

# R&S®CMsequencer

One graphical scripting tool for  
every automated 5G testing need



Product Brochure  
Version 02.00

**ROHDE & SCHWARZ**

Make ideas real



## AT A GLANCE

R&S®CMsequencer is a graphical scripting interface that creates, configures and executes test scripts on the R&S®CMX500 radio communication tester. R&S®CMsequencer is part of R&S®CMSquares, the powerful R&S®CMX500 user interface and control center.

## Background

It is impossible to underestimate the significance of automated testing in the wireless industry. Countless tools, apps and automation frameworks have been developed for such testing because it is so important and the number of applications is so vast. When testing with the 5G R&S®CMX500 radio communication tester, an automated testing that covers all aspects of 5G testing is mission critical, whether for FR1 RF parametric tests, FR2 over-the-air (OTA) measurements or end-to-end (E2E) maximum IP throughput.

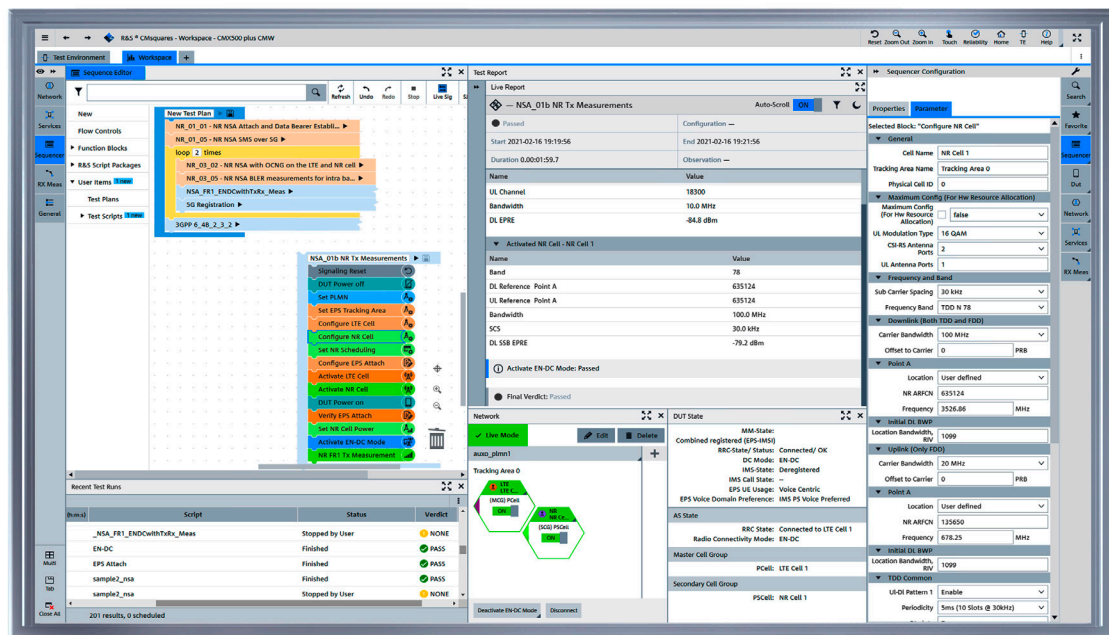
Historically, separate tools/applications with nothing in common and completely disconnected from one another have addressed various testing areas. This means everything may be different, including the user interface and the type of user configuration, the handling of DUT automation and test plans and the way results are generated. Such unparalleled variations often make the user learning curve difficult and steep. Even when using the same network emulator, an enormous amount of time and effort have to be invested in learning the different tools to configure and test hardware functions, reducing efficiency.

## New era in graphically creating and executing tests

History need not repeat itself. Rohde&Schwarz offers a single graphical scripting application for automated 5G testing that covers any testing, automation and result management needs. Thanks to the unique, intuitive and flexible graphical user interface, R&S®CMX500 users never have to deal with multiple tools. Handling different testing use cases with a unified user interface flattens the learning curve and opens up opportunities to move beyond the testing limits imposed by fragmented applications.

The future will have a more unified approach, where all necessary functions for any kind of 5G testing are available from a single graphical user interface.

With R&S®CMsquares sequencer or just R&S®CMsequencer, Rohde&Schwarz provides unique and intuitive ways to create test sequences for a wide range of test use cases, including 5G RF parametric testing, 3GPP RF testing, protocol verification and E2E IP testing. Working seamlessly with R&S®CMsquares interactive mode, R&S®CMsequencer makes it simple to create and execute test scripts and test plans in an automated environment. Users build tests by arranging color coded functional blocks one after the other, making the whole process child's play. 5G testing has never been easier.



R&S<sup>®</sup>CMsequencer, well nested in web based R&S<sup>®</sup>CMsquares, brings the right balance of simplicity and flexibility to graphical scripting.

# BENEFITS

R&S®CMsequencer is ideal for many testing activities with the R&S®CMX500. Chipset manufacturers, module makers, OEMs, network operators, regulatory organizations, service and repair companies – R&S®CMsequencer can support almost any use case. R&S®CMsequencer simplifies workflows and helps create and execute test scripts and test plans and clearly displays the execution results.

## STATE-OF-THE-ART, FUTURE-PROOF SOFTWARE

The world of software is trending towards web applications. R&S®CMsequencer and R&S®CMsquares interactive mode are web based applications and can work on any operating system.

## COMPLETE TEST COVERAGE IN ONE GRAPHICAL APPLICATION

In RF parametric tests, 3GPP RF tests, throughput tests, mobility tests, failure scenarios or any combination of them – R&S®CMsequencer provides a single location for creating and executing tests.

## BUILT-IN AUTOMATED CAMPAIGN MANAGEMENT

R&S®CMsequencer has sophisticated features to create test campaigns, automate DUT handling during remote execution and result collection, including 3D measurement charts for FR2.

## SIMPLIFIED WAY TO CONTROL EXTERNAL EQUIPMENT

OTA chambers for FR2 testing, power supplies for battery life testing or other external equipment – R&S®CMsequencer makes controlling and handling external equipment easy.

## AUTOMATIC DUT-SUPPORTED BAND COMBINATION TESTS

Effortless scanning through all DUT-supported band combinations and verifying KPIs (RF, throughput, etc.) in each band combination.

# R&S®CMsequencer HIGHLIGHTS

R&S®CMsequencer is embedded in the R&S®CMsquares web interface concept from Rohde & Schwarz, where it introduces users to seamless and uniform testing in both interactive and graphical scripting modes.

## Unblock tests with blocks

R&S®CMsequencer blocks form both the biggest and smallest units. From test campaigns to changing scheduling configurations, from controlling positioners in OTA chambers to adding user prompts, blocks are available for any operation. Having a single unit streamlines the creation of both simple and more complicated test sequences.

Blocks are placed in categories and rules are applied to the blocks in a particular category. Test script blocks can contain signaling or RF measuring blocks, but a test script block cannot contain another test script block. A block with multiple test script blocks is a test plan block.

Functional blocks are color coded for better understanding. For example, LTE blocks are orange, whereas NR blocks are green. Every block covers certain parameters. Users can set these parameters to control block actions

and configure R&S®CMX500 and DUT signaling interactions. For example, NR cell properties such as band, bandwidth and subcarrier spacing (SCS) can be configured in an NR cell block.

## View events and measurements live or offline

Test sequences that merely provide a pass/fail verdict are usually inadequate. Reports often need to outline the important events that occurred during execution. When performing RF or E2E measurements, measurement reports presenting measurement values as tables or graphical charts can also be valuable.

Such reports are important during runtime when executing individual test scripts. With live reporting, users get results immediately rather than having to wait until the end of the test script execution. But for regression tests or running test plans in an automated environment, offline test reports are essential for post analysis and generating final results.

## Sequential arrangement of blocks with detailed parameterization

Test scripting could not be any easier.

The diagram illustrates the sequential arrangement of blocks in a test script and the detailed parameterization for an NR Cell block.

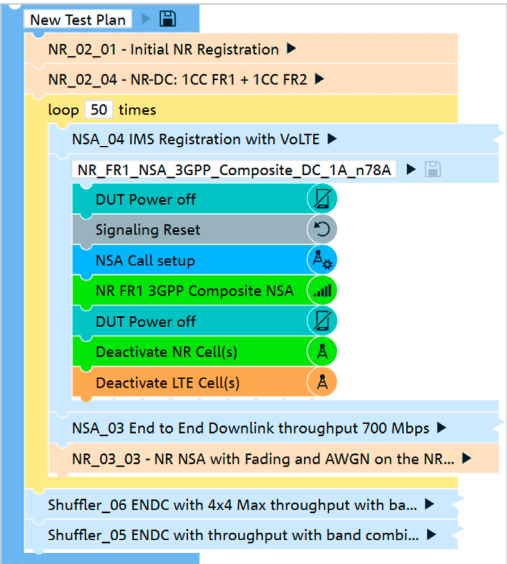
**Test Script Blocks (Left):**

- NSA RF meas, Voice call, Max Tput
- Signaling Reset
- NSA Call setup
- LTE Tx Measurement
- NR FR1 Tx Measurement
- Cellular Rx Sensitivity
- User Prompt
- Establish Call
- Wait
- Release Call
- Set NR Scheduling
- Start IP Data Service
- Wait
- Stop IP Data Service

**NR Cell Parameterization (Right):**

Properties	Parameter
<b>NR Cell</b>	
Cell Name	NR Cell 1
Max. Cell Power	-44.800 dBm
<b>Downlink-Uplink</b>	
Frequency Range	FR1
Duplex Mode	TDD
Frequency Band Indicator	TDD N 78
SubCarrierSpacing	30 kHz
<b>Downlink-Uplink</b>	
Carrier Bandwidth	100 MHz
Point A Location	Mid Range
Set Carrier Center	false

R&S®CMsequencer can do both live and offline reports. When executed from the graphical user interface, live reporting squares show important events and measurement results both in tables and graphs. FR2 reports also include 3D measurement graphs. At the end of every test, an offline report is created in various formats (.pdf, .csv, .html).



### Manage automated test campaigns

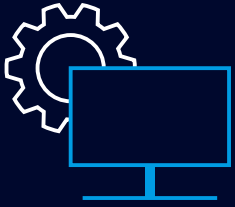
Using the same graphical interface that was used to create the tests to add them into automated regression campaigns saves a lot of time. In an environment with a familiar look and feel, test sequences can be added to a test plan and executed with a single click. Scripts created in both R&S®CMsequencer and the R&S®CMSquares Python interface can be executed. R&S®CMsequencer is the default campaign management tool in the R&S®CMSquares software toolchain.

Robust features for managing test campaigns on the R&S®CMX500, regardless of the interface used to create test scripts.

Activated LTE Cell - LTE Cell 1								
Activated NR Cell - NR Cell 1								
Name				Value				
Band				78				
DL Reference Point A				620046				
UL Reference Point A				620046				
Bandwidth				10.0 MHz				
SCS				30.0 kHz				
DL SSB EPRE				-69.3 dBm				
DUT Information								
IMEI				353585110017012				
<div><div></div> Activate EN-DC Mode: Passed</div>								
NR FR1 - 6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1 @ DC_1A_n78/15kHz [30kHz/5MHz] 10MHz								
Test Item	Test Condition			Lower Limit	Upper Limit	Measured	Unit	Verdict
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM QPSK;Inner_Full(12@6);Pumaxpc3;ID:23			19.50	25.00	26.07	dBm	Failed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM QPSK;Edge_1RB_Left(1@0);Pumaxpc3;ID:24			17.50	25.00	24.30	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM QPSK;Edge_1RB_Right(1@23);Pumaxpc3;ID:25			17.50	25.00	23.85	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM QPSK;Outer_Full(24@0);Pumaxpc3;ID:26			17.50	25.00	24.61	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 16 QAM;Inner_Full(12@6);Pumaxpc3;ID:27			19.00	25.00	25.62	dBm	Failed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 16 QAM;Edge_1RB_Left(1@0);Pumaxpc3;ID:28			17.50	25.00	24.48	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 16 QAM;Edge_1RB_Right(1@23);Pumaxpc3;ID:29			17.50	25.00	24.00	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 16 QAM;Outer_Full(24@0);Pumaxpc3;ID:30			17.50	25.00	24.63	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 64 QAM;Edge_1RB_Left(1@0);Pumaxpc3;ID:31			16.00	25.00	24.22	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 64 QAM;Edge_1RB_Right(1@23);Pumaxpc3;ID:32			16.00	25.00	23.73	dBm	Passed
6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1	n78;620334;10MHz;30kHz;CP-OFDM 64 QAM;Outer_Full(24@0);Pumaxpc3;ID:33			16.00	25.00	24.04	dBm	Passed

Live updates on executing scripts with optional downloads of reports in various file formats.

# TESTING USE CASES



## 3GPP RF AUTOMATED TESTS

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## ITERATE THROUGH DEVICE MRDC BAND COMBINATIONS

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## MULTI-EVAL, BLER AND SENSITIVITY TESTS

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## MOBILITY, FAILURE AND REJECT SCENARIOS

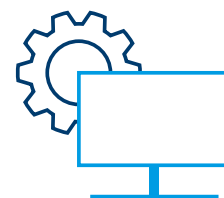
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## END-TO-END APPLICATION TESTS

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# 3GPP RF AUTOMATED TESTS



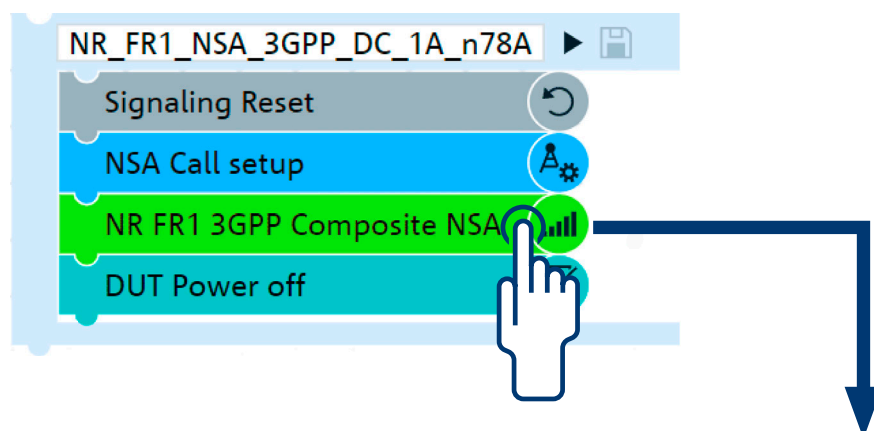
Verifying 3GPP RF test cases in line with TS38.521 (pre-conformance) is one of the most basic and important use cases for 5G testing. Verifying sections 6 and 7, TX and RX tests provide the basic sanity tests for device RF characteristics.

R&S®CMsequencer offers these tests simply and automatically for a one-click test execution solution. Special 3GPP blocks that comply with the configuration and test points in 3GPP TS38.521 offer a ready-made way to test device RF functions. R&S®CMsequencer 3GPP blocks also allow modification of default configurations and the flexibility to test non-compliant configurations.

Even though easy 3GPP testing configuration and execution are important, comprehensive measurement reports for these tests are also vital. R&S®CMsequencer measurement reports come in various formats providing a tabular summary of all 3GPP measurements with verdicts for each measurement added to the right. Results and verdicts are immediately available along with summary verdicts for all 3GPP tests.

## 3GPP RF automated tests

3GPP RF automated tests are a smart way to test 3GPP compliant RF test cases and allow test point configuration modification.



“NR FR1 3GPP Composite NSA” opens a window where users can select and configure 3GPP TX and RX tests.

3GPP Settings ...

Set Default
Delete User Band
Add User Band

Testcase ID  
☐ R15

☐ 6 Transmitter characteristics

☐ 6.2B.1.3 UE Maximum Output Power for Inter-Band EN-DC within FR1
☐ 6.2B.2.3 UE Maximum Output Power reduction for Inter-Band EN-DC within FR1
☐ 6.2B.3.3 UE Additional Maximum Output Power reduction for Inter-Band EN-DC within FR1
☐ 6.2B.4.1.3 Configured Output Power for Inter-Band EN-DC within FR1
☐ 6.3B.1.3 Minimum output power for inter-band EN-DC within FR1
☐ 6.3B.3.3 Tx ON/OFF time mask for inter-band EN-DC within FR1
☐ 6.3B.4.3 PRACH Time Mask for inter-band EN-DC within FR1
☐ 6.3B.8.1.3 Absolute Power Tolerance for inter-band EN-DC within FR1

3GPP Config

Band Combination		LTE		NR				UE Capabilities		
Band	Test	Bandwidth (MHz)	Channel	SCS (kHz)	BW Low	BW Mid	BW High	Channel	User Defined UE Capability	Access Stratum Release
DC_1A_n77A	<input type="checkbox"/>	5	mid	30	low	mid	high	low,mid,high	<input type="checkbox"/>	rel16
DC_1A_n78A	<input type="checkbox"/>	5	mid	30	low	mid	high	low,mid,high	<input type="checkbox"/>	rel16
DC_1A_n79A	<input type="checkbox"/>	5	mid	30	low	mid	high	low,mid,high	<input type="checkbox"/>	rel16
DC_2A_n5A	<input type="checkbox"/>	5	mid	15	low	mid	high	low,mid,high	<input type="checkbox"/>	rel16
DC_2A_n41A	<input type="checkbox"/>	5	mid	30	low	mid	high	low,mid,high	<input type="checkbox"/>	rel16



# MULTI-EVAL, BLER AND SENSITIVITY TESTS



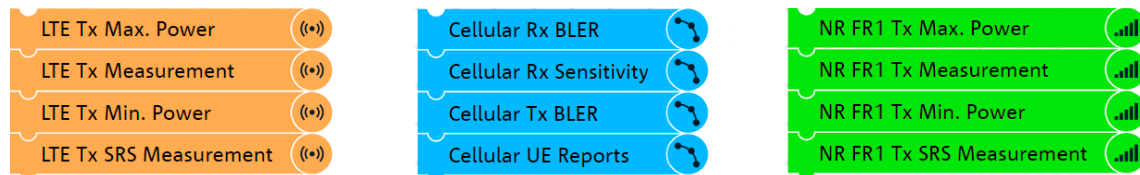
R&S<sup>®</sup>CMsequencer offers blocks to thoroughly verify RF parametric DUT tests for more R&D focused RF applications. Transmission and receiver characteristic tests, such as error vector magnitude (EVM), spurious emissions and RX sensitivity are just a block away with R&S<sup>®</sup>CMsequencer. Sweeping channels, bands, bandwidth and TX/RX testing for every iteration is greatly simplified with R&S<sup>®</sup>CMsequencer. Fast frequency change allows time-optimized performance of such sweep tests.

As with 3GPP tests, comprehensive test reports are generated in .csv format for post processing. Executing these tests (including 3GPP tests) can be automated both with R&S<sup>®</sup>CMsequencer and your custom automation framework.

Faceless R&S<sup>®</sup>CMsequencer enables the integration of execution R&S<sup>®</sup>CMsequencer test scripts and test plans and collection of test results in any custom automation framework.

Note: R&S<sup>®</sup>CMsequencer offers complete flexibility when mixing 3GPP test blocks with R&D RF measurement blocks. Having one single test creation and automation tool for all 5G testing use cases, gives users the freedom to fulfill their testing needs with complete flexibility and confidence.

All RF related TX/RX measurements are just a block away.



▶ Activated LTE Cell - LTE Cell 1						
▶ Activated NR Cell - NR Cell 1						
▶ LTE TX Measurements - Modulation @Band 2, UL ARFCN = 18900, UL Freq. = 1880.0MHz, DC Mode = OFF						
▶ LTE TX Measurements - ESFL @Band 2, UL ARFCN = 18900, UL Freq. = 1880.0MHz, DC Mode = OFF						
▶ LTE TX Measurements - Spectrum @Band 2, UL ARFCN = 18900, UL Freq. = 1880.0MHz, DC Mode = OFF						
i Activate EN-DC Mode: Passed						
▶ NR FR1 TX Measurement @NR Band n41; UL: Point-A ARFCN 518600 (2593.000 MHz); Center Freq. = 2642.140; DC-MODE = EN-DC						
▶ LTE RX Sensitivity @Band 2, DL ARFCN = 900, DL Freq. = 1960.0MHz, DC Mode = EN-DC						
▼ NR RX Sensitivity @Band 41, DL ARFCN = 518600, DL Freq. = 2593.0MHz, DC Mode = EN-DC						
Test Item	Target Throughput[%]	Measured Throughput[%]	Sensitivity Limit	Cell Power	Unit	Verdict
NR Sensitivity #1	95.0	100.0	-85.6	-75.0	dBm	Passed
NR Sensitivity #2	95.0	100.0	-85.6	-76.0	dBm	Passed
NR Sensitivity #3	95.0	100.0	-85.6	-77.0	dBm	Passed
NR Sensitivity #4	95.0	100.0	-85.6	-78.0	dBm	Passed
NR Sensitivity #5	95.0	100.0	-85.6	-79.0	dBm	Passed
NR Sensitivity #6	95.0	100.0	-85.6	-80.0	dBm	Passed



# END-TO-END APPLICATION TESTS



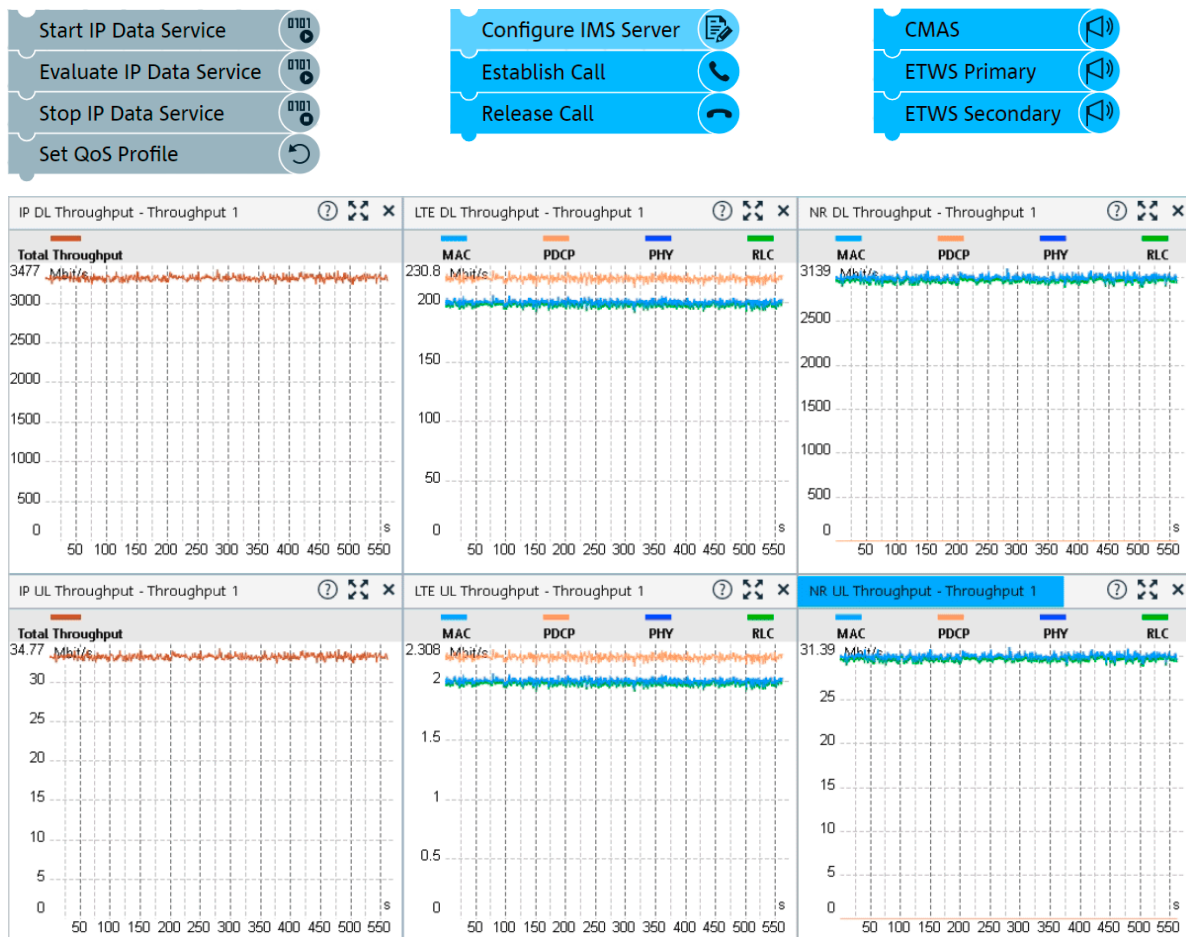
Verification of high-level KPIs such as end-to-end (E2E) throughput, audio tests or battery-life tests are extremely important for 5G DUTs. To fulfill these testing needs, R&S®CMsequencer offers blocks and functions to automatically verify such high-level KPIs.

Features such as carrier aggregation (CA) with E2E IP level throughput (TCP/UDP), VoNR, EPS fallback to LTE, battery consumption monitoring and audio codec tests can be easily created and tested with R&S®CMsequencer. Additional equipment for testing these functions can be handled directly by R&S®CMsequencer. This can all be

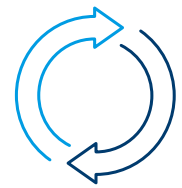
done from the comfort of R&S®CMsequencer for external equipment configuration and control. Test reports log all the data generated during the tests as tables and charts or graphs.

Note: When an E2E application is configured with R&S®CMsequencer, measurements are automatically reflected in R&S®CMsquares interactive mode. Users can seamlessly switch to interactive mode to continue interactive testing.

E2E application tests: R&S®CMsequencer offers exhaustive E2E IP level testing possibilities.



# ITERATE THROUGH DEVICE MRDC BAND COMBINATIONS



As specified in 3GPP, LTE and NR have many thousand band combinations. If a device had to be verified against all the band combinations it supports during functional or RF verification, testing times would be extremely long and the tests would require a lot of manual effort from users.

The R&S®CMsequencer Shuffler easily performs an automatic iteration across the bands and band combinations reported by the DUT. This drastically reduces the time and effort needed to test RF, signaling and IP throughput performance for all supported combinations.

Any combination of LTE, NR FR1, NR FR2, EN-DC, NR-DC and NR-CA can be tested as long as the required resources are supported by R&S®CMX500 hardware capabilities. These combinations can be read directly from the UE, or users can feed these band combinations through a file.

With pre-defined and verified test scripts from Rohde&Schwarz, users do not have to start from scratch and with minimal changes can adapt these tests to their needs. Thanks to this high level of automation and flexibility, iterating band combination testing has never been so quick and easy.

## Highlights

- ▶ Single-click solution to iterate through all band combinations reported in UE capabilities
- ▶ Highly flexible testing of various device functionalities (TX/RX measurements, throughput, VoLTE/VoNR, etc.)
- ▶ All band combinations in a single test report
- ▶ Band combination input from various sources (e.g. csv file)

## R&S®CMsequencer Shuffler

The R&S®CMsequencer Shuffler iterates through device MRDC band combinations for fully automated DUT health checks.

The diagram illustrates the R&S®CMsequencer Shuffler's functionality. On the left, a smartphone screen displays a list of MRDC band combinations: DC-1A-78A, DC-7A-7A-N77A, DC-2A-2A-7A-N71A, and DC-3A-3A-7A-7A-8A-N78A. A red oval highlights the first three combinations. A large arrow points from the smartphone screen to a test report on the right. The test report is a table with the following structure:

MRDC BandCombination	Test Results
DC_1A_n77A	Activated LTE Cell - LTE Cell 1 Activated NR Cell - NR Cell 1 Activate EN-DC Mode: Passed NR FR1 TX Measurement @NR Band n77; UL: Point-A ARFCN 650000 (3750.000 MHz); Center Freq. = 3799.140; DC-MODE = EN-DC
DC_1A_n79A	Activated LTE Cell - LTE Cell 1 Activated NR Cell - NR Cell 1 Activate EN-DC Mode: Passed NR FR1 TX Measurement @NR Band n79; UL: Point-A ARFCN 713334 (4700.010 MHz); Center Freq. = 4749.150; DC-MODE = EN-DC
DC_3A_n7A	Activated LTE Cell - LTE Cell 1 Activated NR Cell - NR Cell 1 Activate EN-DC Mode: Passed NR FR1 TX Measurement @NR Band n7; UL: Point-A ARFCN 135650 (678.250 MHz); Center Freq. = 687.790; DC-MODE = OFF
DC_3A_n28A	Activated LTE Cell - LTE Cell 1 Activated NR Cell - NR Cell 1 Activate EN-DC Mode: Passed NR FR1 TX Measurement @NR Band n28; UL: Point-A ARFCN 135650 (678.250 MHz); Center Freq. = 682.930; DC-MODE = OFF

# MOBILITY, FAILURE AND REJECT SCENARIOS



One of the main advantages of a test and measurement instrument is to create mobility, failure and reject scenarios with all possible error causes. R&S®CMsequencer creates negative testing use cases to ensure device functionality in all imaginable conditions. Dedicated blocks support RRC, NAS or IMS related rejects or failures with 3GPP defined fallbacks to bring the DUT in a well-defined state.

Verify EPS Attach Failure	
LTE SCG Addition Failure	
Verify EPS PDN Connectivity Reject	
Verify EPS Tracking Area Update Reject	
Verify EPS Bearer Resource Allocation Reject	
Verify EPS Service Reject	
Verify 5GS PDU Session Establishment Reject	
Verify 5GS Registration Failure	
Radio Link Failure	

Dedicated reject and failure block examples.

## Dedicated reject and failure block examples

Mobility	LTE	NR
LTE	<ul style="list-style-type: none"> <li>▶ Reselection</li> <li>▶ Handover (with and without EN-DC)</li> <li>▶ Handover (with NR cell change)</li> <li>▶ Redirection</li> <li>▶ Radio link failure (with and without EN-DC)</li> <li>▶ Fast frequency change (both LTE and NR)</li> </ul>	<ul style="list-style-type: none"> <li>▶ Reselection</li> <li>▶ Handover</li> <li>▶ Redirection</li> </ul>
NR	<ul style="list-style-type: none"> <li>▶ Reselection</li> <li>▶ Handover (with and without EN-DC)</li> <li>▶ Redirection</li> <li>▶ EPS fallback with HO and redirection</li> </ul>	<ul style="list-style-type: none"> <li>▶ Reselection</li> <li>▶ Handover</li> <li>▶ Redirection</li> <li>▶ Fast frequency change</li> </ul>

## Service that adds value

- ▶ Worldwide
- ▶ Local and personalized
- ▶ Customized and flexible
- ▶ Uncompromising quality
- ▶ Long-term dependability

## Rohde & Schwarz

The Rohde & Schwarz technology group is among the trailblazers when it comes to paving the way for a safer and connected world with its leading solutions in test & measurement, technology systems and networks & cybersecurity. Founded more than 85 years ago, the group is a reliable partner for industry and government customers around the globe. The independent company is headquartered in Munich, Germany and has an extensive sales and service network with locations in more than 70 countries.

[www.rohde-schwarz.com](http://www.rohde-schwarz.com)

## Sustainable product design

- ▶ Environmental compatibility and eco-footprint
- ▶ Energy efficiency and low emissions
- ▶ Longevity and optimized total cost of ownership

Certified Quality Management  
**ISO 9001**

Certified Environmental Management  
**ISO 14001**

## Rohde & Schwarz training

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