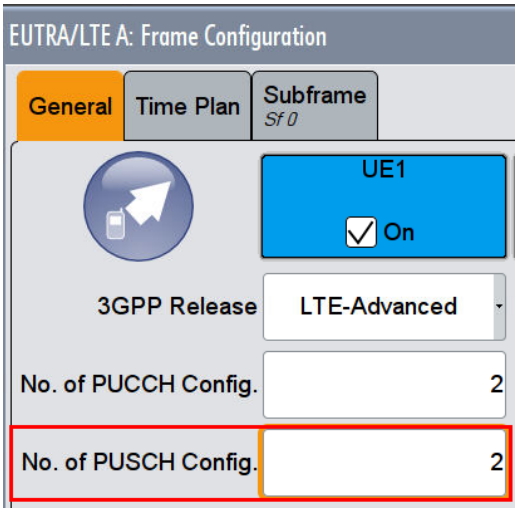


Fig. 3-144: UE1 and No of PUCCH Configuration

4. Enter in tab PUCCH the **number of antenna** ports, here 2 (Fig. 3-145).

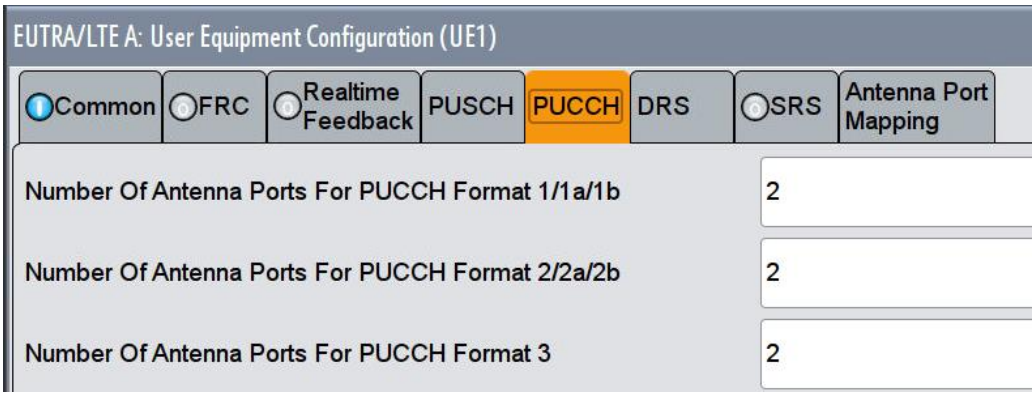


Fig. 3-145: Number of antenna ports for the different PUCCH formats is 2

5. Check the antenna port mapping (Fig. 3-146)

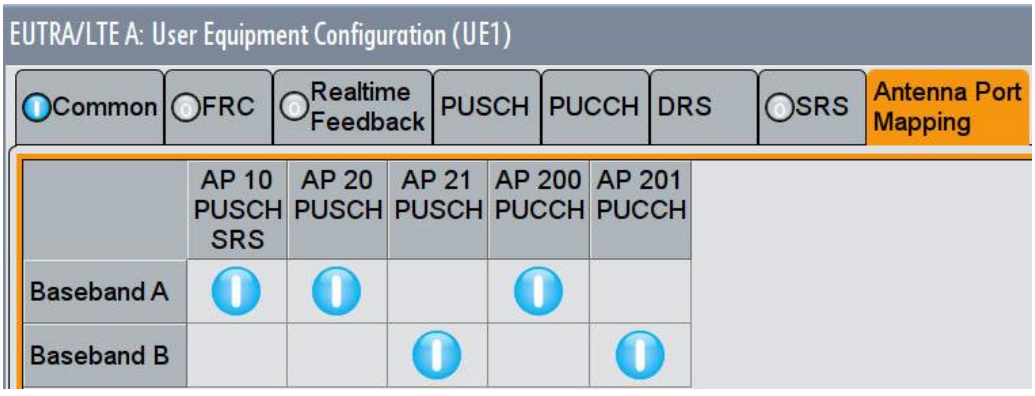


Fig. 3-146: The antenna port mapping. The PUCCH AP200 is generated by BB A, the AP201 by BB B

6. Click **Frame Configuration**
7. Set **No of PUCCH Config** to 2 (Fig. 3-144)
8. Click tab **Subframe**
9. Set for the PUCCH the **Format** to **F1a** and the state **On** (Fig. 3-147)

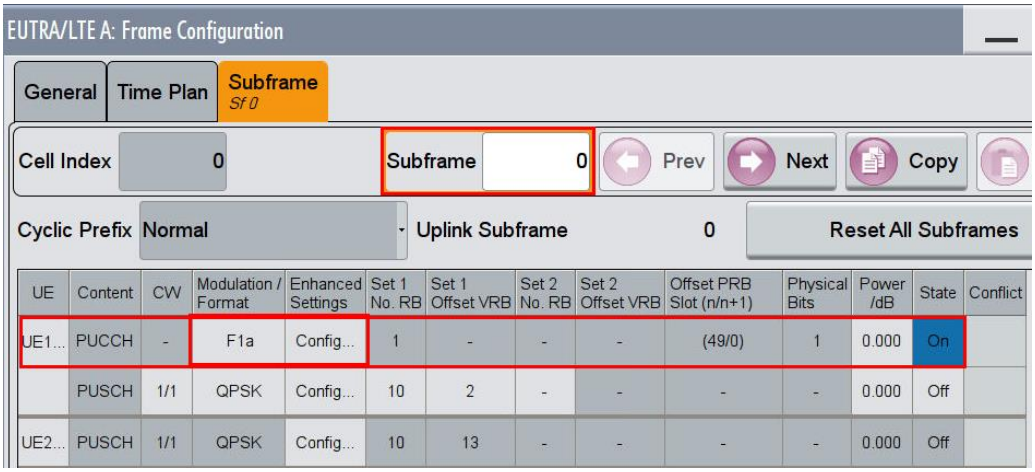


Fig. 3-147: PUCCH with format F1a in subframe 0

10. Click in column **Enhanced Settings** Config
11. Set the resource index **n_PUCCH** to 1 and 2. (Fig. 3-148)
12. Set the **ACK/NACK Pattern** (one bit) to '1' (Fig. 3-149)

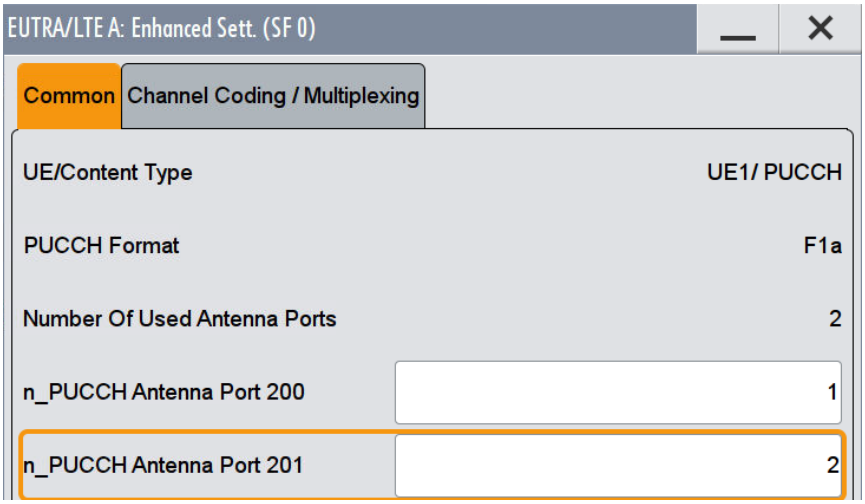


Fig. 3-148: Set the parameters n_PUCCH to 1 and 2

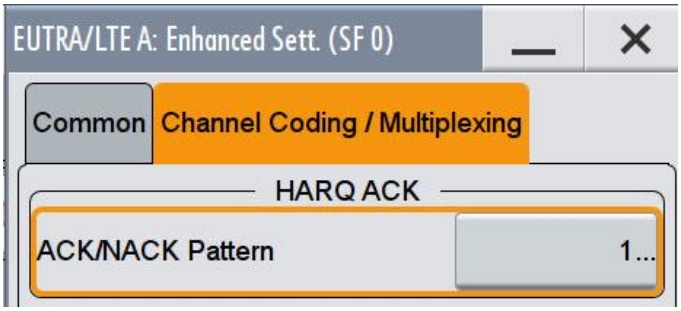


Fig. 3-149: Set one bit ACK pattern to '1' (ACK)

13. Make sure that the PUCCH in the second configurable subframe is not transmitted. (example: subframe 1 **State Off**) (Fig. 3-150)

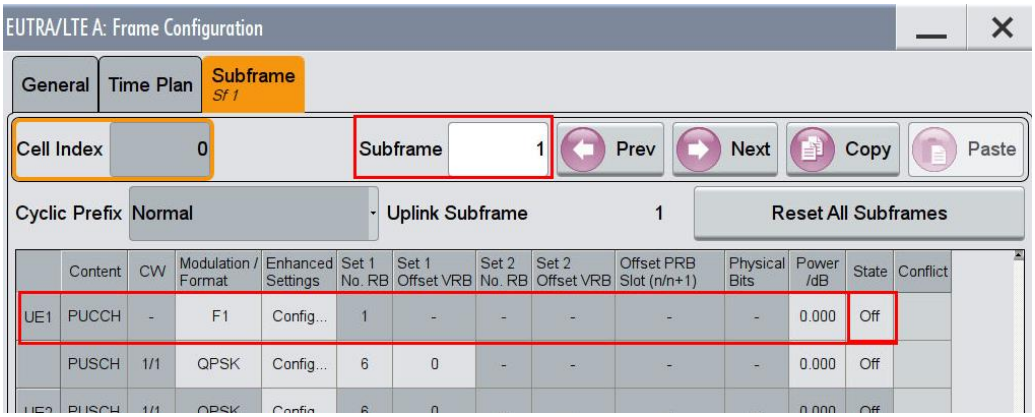


Fig. 3-150: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

14. Set **Fading** according to Table 3-56, Table 3-57 and Table 3-58(see 3.1.3) (example EPA 5 Hz Low)
15. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4) (example: Noise = -80.5 dBm; SNR = SNR + Correction = -5.7 dB -16.99 dB = -22.69 dB)

Demo Program

Fig. 3-151 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.7 ACK missed (2 Tx)**. The tests are listed by their fading profile. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). The resource index n_PUCCH for AP200 is set to 1, for AP201 to 2. This example configures a PUCCH with ACK information in every second subframe. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas.

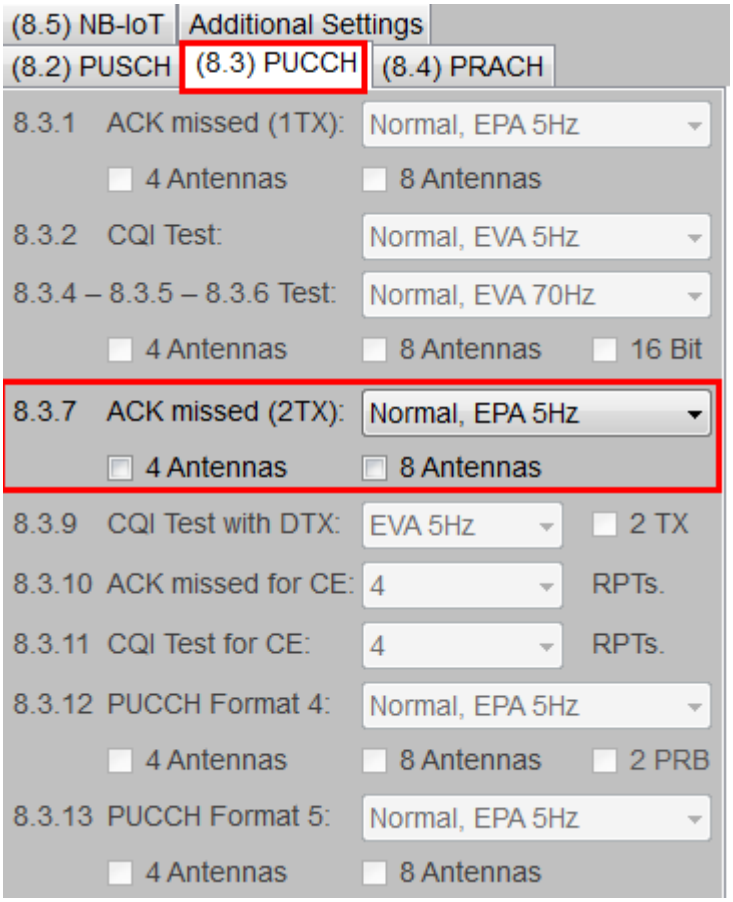


Fig. 3-151: Parameter for PUCCH test 8.3.7

Fig. 3-152 shows the report.

```
******* Performance Tests *******

8.3.7 ACK missed Detection for PUCCH Format 1A(Two Antenna Ports)
with 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: TDD
UL/DL Configuration: 1
Special Subframe Configuration: 0
Fading: EPA5Hz Low
AWGN: -80.5 dBm
SNR: -5.7 dB
SNR Correction: -16.99 dB

ACK/NACK Pattern (One Bit): '1'
Finished!
```

Fig. 3-152: Report 8.3.7

3.3.8 CQI performance requirements for PUCCH format 2 transmission on two antenna ports (Clause 8.3.8)

The test verifies the receivers' performance at CQI detection under multipath fading conditions for a given SNR. The performance is measured by the required SNR at BLER probability of detection equal to 0.99.

The fraction of falsely detected CQIs shall be less than 1% and the fraction of correctly detected CQIs shall be larger than 99%. The statistics are kept by the base station under test.

This test is applicable for all categories of BS. It is similar to the test 8.3.2 (see 3.3.1) but uses two antenna ports (UL-MIMO with ports 200 and 201).

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

Test requirements 8.3.8										
Number of TX antennas	Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
					1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	2	Normal	EVA 5	Low	-4.9	-4.8	-5.1	-5.0	-5.1	-5.1

Table 3-59: Requirements for PUCCH test 8.3.8.

Test setup

Fig. 3-153 shows the test setup.

The wanted signal generated by SMW basebands A and B uses a 2x2 MIMO configuration. Multipath fading is simulated in the channel simulators, AWGN is added.

The SMW needs an external trigger at USER3.

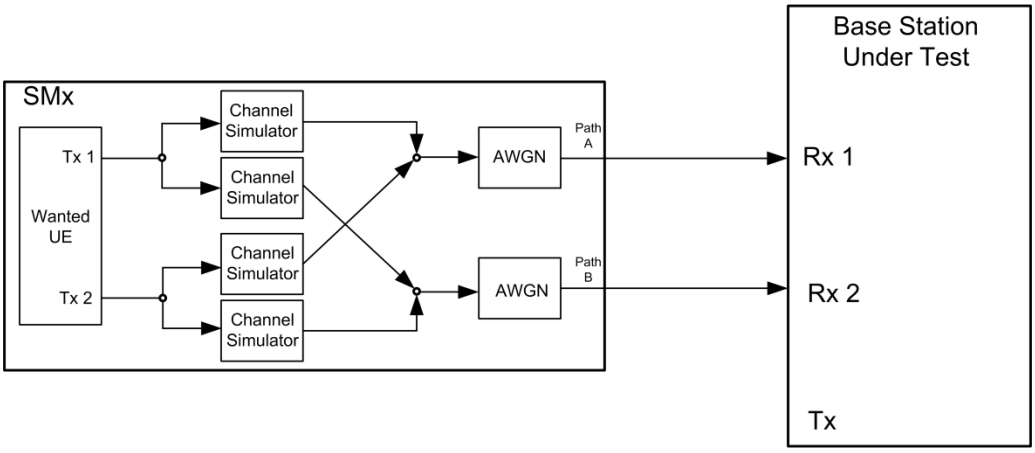


Fig. 3-153: Test setup for PUCCH test 8.3.8

Test Procedure

As an example the settings for normal prefix, EVA 5 Hz and 10 MHz are shown. The CQI is set in every second subframe.

1. Set the **routing** to 1x2x2 (see 3.1.1), thus two baseband blocks are routed to two paths (2x2 MIMO).
2. For the basic LTE steps see section 0.
3. Click on UE1.

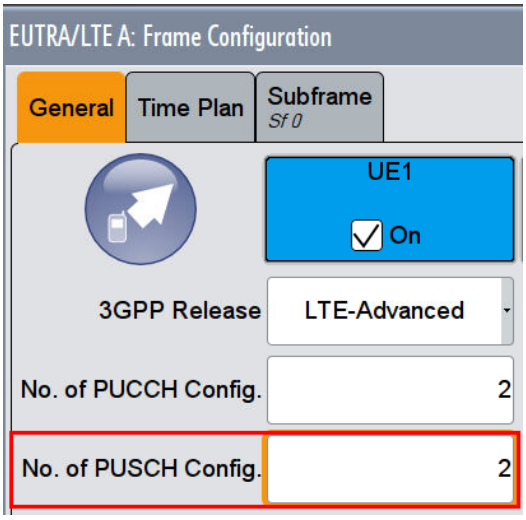


Fig. 3-154: UE1 and No of PUCCH Configuration

4. Enter in tab PUCCH the **number of antenna** ports, here 2 (Fig. 3-155).

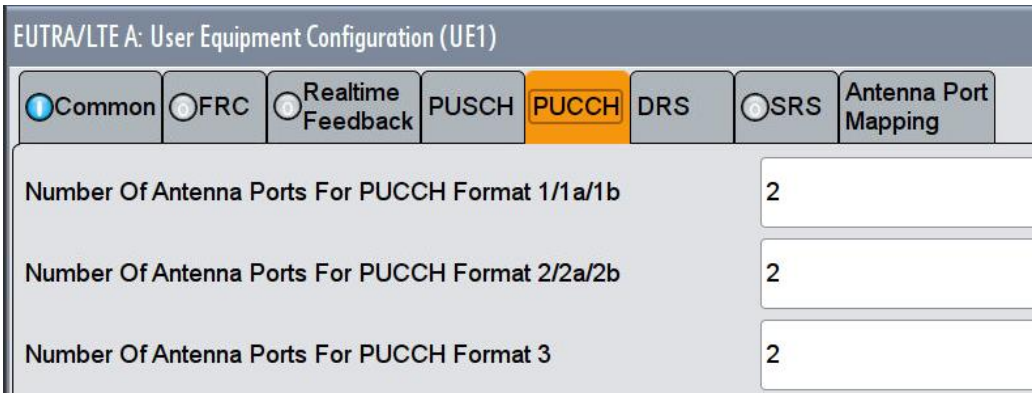


Fig. 3-155: Number of antenna ports for the different PUCCH formats is 2

5. Check the antenna port mapping (Fig. 3-156)

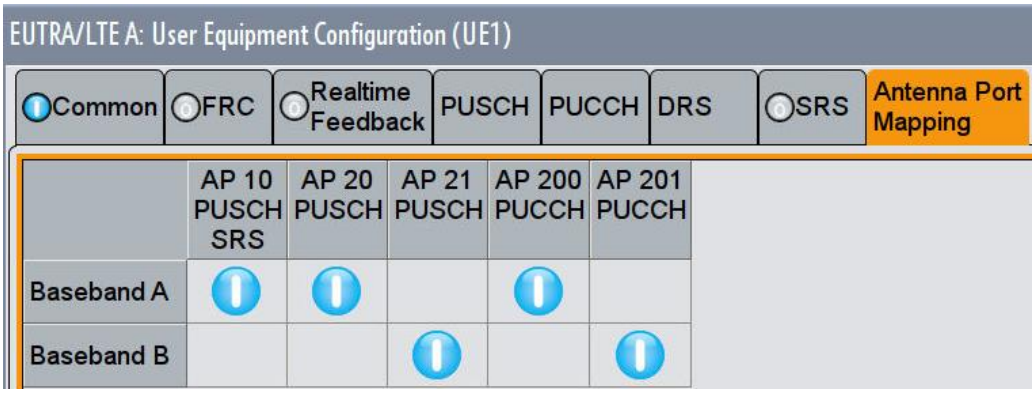


Fig. 3-156: The antenna port mapping. The PUCCH AP200 is generated by BB A, the AP201 by BB B

6. Click **Frame Configuration**
7. Set **No of PUCCH Config** to 2 (Fig. 3-154)
8. Click tab **Subframe**
9. Set for the PUCCH the **Format** to **F2** and the state **On** (Fig. 3-157)

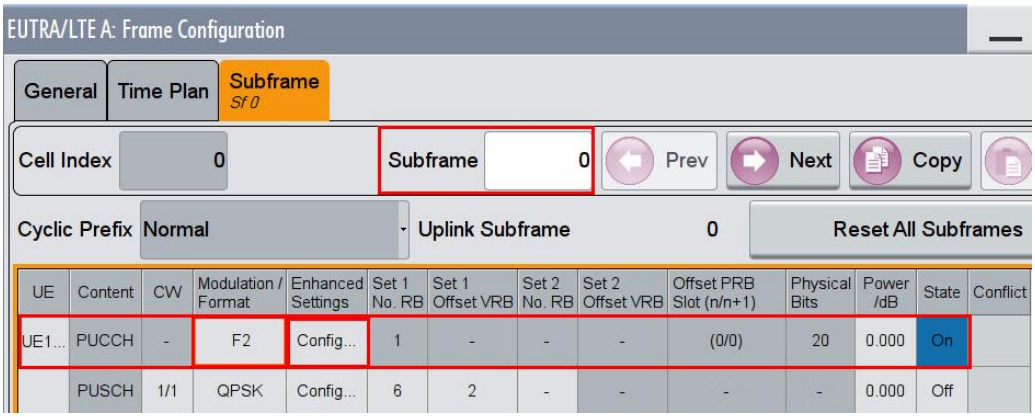


Fig. 3-157: PUCCH with format F2 in subframe 0

10. Click in column **Enhanced Settings** Config
11. Set the resource index **n_PUCCH** to 1 and 2. (Fig. 3-158)
12. Set the **Number of CQI bits** to '4' and the **CQI pattern** to '1111' (Fig. 3-159)

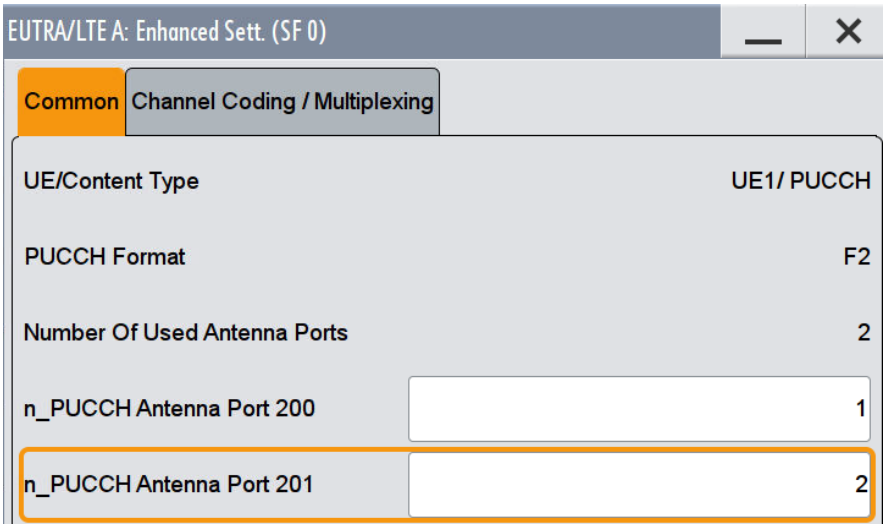


Fig. 3-158: Set the parameters n_PUCCH to 1 and 2

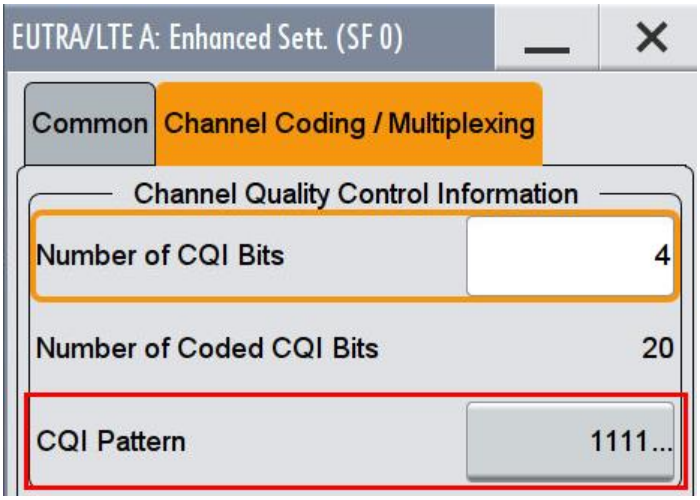


Fig. 3-159: Set four bits CQI pattern to '1111'

13. Make sure that the PUCCH in the second configurable subframe is not transmitted. (example: subframe 1 **State Off**) (Fig. 3-160)

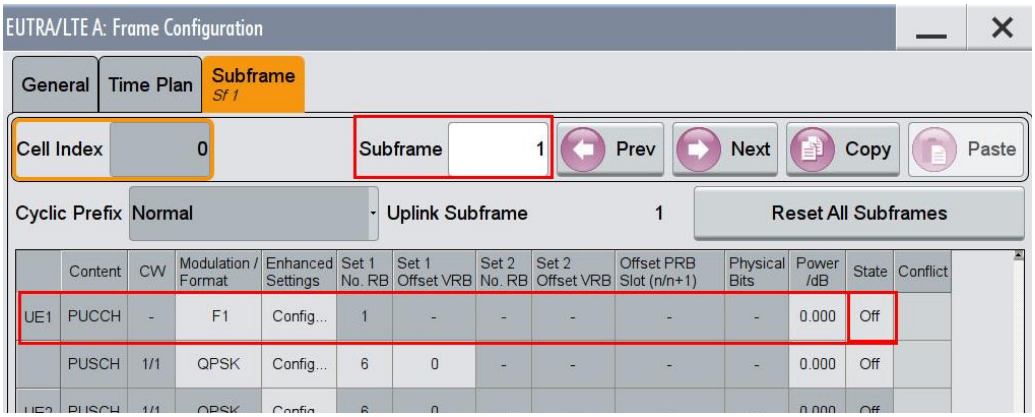


Fig. 3-160: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

14. Set **Fading** according to Table 3-46 (see 3.1.3) (example EVA 5 Hz Low)
15. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = - 5.0 dB - 16.99 dB = -21.99 dB)

Demo Program

For this test, no additional parameters have to be set. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). The resource index n_PUCCH for AP200 is set to 1, for AP201 to 2. This example configures a PUCCH with CQI information in every second subframe.

Fig. 3-161 shows the report.

```
******* Performance Tests *******

8.3.8 CQI for PUCCH Format 2 (Two Antenna Ports)

Bandwidth: 10 MHz
Duplex Mode: TDD
UL/DL Configuration: 1
Special Subframe Configuration: 0
Fading: EVA5Hz Low
AWGN: -80.5 dBm
SNR: -5 dB
SNR Correction: -16.99 dB

CQI Pattern (4 Bits): '1111'
Finished!
```

Fig. 3-161: Report 8.3.7

3.3.9 CQI performance requirements for PUCCH format 2 with DTX detection (Clause 8.3.9)

This test verifies the receiver's ability to detect CQI under multipath fading propagation conditions for a given SNR. The performance is measured by the required SNR at CQI BLER of 1% and CQI false alarm rate of 10%.[1]

The CQI false alarm probability shall not exceed 10% and the CQI block error probability shall not exceed 1% at the given SNR. The CQI false alarm probability is defined as the conditional probability of false detecting the CQI information transmitted from UE when no CQI information is sent.

The performance requirement of PUCCH format 2 for CQI is determined by the block error probability (BLER) of CQI. The CQI BLER is defined as the sum of the:

- Conditional probability of incorrectly decoding the CQI information when the CQI information is sent and
- Conditional probability of detecting UE transmission as DTX, when the CQI information is sent.

For the test, four bits of information CQI (≡ '1111') are transmitted in the PUCCH format 2 with following pattern. The statistics number of incorrectly decoded CQI and the number of incorrectly detected DTX are kept.

Test requirements 8.3.9										
Number of TX antennas	Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
					1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
1	2	Normal	EVA 5*	Low	-3.1	-3.4	-3.8	-3.4	-3.6	-3.6
			ETU 70**	Low	-3.1	-3.4	-3.1	-3.5	-3.3	-3.5
2	2		EVA 5	Low	-4.5	-4.4	-4.7	-4.6	-4.5	-4.7
Note*: Only applicable for Local Area base station and Home base station Note**: Only applicable for Wide Area base station and Medium Range base station										

Table 3-60: Requirements for PUCCH test 8.3.9.

Test setup

Fig. 3-162 shows the test setup for one Tx antenna. The wanted signal generated by SMW baseband A is split up in two paths.

Fig. 3-163 shows the test setup for two Tx antennas. The wanted signal generated by SMW basebands A and B uses a 2x2 MIMO configuration.

For both setups, multipath fading is simulated in the channel simulators, AWGN is added. The SMW needs an external trigger at USER3.

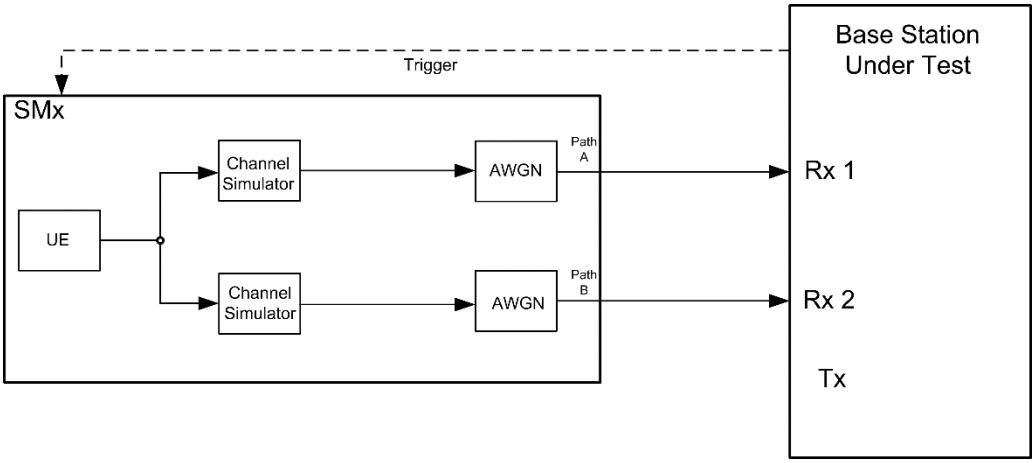


Fig. 3-162: Test setup for PUCCH test 8.3.9 for one Tx antenna

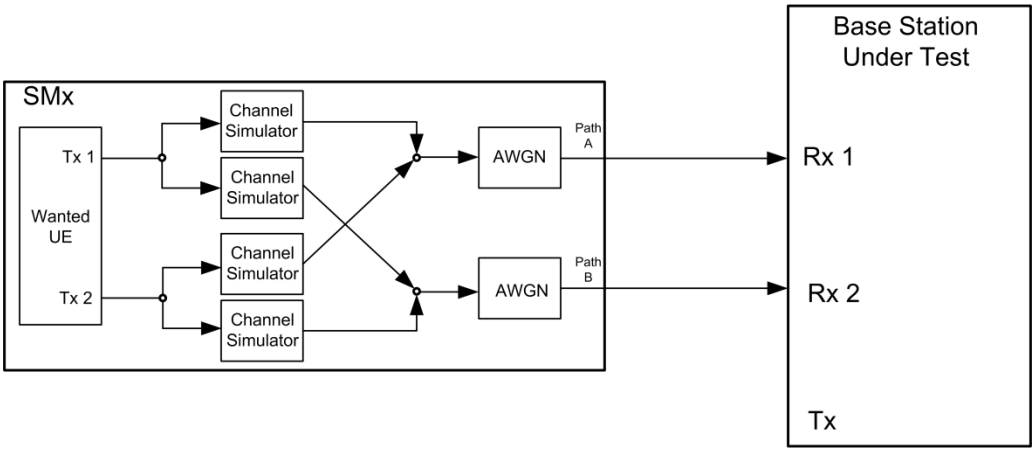


Fig. 3-163: Test setup for PUCCH test 8.3.9 for two Tx antennas

Test Procedure:

As an example, the settings for 2 TX antennas, normal prefix, EVA 5 Hz and 10 MHz are shown. The CQI is set in every second subframe.

1. Set the **routing** to 1x2x2 (see 3.1.1), thus two baseband blocks are routed to two paths (2x2 MIMO).
2. For the basic LTE steps, see section 0.
3. Click on UE1.
4. Enter in tab PUCCH the **Number of Antenna Ports**, here 2 (Fig. 3-164).
5. Check the antenna port mapping (Fig. 3-165).

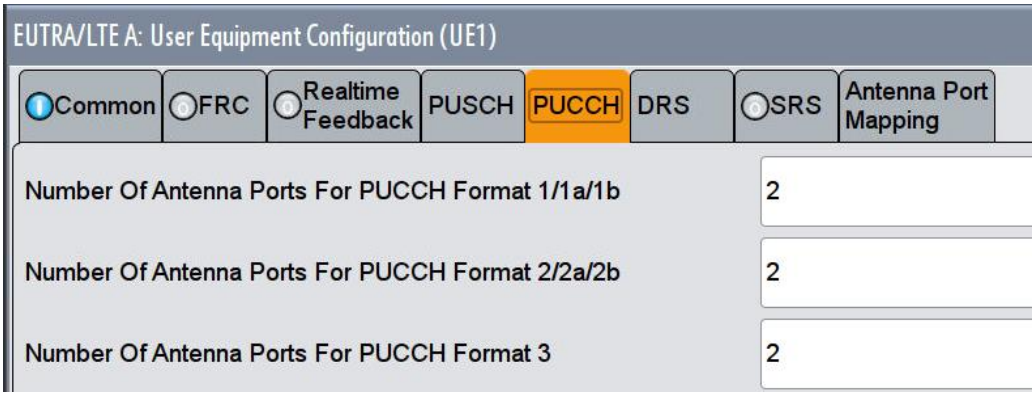


Fig. 3-164: Number of antenna ports for the different PUCCH formats is 2

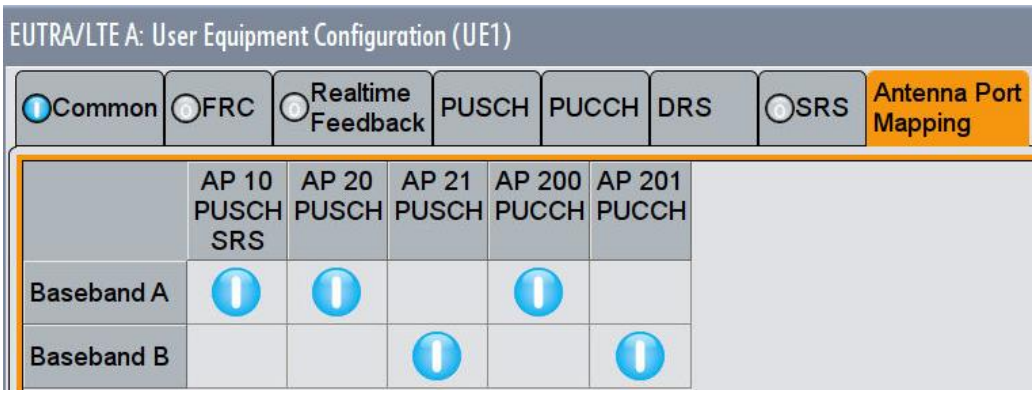


Fig. 3-165: The antenna port mapping. The PUCCH AP200 is generated by BB A, the AP201 by BB B

6. Click **Frame Configuration**.
7. Set **No of PUCCH Config** to 2 (Fig. 3-166).

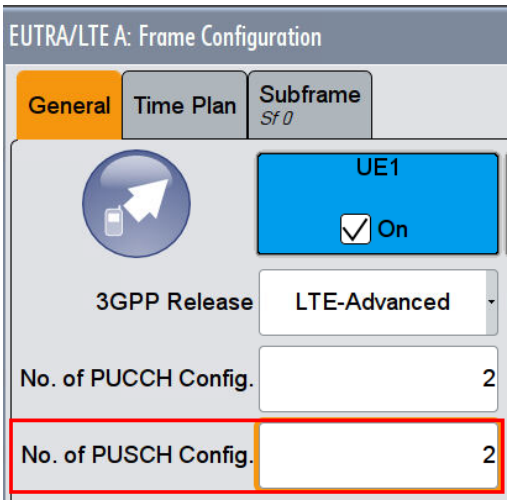


Fig. 3-166: UE1 and No of PUCCH Configuration

8. Click tab **Subframe**.
9. Set for the PUCCH the **Format** to **F2** and the state **On** (Fig. 3-167).

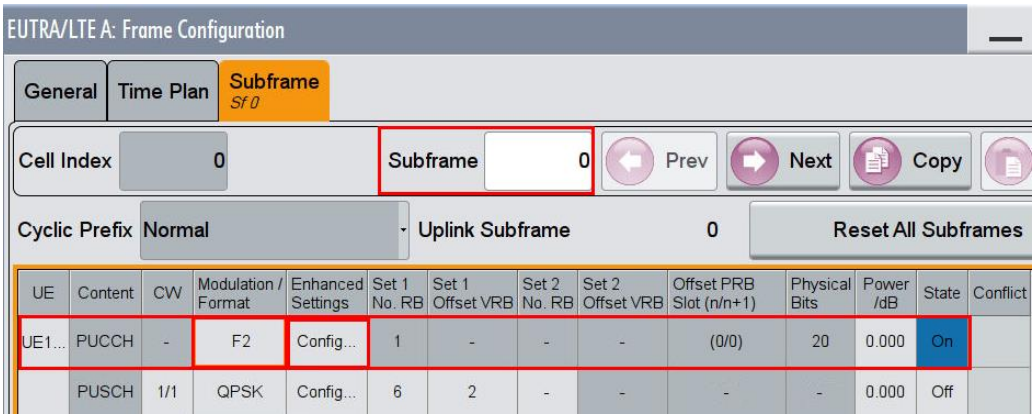


Fig. 3-167: PUCCH with format F2 in subframe 0

10. Click in column **Enhanced Settings Config**
11. Set the resource index **n_PUCCH** to 1 and 2 (Fig. 3-168).

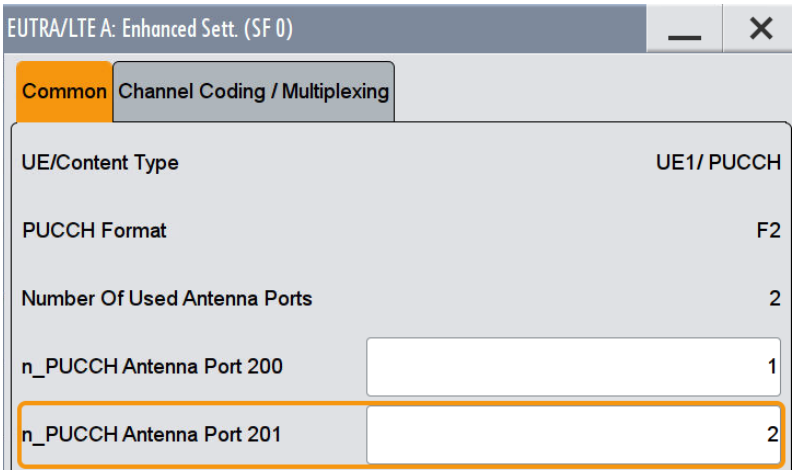


Fig. 3-168: Set the parameters n_PUCCH to 1 and 2

12. Set the **Number of CQI bits** to **4** and the **CQI pattern** to **1111** (Fig. 3-169).

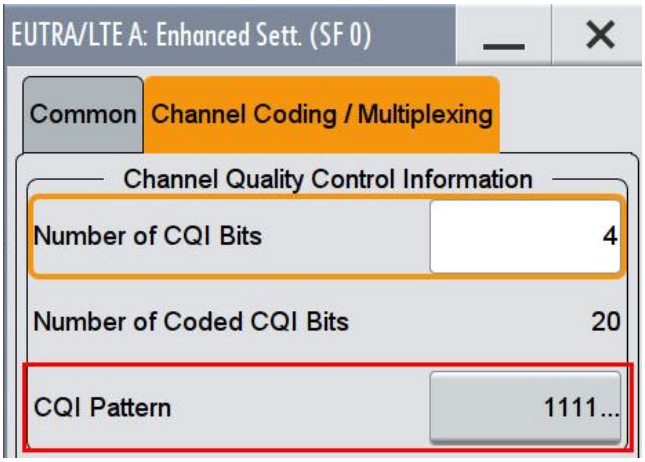


Fig. 3-169: Set four bits CQI pattern to '1111'

13. Make sure that the PUCCH in the second configurable subframe is not transmitted (example: subframe 1 **State Off**) (Fig. 3-170).

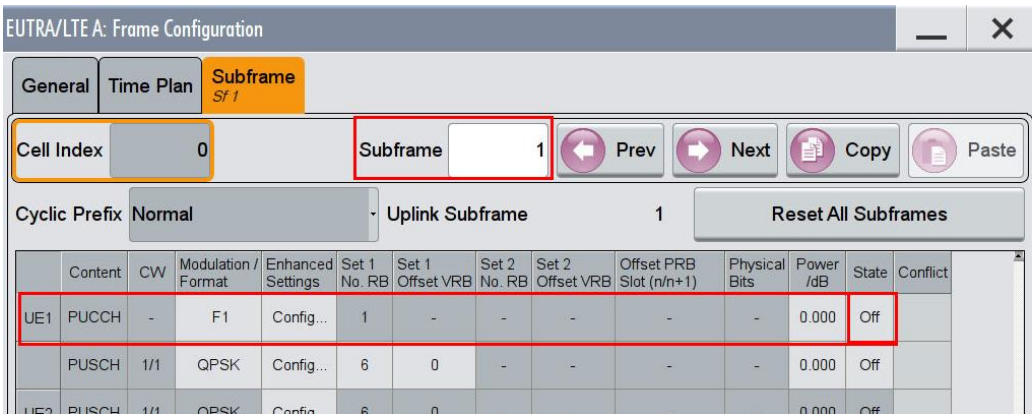


Fig. 3-170: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

AWGN and Fading

14. Set **Fading** according to Table 3-60 (see 3.1.3)
15. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -4.6 dB -16.99 dB = -21.59 dB)

Demo Program

Fig. 3-171 shows the parameters of the test. You can select the test in the section **8.3 PUCCH.** Select one test under **8.3.9 CQI F2 DTX**. The tests are listed by their fading profile. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). The resource index n_PUCCH for AP200 is set to 1, for AP201 to 2. This example configures a PUCCH with ACK information in every second subframe. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas. To use one single SMW, mark the basic **Use 1 SMW for 4/8 antenna tests and 8.3.3.** The test is performed with 1Tx antenna by default. Enable **2 Tx Antennas** to use two Tx Antennas.

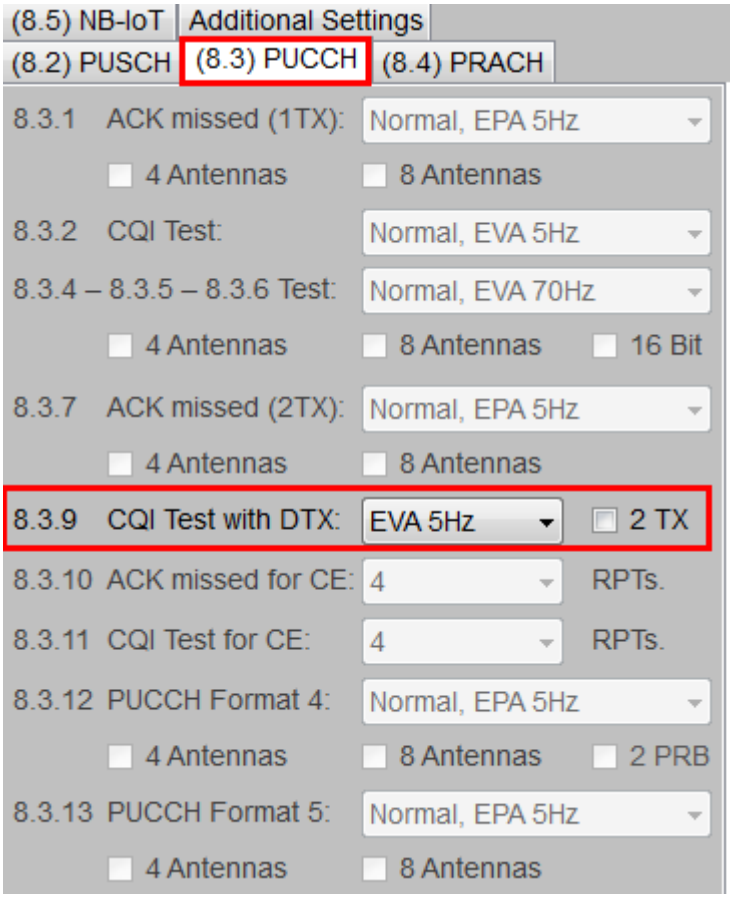


Fig. 3-171: Parameter for PUCCH test 8.3.9

Fig. 3-172shows the report.

```
******* Performance Tests *******

8.3.9 CQI for PUCCH Format 2 with DTX Detection
with 1TX Antenna.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EVA5Hz Low
AWGN: -80.5 dBm
SNR: -3.4 dB
SNR Correction: -16.99 dB

CQI Pattern (4 Bits): '1111'
Finished!
```

Fig. 3-172: Report 8.3.9

3.3.10 ACK missed detection for PUCCH format 1a transmission on single antenna port for coverage enhancement (Clause 8.3.10)

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 statistics are kept by the base station under test.

This test is applicable for BS supporting coverage enhancement.

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

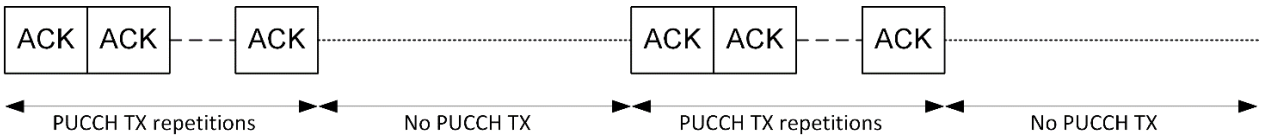


Table 3-61 shows the test requirements.

Test requirement PUCCH 8.3.10, 2 RX antennas								
Cyclic Prefix	Propagation Conditions	Correlation matrix	Repetitions	Channel Bandwidth / SNR [dB]				
				3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Normal	EPA 5	Low	4	-4.6	-4.9	-4.9	-5.0	-4.9
			8	-8.6	-10.4	-10.3	-10.5	-10.7
			32	-13.1	-14.2	-14.5	-14.5	-14.5

Table 3-61: Test requirements PUCCH test 8.3.10 for 2 RX antennas

The hopping interval is 4 for FDD and 10 for TDD.

To generate a test pattern with 50% transmission and 50% gap, the SMW uses following numbers of frames to ensure a continuous pattern in the ARB of the SMW:

Transmission and frames for FDD			
Repetition	**Subframes for transmission and gap**	**Number of transmissions**	**Number of frames**
4	8	5	4
8	16	5	8
32	64	5	32

Table 3-62: Transmission and frames FDD

As for TDD there is no Uplink/Downlink configuration mentioned, configuration 2 is used.

Transmission and frames for TDD, DL/UL configuration 2		
Repetition	**Number of transmissions**	**Number of frames**
4	1	4
8	1	8
32	1	32

Table 3-63: Transmission and frames TDD, DL/UL configuration 2

Test setup

Fig. 3-173 shows the test setup.

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.

The SMW needs an external trigger at USER3.

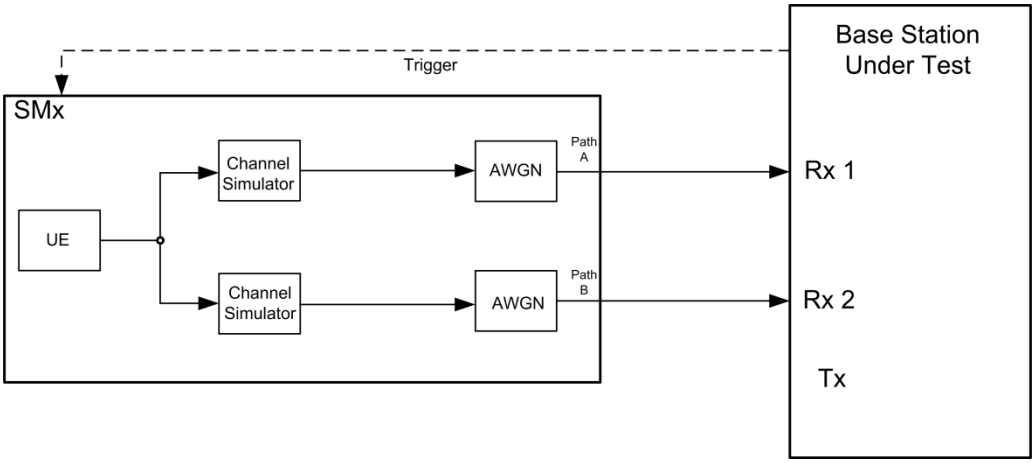


Fig. 3-173: Test setup for PUCCH test 8.3.10

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz, 10 MHz and 32 repetitions are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **UE1o to eMTC** (Fig. 3-84).

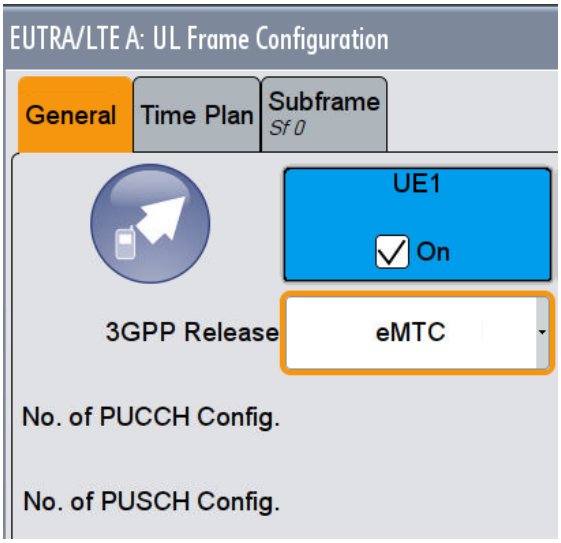


Fig. 3-174: UE1 transmits eMTC

5. Click UE1.
6. Set **Content** to **PUCCH Format F1a** and the **Repetition** (example 32) (Fig. 3-85). Please note that the available repetitions depend on the CE Level.
7. To generate the test pattern, create **5 Transmissions**. Set the **Start Subfr** increasing by *Subframes transmission and gap* of Table 3-95 (Example: **32 (0, 64, 128, 192, 256))**.

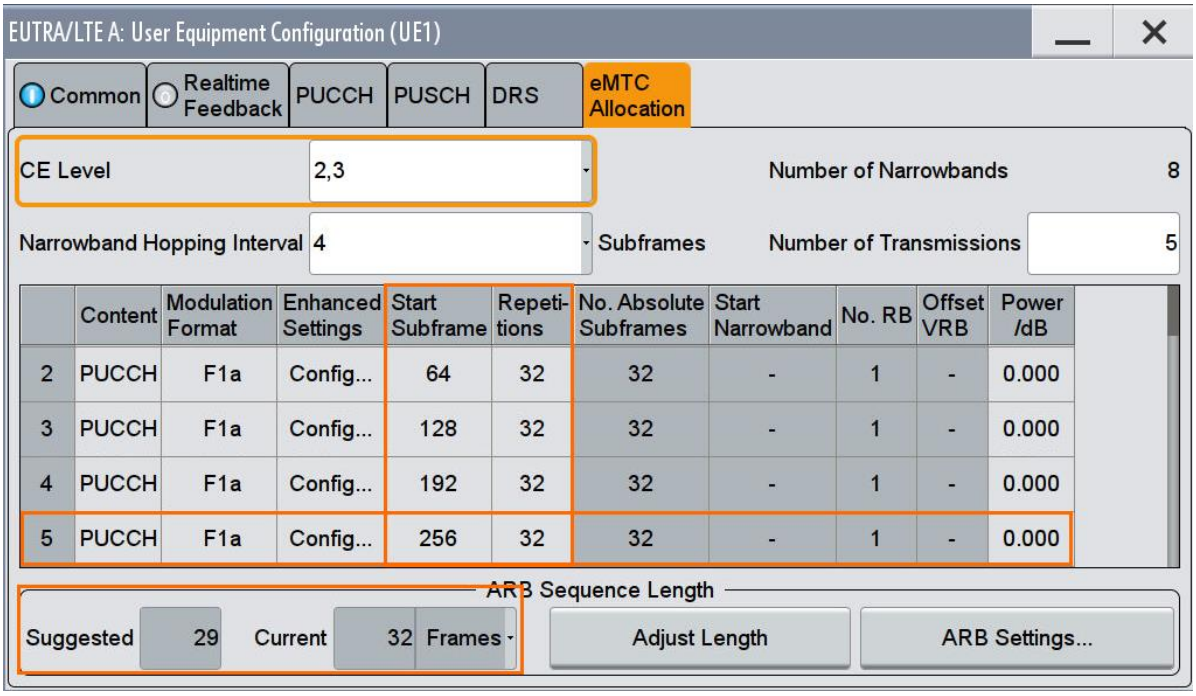
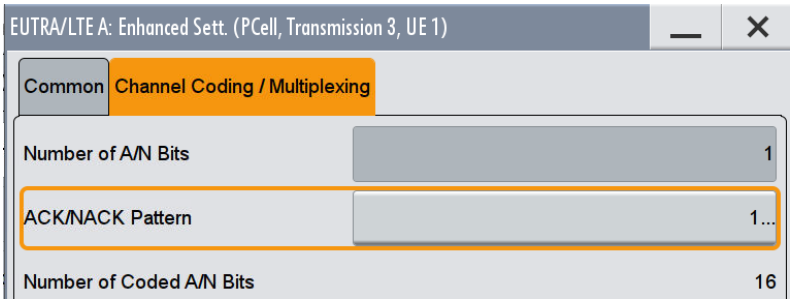


Fig. 3-175: Five transmissions of NPUSCH format 2 to generate the wanted pattern

8. Click in every transmission on **Enhanced Settings Config…** to set the **ACK/NACK Pattern** to '**1**'.



9. Click **ARB Settings** to set the **Sequence Length** to Number of frames in Table 3-95 (Example: '**32**')

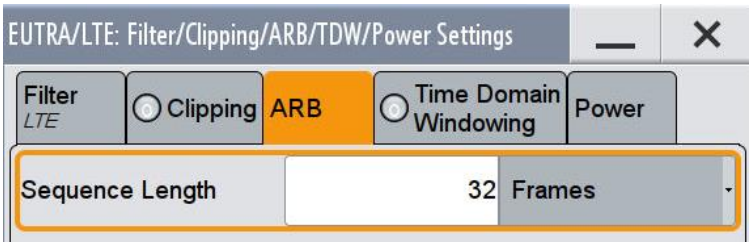


Fig. 3-176: 32 frames to generate the pattern continuously

10. Switch On EUTRA/LTE A.

AWGN and Fading

11. Set **Fading** according to **EPA 5 Hz Low** (see 3.1.3)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -14.5 dB -16.99 dB = -31.49 dB)

Demo Program

Fig. 3-177 shows the parameters of the test. You can select the test in the tabulator **8.3 PUCCH.** Select one test under **8.3.10 ACK missed for CE**. The tests are listed by their repetition. When selecting a particular test, all settings are default according to the specification. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). This example configures a PUCCH with a ration of PUCCH transmission with ACK information to no PUCCH transmission of 50:50.

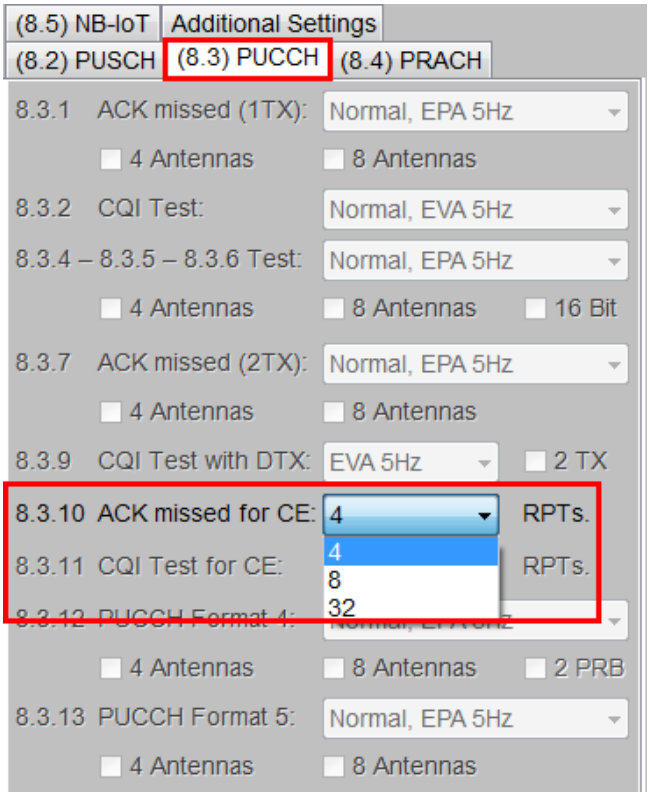


Fig. 3-177: Parameter for PUCCH test 8.3.10

Fig. 3-178 shows the report.

```
******* Performance Tests *******

8.3.10 ACK missed Detection for PUCCH Format 1A Transmission on Single Antenna Port for Coverage
Enhancement
with 4 Repetitions.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
AWGN: -83.5 dBm
SNR: -4.9 dB
SNR Correction: -16.99 dB

ACK/NACK Pattern (One Bit): '1'
Finished!
```

Fig. 3-178: Report 8.3.10

3.3.11 CQI performance requirements for PUCCH format 2 transmission on single antenna port for coverage enhancement (Clause 8.3.11)

The test verifies the receivers' performance at detecting CQI under multipath fading conditions for a given SNR. The performance measured by the BLER shall be less 1%. The statistics are kept by the base station under test.

This test is applicable for BS supporting coverage enhancement.

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

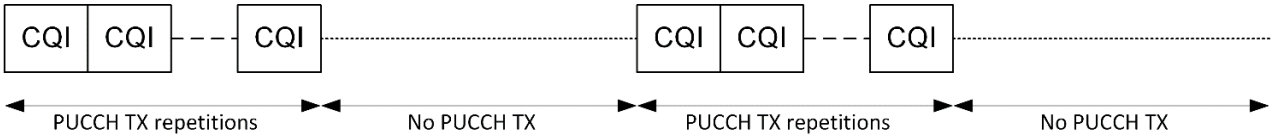


Table 3-61 shows the test requirements.

Test requirement PUCCH 8.3.11, 2 RX antennas								
Cyclic Prefix	Propagation Conditions	Correlation matrix	Repetitions	Channel Bandwidth / SNR [dB]				
				3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Normal	EVA 5	Low	4	-3.5	-4.4	-4.5	-4.3	-4.1
			8	-9.2	-9.7	-9.4	-9.5	-9.4
			32	-13.1	-13.5	-13.2	-13.4	-13.3

Table 3-64: Test requirements PUCCH test 8.3.10 for 2 RX antennas

The hopping interval is 4 for FDD and 10 for TDD.

To generate a test pattern with 50% transmission and 50% gap, the SMW uses following numbers of frames to ensure a continuous pattern in the ARB of the SMW:

Transmission and frames			
Repetition	**Subframes for transmission and gap**	**Number of transmissions**	**Number of frames**
4	8	5	4
8	16	5	8
32	64	5	32

Table 3-65: Transmission and frames

As for TDD there is no Uplink/Downlink configuration mentioned, configuration 2 is used.

Transmission and frames for TDD, DL/UL configuration 2		
Repetition	**Number of transmissions**	**Number of frames**
4	1	4
8	1	8
32	1	32

Table 3-66: Transmission and frames TDD, DL/UL configuration

Test setup

Fig. 3-173 shows the test setup.

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.

The SMW needs an external trigger at USER3.

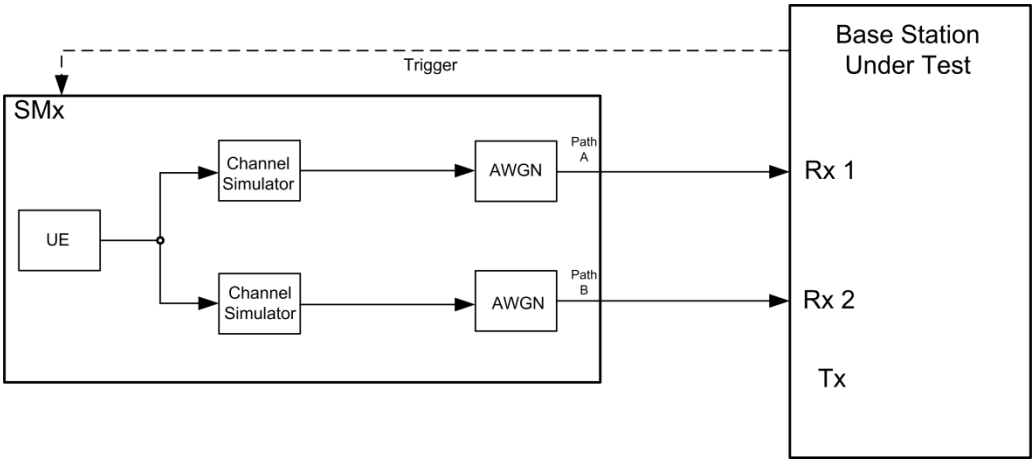


Fig. 3-179: Test setup for PUCCH test 8.3.11

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EVA 5 Hz, 10 MHz and 4 repetitions are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**
4. Set **UE1o to eMTC** (Fig. 3-84).

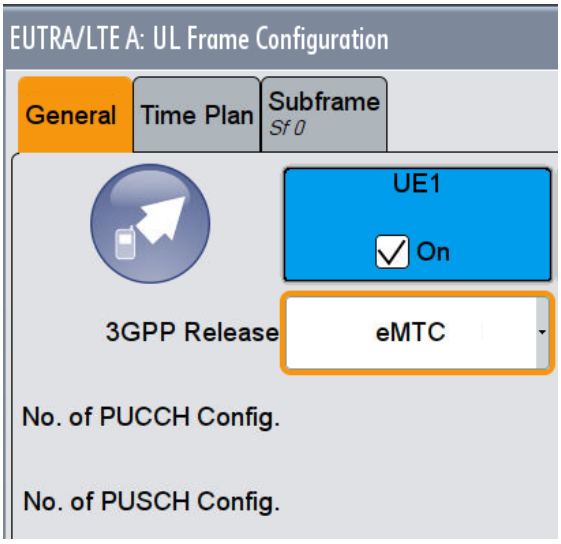


Fig. 3-180: UE1 transmits eMTC

5. Click UE1 and set the **CE Level** to **2,3**.
6. Set **Content** to **PUCCH** and **Modulation Format** to **F2** and the repetition (example 32) (Fig. 3-85).
7. To generate the test pattern, create **5 Transmissions**. Set the **Start Subfr** increasing by *Subframes transmission and gap* of Table 3-95 (Example: **4 (0, 8, 16, 24, 32))**.

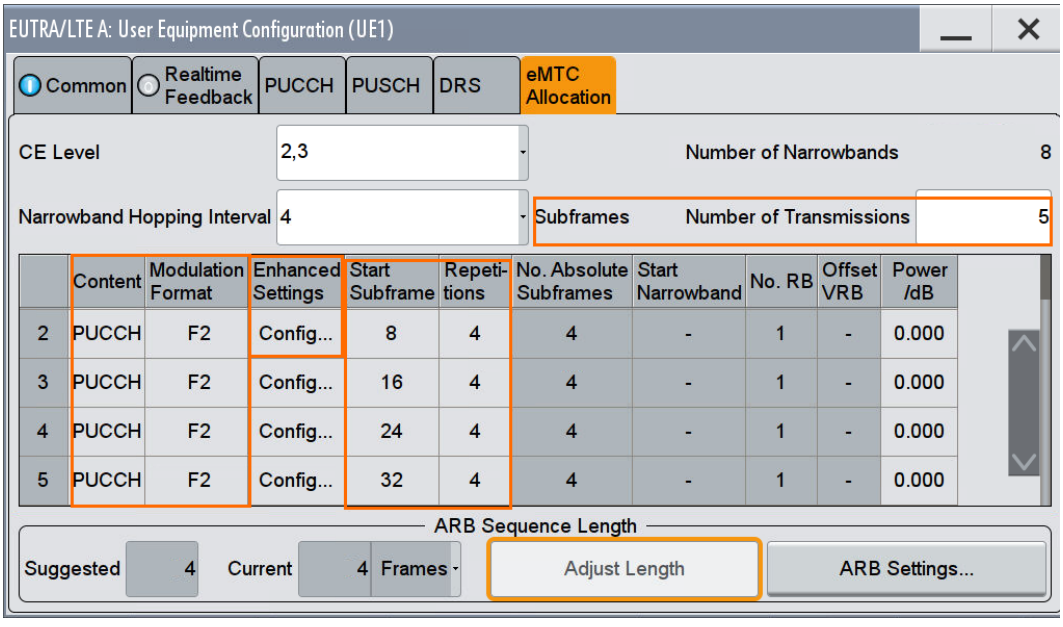
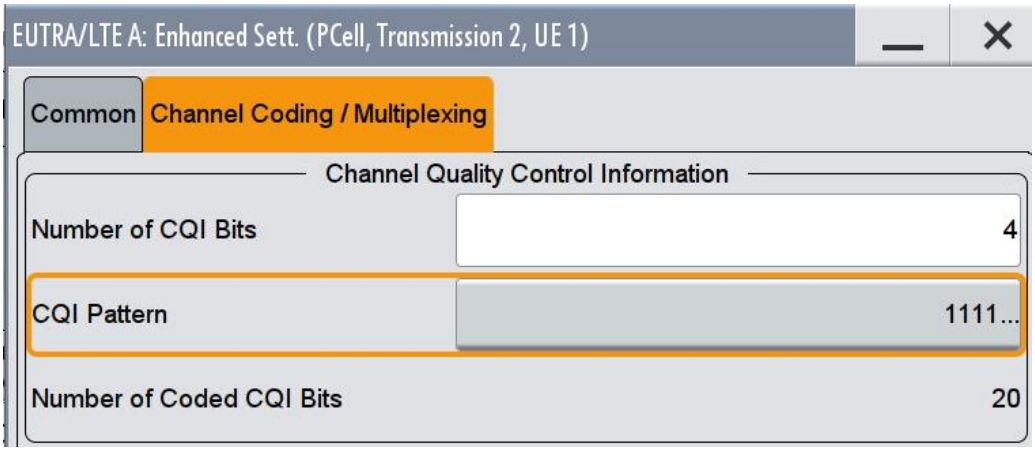


Fig. 3-181: Five transmissions of NPUSCH format 2 to generate the wanted pattern

8. Click in every transmission on **Enhanced Settings Config…** to set the **CQI Pattern** to '**1111**'.



9. Click **ARB Settings** to set the **Sequence Length** to Number of frames in Table 3-95 (Example: '**4**')
10. Switch On EUTRA/LTE A.

AWGN and Fading

11. Set **Fading** according to **EVA 5 Hz Low** (see 3.1.3)
12. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = -13.2 dB -16.99 dB = -30.19 dB)

Demo Program

Fig. 3-182 shows the parameters of the test. You can select the test in the tabulator **8.3 PUCCH.** Select one test under **8.3.11 CQI Test for CE**. The tests are listed by their repetition. When selecting a particular test, all settings are default according to the specification. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). This example configures a PUCCH with a ration of PUCCH transmission with CQI information to no PUCCH transmission of 50:50.

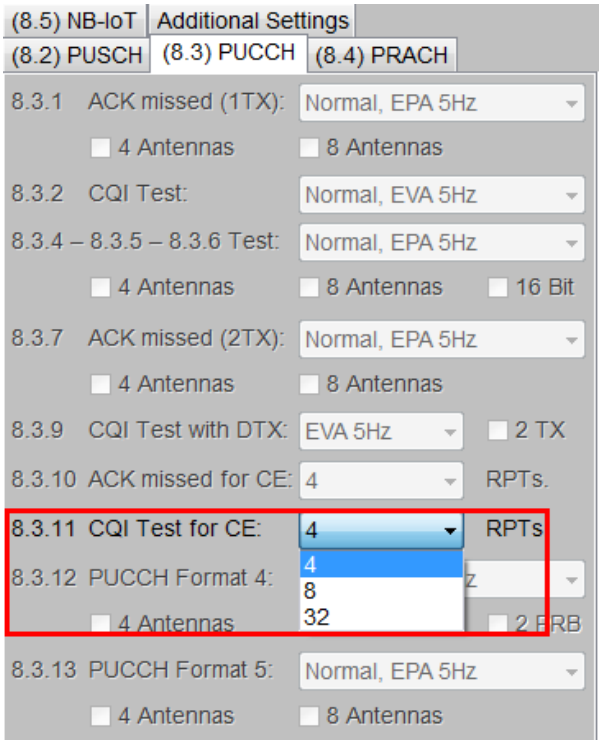


Fig. 3-182: Parameter for PUCCH test 8.3.11

Fig. 3-183 shows the report.

```
******* Performance Tests *******

8.3.11 CQI Performance Requirements for PUCCH Format 2 Transmission on Single Antenna Port for Coverage Enhancement
with 4 Repetitions.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EVA5Hz Low
AWGN: -83.5 dBm
SNR: -4.5 dB
SNR Correction: -16.99 dB

CQI Pattern (4 Bits): '1111'
Finished!
```

Fig. 3-183: Report 8.3.11

3.3.12 ACK missed detection for PUCCH format 4 (Clause 8.3.12)

The test verifies the receivers' performance at detecting ACK in PUSCH format 4 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 to all BS.

For the test 24 bits (with 1 PRB) or 64 bits (for 2 PRB) of information ACK (≡ 'All 1') are transmitted in the PUCCH format 4.

Table 3-67 and Table 3-68 show the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.12 with 1 PRB									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	1.8	1.7	1.6
		EVA 70	Low	-	-	-	2.0	1.8	1.8
4	Normal	EPA 5	Low	-	-	-	-2.4	-2.2	-2.3
		EVA 70	Low	-	-	-	2.0	-2.4	-2.4
8	Normal	EPA 5	Low	-	-	-	-5.5	-5.5	-5.5
		EVA 70	Low	-	-	-	-5.4	-5.4	-5.5

Table 3-67: Test requirements PUCCH test 8.3.12 with 1 PRB

Test requirement PUCCH 8.3.12 with 2 PRB									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	2.3	2.1	2.1
		EVA 70	Low	-	-	-	2.7	2.6	2.5
4	Normal	EPA 5	Low	-	-	-	-2.4	-2.3	-2.3
		EVA 70	Low	-	-	-	-1.9	-2.1	-2.1
8	Normal	EPA 5	Low	-	-	-	-5.7	-5.6	-5.8
		EVA 70	Low	-	-	-	-5.4	-5.6	-5.6

Table 3-68: Test requirements PUCCH test 8.3.12 with 2 PRB

Test setup

Fig. 3-173 shows the test setup.

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

The SMW needs an external trigger at USER3.

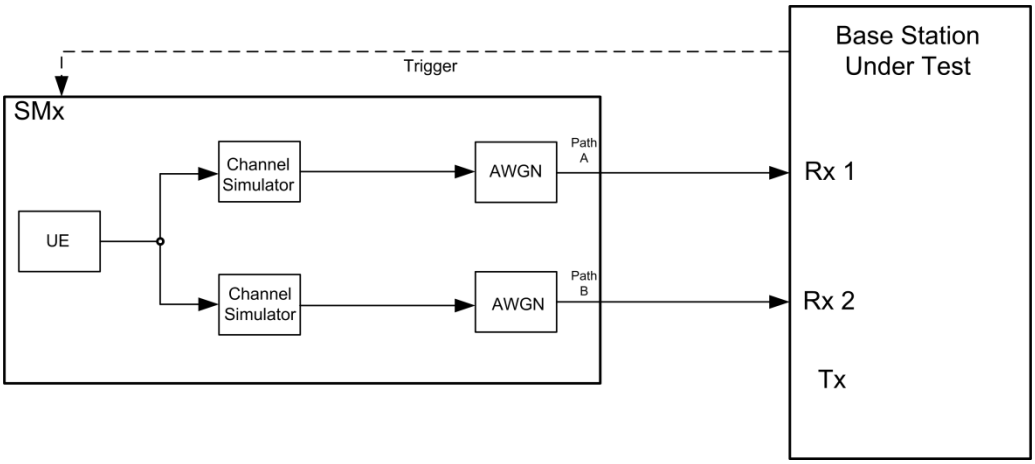


Fig. 3-184: Test setup for PUCCH test 8.3.10

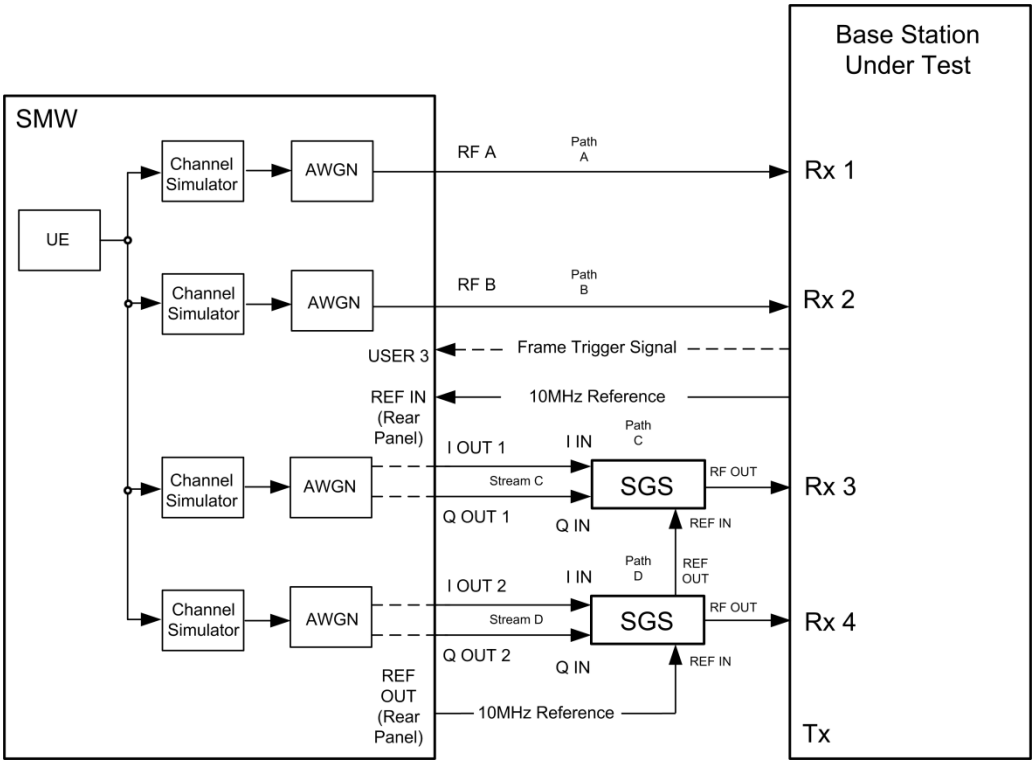


Fig. 3-185: Test setup for PUCCH test 8.3.12 for 4 antennas with one SMW

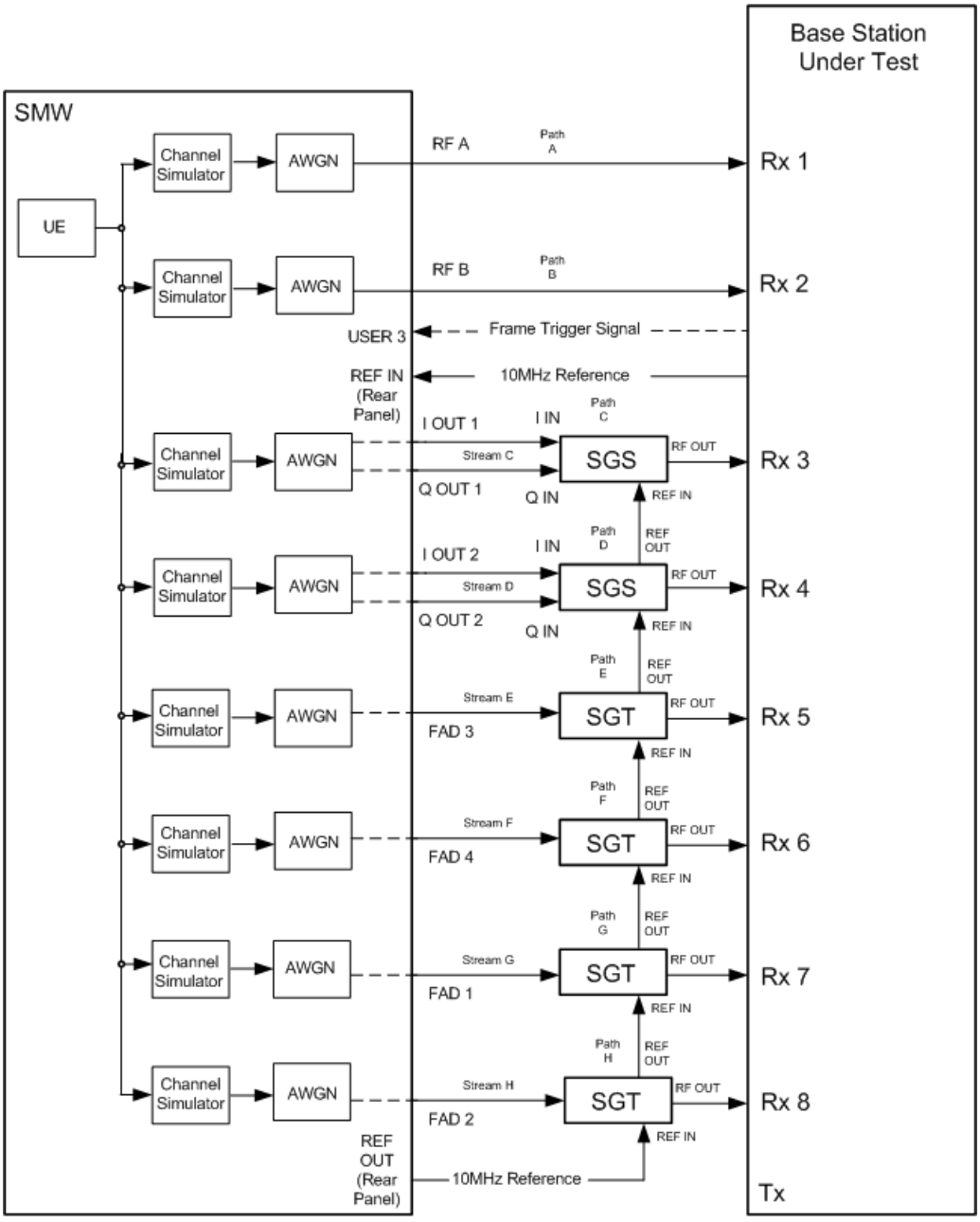


Fig. 3-186: Test setup for PUCCH test 8.3.12 for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz, 10 MHz and 2 PRB are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**

4. Set **UE1o to LTE-Advanced and No. of PUCCH Config to 2** (Fig. 3-84).

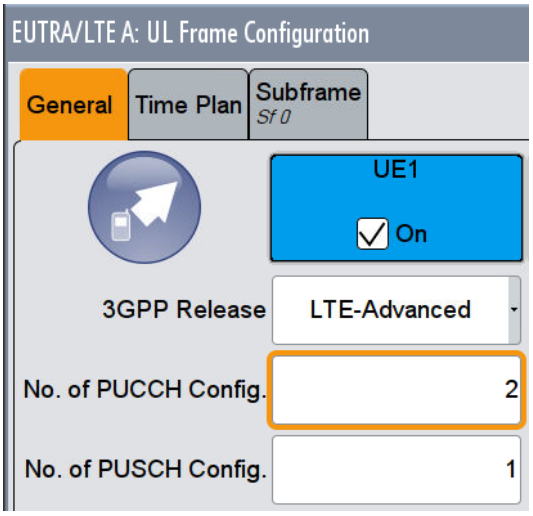


Fig. 3-187: UE1

5. Click on tab **Subframe**.
6. Set **Modulation/Format** in the row **PUCCH F4** and the **State ON** (Fig. 3-85).

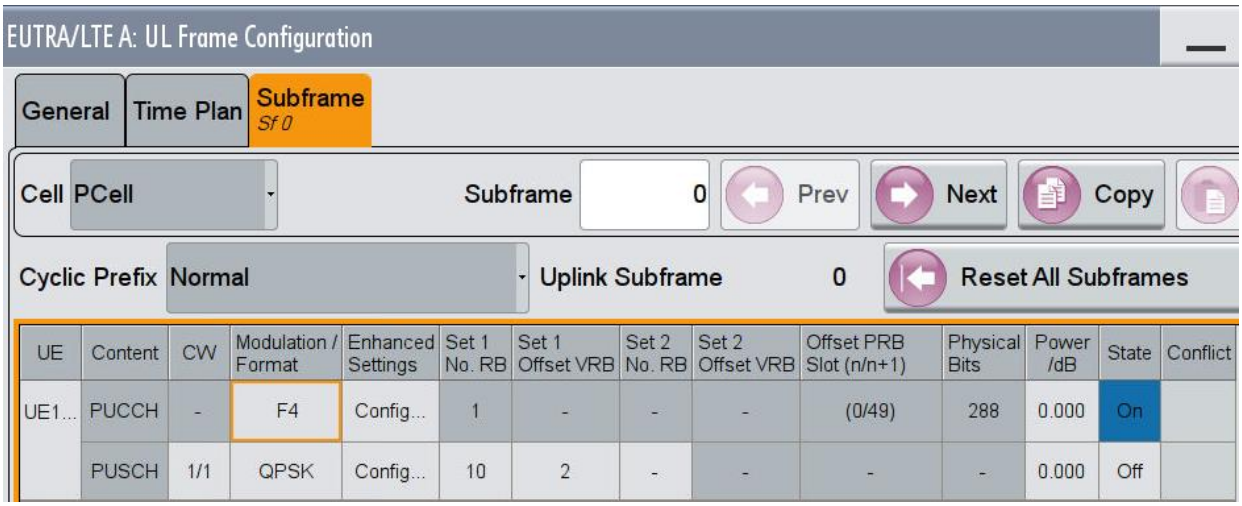


Fig. 3-188: PUCCH format 4

7. Click **Enhanced Settings Config** in the row PUCCH.
8. Set **M_RB** (example: **2**) and in the tab Channel Coding Multiplexing the Number of Bit (example 64) and all bits to '1111……'.

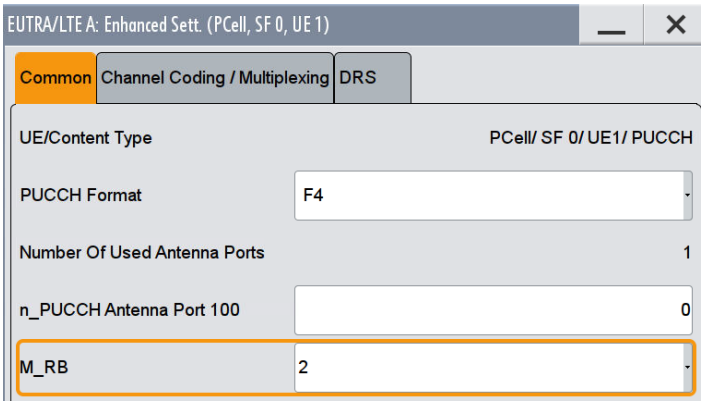


Fig. 3-189: Number of RB for 8.3.12

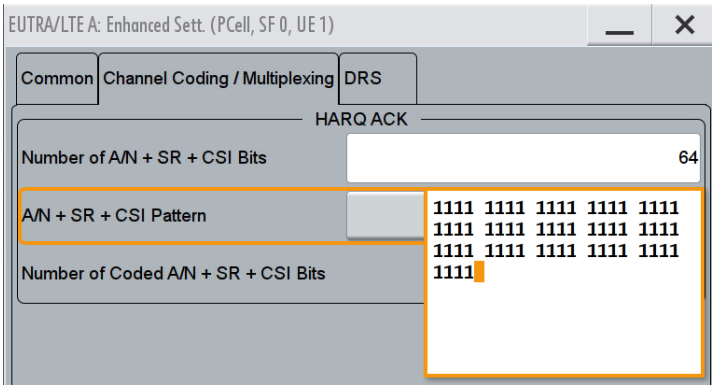


Fig. 3-190: 64 ACK bits

9. To generate the test pattern, disable the PUCCH transmission in subframe 1.

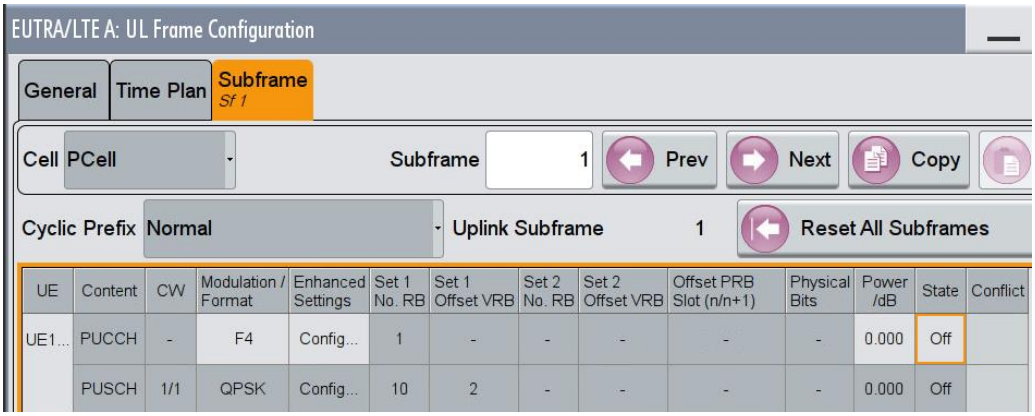


Fig. 3-191: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

10. Switch On EUTRA/LTE A.
11. The SMW shows the correct settings in the time plan.

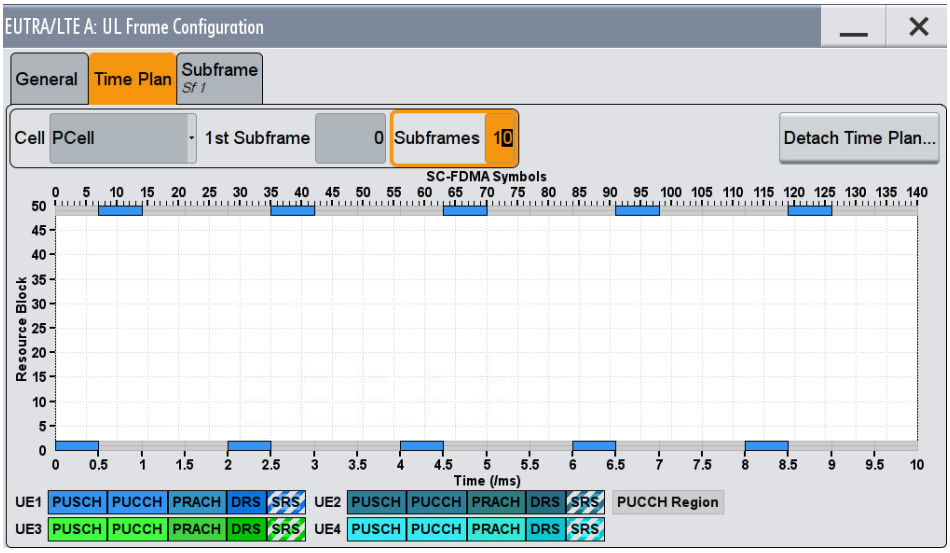


Fig. 3-192: Timeplan 8.3.12

AWGN and Fading

12. Set **Fading** according to **EPA 5 Hz Low** (see 3.1.3)
13. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = 1.8 dB -13.98 dB = -12.18 dB)

Demo Program

Fig. 3-193 shows the parameters of the test. You can select the test in the tabulator **8.3 PUCCH.** Select one test under **8.3.12 PUCCH Format 4**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). This example configures a PUCCH with a ration of PUCCH transmission with ACK information to no PUCCH transmission of 50:50. **4 Antennas** enables the test for four antennas. **8 Antennas** enables the test for eight antennas. Check **2 PRB** to transmit 64 bits.

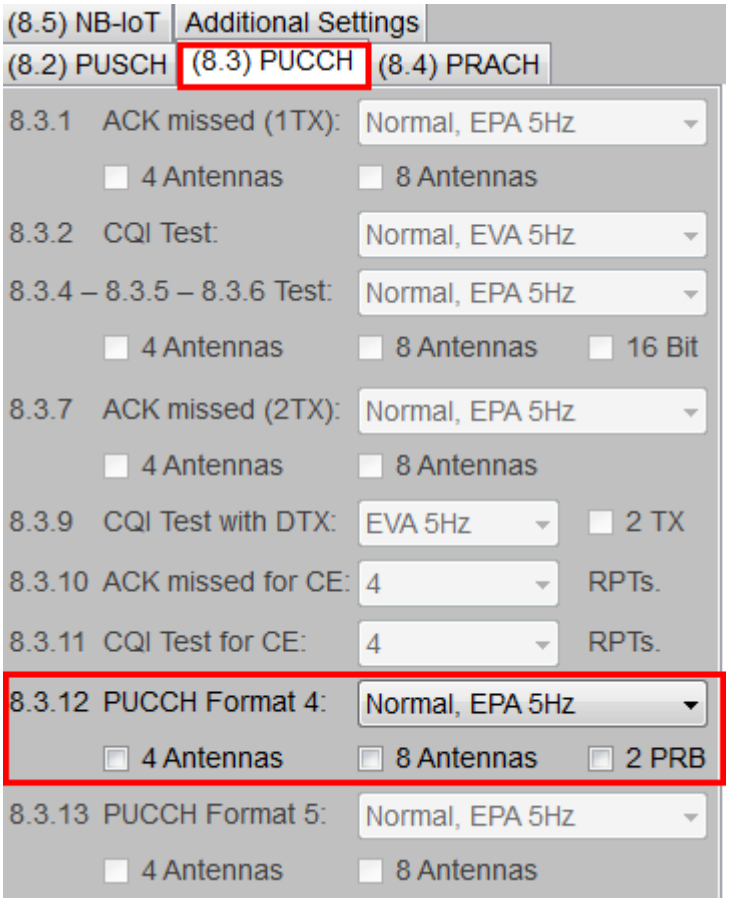


Fig. 3-193: Parameter for PUCCH test 8.3.12

Fig. 3-194 shows the report.

```
******* Performance Tests *******

8.3.12 ACK missed Detection for PUCCH Format 4
with 1 PRB and 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
AWGN: -83.5 dBm
SNR: 1.8 dB
SNR Correction: -16.99 dB

A/N + SR + CSI Pattern (24 Bits): '1111 1111 1111 1111 1111 1111'
Finished!
```

Fig. 3-194: Report 8.3.12

3.3.13 ACK missed detection for PUCCH format 5 (Clause 8.3.13)

The test verifies the receivers' performance at detecting ACK in PUCCH format 5 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 to all BS.

For the test 24 bits of information ACK (≡ 'All 1') are transmitted in the PUCCH format 5.

Table 3-61 shows the test requirements for two, four and eight RX antennas.

Test requirement PUCCH 8.3.13									
Number of RX antennas	Cyclic Prefix	Propagation Conditions	Correlation matrix	Channel Bandwidth / SNR [dB]					
				1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
2	Normal	EPA 5	Low	-	-	-	2.2	1.9	1.9
		EVA 70	Low	-	-	-	2.2	2.1	2.1
4	Normal	EPA 5	Low	-	-	-	-2.3	-2.2	-2.2
		EVA 70	Low	-	-	-	-1.9	-2.2	-2.1
8	Normal	EPA 5	Low	-	-	-	-5.4	-5.3	-5.4
		EVA 70	Low	-	-	-	-5.2	-5.3	-5.4

Table 3-69: Test requirements PUCCH test 8.3.13

Test setup

Fig. 3-173 shows the test setup.

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

The SMW needs an external trigger at USER3.

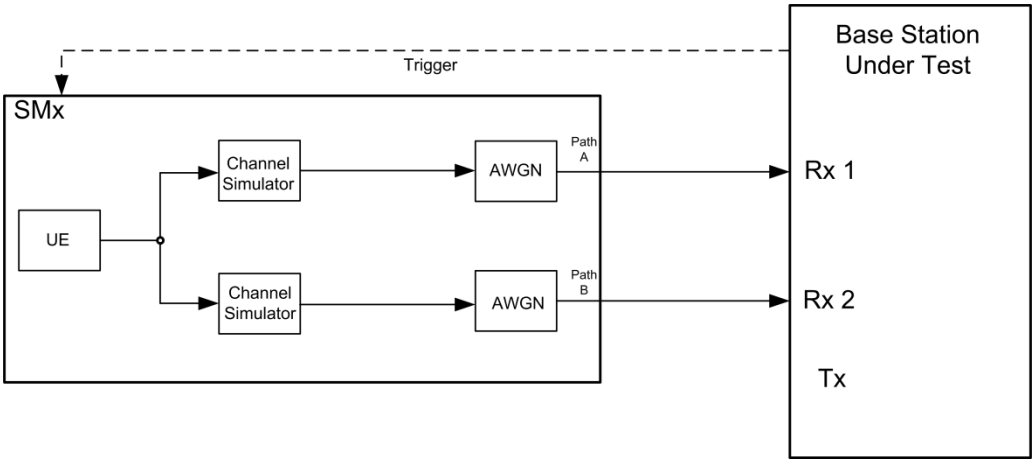


Fig. 3-195: Test setup for PUCCH test 8.3.13

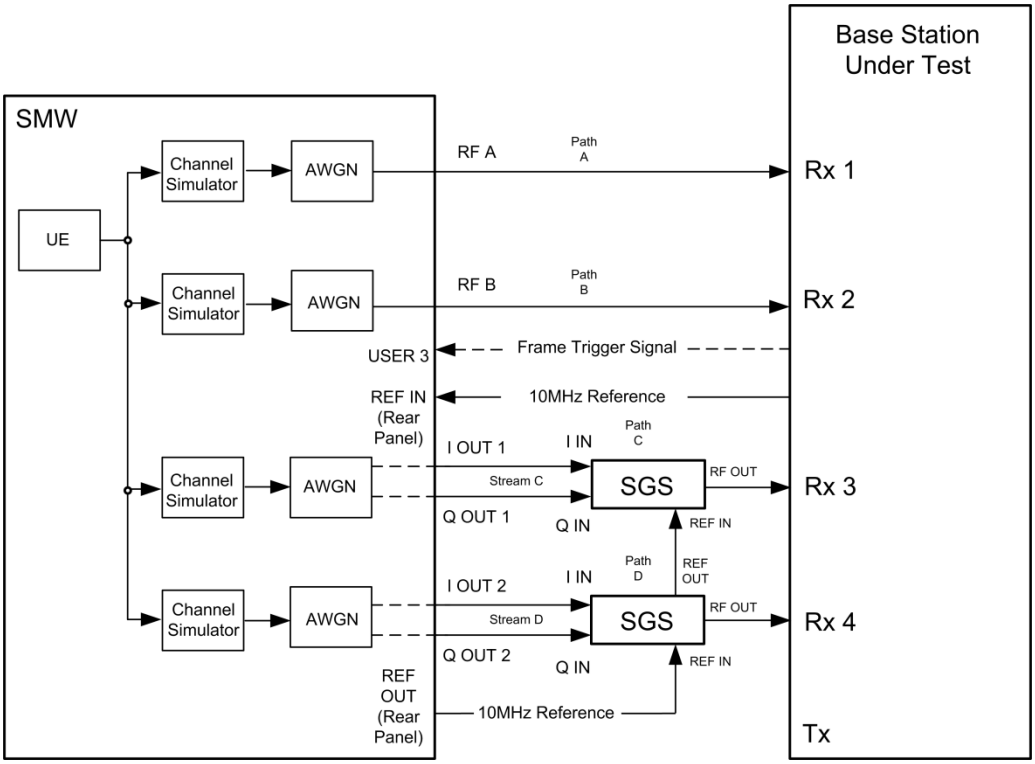


Fig. 3-196: Test setup for PUCCH test 8.3.13 for 4 antennas with one SMW

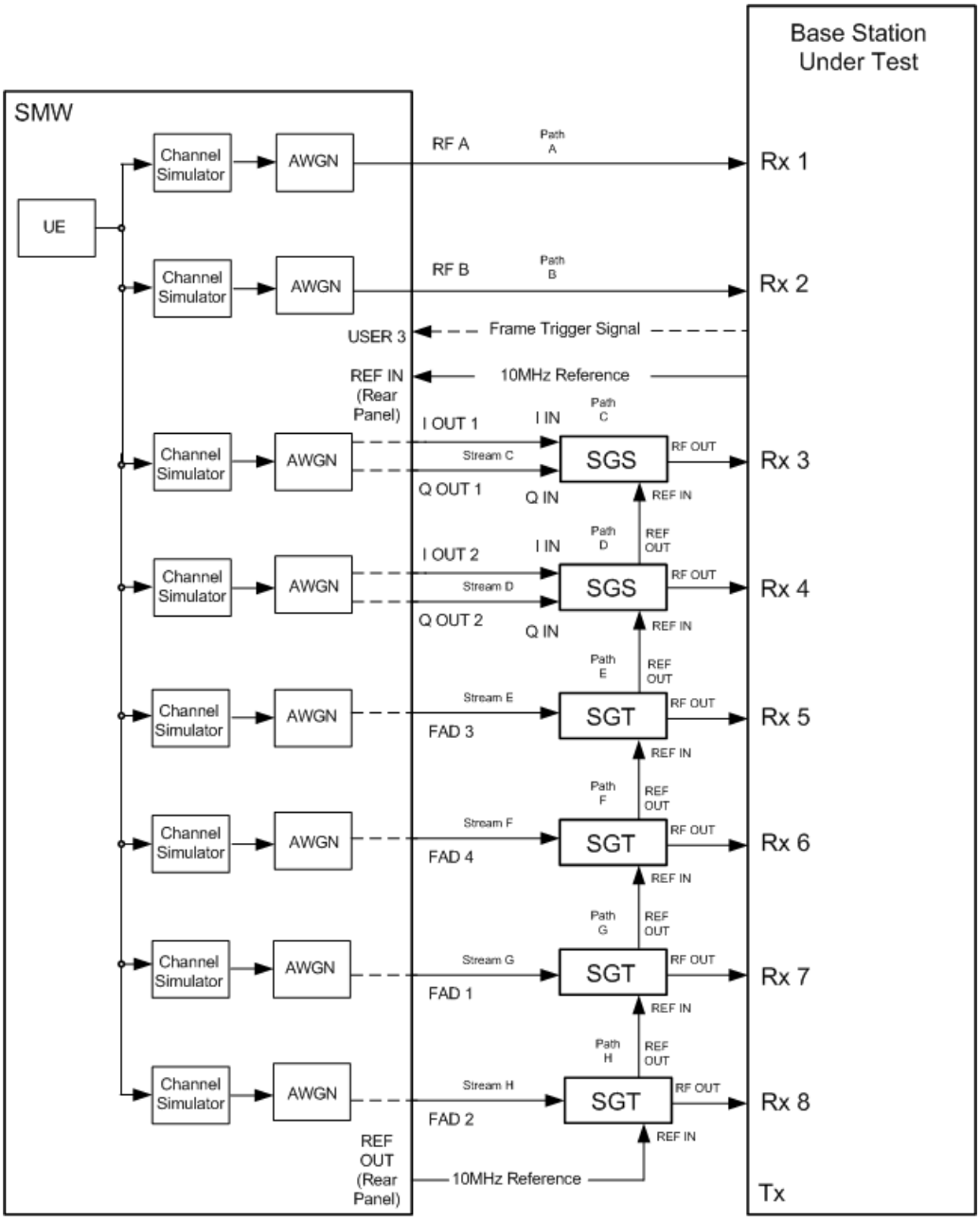


Fig. 3-197: Test setup for PUCCH test 8.3.13 for 8 antennas with one SMW

Test Procedure

As an example, the settings for two RX antennas, normal prefix, EPA 5 Hz, 10 MHz are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic LTE steps see section 3.1.2.
3. Click **Frame Configuration**

4. Set **UE1o to LTE-Advanced and No. of PUCCH Config to 2** (Fig. 3-84).

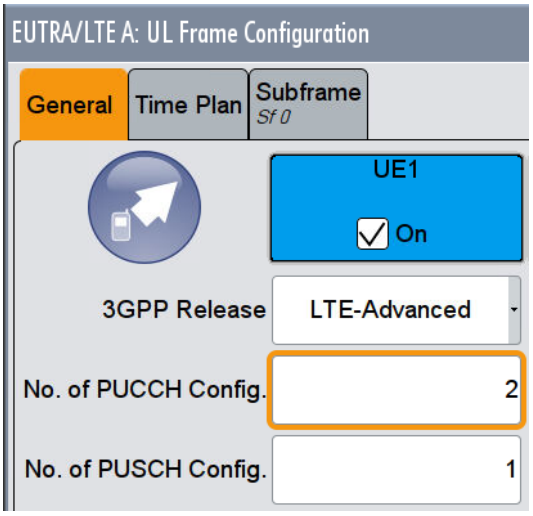


Fig. 3-198: UE1

5. Click on tab **Subframe**.
6. Set **Modulation/Format** in the row **PUCCH F5** and the **State ON** (Fig. 3-85).

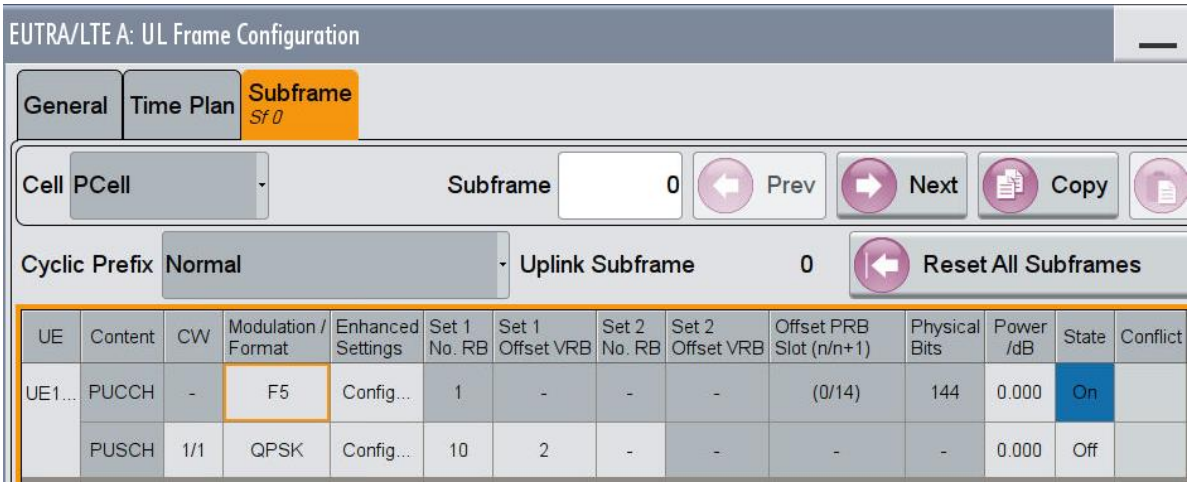


Fig. 3-199: PUCCH format 5

7. Click **Enhanced Settings Config** in the row PUCCH.
8. Set in the tab **Channel Coding Multiplexing** the **Number of Bit** to 24 and all bits to '1111……'.

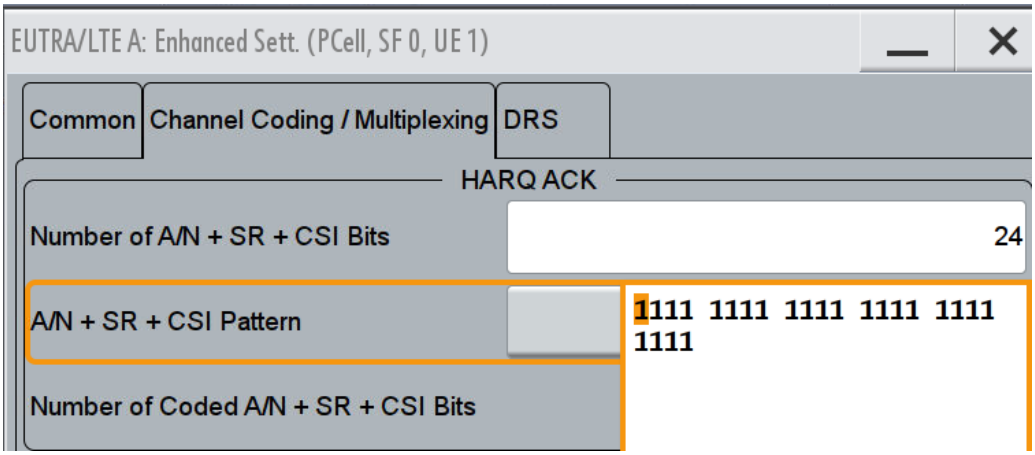


Fig. 3-200: 24 ACK bits

9. To generate the test pattern, disable the PUCCH transmission in subframe 1.

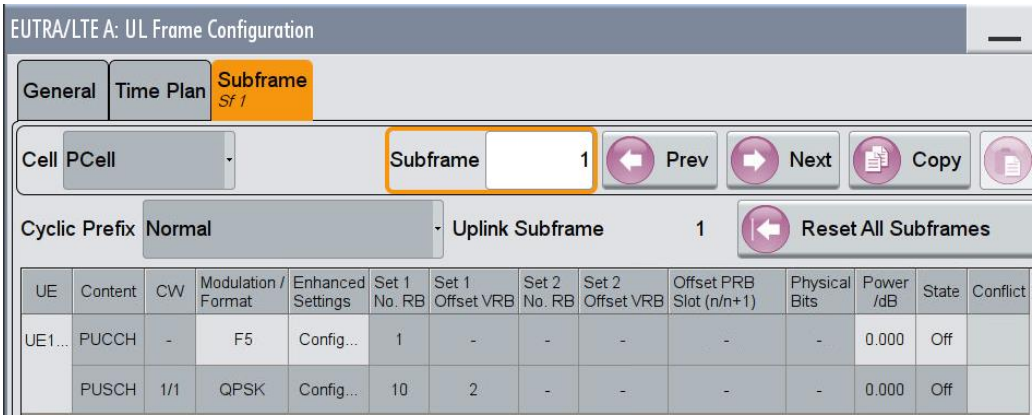
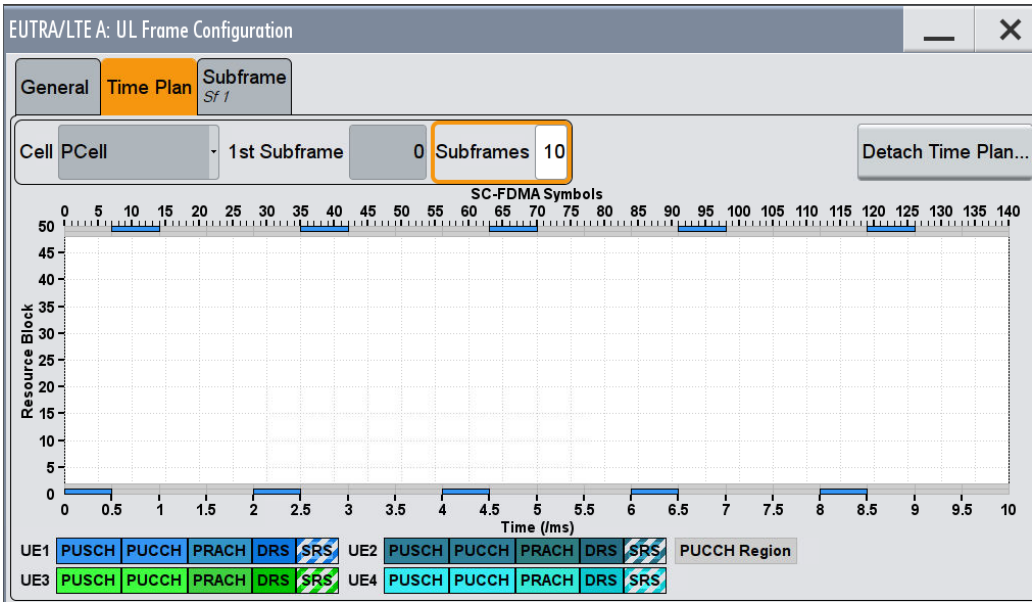


Fig. 3-201: In the second configurable subframe (subframe #1) the PUCCH is not transmitted (state Off)

10. Switch On EUTRA/LTE A.
11. The SMW shows the correct settings in the time plan.



AWGN and Fading

12. Set **Fading** according to **EPA 5 Hz Low** (see 3.1.3)
13. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -80.5 dBm; SNR = SNR + Correction = 2.2 dB -16.99 dB = -14.79 dB)

Demo Program

Fig. 3-202 shows the parameters of the test. You can select the test in the tabulator **8.3 PUCCH.** Select one test under **8.3.13 PUCCH Format 5**. The tests are listed by their cyclic prefix and fading profile. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the fading profile and the channel bandwidth. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (default: Low). This example configures a PUCCH with a ration of PUCCH transmission with ACK information to no PUCCH transmission of 50:50. **4 Antennas** enables the test for four antennas.
8 Antennas enables the test for eight antennas.

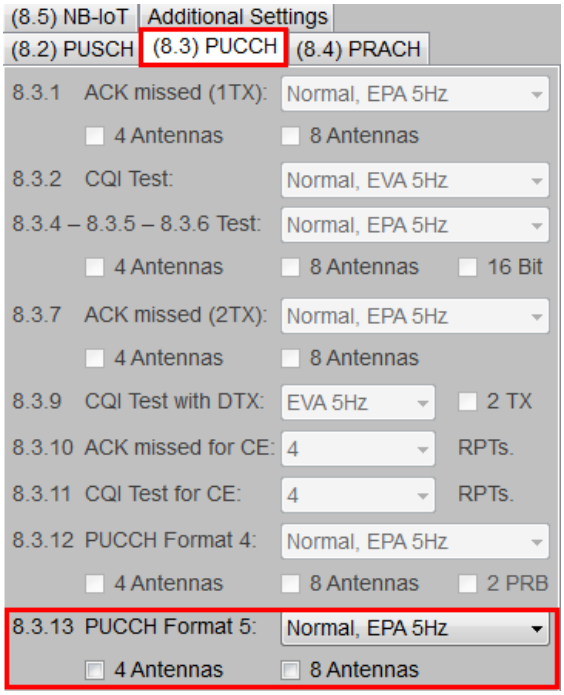


Fig. 3-202: Parameter for PUCCH test 8.3.13

Fig. 3-203 shows the report.

```
******* Performance Tests *******

8.3.13 ACK missed Detection for PUCCH Format 5
with 2RX Antennas.

Bandwidth: 10 MHz
Duplex Mode: FDD
Fading: EPA5Hz Low
AWGN: -83.5 dBm
SNR: 2.2 dB
SNR Correction: -16.99 dB

A/N + SR + CSI Pattern (24 Bits): '1111 1111 1111 1111 1111 1111'
Finished!
```

Fig. 3-203: Report 8.3.13

3.4 Performance requirements for PRACH (Clause 8.4)

This section covers the performance of the physical random access channel (PRACH). All tests in this subclause are performed with the AWGN power level given in Table 3-70.

AWGN Power level for PRACH Tests	
Channel Bandwidth [MHz]	**AWGN Power Level**
1.4	-89.7dBm / 1.08MHz
3	-85.7dBm / 2.7MHz
5	-83.5dBm / 4.5MHz
10	-80.5dBm / 9MHz
15	-78.7dBm / 13.5MHz
20	-77.4dBm / 18MHz

Table 3-70: AWGN Power Levels for PRACH Tests

As the PRACH (Burst Format 0…3: 839 x 1250 Hz, Burst Format 4: 139 x 7500 Hz) does not occupy the full AWGN bandwidth, a special SNR correction factor is applied, which depends on the bandwidth and the burst format (Table 3-71).

SNR Correction Factor for PRACH Tests		
Bandwidth in MHz	**Factor in dB**	
	Burst Format 0…3	Burst format 4
1.4	-0.13	-0.15
3	-4.11	-4.13
5	-6.33	-6.35
10	-9.34	-9.36
15	- 11.10	-11.13
20	- 12.34	-12.37

Table 3-71: SNR Correction Factor for PRACH Tests

3.4.1 PRACH false alarm probability and missed detection (Clause 8.4.1)

The performance is measured by the base station and is determined by the total probability of false detection of the preamble (Pfa) and the probability of detection of preamble (Pd). Pd shall be 99% or greater, Pfa 0.1% or less. The statistics are kept by the base station under test.

The test for Pfa is done when the input signal is only noise, thus PRACH is not transmitted. The test for Pd shall verify the receiver's ability to detect PRACH preamble under multipath fading propagation conditions for a given SNR.

While normal mode test is applicable to all BS, the high speed mode test is applicable to high speed BS.

Fig. 3-204 shows the pattern of the transmitted preamble. The timing offset base is set to 50% of Ncs. A cyclic timing offsets is applied to the preamble (Fig. 3-205). Thus, ten preambles have to be transmitted.

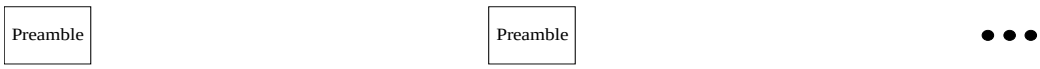


Fig. 3-204: PRACH Test Pattern

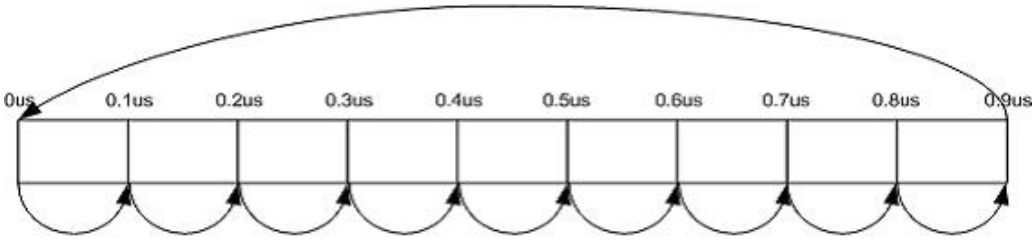


Fig. 3-205: Timing Offset

Table 3-72 to Table 3-76 list the parameters like propagation conditions and SNR according to different burst formats. For some test cases, an additional frequency offset is required.

Requirements PRACH 8.4.1 for 2RX Antennas

Mode	Propagation Conditions	Frequency Offset	SNR [dB]				
			Burst Format 0	Burst Format 1	Burst Format 2	Burst Format 3	Burst Format 4
Normal	AWGN	0	-13.9	-13.9	-16.1	-16.2	-6.9
	ETU 70	270 Hz	- 7.4	- 7.2	- 9.4	- 9.5	0.5
High Speed Type A	AWGN	0	-13.8	-13.9	-16.0	-16.3	-
	ETU 70	270 Hz	- 6.8	- 6.7	- 8.7	- 8.9	-
	AWGN	625 Hz	-12.1	-12.0	-14.1	-14.1	-
	AWGN	1340 Hz	-13.1	-13.2	-15.2	-15.4	-
High Speed Type B	AWGN	0	-14.2	-13.8	-16.4	-16.5	-
	ETU 70	270 Hz	-6.7	-6.3	-8.5	-8.6	-
	AWGN	625 Hz	-11.7	-11.4	-13.6	-13.6	-
	AWGN	1875 Hz	-11.5	-11.1	-13.5	-13.7	-

Table 3-72: Requirements PRACH Test 8.4.1 for 2RX Antennas

Requirements PRACH 8.4.1 for 4RX Antennas							
Mode	Propagation Conditions	Frequency Offset	SNR [dB]				
			Burst Format 0	Burst Format 1	Burst Format 2	Burst Format 3	Burst Format 4
Normal	AWGN	0	-16.6	-16.4	-18.7	-18.5	-9.5
	ETU 70	270 Hz	-11.5	-11.1	-13.5	-13.3	-4.5
High Speed Type A	AWGN	0	-16.6	-16.3	-18.6	-18.5	-
	ETU 70	270 Hz	-11.2	-10.8	-13.1	-13.1	-
	AWGN	625 Hz	-14.6	-14.3	-16.5	-16.5	-
	AWGN	1340 Hz	-15.6	-15.2	-17.5	-17.5	-
High Speed Type B	AWGN	0	-16.8	-16.3	-18.8	-18.8	-
	ETU 70	270 Hz	-11.2	-10.7	-12.9	-12.8	-
	AWGN	625 Hz	-14.1	-13.8	-15.8	-15.9	-
	AWGN	1875 Hz	-13.9	-13.5	-15.6	-16.0	-

Table 3-73: Requirements PRACH Test 8.4.1 for 4RX Antennas

Requirements PRACH 8.4.1 for 8RX Antennas							
Mode	Propagation Conditions	Frequency Offset	SNR [dB]				
			Burst Format 0	Burst Format 1	Burst Format 2	Burst Format 3	Burst Format 4
Normal	AWGN	0	-19.5	-19.1	-21.2	-21.0	-11.5
	ETU 70	270 Hz	-15.7	-15.3	-17.2	-16.9	- 8.0
High Speed Type A	AWGN	0	-19.0	-18.8	-20.6	-20.7	-
	ETU 70	270 Hz	-15.0	-14.5	-16.4	-16.4	-
	AWGN	625 Hz	-17.4	-17.1	-19.0	-19.1	-
	AWGN	1340 Hz	-18.4	-18.1	-20.2	-20.2	-
High Speed Type B	AWGN	0	-19.3	-18.8	-20.9	-20.9	-
	ETU 70 Low	270 Hz	-14.7	-14.5	-16.5	-16.9	-
	AWGN	625 Hz	-16.1	-16.0	-17.8	-17.9	-
	AWGN	1875 Hz	-16.0	-15.7	-17.7	-18.1	-

Table 3-74: Requirements PRACH Test 8.4.1 for 8RX Antennas

Requirements PRACH 8.4.1 for Coverage Enhancement (2RX Antennas, PRACH Frequency Hopping OFF)						
Propagation Conditions	Frequency Offset	Number of Repetitions	SNR [dB]			
			Burst Format 0	Burst Format 1	Burst Format 2	Burst Format 3
AWGN	0	4	-	-	-21.0	-20.8
		8	-21.4	-21.0	-	-
		16	-	-	-24.8	-24.7
		32	-25.3	-25.0	-	-
EPA 1	270 Hz	4	-	-	-11.5	-11.1
		8	-12.4	-11.7	-	-
		16	-	-	-16.6	-16.6
		32	-18.4	-18.0	-	-

Table 3-75: Requirements PRACH Test 8.4.1 for Coverage Enhancement, Frequency Hopping OFF

Requirements PRACH 8.4.1 for Coverage Enhancement (2RX Antennas, PRACH Frequency Hopping ON)						
Propagation Conditions	Frequency Offset	Number of Repetitions	SNR [dB]			
			Burst Format 0	Burst Format 1	Burst Format 2	Burst Format 3
EPA 1	270 Hz	4	-	-	-14.9	-14.7
		8	-15.6	-15.2	-	-
		16	-	-	-19.5	-19.6
		32	-20.7	-20.5	-	-
Requirements in this table apply for channel bandwidth of 5MHz, 10MHz or 20MHz. For channel bandwidth of 3MHz, the requirements in Table 3-75 apply.						

Table 3-76: Requirements PRACH Test 8.4.1 for Coverage Enhancement, Frequency Hopping ON

Test Setup

Fig. 3-206 to Fig. 3-208 show the test setup.

The wanted signal generated by the SMW's baseband A is split up in two paths. Multipath fading is simulated in the channel simulators and AWGN is added.

For four and eight RX antennas, the test can be done with just one SMW. Please note: Suitable options are required!

The SMW needs an external trigger at USER3.

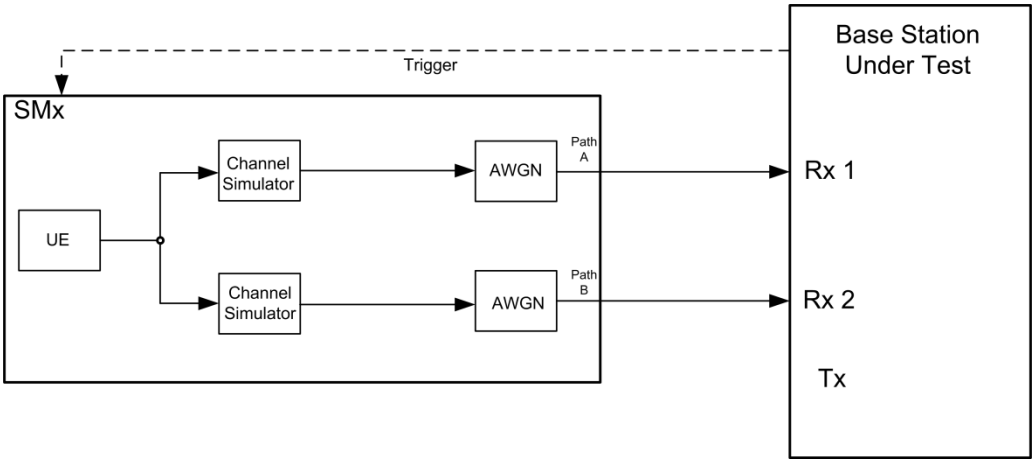


Fig. 3-206: Test Setup for PUCCH Test 8.4.1 for 2 Antennas

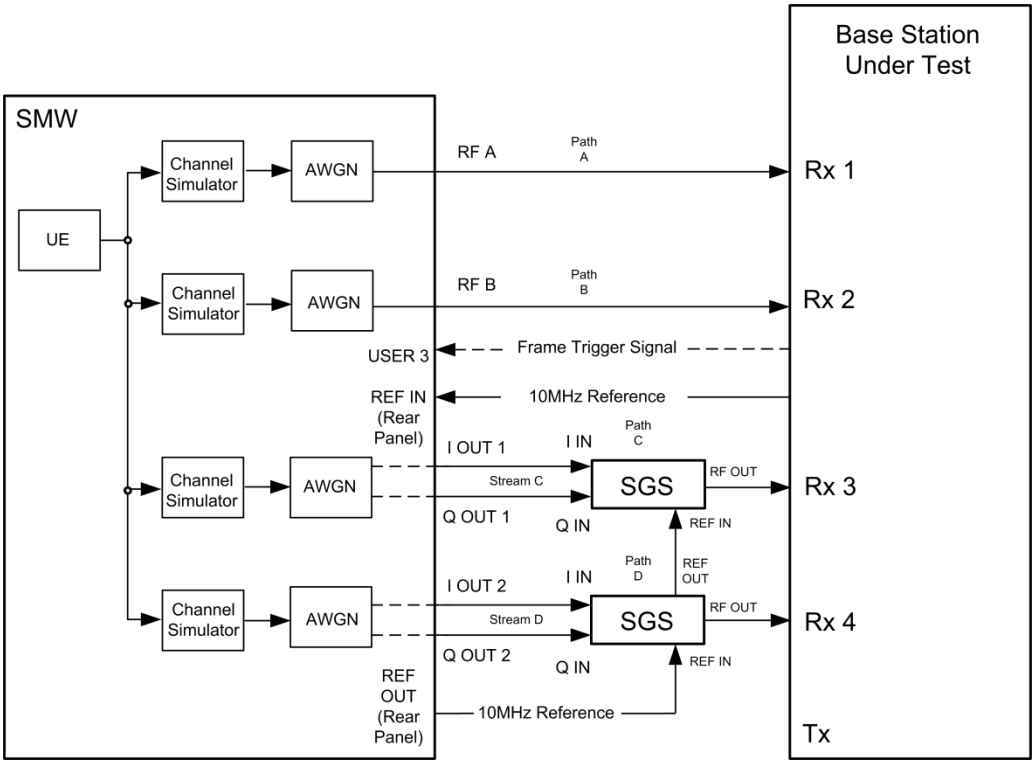


Fig. 3-207: Test Setup for PUCCH Test 8.4.1 for 4 Antennas with one SMW

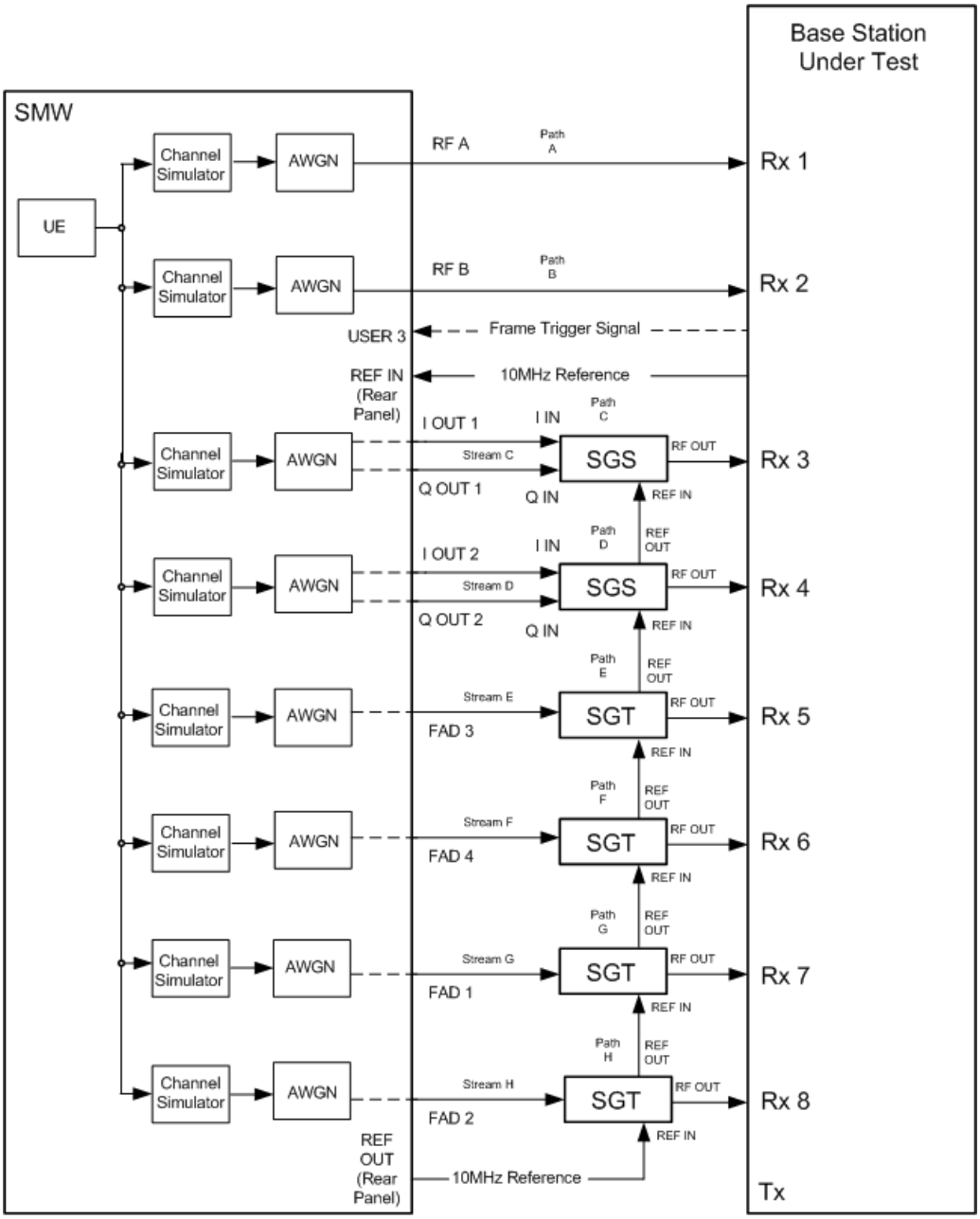


Fig. 3-208: Test Setup for PUCCH Test 8.4.1 for 8 Antennas with one SMW

Demo Program

Fig. 3-209 shows the parameters of the test. The test can be select in section **PRACH**. The tests are listed by their cyclic prefix, the fading profile and the frequency offset. When selecting a particular test, all settings are default according to the specification. The setting of the SNR depends on the channel bandwidth and the fading profile. The fading settings are displayed in the section **Fading**. There, also select the correlation matrix (Default: Low).

For normal or high speed mode **4 Antennas** respectively **8 Antennas** enables the test with four or eight antennas. Alternatively mark **Coverage Enhancement / eMTC** for PRACH for eMTC or **False Detection** to generate noise only.

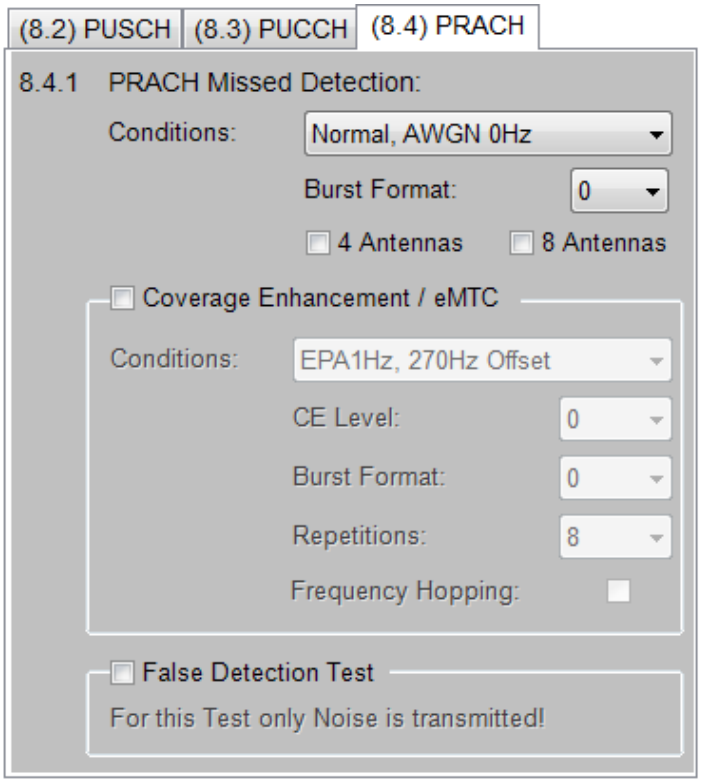


Fig. 3-209: Parameter for PRACH Test 8.4.1

Fig. 3-210 shows the report.

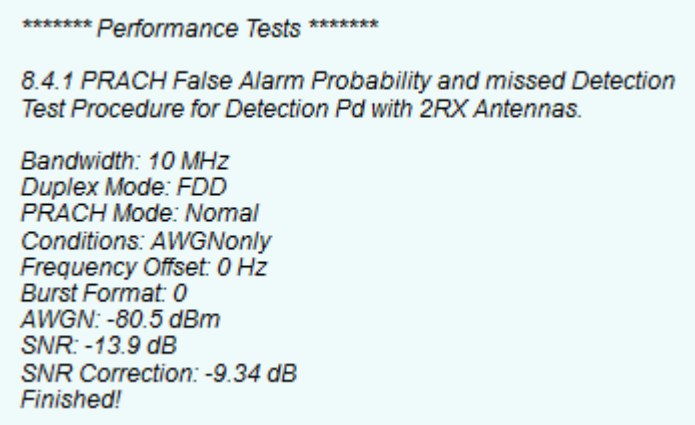


Fig. 3-210: Report 8.4.1

3.4.1.1 Test procedure for detection Pd

Test procedure for Normal and High Speed Mode

As in [7, Table 5.7.1-1…4] many different configurations are possible, but only certain ones are used here.

Table 3-77 shows the used FDD configurations.

FDD PRACH Configuration	
Burst Format / Preamble Format	**PRACH Configuration Index**
0	6
1	22
2	38
3	**54**

Table 3-77: Used FDD PRACH Configurations.

With these used configurations in FDD mode, a PRACH is transmitted in subframe 1 and 6, so five frames are necessary to transmit ten PRACH's.

Table 3-78 shows the used TDD configurations.

TDD PRACH Configuration		
Burst Format / Preamble Format	**PRACH Configuration Index**	**Possible UL/DL Configuration**
0	3	all
1	23	0,1,3,4,6
2	33	0,1,3,4,6
3	43	0,3,6
4	51	all

Table 3-78: Used TDD PRACH Configurations.

Burst Format 4 is only possible in TDD mode for Special Subframe Configurations 5…8 and without High Speed Mode. The possible UL/DL Configuration depends on the Burst Format. With these used configurations, only one PRACH is transmitted each frame, so ten frames are necessary to transmit ten PRACHs.

An example shows how to perform the settings for a two-antenna test setup with a channel bandwidth of 10 MHz, FDD, Normal Mode, ETU 70 and an offset of 270 Hz as well as burst format 0.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1)
2. For the basic LTE steps see section 3.1.2.
3. Click **Filter/Clipping/ARB/TDW/Power.**

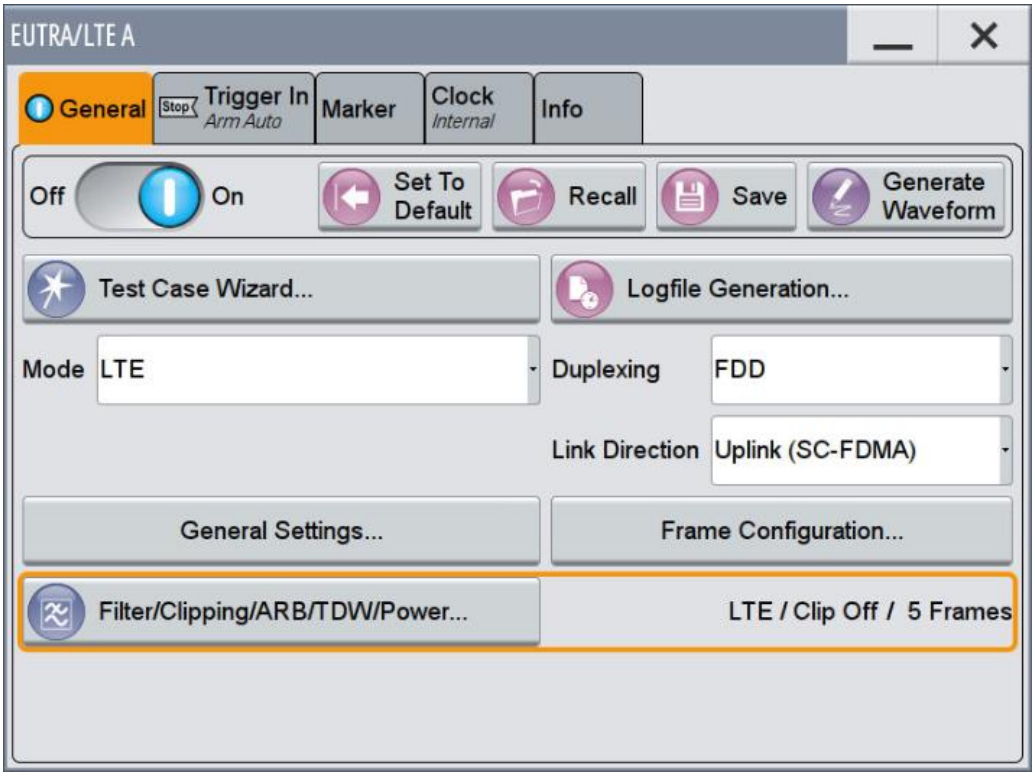


Fig. 3-211: Additional Settings: Here Frames.

4. Set the Sequence Length in tab **ARB** (Example: FDD → 5 Frames).

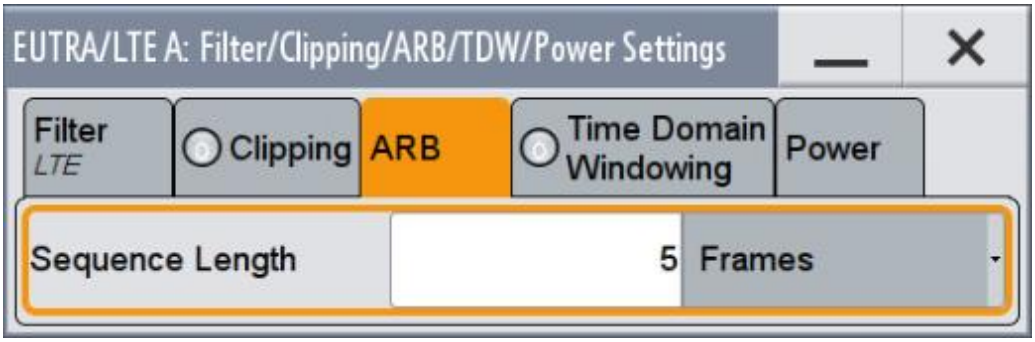


Fig. 3-212: Setting the Number of Frames (FDD: 5, TDD 10).

5. Click **General UL Settings.**
6. Set PRACH Configuration according to Table 3-77 or Table 3-78 (see Fig. 3-213).

   Example: Burst Format 0 → PRACH Configuration 6

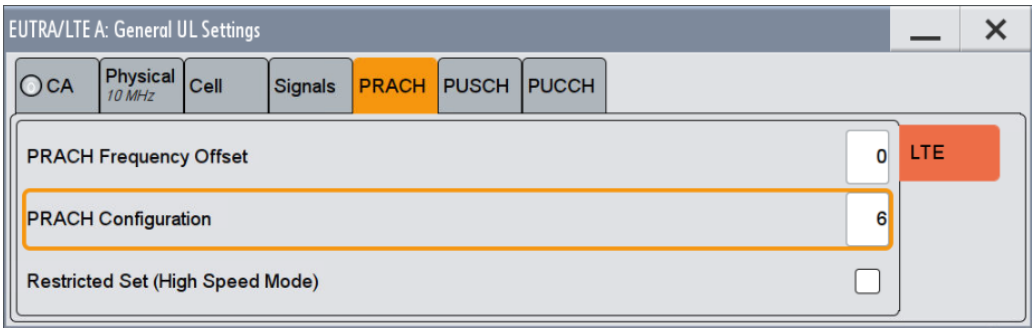


Fig. 3-213: PRACH Configuration

Test Preambles

The transmitted test preambles depend on the burst format, the Ncs, a logical sequence index and v. The value for Ncs cannot be directly set in the SMW, but the Ncs configuration. Table 3-79 shows the relationship between Ncs value and Ncs configuration, according to TS 136.211 Table 5.7.2-2.

Ncs Configuration				
N_{CS} Value				N_{CS} Configuration
Burst Format 0…3			Burst Format 4	
Unrestricted Set	Restricted Set Type A	Restricted Set Type B		
0	15	15	2	0
13	18	18	4	1
15	22	22	6	2
18	26	26	8	3
22	32	32	10	4
26	38	38	12	5
32	46	46	15	6
38	55	55	-	7
46	68	68	-	8
59	82	82	-	9
76	100	100	-	10
93	128	118	-	11
119	158	137	-	12
167	202	-	-	13
279	237	-	-	14
419	-	-	-	15

Table 3-79: Preamble Ncs Configuration [6]

Timing offset base value shall be 50% Ncs. The duration of Ncs can be calculated via:

t_{Ncs} = Ncs * (1 / (Δf_{RA} * N_{ZC})), where Δf_{RA} and N_{ZC} are:

Sequence Length and Baseband Parameters		
Burst Format	N_{ZC}	Δf_{RA}
0…3	839	1250 Hz
4	139	7500 Hz

Table 3-80: Parameters for Calculation of t_{Ncs}

This leads to test preamble parameters in Table 3-81 and Table 3-82, which have to be set in the SMW.

Test Preambles for Normal Mode					
Burst Format	**Ncs**	**Ncs Configuration (SMW)**	**Logical Sequence Index**	**v**	**Base Offset Value (us)**
0	13	1	22	32	6.2
1	167	13	22	2	79.62
2	167	13	22	0	79.62
3	0	0	22	0	0

Table 3-81: Test Preambles for Normal Mode

Test Preambles for High Speed Mode Type A					
Burst Format	**Ncs**	**Ncs Configuration (SMW)**	**Logical Sequence Index**	**v**	**Base Offset Value (us)**
0	15	0	384	0	7.15
1	202	13	384	0	96.31
2	202	13	384	0	96.31

Table 3-82: Test Preambles for High Speed Mode Type A

Test Preambles for High Speed Mode Type B					
Burst Format	**Ncs**	**Ncs Configuration (SMW)**	**Logical Sequence Index**	**v**	**Base Offset Value (us)**
0	15	0	30	30	7.15
1	100	10	168	20	47.68
2	118	11	204	10	56.26
3	137	12	264	0	65.32

Table 3-83: Test Preambles for High Speed Mode Type B

7. Click **Frame Configuration** and on **UE1.**
8. Set Mode to PRACH.

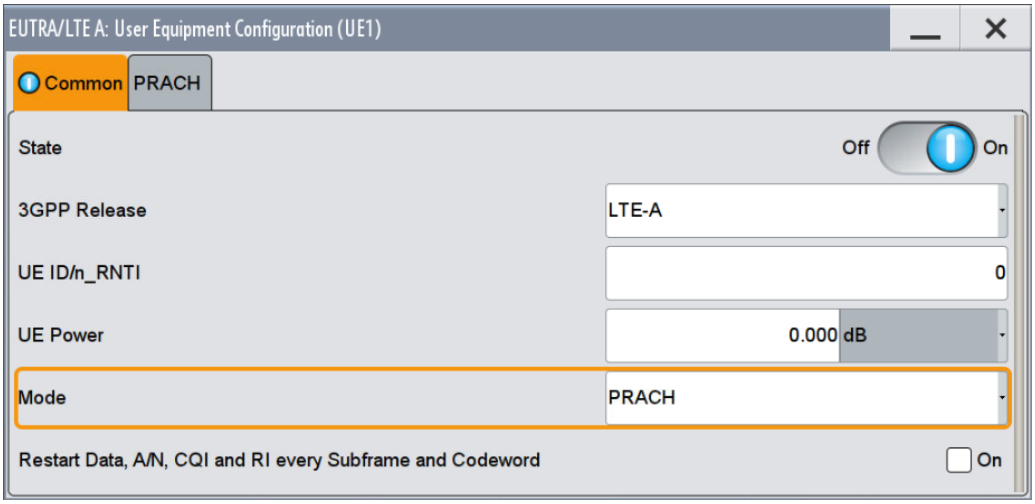
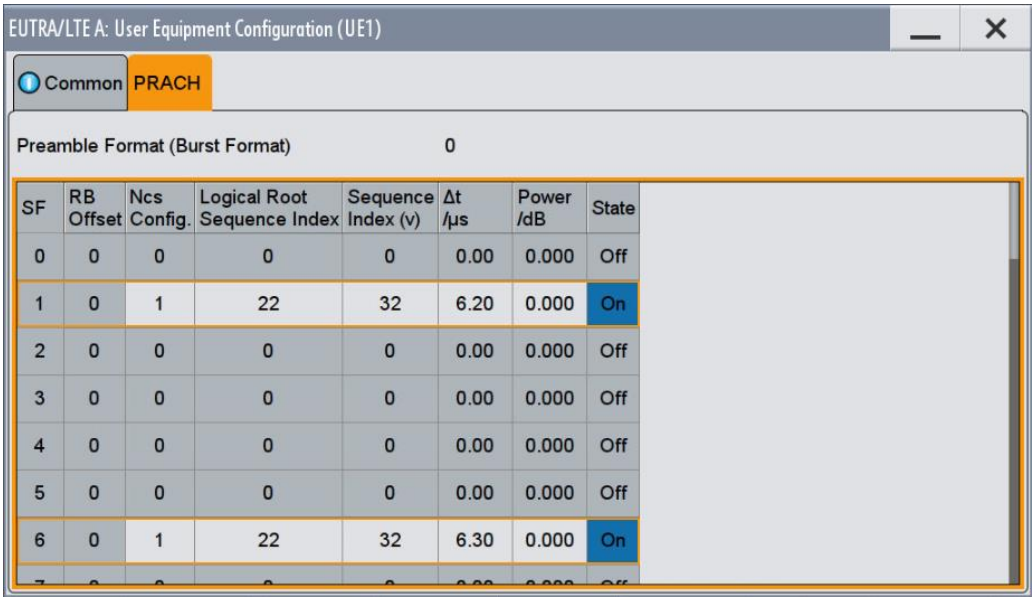


Fig. 3-214: UE in PRACH Mode.

9. In the tab **PRACH**, enter the settings according to Table 3-81 or Table 3-82 (see Fig. 3-215). For this example set Ncs Conf. to 1, Log. Root Seq. Index to 22, Seq. Index (v) to 32 and Delta t to 6.2 us.



SF	RB Offset	Ncs Config.	Logical Root Sequence Index	Sequence Index (v)	Δt /µs	Power /dB	State
0	0	0	0	0	0.00	0.000	Off
1	0	1	22	32	6.20	0.000	On
2	0	0	0	0	0.00	0.000	Off
3	0	0	0	0	0.00	0.000	Off
4	0	0	0	0	0.00	0.000	Off
5	0	0	0	0	0.00	0.000	Off
6	0	1	22	32	6.30	0.000	On

Fig. 3-215: Details of the Test Preambles.

10. Make sure to configure all 10 preambles and to increase the Delta t by 0.1 us.

AWGN and Fading

11. Set **Fading** according to Table 3-72, Table 3-73 or Table 3-74 (see 3.1.3)

    Example: EVA 70 Hz Low

12. Set **Noise Power** and **SNR.** Take in account the **SNR Correction Factor** (see 3.1.4). For this example Noise Power has to be set to -80.5 dBm. SNR results from SNR (-7.4 dB) and the corresponding Correction Factor (-9.34 dB) and has to be set to -14.04 dB.

Test procedure for Coverage Enhancement

As in [7, Table 5.7.1-1…4] many different configurations are possible, but only certain ones are used here. The requirements in Table 3-75 and Table 3-76 are defined based on simulation results with the following configuration indexes.

PRACH Configuration	
Burst Format	**PRACH Configuration Index**
0	3
1	19
2	35
3	51

Table 3-84: Used PRACH Configurations for Coverage Enhancement

An example shows how to perform the settings for a coverage enhancement test setup with a channel bandwidth of 10 MHz, EPA 1 Low and an offset of 270 Hz, burst format 0 and without frequency hopping.

1. Set the routing in the SMW to **1 x 1 x 2** (see 3.1.1).
2. For the basic LTE steps see section 3.1.2.
3. Click **General UL Settings** and open the **PRACH** tab.
4. For **eMTC** set the PRACH Configuration and the Number of Repetitions for the corresponding CE Level according to Table 3-84, Table 3-75 and Table 3-76.

   Example: Burst Format 0 → Configuration 3 and Repetitions 8.

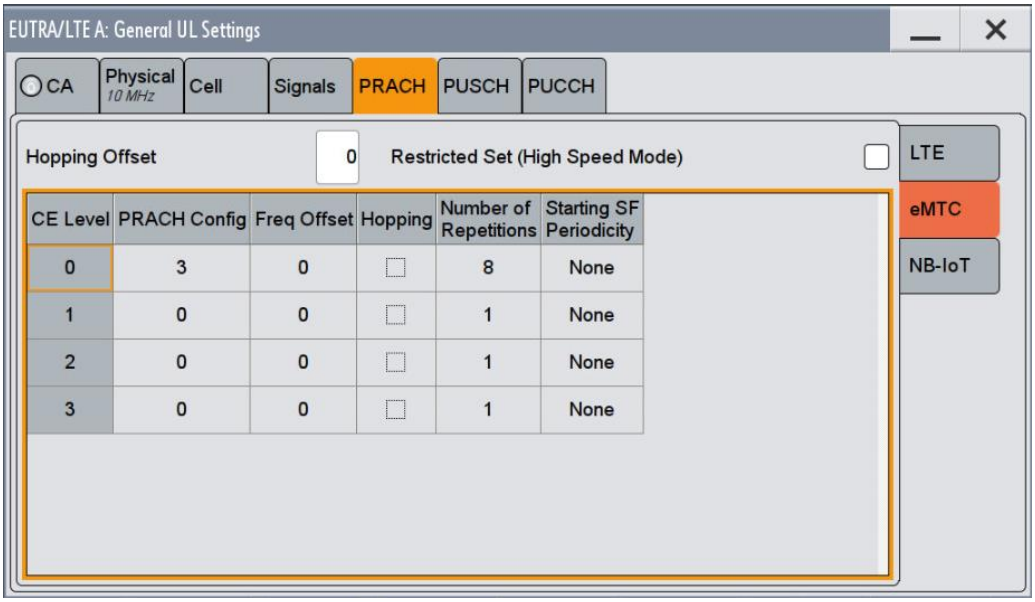


Fig. 3-216: PRACH Configuration and Number of Repetitions

Test Preambles

The transmitted test preambles depend on the Burst Format, the NCS, a Logical Root Sequence Index and the Sequence Index (v). Based to Table 3-79, this leads to the following test preamble parameters, which have to be set in the SMW.

Test Preambles for Coverage Enhancement				
Burst Format	**NCS Config.** (SMW)	**Logical Root Sequence Index**	**Sequence Index** (v)	**Base Offset Value** (us)
0	1	22	32	6.2
1	13	22	2	79.62
2	13	22	0	0.0
3	0	22	0	4.8

Table 3-85: Test Preambles for Coverage Enhancement

5. Click **Frame Configuration** and enable **UE1** for **eMTC**.

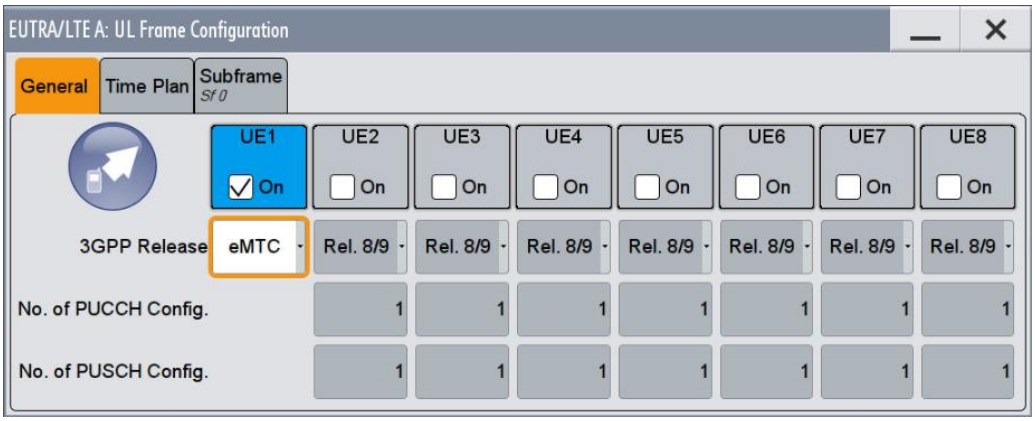


Fig. 3-217: Set UE1 to eMTC Mode.

6. Open the UE Configuration by clicking **UE1** and set **Mode** to **PRACH** (Fig. 3-214).
7. In the tab **PRACH**, enter the CE Level and the settings according to Table 3-85.

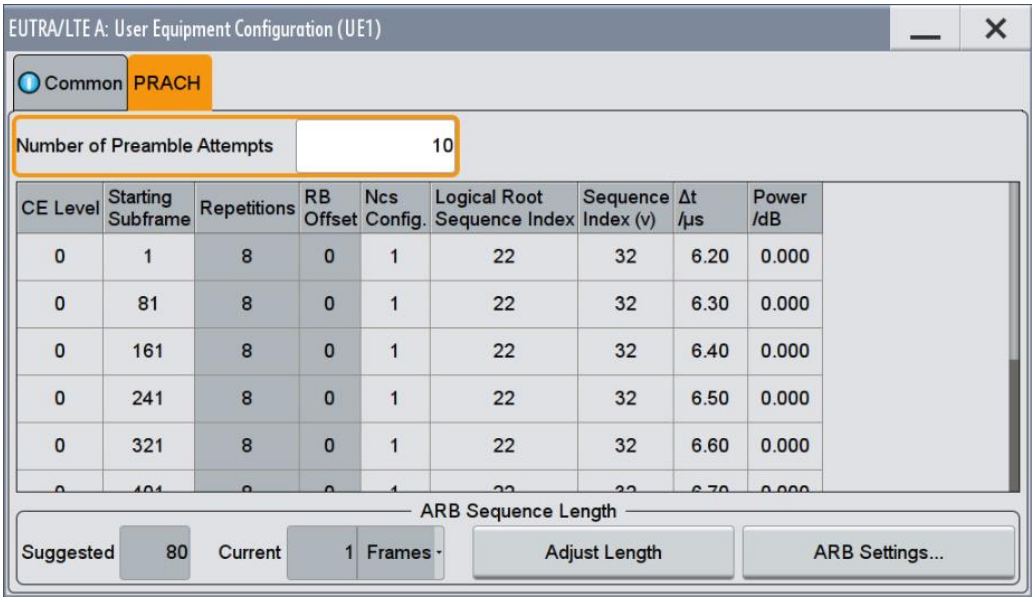


Fig. 3-218: Details of the Test Preambles.

8. Make sure to configure all 10 preambles and to increase the Delta t by 0.1 us.

9. This example requires a frequency offset of 270 Hz, which can be set directly in the baseband. To apply this, select **Baseband A** and **Baseband Offsets**.

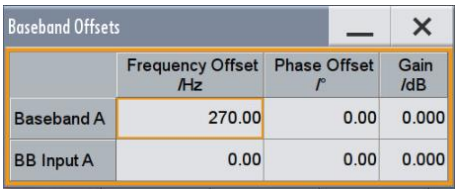


Fig. 3-219: Frequency Offset

AWGN and Fading

10. Set **Fading** according to Table 3-75 and Table 3-76 (see 3.1.3).

11. Set **Noise Power** and **SNR.** Take in account the **SNR Correction Factor** (see 3.1.4). For this example Noise Power has to be set to -80.5 dBm. SNR results from SNR (-12.4 dB) and the corresponding Correction Factor (-9.34 dB) and has to be set to -21.74 dB.

3.4.1.2 Test procedure for false detection Pfa

For this test, only noise is transmitted.

1. In the block diagram, select **AWGN**.
2. Set the Mode to **Noise Only** (Fig. 3-220).
3. Set **System Bandwidth** and **Ratio**.

   Example: 10 MHz $BW_{channel}$ → 9 MHz System Bandwidth

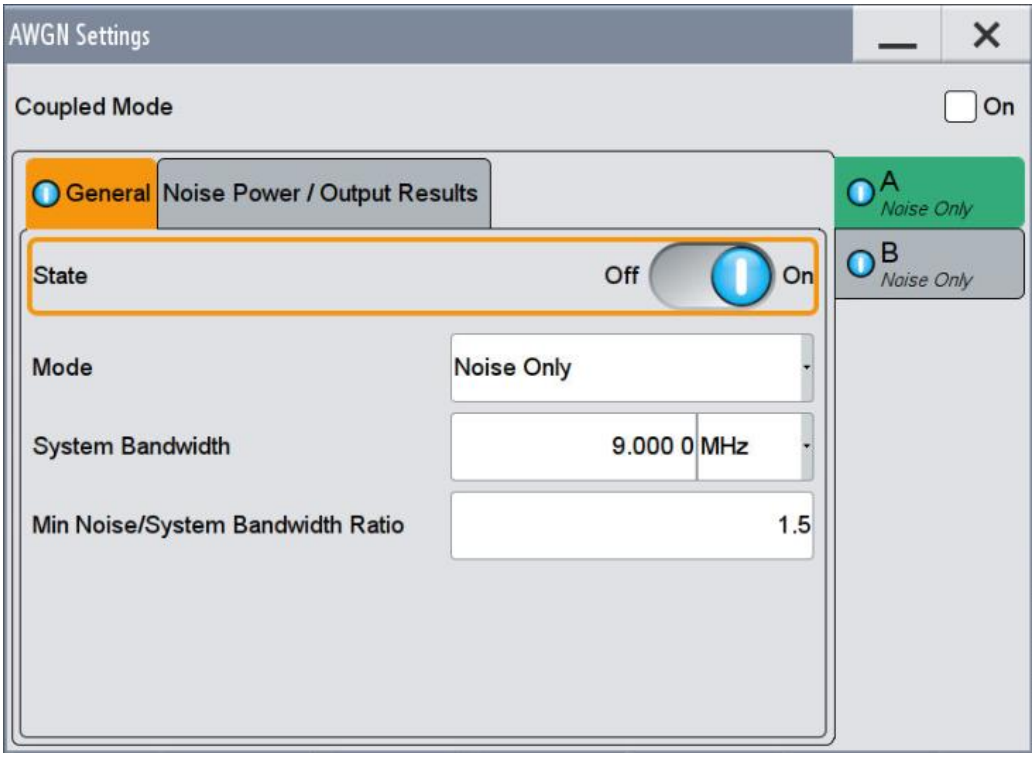


Fig. 3-220: For the Pfa test, the SMW generates noise only.

4. In the tab **Noise Power / Output Results** set the **Noise Power** according to Table 3-70.

   Example: 10 MHz → -80.5 dBm

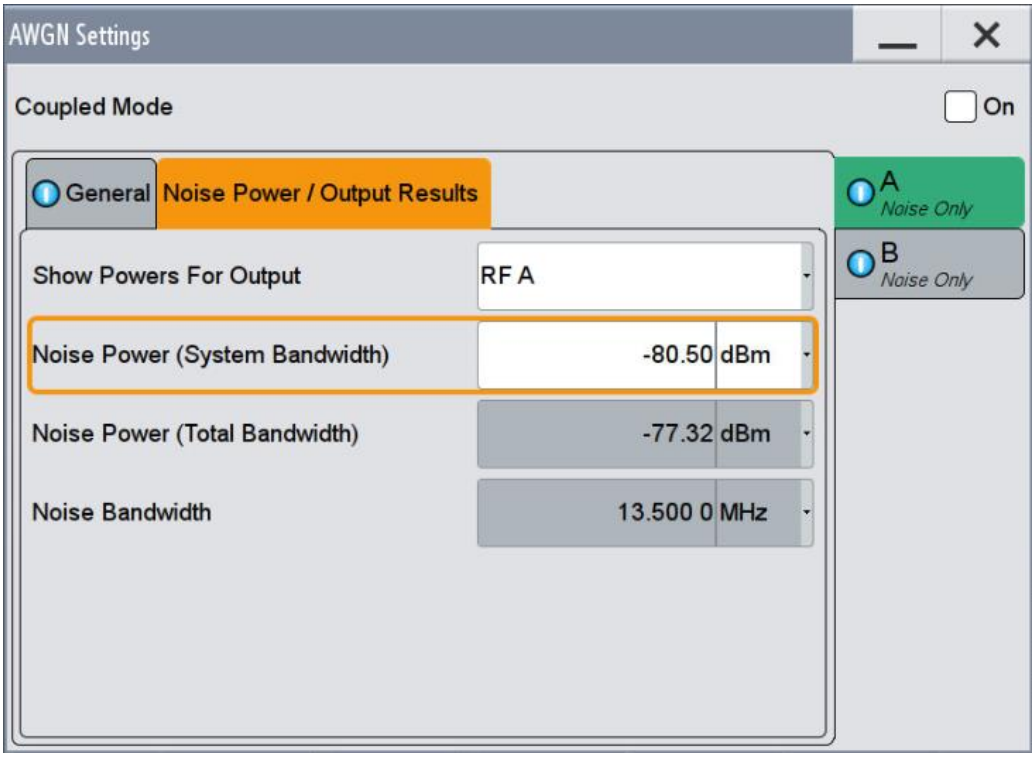


Fig. 3-221: Setting the noise power.

5. Repeat the steps with the second path (see Fig. 3-220 and Fig. 3-221).

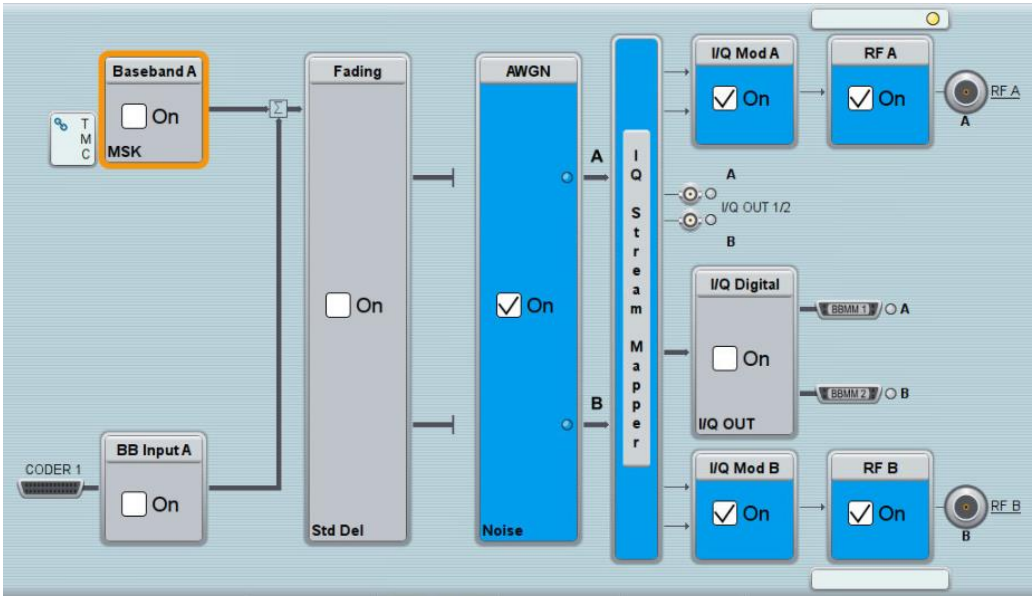


Fig. 3-222: Overview SMW for the noise only settings.

3.5 Performance requirements for Narrowband IoT (Clause 8.5)

This section covers the performance tests for NB-IoT.

All tests in this subclause are performed with the AWGN power level given in Table 3-86.

AWGN power level for NB-IoT tests	
Channel bandwidth [MHz]	**AWGN power level**
0.2	- 100.5 dBm / 0.18 MHz

Table 3-86: AWGN power level for NB-IoT tests

SNR Correction Factor

For FRC's not using all subcarriers (NPUSCH format 1), NPUSCH format 2 and NPRACH, a special SNR correction factor has to be applied by the user.

SNRΔ = 10 log (used subcarriers / possible subcarriers)

Example: For FRC A16-1 (for 3.75 kHz spacing) only one subcarrier is used. 3.75 kHz spacing allows 48 subcarriers. Thus SNRΔ = 10 log (1 / 48) = -16.81 dB.
This factor depends on the bandwidth, see Table 3-87.

SNR Correction factor for NB-IoT					
Subcarrier spacing in kHz	**Max subcarriers**	**Channel**	**FRC**	**Number of subcarriers**	**SNRΔ**
3.75	48	NPUSCH F1	16-1	1	- 16.81
		NPUSCH F2	---	1	
		NPRACH	---	1	
15	12	NPUSCH F1	16-2	1	- 10.79
			16-3	3	- 6.02
			16-4	6	- 3.01
			16-5	12	0.00
		NPUSCH F2	---	1	- 10.79

Table 3-87: SNR correction factor for PUSCH tests with 1RB allocated.

Testsetup

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.

The SMW needs an external trigger at USER3. A HARQ-Feedback signal from the base station is required for 8.5.1 tests.

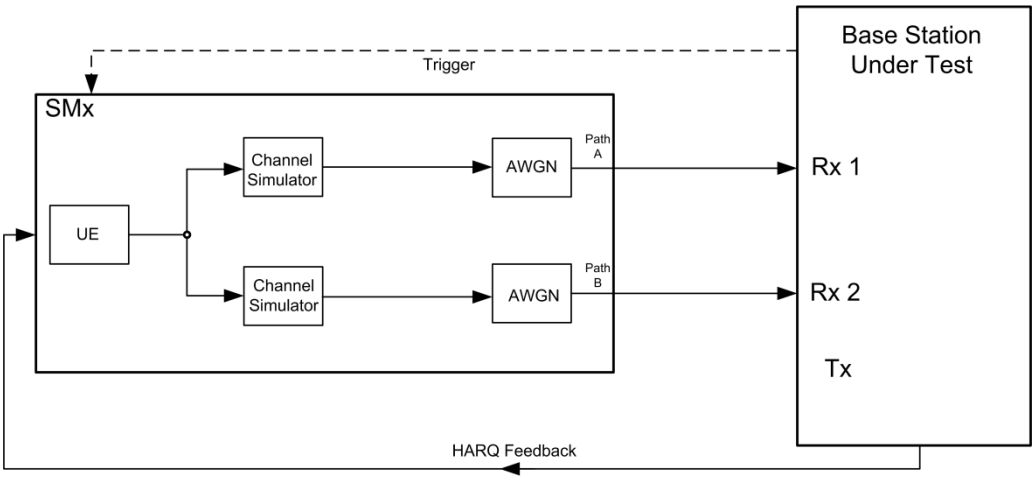


Fig. 3-223: Test Setup for NB-IoT tests 8.5 (the feedback is necessary for 8.5.1 only)

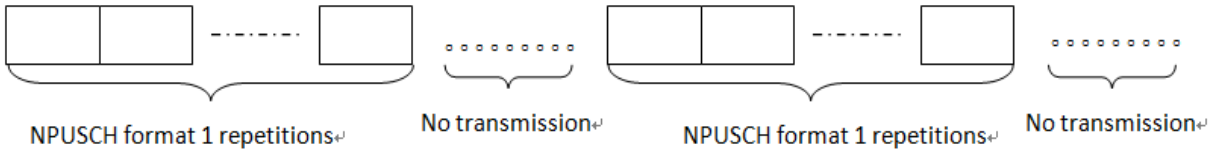
3.5.1 Performance requirements for NPUSCH format 1 (Clause 8.5.1)

The test verifies the receiver's ability to achieve the data throughput in the NPUSCH (format 1) under multipath fading propagation.

The throughput is measured by the base station under test. The required throughput is expressed as a fraction of maximum throughput for the FRC's. HARQ re-transmission is assumed.

Test parameters 8.5.1	
Parameter	**Value**
Maximum number of HARQ transmissions	4
Redundancy version (RV) sequence	RV0, RV2

Following test pattern applies:



Test Requirements

Table 3-88 to Table 3-90 list the different requirements, which depend on the subcarrier spacing and the repetitions.

Parameter for NPUSCH format 1, 3.75 kHz subcarrier spacing								
Tx Antennas	**RX Antennas**	**Allocated Subcarriers**	**Propagation Conditions**	**FRC**	**Repetition number**	**Throughput**	**SNR in dB**	
1	2	1	ETU 1 Hz Low	A16-1	1	70 %	- 1.3	
					16		- 8.6	
					64		- 11.6	

Table 3-88: NPUSCH format 1, 3.75 kHz subcarrier spacing

Parameter for NPUSCH format 1, 15 kHz subcarrier spacing, single subcarrier								
Tx Antennas	**RX Antennas**	**Allocated Subcarriers**	**Propagation Conditions**	**FRC**	**Repetition number**	**Throughput**	**SNR in dB**	
1	2	1	ETU 1 Hz Low	A16-2	1	70 %	- 1.5	
					16		- 8.2	
					64		- 12.0	

Table 3-89: NPUSCH format 1, 15 kHz subcarrier spacing, single subcarrier

Parameter for NPUSCH format 1, 15 kHz subcarrier spacing, multiple subcarriers								
Tx Antennas	RX Antennas	Allocated Subcarriers	Propagation Conditions	FRC	Repetition number	Throughput	SNR in dB	
1	2	3	ETU 1 Hz Low	A16-3	2	70 %	- 2.4	
					16		- 7.5	
					64		- 10.8	
		6		A16-4	2		0.0	
					16		- 6.2	
					64		- 9.9	
		12		A16-5	2		- 0.1	
					16		- 5.8	
					64		- 9.5	

Table 3-90: NPUSCH format 1, 15 kHz subcarrier spacing, multiple subcarrier

To generate a test pattern with 50% transmission and 50% gap, the SMW uses following numbers of frames to ensure a continuous pattern in the ARB of the SMW:

Transmission and frames for PUSCH F1 3.75 kHz spacing			
Repetition	Subframes for transmission and gap	Number of transmissions	Number of frames
1	128	5	64
16	2048	5	1024
64	8192	5	4096

Table 3-91: Transmission and frames 3.75 kHz spacing

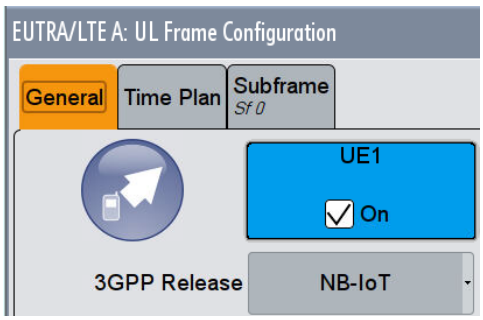
Transmission and frames for PUSCH F1 15 kHz spacing				
Subcarriers	Repetition	Subframes for transmission and gap	Number of transmissions	Number of frames
1	1	32	5	16
	16	512	5	256
	64	2048	5	1024
3	2	16	5	8
	16	128	5	64
	64	512	5	256
6	2	8	5	4
	16	64	5	32
	64	256	5	128
12	2	4	5	2
	16	32	5	16
	64	128	5	64

Table 3-92: Transmission and frames 15 kHz spacing

Test Procedure

As an example, the settings for two RX antennas, 15 kHz spacing with one subcarrier (FRC A16-2) and 1 repetition are shown. The PUSCH is transmitted 50 percent of the time, for 50 percent there are no transmissions.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic NB-IoT steps see section 3.1.2.
3. Click **Frame Configuration.**



4. Click on **UE1**.
5. Click on the tab NB-IoT Allocation
6. To generate the test pattern, create **5 Transmissions**.
7. Switch on the **FRC in the tab FRC** (example **FRC A16-2**).

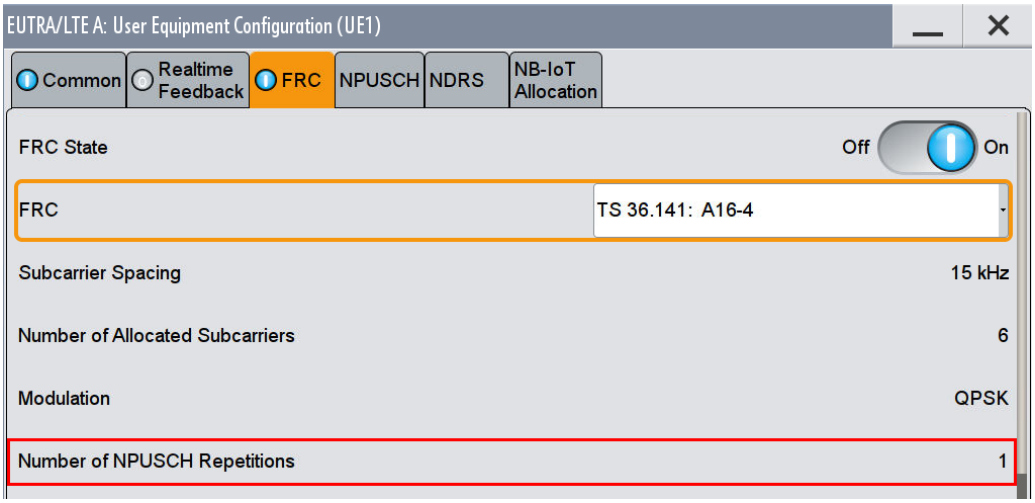


Fig. 3-224: NPUSCH F1: FRC

8. Set the **Start Subfr** increasing by *Subframes transmission and gap* of Table 3-92 (Example: **1 (0, 32, 64, 96, 128))**.

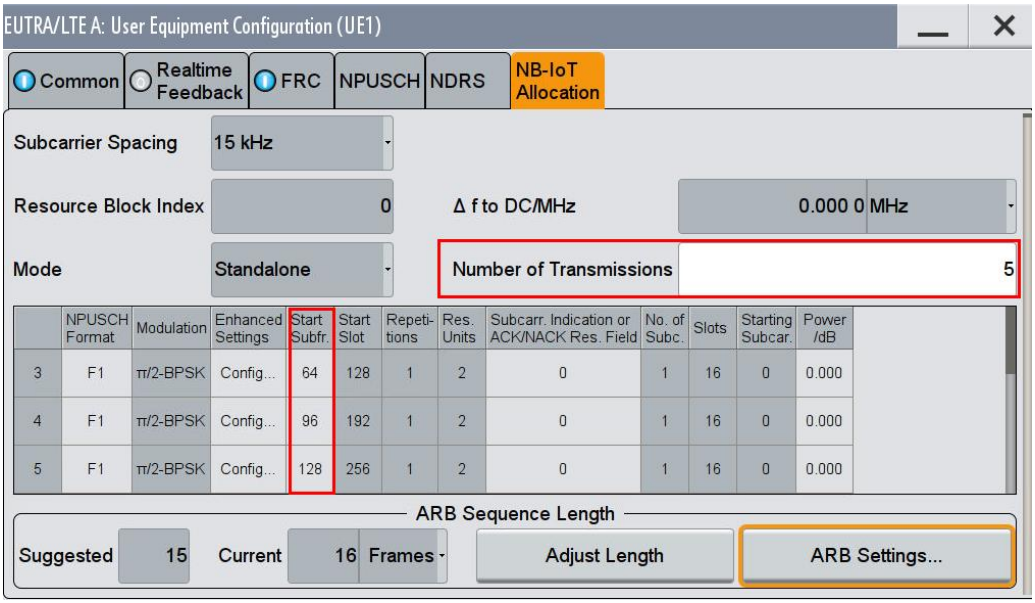


Fig. 3-225: Transmission settings

9. Enable the wanted Realtime feedback.
10. Click **ARB Settings** to set the **Sequence Length** to Number of frames in Table 3-95 (Example: '16')

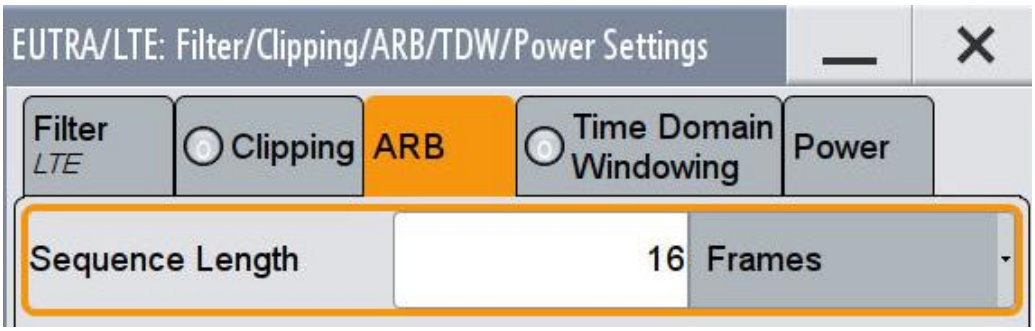


Fig. 3-226: 16 frames to generate the pattern continuously

11. Switch On EUTRA/LTE A.

AWGN and Fading

12. Set **Fading** according to **ETU 1 Hz Low** (see 3.1.3)
13. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -100.5 dBm; SNR = SNR + Correction = -9.9 dB -3.01 dB = -12.91 dB)

Demo program

Fig. 3-227 shows the parameters of the test. You can select the test in the section **8.5 NB-IoT.** Select one test under **8.5.1 NPUSCH Format 1**. The tests are listed by the subcarrier spacing, the number of subcarriers and the repetition. When selecting a

particular test all settings are default according to the specification. The setting of the SNR depends on the spacing. For FRCs using not all subcarriers a special SNR correction factor is applied. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). Set also parameters in the section **Real-Time Feedback.**

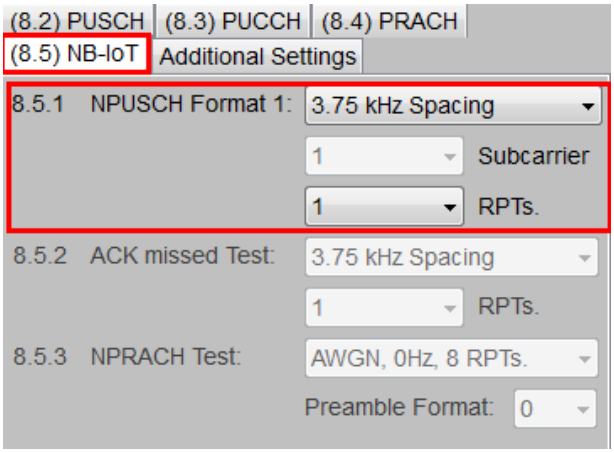


Fig. 3-227: Parameter for PUSCH test 8.5.1

Fig. 3-228 shows the report.

```
******* Performance Tests *******

8.5.1 Performance Requirements for NPUSCH Format 1

Subcarrier Spacing: 3.75 kHz
Repetition: 1

Bandwidth: 0.2 MHz
Duplex Mode: FDD
Fading: ETU1 Hz Low
FRC: A16-1
AWGN: -100.5 dBm
SNR: -1.3 dB
SNR Correction: -16.81 dB
Finished!
```

Fig. 3-228: Report 8.5.1

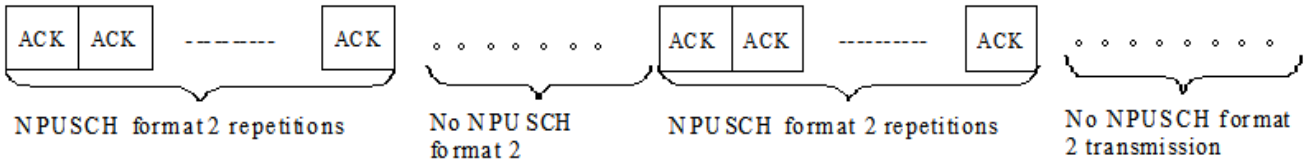
3.5.2 ACK missed detection for NPUSCH format 2 (Clause 8.5.2)

The test verifies the receiver's ability to detect the ACK inside the NPUSCH (format 2) under multipath fading propagation. 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 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.

Following test pattern applies:



Test Requirement

Parameter for NPUSCH format 2, 3.75 kHz subcarrier spacing						
Tx Antennas	**RX Antennas**	**Allocated Subcarriers**	**Propagation Conditions**	**Repetition number**	**SNR in dB**	**Resulting Level**
1	2	1	EPA 5 Low	1	7.6	- 109.71
				16	- 4.7	- 122.01
				64	- 10.3	- 127.61

Table 3-93: NPUSCH format 2, 3.75 kHz

Parameter for NPUSCH format 2, 15 kHz subcarrier spacing						
Tx Antennas	**RX Antennas**	**Allocated Subcarriers**	**Propagation Conditions**	**Repetition number**	**SNR in dB**	**Resulting Level**
1	2	1	EPA 5 Low	1	6.9	- 104.39
				16	- 3.3	- 114.59
				64	- 8.9	- 120.19

Table 3-94: NPUSCH format 2, 15 kHz

To generate a test pattern with 50% transmission and 50% gap, the SMW uses following numbers of frames to ensure a continuous pattern in the ARB of the SMW:

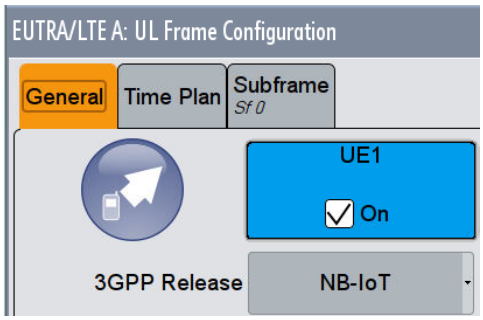
Transmission and frames				
Repetition	Subcarrier Spacing	Subframes for transmission and gap	Number of transmissions	Number of frames
1	3.75	16	5	8
	15	4		2
16	3.75	256		128
	15	64		32
64	3.75	1024		512
	15	256		128

Table 3-95: Transmission and frames

Test Procedure

As an example, the settings for two RX antennas, 15 kHz spacing and 16 repetitions are shown. The PUSCH is transmitted for 32 subframes, then the next 32 subframes are no transmissions.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic NB-IoT steps see section 3.1.2.
3. Click **Frame Configuration.**



4. Click on **UE1**.
5. To generate the test pattern, create **5 Transmissions**. Set all to **NPUSCH Format F2** and the **Repetition** to '16'. Set the **Start Subfr** increasing by *Subframes transmission and gap* of Table 3-95 (Example: **64 (0, 64, 128, 192, 256))**.

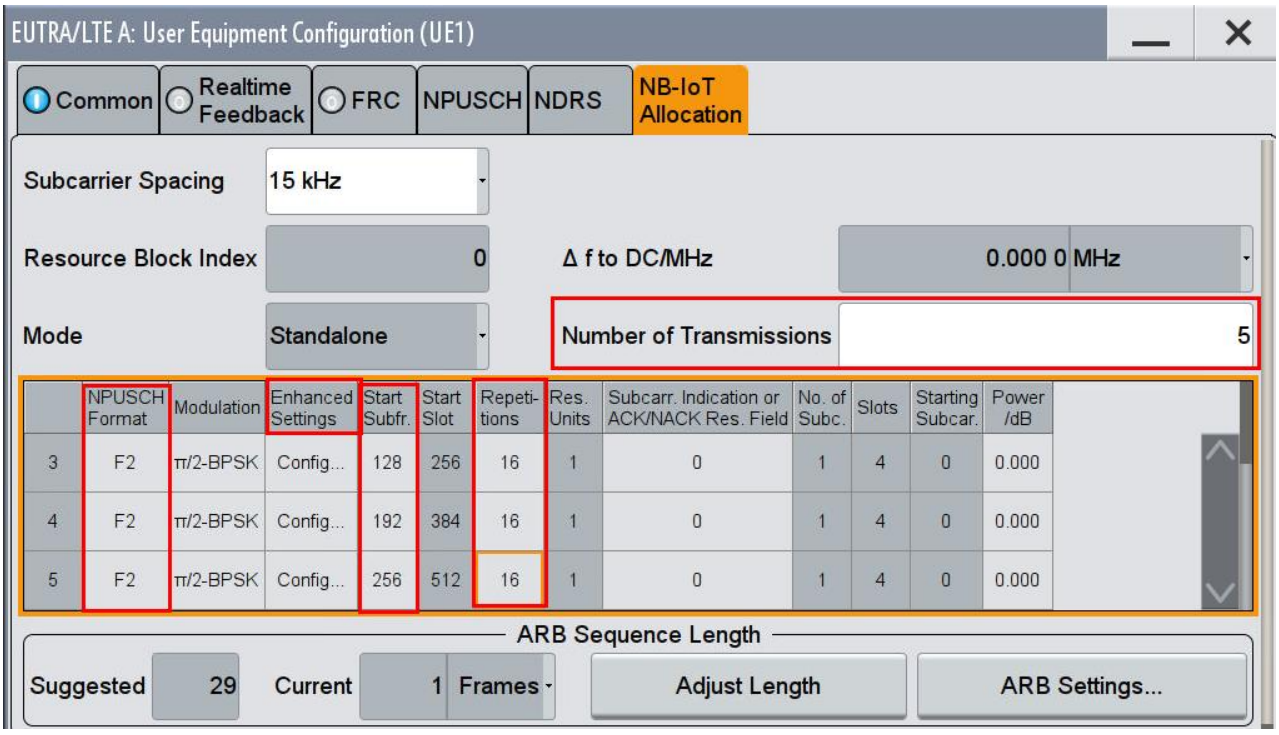
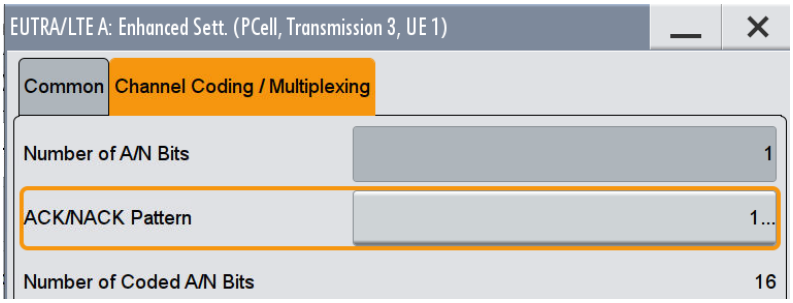


Fig. 3-229: Five transmissions of NPUSCH format 2 to generate the wanted pattern

6. Click in every transmission on **Enhanced Settings Config…** to set the **ACK/NACK Pattern** to '**1**'.



7. Click **ARB Settings** to set the **Sequence Length** to Number of frames in Table 3-95 (Example: '**32**')

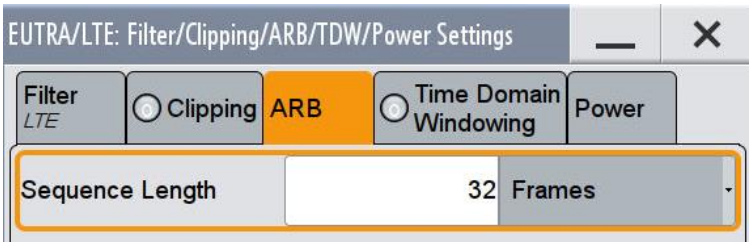


Fig. 3-230: 32 frames to generate the pattern continuously

8. Switch On EUTRA/LTE A.

AWGN and Fading

9. Set **Fading** according to **EPA 5 Hz Low** (see 3.1.3)
10. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -100.5 dBm; SNR = SNR + Correction = -3.3 dB -10.79 dB = -14.09 dB)

Demo program

Fig. 3-231 shows the parameters of the test. You can select the test in the section **8.5 NB-IoT.** Select one test under **8.5.2 ACK missed test**. The tests are listed by the subcarrier spacing and the repetition. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the spacing. As only one subcarriers is used a special SNR correction factor is applied. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low).

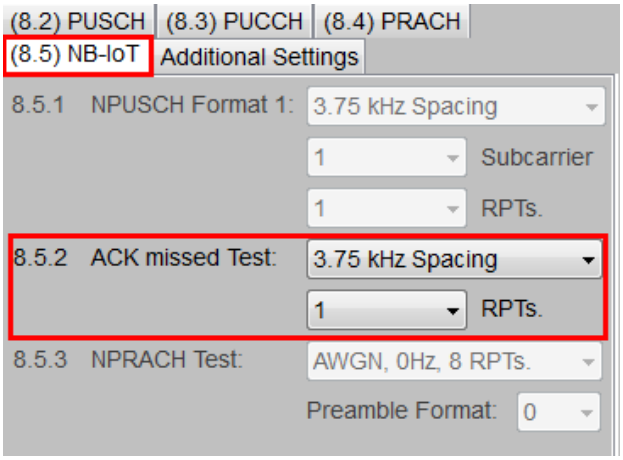


Fig. 3-231: Parameter for PUSCH test 8.5.2

Fig. 3-232 shows the report.

```
******* Performance Tests *******

8.5.2 ACK missed Detection for NPUSCH Format 2

Subcarrier Spacing: 3.75 kHz
Repetition: 1

Bandwidth: 0.2 MHz
Duplex Mode: FDD
Fading: EPA5 Hz Low
AWGN: -100.5 dBm
SNR: 7.6 dB
SNR Correction: -16.81 dB
Finished!
```

Fig. 3-232: Report 8.5.2

3.5.3 Performance requirements for NPRACH (Clause 8.5.3)

The performance is measured by the base station and is determined by the total probability of false detection of the preamble (Pfa) and the probability of detection of preamble (Pd). Pd shall be 99% or greater, Pfa shall be 0.1% or less. The statistics are kept by the base station under test.

The test for Pfa is done when the input signal is only noise, thus NPRACH is not transmitted.

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

Fig. 3-233 shows the pattern of the transmitted preamble. The preambles are sent with a fixed timing offset of 0.5 T_{CP} during the test.

Timing offset 0.5 T_{CP}	
Preamble Format	**Offset**
0	67 µs
1	267 µs

Table 3-96: NPRACH timing offsets

Fig. 3-233: NPRACH test pattern

The test requires two different NPRACH configurations as in Table 3-97.

NPRACH Test Parameters		
Parameter	**Configuration 0**	**Configuration 1**
Narrowband physical layer cell identity	0	0
nprach-Periodicity (ms)	80	320
nprach-SubcarrierOffset	0	0
nprach-NumSubcarriers	12	12
numRepetitionsPerPreambleAttempt	8	32

Table 3-97: NPRACH Test parameter configurations

Requirements NPRACH 8.5.3						
Tx Antennas	**Rx Antennas**	**Repetition number**	**Propagation conditions**	**Frequency offset**	**SNR [dB]**	
					Preamble Format 0	**Preamble Format 1**
1	2	8	AWGN	0	- 1.8	- 1.8
			EPA 1 Low	200 Hz	6.7	6.7
		32	AWGN	0	- 6.5	- 6.5
			EPA 1 Low	200 Hz	1.1	1.1

Table 3-98: NPRACH tests

Test Procedure

As an example, the settings for two RX antennas, 8 repetitions and EPA 1 low are shown.

1. Set the **routing** to 1x1x2 (see 3.1.1), thus one baseband block is routed to two paths.
2. For the basic NB-IoT steps see section 3.1.2.

The test requires two different NPRACH configurations and both Preamble Formats.

3. In **General Settings**, you can find the relevant settings in the tab **PRACH** and **NB-IoT**. Set two configurations according Table 3-97.

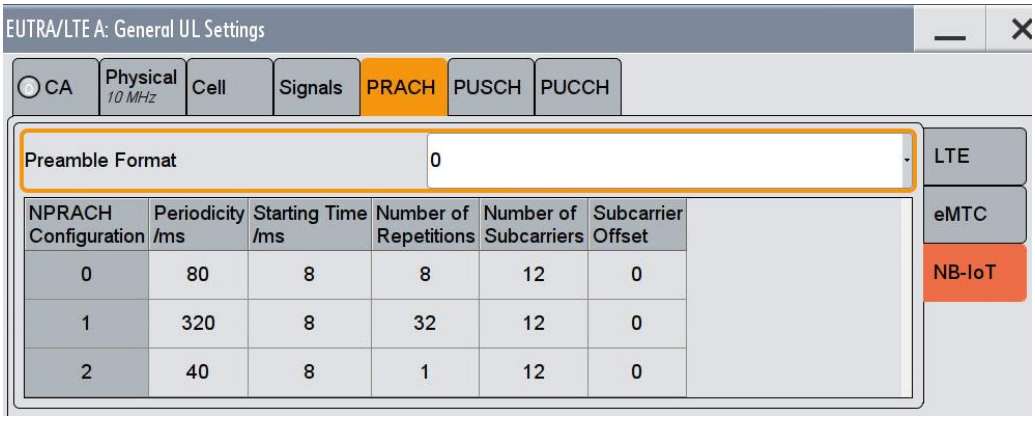


Fig. 3-234: General NPRACH settings

4. In **Frame Configuration**, set in the UE block the **Mode** to **PRACH**

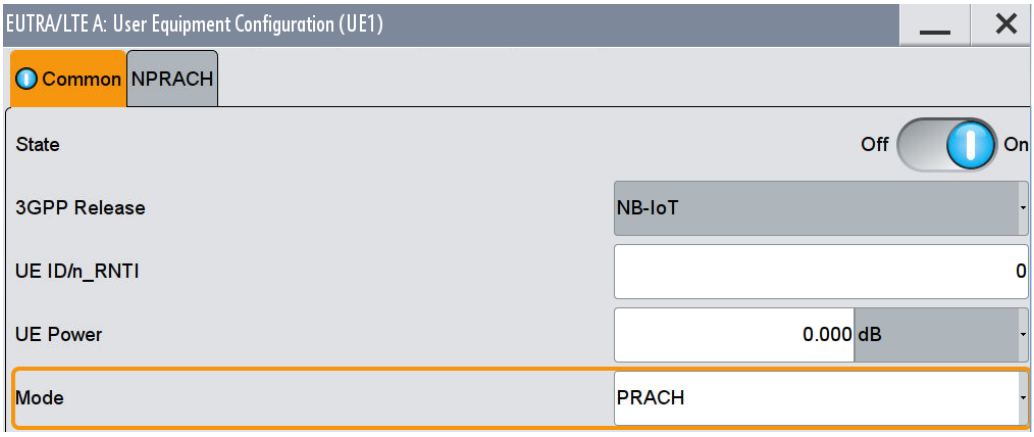


Fig. 3-235: NPRACH mode

5. In the **NPRACH** tab, set the wanted configuration. The SMW calculates automatically the necessary number of frames. Click **Adjust Length** to set them. (example: Preamble Format 0 with Configuration 0 (8 repetitions) This leads to 6 frames).

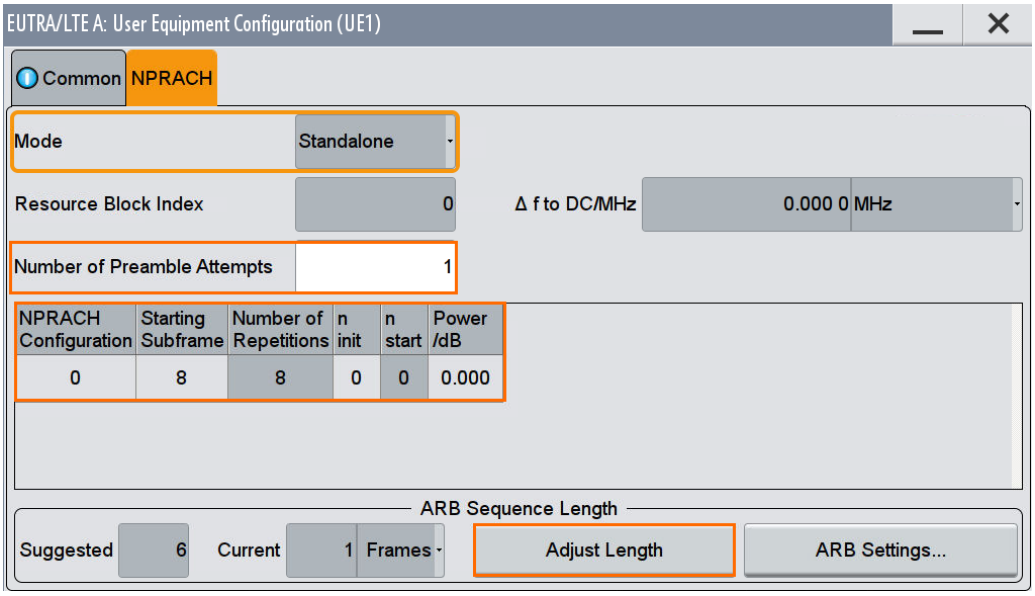


Fig. 3-236: NPRACH configuration

6. The example requires a frequency offset of 200 Hz. Set this directly in the baseband.

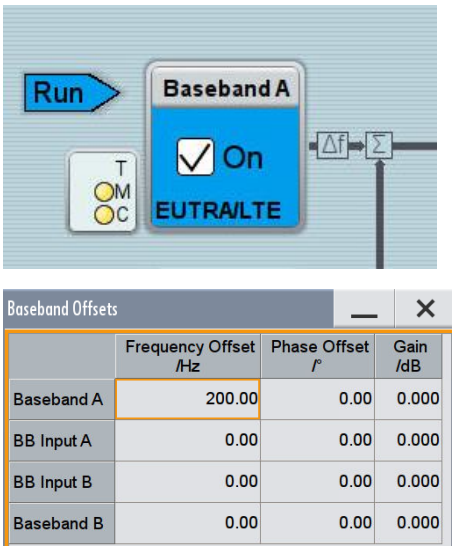


Fig. 3-237: Frequency offset

7. Set the timing offset for the NPRACH (see Table 3-96) in the tab **Trigger In**. Please note that this delay is not possible with the AUTO trigger mode.

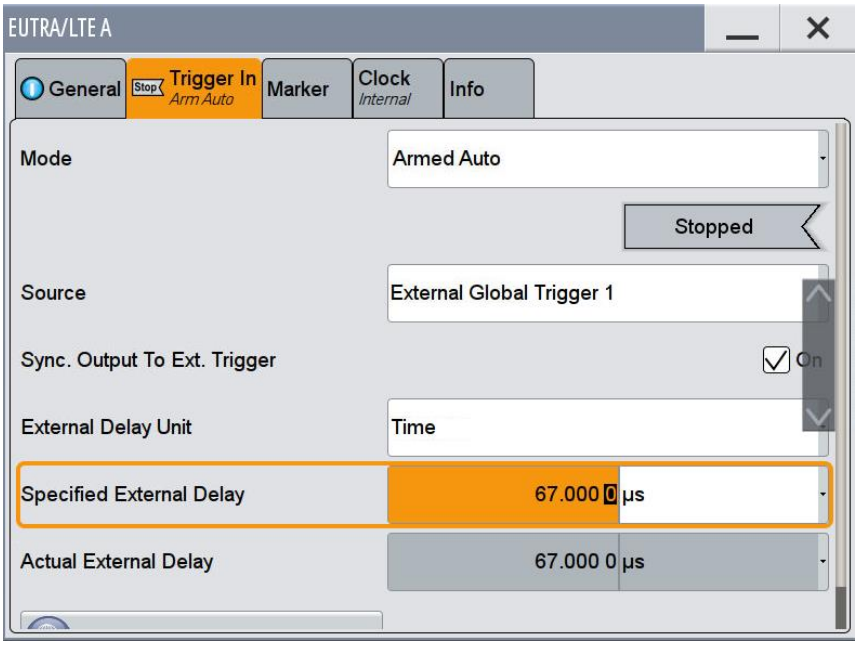


Fig. 3-238: NPRACH timing offset via trigger delay

AWGN and Fading

8. Set **Fading** according to **EPA 1 Hz Low** (see 3.1.3)
9. Set **noise power** and **SNR. Take in account the SNR correction factor** (see 3.1.4)(example: Noise = -100.5 dBm; SNR = SNR + Correction = 6.7 dB -16.81 dB = -10.11 dB)

Demo program

Fig. 3-239 shows the parameters of the test. You can select the test in the section **8.5 NB-IoT.** Select one test under **8.5.3 NPRACH Test**. The tests are listed by the fading, offset and the repetition. When selecting a particular test all settings are default according to the specification. The setting of the SNR depends on the spacing. As only one subcarriers is used a special SNR correction factor is applied. The fading settings are displayed in the section **Fading**. There also select the correlation matrix (default: Low). In addition, select the **Preamble Format**.

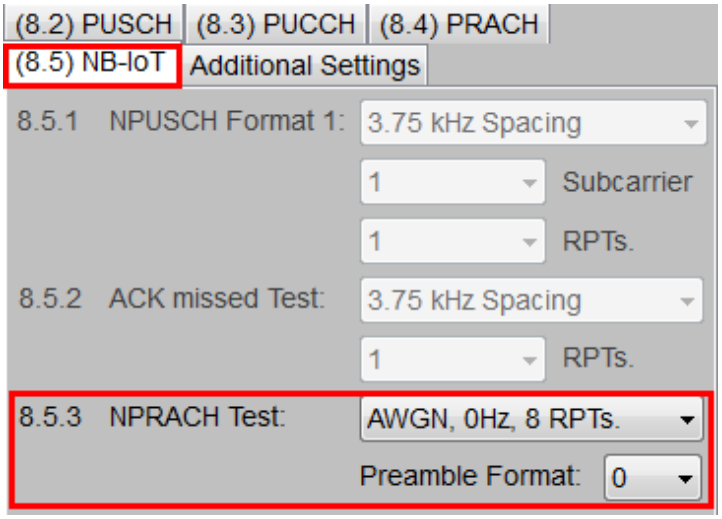


Fig. 3-239: Parameter for PUSCH test 8.5.3

Fig. 3-240 shows the report.

```
******* Performance Tests *******

8.5.3 Performance Requirements for NPRACH

Scenario: AWGN, 0 Hz Frequency Offset and 8 Repetitions
Preamble Format: 0

Bandwidth: 0.2 MHz
Duplex Mode: FDD
AWGN: -100.5 dBm
SNR: -1.8 dB
SNR Correction: -16.81 dB
Finished!
```

Fig. 3-240: Report 8.5.3

4 Appendix

4.1 R&S TSrun Program

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

Requirements

Operating system:

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

General PC requirements:

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

Remote control interface:

- National Instruments VISA
- GPIB card

Or

- LAN connectionAfter TSrun is launched, the following splash screen appears:

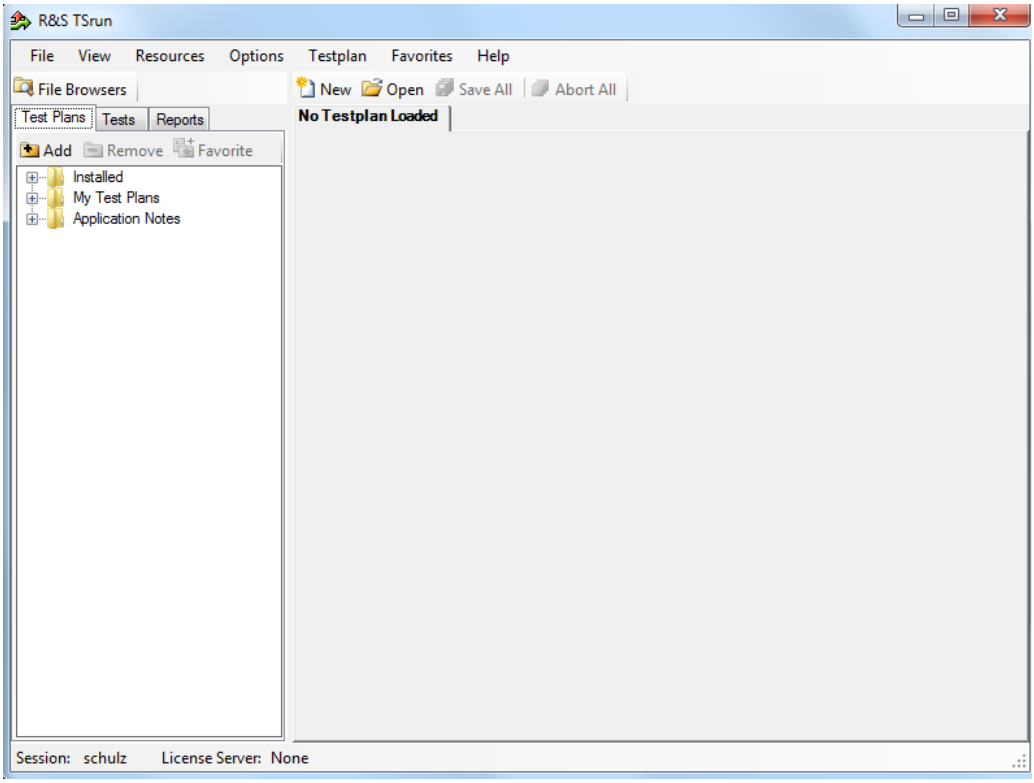


Fig. 4-1: Overview TSrun

Tests and test plans

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

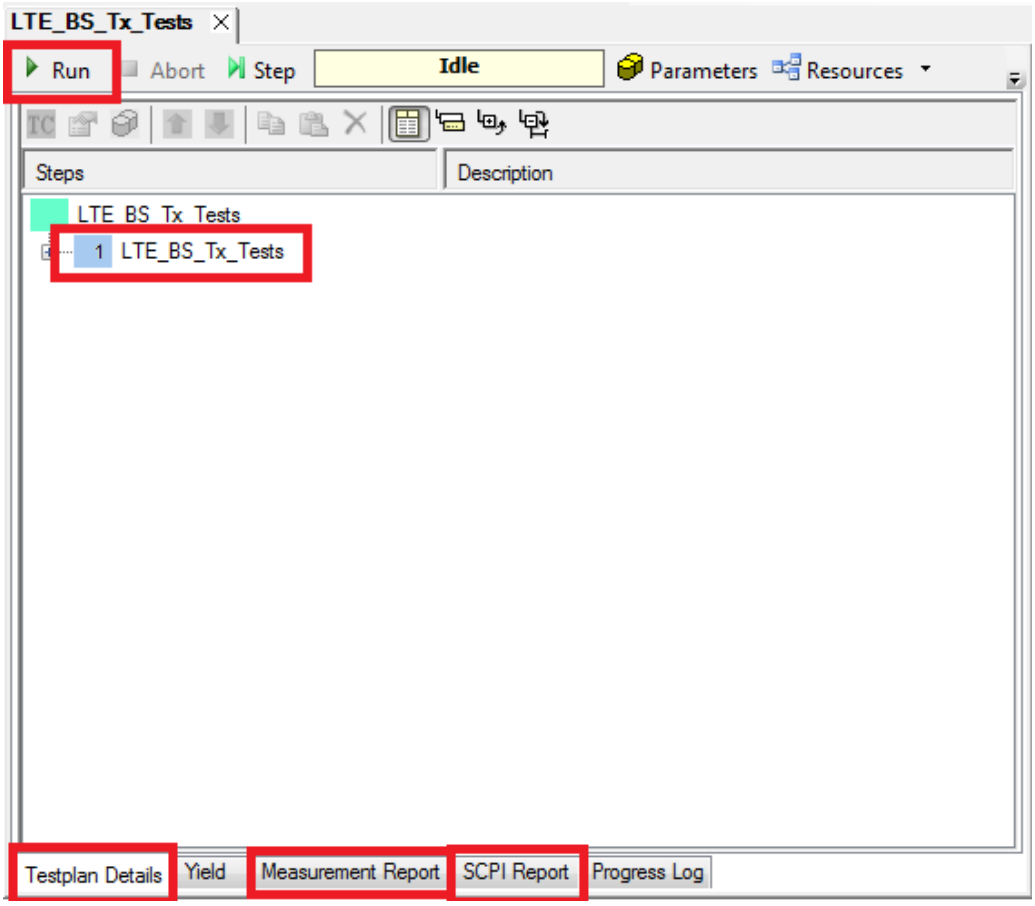


Fig. 4-2: Overview of a test plan in TSrun. The test plan in the example contains only one test (LTE_BS_Tx_Tests). After the test is completed, the bar along the bottom can be used to display the measurement and SCPI reports.

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

Click RUN to start the current test plan.

SCPI connections

Under Resources|SCPI Connections, you can add all required instruments for remote control.

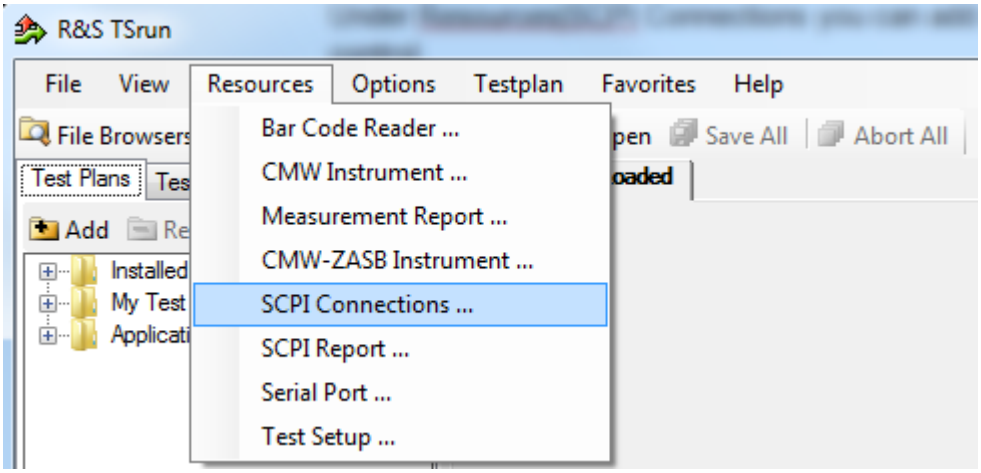


Fig. 4-3: Setting the SCPI connections.

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

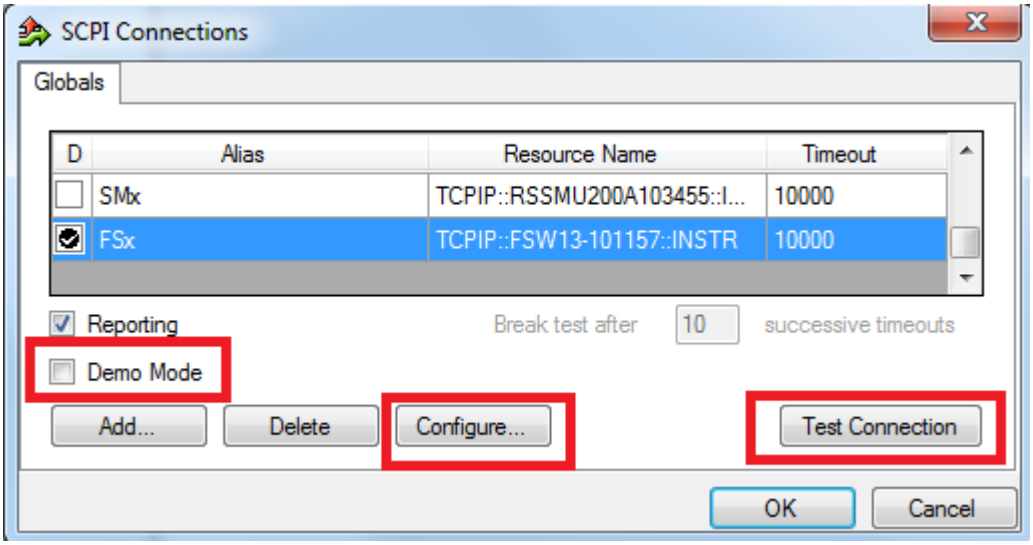


Fig. 4-4: SCPI connections.

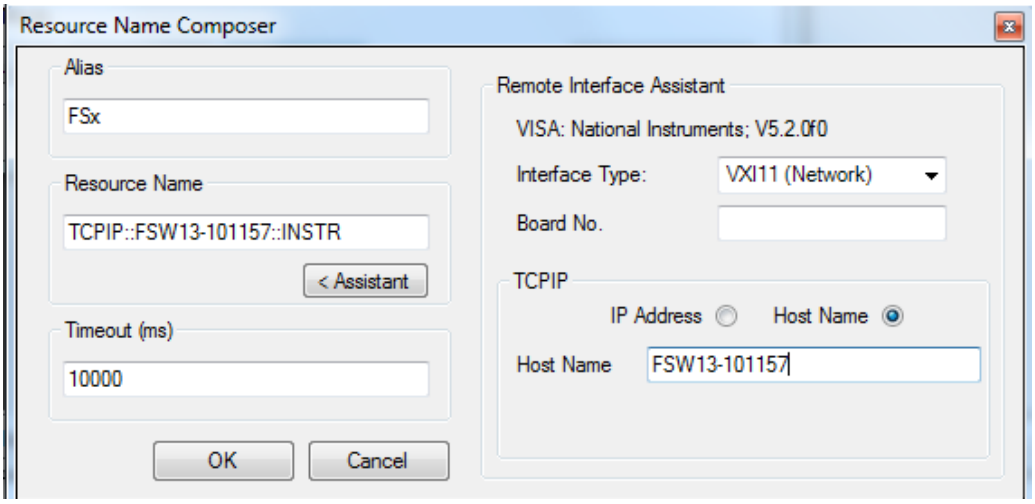


Fig. 4-5: Wizard for entering VISA parameters. Both the IP address and a host name can be entered directly.

Reports: Measurement and SCPI

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

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

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

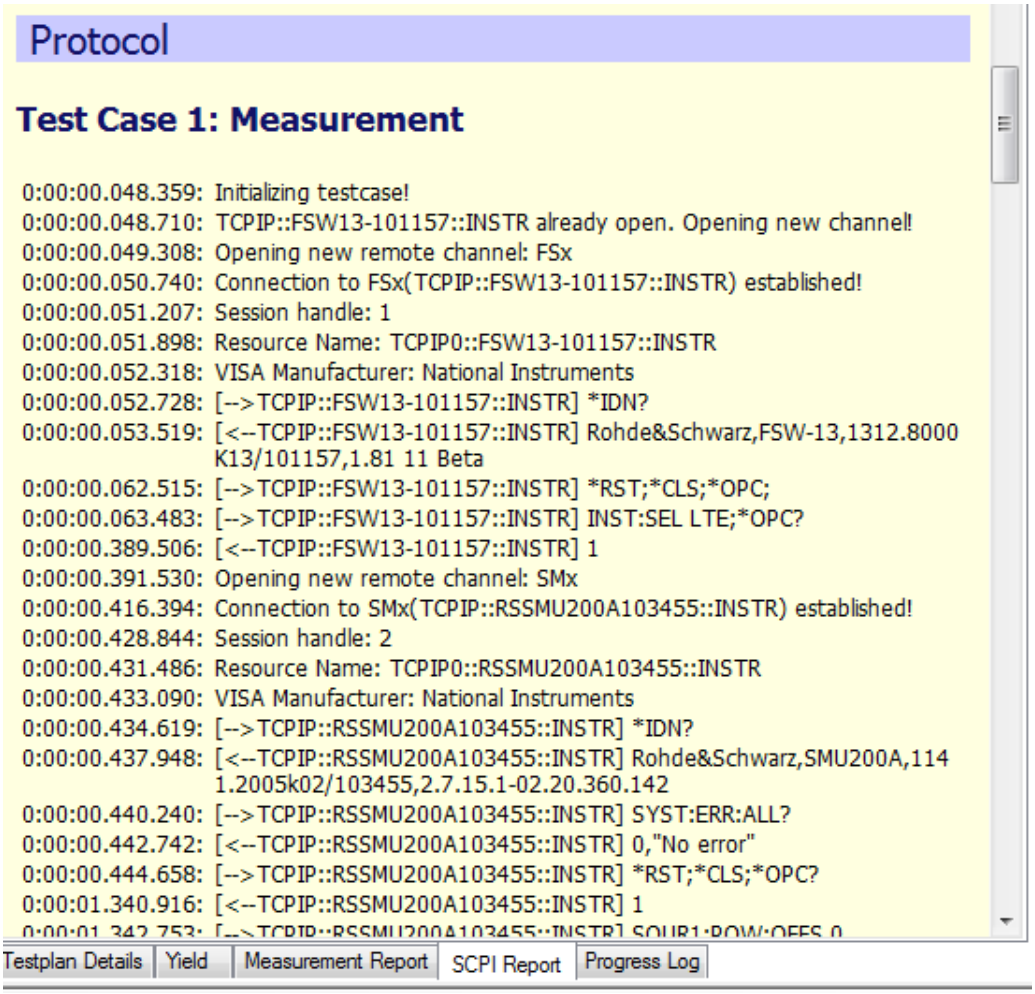


Fig. 4-6: SCPI report.

4.2 References

[1] Technical Specification Group Radio Access Network; **E-UTRA Base Station Conformance Testing**, **Release 14; 3GPP TS 36.141**, V 14.9.0, March 2019

[2] Rohde & Schwarz: **UMTS Long Term Evolution (LTE) Technology Introduction**, Application Note 1MA111, October 2012

[3] Rohde & Schwarz: **LTE-A Base Station Receiver Tests according to TS 36.141 Rel. 14**, Application Note 1MA195, May 2019

[4] Rohde & Schwarz: **LTE-A Base Station Transmitter Tests according to TS 36.141 Rel. 14**, Application Note 1MA154, May 2019

[5] Technical Specification Group Radio Access Network; **E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) Conformance Testing**, **Release 10; 3GPP TS 37.141**, V 10.10.0, July 2013

[6] Technical Specification Group Radio Access Network; **E-UTRA Physical Layer Procedures, Release 10; 3GPP TS 36.213**, V10.10.0, June 2013

[7] Technical Specification Group Radio Access Network; **E-UTRA Physical Channels and Modulation, Release 10; 3GPP TS 36.211**, V10.7.0, February 2013

[8] Rohde & Schwarz: **Measuring Multistandard Radio Base Stations according to TS 37.141,** Application Note 1MA198, July 2012

[9] Rohde & Schwarz: **LTE-Advanced (3GPP Rel.11) Technology Introduction,** White Paper 1MA232, July 2013

[10] Rohde & Schwarz: **LTE-Advanced (3GPP Rel.12) Technology Introduction,** White Paper 1MA252, June 2014

4.3 Additional Information

Please send your comments and suggestions regarding this white paper to

TM-Applications@rohde-schwarz.com

4.4 Ordering Information

Ordering Information for Signal Generators		
Vector Signal Generator		
Product Description	**Type**	**Ordering No.**
Vector Signal Generator	**SMW200A**	**1412.0000.02**
Baseband Generator	SMW-B10	1413.1200.02
Baseband Generator	SMW-B11	1159.8411.02
Baseband Main Module	SMW-B13	1141.8003.04
Fading Simulator	SMW-B14	1413.1500.02
1st RF path	SMW-B10x	
2nd RF path	SMW-B20x	
AWGN	SMW-K62	1413.3484.02
Digital Standard LTE/EUTRA	SMW-K55	1413.4180.02
LTE Release 10 / LTE-Advanced	SMW-K85	1413.5487.02
LTE Release 13/14	SMW-K119	1414.3542.02
Cellular IoT	SMW-K115	1414.2723.02
Dynamic Fading	SMW-K71	1413.3532.02
MIMO Fading/Routing	SMW-K74	1413.3632.02
Differential Analog I/Q Outputs	SMW-K16	1413.3384.02
Digital Baseband Output	SMW-K18	1413.3432.02
Signal Generator		
Product Description	**Type**	**Ordering No.**
SGMA RF Source	**SGS100A**	**1416.0505.02**
SGMA RF Source	**SGT100A**	**1419.4501.02**

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

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Environmental commitment

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

Certified Quality System
ISO 9001

PAD-T-M: 3573.7380.02/02.00/CI/1/EN/

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