

# Signal generator, signal and spectrum analyzer and power sensor solutions for 5G

When it comes to wideband signal generation and analysis, Rohde & Schwarz provides solutions that go all the way to millimeterwave frequencies and even beyond. Our signal generation and analysis solution portfolio covers the bandwidth and frequency requirements for 5G and offers a wide range of features and application software to address 5G testing challenges.





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# 5G test and measurement challenges

Three things distinguish the 5G air interface from previous cellular generations: higher carrier frequencies, wider carrier bandwidths and flexible physical layer parameterization to support different requirements. The impact of these features on 5G product development and testing includes the following:

## Millimeterwave signal generation and analysis

5G is the first cellular technology to tap into the bandwidth reserves in the centimeterwave and millimeterwave frequency bands. The unique radio properties in these bands make component manufacturing very challenging. To master these challenges, test solutions with excellent RF performance even in the millimeterwave range are needed.

## Wideband signal generation and analysis

5G will support single carrier bandwidths of up to 100 MHz for carrier frequencies below 6 GHz and up to 400 MHz for carrier frequencies in the millimeterwave range. With carrier aggregation, signal bandwidths in the 1 GHz region come into play, making test solutions with wideband signal generation and analysis capabilities a must.

## Over-the-air testing

The short wavelength of millimeterwave frequencies and the higher losses in circuits necessitate a tight integration, making it impractical to supply connections for testing. At the same time, the effects of connectors and test fixtures become non-negligible, potentially affecting the validity of conducted measurements. As a result, over-the-air (OTA) testing will play an important role for higher carrier frequencies, which calls for innovative test solutions.



## Signal configuration and analysis

The 5G physical layer offers a degree of flexibility never seen before, allowing a multitude of parameter options and combinations. As a result, configuring signals for testing can be complicated, time-consuming and prone to error. One needs dedicated solutions that simplify and speed up signal configuration for testing and for subsequent analysis.

## Massive MIMO and beamforming/beam-steering verification

5G employs massive MIMO and beamforming to combat the effects of higher attenuation at higher frequencies and to improve capacity. In particular, beam steering and beam sweeping will be important to cope with the dynamic nature of the wireless channel. Test solutions need to offer a simple way to verify the accuracy of beamforming and the effectiveness of beam-steering techniques.

## Selected Rohde & Schwarz solutions

### Vector signal generators

- ▮ Wideband (up to 2 GHz bandwidth) signal generation up to millimeterwave frequencies
- ▮ General purpose over-the-air receiver testing
- ▮ MIMO and beamforming

### Signal and spectrum analyzers

- ▮ Wideband (up to 5 GHz bandwidth) signal and spectrum analysis up to 90 GHz
- ▮ General-purpose over-the-air transmitter testing

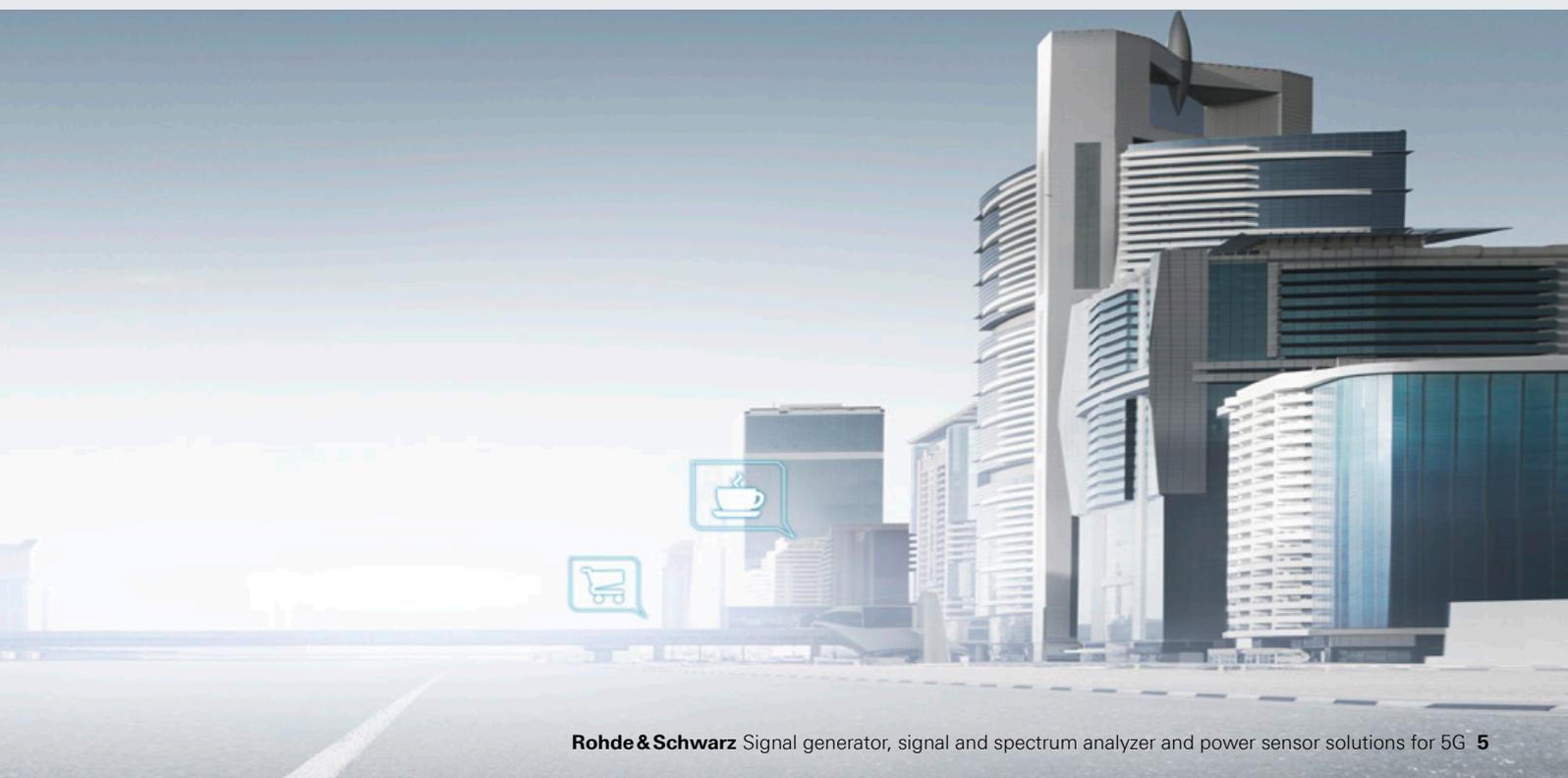
### Power sensors

- ▮ Over-the-air 2D/3D power level calibration and beamforming/beam-steering verification up to 90 GHz

### Dedicated application software

- ▮ Signal configuration and analysis for 5G NR, V5GTF and generic OFDM
- ▮ Amplifier development and characterization
- ▮ Compensating the effects of test fixtures

For more 5G test solutions, see  
[www.rohde-schwarz.com/5G](http://www.rohde-schwarz.com/5G)



# Vector signal generators

Rohde & Schwarz offers a variety of 5G-ready solutions for wideband signal generation applications ranging from research and development to production testing. Our vector signal generators distinguish themselves in their respective class with excellent RF performance out of the box, intuitive user interface and a fully flexible hardware and software option concept.

Thanks to automatic internal amplitude correction, all Rohde & Schwarz vector signal generators produce extremely flat signals over the entire frequency range up to their maximum rated power (e.g. < 0.4 dB measured over 2 GHz bandwidth for the R&S®SMW200A). They also exhibit excellent spectral characteristics, making them ideal for use in both conducted and over-the-air testing. The outstanding amplitude and frequency characteristics ensure that extremely clean 5G NR signals (measured error vector magnitude of less than 0.3% on the R&S®SMW200A for a 5G NR downlink signal with 100 MHz bandwidth) can be generated to test the true performance of a DUT.

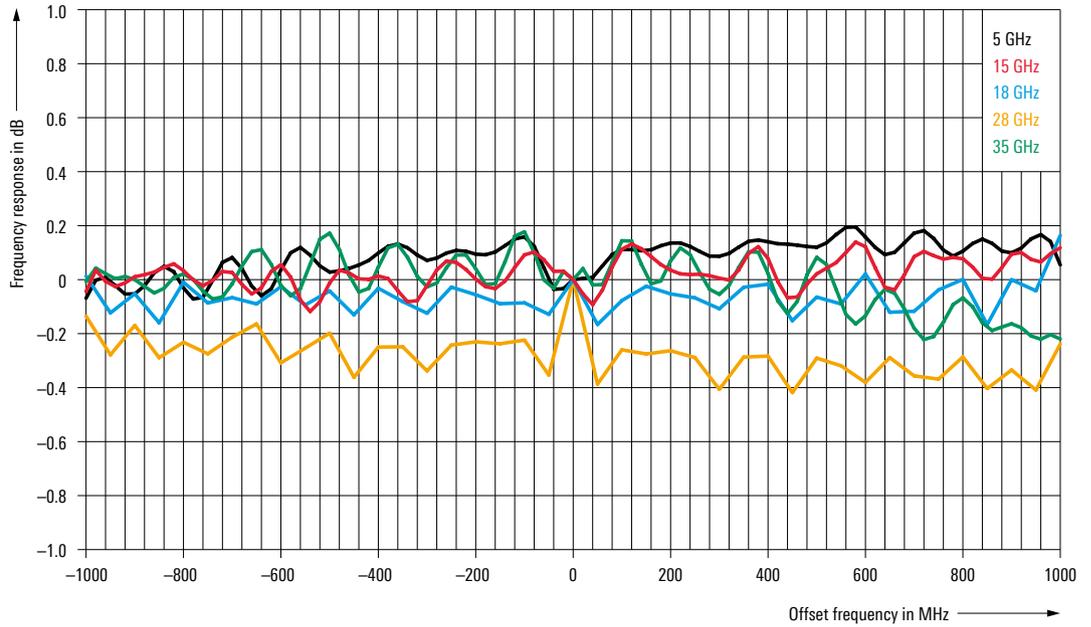
Advanced applications benefit from the full flexibility and scalability offered by the R&S®SMW200A. Up to six R&S®SGT100A SGMA vector RF sources can be connected to a single R&S®SMW200A to provide a compact setup with eight RF outputs, all controlled and configured from the R&S®SMW200A. The setup is scalable and easily duplicated if more RF outputs are required. This capability is especially useful for applications such as beamforming, MIMO, carrier aggregation and multistandard radio testing. The R&S®SMW200A can also be equipped with an optional realtime fading simulator and an AWGN generator, making it an excellent one-box solution for base station performance testing and as a channel emulator for terminal testing.

## Vector signal generator portfolio for 5G applications



|                             | R&S®SMW200A  | R&S®SMBV100B                                  | R&S®SGT100A  | R&S®SGS100A/<br>R&S®SGU100A                          |
|-----------------------------|--|---|--|--|
| <b>Application</b>          | R&D, integration and verification, conformance testing | R&D, production, integration and verification | Production, automated use, RF source for R&S®SMW200A | Production, automated use, RF source for R&S®SMW200A |
| <b>Frequency</b>            | 100 kHz to 40 GHz                                      | 8 kHz to 6 GHz                                | 1 MHz to 6 GHz                                       | 1 MHz to 40 GHz                                      |
| <b>Modulation bandwidth</b> | ≤ 2 GHz  | ≤ 500 MHz                                     | ≤ 240 MHz  | ≤ 2 GHz (ext. analog I/Q)                            |
| <b>RF outputs</b>           | 1 or 2   | 1   | 1  | 1  |
| <b>Rated output power</b>   | + 18 dBm   | + 25 dBm (with option)                        | +17 dBm  | + 15 dBm   |

## Measured I/Q modulation frequency response of the R&S®SMW200A vector signal generator



The R&S®SMW200A produces extremely flat signals over the entire bandwidth, making it possible to test the true performance of a DUT in both conducted and over-the-air measurements.

## Scalable setups for generating signals for advanced 5G applications



|                             | R&S®SMW200A +<br>R&S®SZU100A      | R&S®SMW200A +<br>R&S®SGT100A           | R&S®SMW200A +<br>R&S®SGS100A/<br>R&S®SGU100A | R&S®SMW200A +<br>R&S®SGS100A/<br>R&S®SGU100A |
|-----------------------------|-----------------------------------|--|--|--|
| <b>Application</b>          | R&D, integration and verification | Beamforming, MIMO, carrier aggregation | Beamforming, MIMO, carrier aggregation       | Beamforming, MIMO, carrier aggregation       |
| <b>Frequency</b>            | 57.32 GHz to 65.80 GHz            | 1 MHz to 6 GHz                         | 1 MHz to 40 GHz                              | 1 MHz to 40 GHz                              |
| <b>Modulation bandwidth</b> | ≤ 2 GHz                           | ≤ 160 MHz                              | ≤ 160 MHz                                    | ≤ 2 GHz                                      |
| <b>RF outputs</b>           | 1                                 | ≤ 8                                    | ≤ 3  | ≤ 2  |
| <b>Rated output power</b>   | + 5 dBm                           | + 17 dBm                               | +15 dBm                                      | + 15 dBm                                     |

# Signal and spectrum analyzers

Rohde & Schwarz offers the widest range of spectrum analyzers in the industry for all different phases of 5G development. The R&S®FSW covers frequencies up to 90 GHz, with a built-in demodulation bandwidth of up to 2 GHz, making it the ideal R&D tool with the highest dynamic range.

The R&S®FSW with the R&S®FSW-B1200/-B2001 option with 1200/2000 MHz internal bandwidth, respectively, enables research and development for next generation mobile standards, especially in the millimeterwave 5G frequency bands, as well as characterization of wideband amplifiers for 5G. It offers a high dynamic range and low input signal distortion, with a spurious-free dynamic range (SFDR) of 65 dBc, allowing users to precisely determine the signal modulation quality. The error vector magnitude (EVM) generated by the R&S®FSW itself is excellent, ensuring reliable measurements on signals with very good inherent EVM. For example, the bandwidth extension and the R&S®VSE-K96 OFDM vector signal analysis software allow the R&S®FSW to measure EVM values in the order of < 1 %, even with 800 MHz wide signals in the 28 GHz range.

Combining the R&S®FSW with the Rohde&Schwarz oscilloscopes from the R&S®RTO family yields an industry-leading 5 GHz of demodulation bandwidth in the RF or more than 8 GHz of bandwidth in analog baseband for analysis of signals between chipsets.

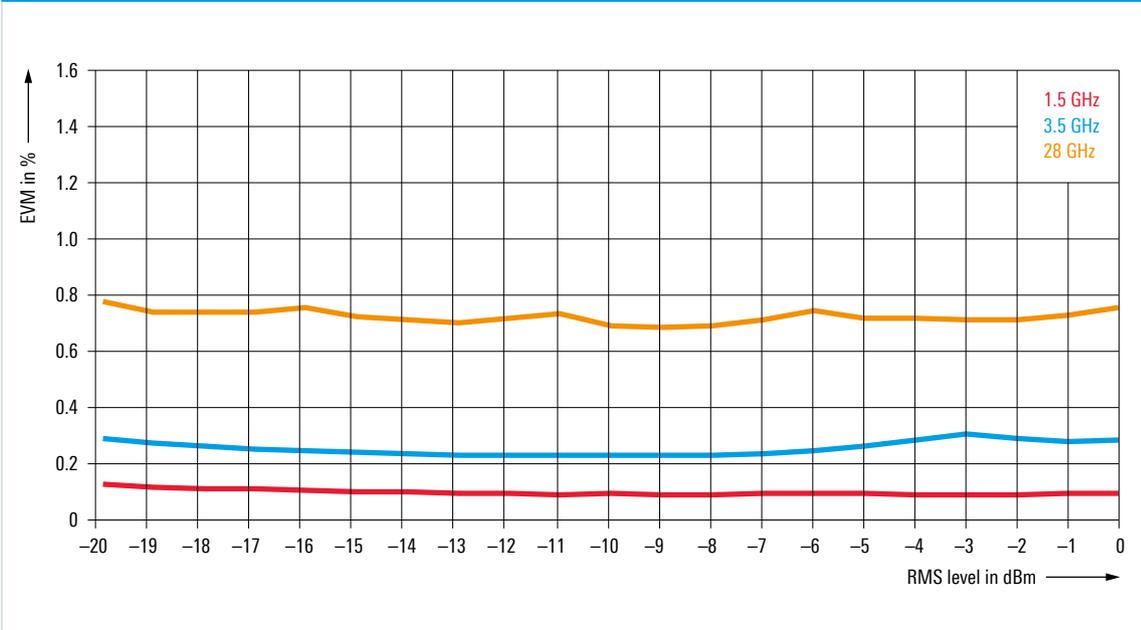
For many applications, the R&S®FSV and R&S®FSVA general-purpose analyzers are a cost-efficient alternative. The R&S®FPS, developed especially for automated test systems, is an exceptionally fast and compact spectrum analyzer featuring excellent RF performance.

## Vector signal and spectrum analysis solution portfolio for 5G applications



|                                    | R&S®FSW43,<br>R&S®FSW50           | R&S®FSW67,<br>R&S®FSW85           | R&S®FSVA        | R&S®FPS                   |
|------------------------------------|-----------------------------------|-----------------------------------|-----------------|---------------------------|
| <b>Application</b>                 | R&D, integration and verification | R&D, integration and verification | R&D, production | Production, automated use |
| <b>Frequency</b>                   | 2 Hz to 43.5/50 GHz               | 2 Hz to 67/85/90 GHz              | 10 Hz to 40 GHz | 10 Hz to 40 GHz           |
| <b>Internal analysis bandwidth</b> | ≤ 2 GHz                           | ≤ 512 MHz                         | ≤ 160 MHz       | ≤ 160 MHz                 |

**Measured error vector magnitude (EVM) of a 100 MHz downlink 5G NR signal using the R&S®SMW200A vector signal generator and the R&S®FSW vector signal analyzer**



A setup consisting of an R&S®FSW with the R&S®FSW-B1200 option in combination with an R&S®SMW200A vector signal generator is easy to operate and provides industry-leading performance and bandwidth for in-depth amplifier and predistortion measurements. The EVM stays below 1% over a wide power range.

**Signal and spectrum analysis setups for advanced 5G applications**



|                           | R&S®FSW67 + R&S®RTO2044           | R&S®FSW85 + R&S®RTO2044           | R&S®FSW43 + R&S®RTO2064           | R&S®FSW85 + R&S®RTO2064           |
|---------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| <b>Application</b>        | R&D, integration and verification |
| <b>Frequency</b>          | 2 Hz to 67 GHz                    | 2 Hz to 85/90 GHz                 | 2 Hz to 43.5 GHz                  | 2 Hz to 85/90 GHz                 |
| <b>Analysis bandwidth</b> | ≤ 2 GHz                           | ≤ 2 GHz                           | ≤ 5 GHz                           | ≤ 5 GHz                           |

# Power sensors

Rohde & Schwarz offers a comprehensive portfolio of power sensors covering DC up to 110 GHz. Ongoing additions to the portfolio bring features to simplify power level calibration for conducted and over-the-air measurements for 5G.

## Frequency selective power sensor

For highly accurate power measurements, even at low power levels, Rohde & Schwarz offers the unique R&S®NRQ6 frequency selective power sensor. This compact device, with its receiver-based architecture, can perform frequency selective power measurements up to 6 GHz and capture I/Q data at the same time, thanks to its 100 MHz analysis bandwidth, making it ideal for calibration and functional software regression testing.

The R&S®NRQ6 frequency selective power sensor is a power sensor and an I/Q data capturing device all in one, making it ideal for calibration and functional software regression testing.



## Power level calibration and beamforming/beam-steering verification

Over-the-air power level calibration and beamforming/beam-steering verification have never been easier, thanks to the unique R&S®NRPM OTA power measurement solution. At its core is the R&S®NRPM-A90/R&S®NRPM-A90D antenna module. This module consists of a single- or dual-polarized Vivaldi antenna with an integrated diode power detector with a frequency limit of up to 90 GHz. The detector connects to the R&S®NRPM3 sensor module for signal processing.

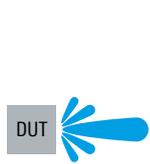
The entire system is calibrated ex-factory, making fast and accurate OTA power level measurements extremely straightforward.

The flexibility and scalability offered by the R&S®NRPM OTA power measurement solution makes it the ideal setup for multidimensional power level calibration and verification of beamforming and beam steering.

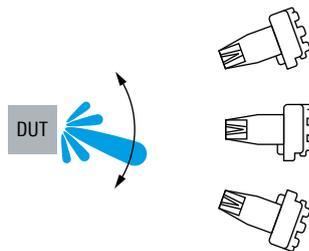


The R&S®NRPM OTA power measurement solution is unique on the market. It uses single- or dual-polarized Vivaldi antennas with integrated power sensors to perform over-the-air power measurements up to 90 GHz. The compact setup can be used on a benchtop and in a shielded box.

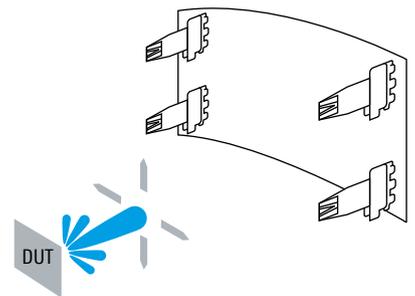
### The R&S®NRPM OTA power measurement solution



Power level calibration



2D power level calibration and beamforming/beam-steering verification



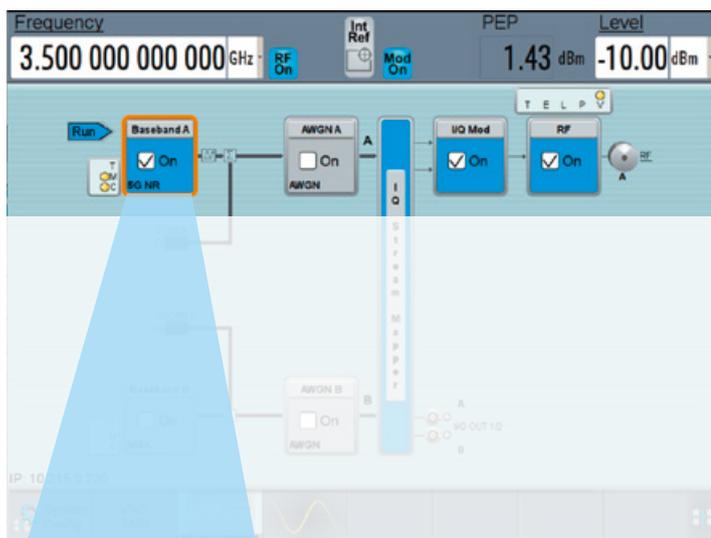
3D power level calibration and beamforming/beam-steering verification

The R&S®NRPM OTA power measurement solution is compact, scalable and versatile, allowing as many antenna modules as needed to be configured for applications such as power level calibration for OTA testing and beamforming/beam-steering verification.

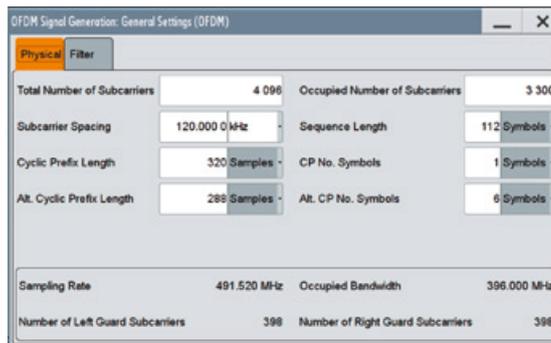
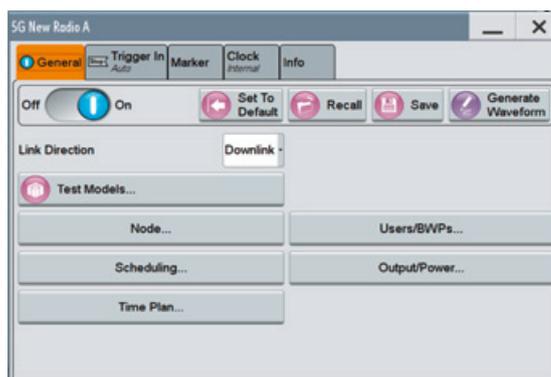
# 5G signal configuration and analysis at your fingertips

Rohde & Schwarz offers dedicated applications for generating and analyzing 5G signals. Standard-compliant 5G NR signals can be configured directly on a Rohde & Schwarz vector signal generator or by using the R&S®WinIQSIM2™ simulation software. Powerful signal analysis applications running directly on Rohde & Schwarz signal and spectrum analyzers provide deep insights, displaying a wide array of performance metrics. The R&S®VSE vector signal explorer PC software brings these powerful signal analysis capabilities to the desktop.

## Dedicated applications for generating and analyzing 5G signals



- OFDM Standards
- EUTRA/LTE/IoT...
- 5G NR...
- V5GTF...
- OFDM Signal Generation...



### 3GPP 5G New Radio (5G NR)

The 5G NR software options (-K144, -K444) simplify up-link and downlink 5G NR signal generation. They support all waveforms, channel bandwidths, modulation schemes and numerology options specified in the standards. The intuitive GUI allows users to configure these and many other parameters, such as bandwidth parts, directly on the instrument. Predefined settings are also available to configure specific test signals quickly. When equipped with the 5G NR software options (-K144, -K145), the R&S®FSW signal and spectrum analyzer detects and sets many parameters automatically, performing detailed signal analysis and displaying many user-configurable performance metrics.

### Verizon 5G Technology Forum (V5GTF)

Developers and manufacturers of products for the Verizon 5GTF specifications can use the V5GTF software options (-K118, -K418) to configure and generate downlink and uplink signals quickly. The Verizon 5GTF personality (-K118, -K119) of the R&S®FSW signal and spectrum analyzer performs the corresponding downlink and uplink signal analysis, providing automatic parameter detection and simultaneous analysis of multiple component carriers.

### Generic OFDM signal generation and analysis

The OFDM signal generation software options (-K114, -K414) enable user-defined OFDM signal configurations that go beyond the standards, providing full parameterization flexibility for even the most sophisticated applications. The R&S®VSE software, with its OFDM signal analysis personality (-K96), offers a powerful, standard-independent and user-configurable OFDM signal analysis solution.

Rohde&Schwarz offers dedicated signal generation and analysis solutions for 3GPP 5G NR and Verizon 5GTF standards. A generic OFDM solution is also available to generate and analyze user-defined OFDM signals.



Analysis of a 5G NR downlink signal with R&S®FSW-K144.



Analysis of a V5GTF downlink signal with R&S®FSW-K118.



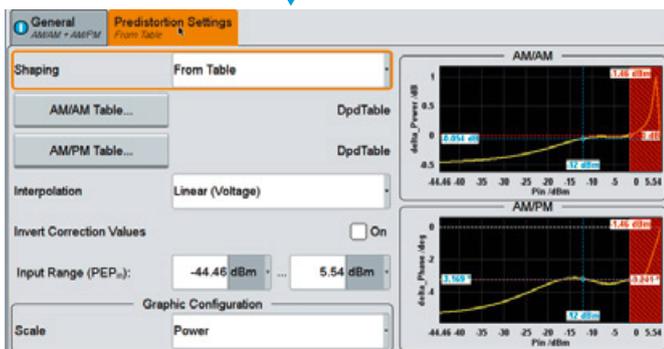
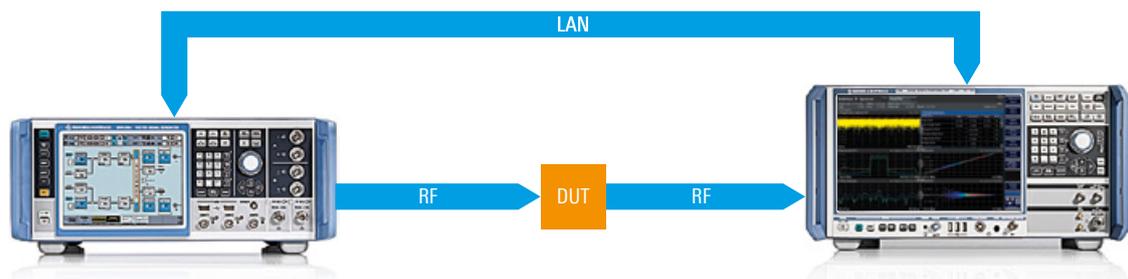
Analysis of a generic OFDM signal with R&S®VSE-K96.

# Power amplifier testing

The digital predistortion option (-K541), together with the amplifier and direct DPD measurement options (-K18, -K18D), provides a complete solution for digital predistortion. When equipped with the amplifier measurements option, an R&S®FSW automatically generates predistortion tables from the analyzed signal and sends them to an R&S®SMW200A (or an R&S®SMBV100B) equipped with -K541, which uses the tables to apply digital predistortion on the input signal in realtime. This helps to push the limits of power amplifier designs.

Thanks to its multichannel signal generation capabilities and its internal modulation bandwidth of up to 2 GHz, the R&S®SMW200A is also the solution of choice for developing and characterizing dual-input amplifier linearization techniques. For example, dual-input Doherty measurement setups can be easily implemented with just a single dual-path R&S®SMW200A equipped with the right software options, without the need for any elaborate and time-consuming calibration procedures as required with two-box solutions.

## Digital predistortion and amplifier characterization



R&S®SMW-K541 for digital predistortion



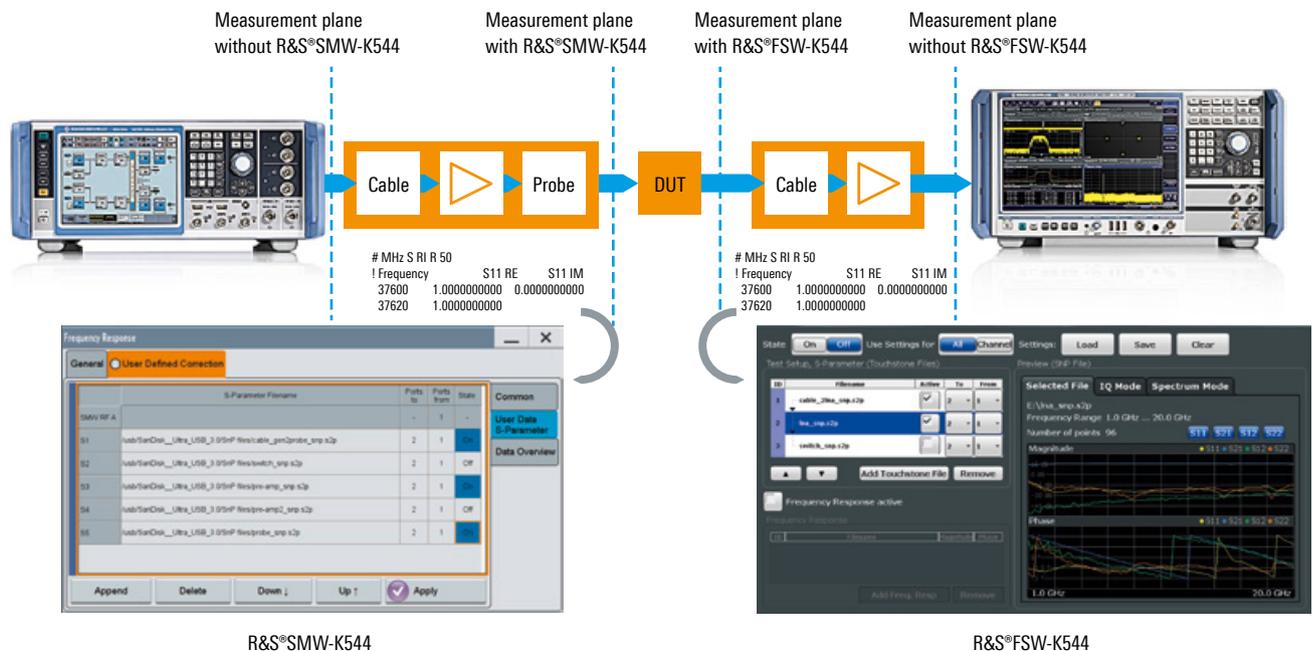
R&S®FSW-K18 for amplifier measurements

The digital predistortion option (R&S®SMW-K541, R&S®SMBVB-K541), together with the amplifier and direct DPD measurement options (R&S®FSW-K18, R&S®FSW-K18D), offers a complete solution for digital predistortion and amplifier characterization. In particular, the unique dual-path capabilities of the R&S®SMW200A offer a compact, powerful and easy-to-use platform for developing and characterizing amplifiers with dual-input architectures (e.g. digital Doherty).

# Compensating the effects of test fixtures

Since the effects of test fixtures become non-negligible at higher carrier frequencies, simple and quick solutions are needed to compensate these effects and measure the true performance of the DUT. The user-defined frequency response correction option (-K544) for the R&S®SMW200A, R&S®SMBV100B and R&S®FSW provides a simple and user-friendly means to accomplish this. Simply load the n-port network parameter data of the test fixture once (e.g. from data sheets or directly measured with a vector network analyzer) and activate the correction parameters of the desired fixtures during testing. The instruments automatically compensate the effects of the activated fixtures internally in realtime, ensuring calibrated measurements directly at the DUT plane, irrespective of waveform, signal level, frequency and bandwidth.

## User-defined frequency response correction



The user-defined frequency response correction option (-K544) for the R&S®SMW200A, R&S®SMBV100B and R&S®FSW is easy to use, compensating the effects of test fixtures in realtime, independent of waveform, signal level, frequency and bandwidth.

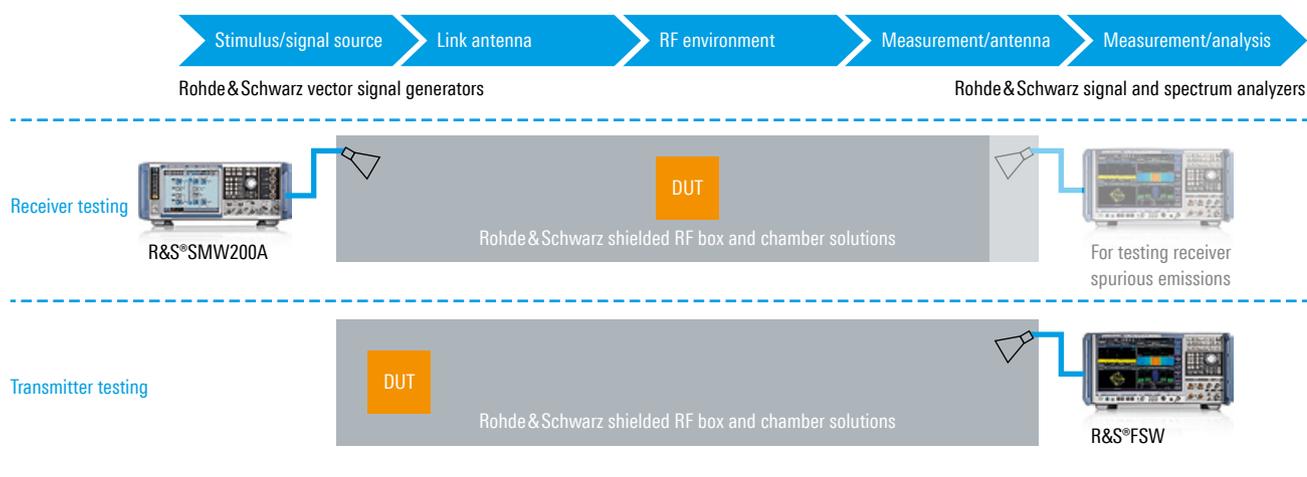
# General-purpose over-the-air testing

## Selected products from Rohde & Schwarz

- R&S®SMW200A/R&S®SMBV100B vector signal generator
- R&S®FSW signal and spectrum analyzer
- Shielded RF boxes and chambers

The R&S®SMW200A vector signal generator with its high output power and wideband signal generation capability serves as an excellent signal source for testing receivers and antenna modules over the air. The R&S®FSW signal and spectrum analyzer, with its wide analysis bandwidth and powerful analysis capabilities, makes an outstanding companion for testing transmitters and receiver spurious emissions. With the help of the user-defined frequency response correction option (-K544), measurements can be calibrated to the plane of the link and measurement antennas, allowing the true performance of the DUT to be measured in both benchtop and shielded OTA measurement setups.

## General-purpose over-the-air testing with the R&S®SMW200A and the R&S®FSW



The R&S®SMW200A is perfect as a signal source for general OTA testing of receivers, thanks to its high output power and its ability to generate extremely clean and flat signals. The R&S®FSW signal and spectrum analyzer, with its wide analysis bandwidth and powerful analysis capabilities, is an outstanding companion for testing transmitters and receiver spurious emissions.

# Base station production testing

## Selected products from Rohde & Schwarz

- ▮ R&S®SGT100A SGMA vector RF source
- ▮ R&S®SGS100A SGMA vector RF source
- ▮ R&S®SGU100A SGMA upconverter
- ▮ R&S®FPS signal and spectrum analyzer
- ▮ R&S®VSE vector signal explorer software
- ▮ R&S®NRQ6 frequency selective power sensor

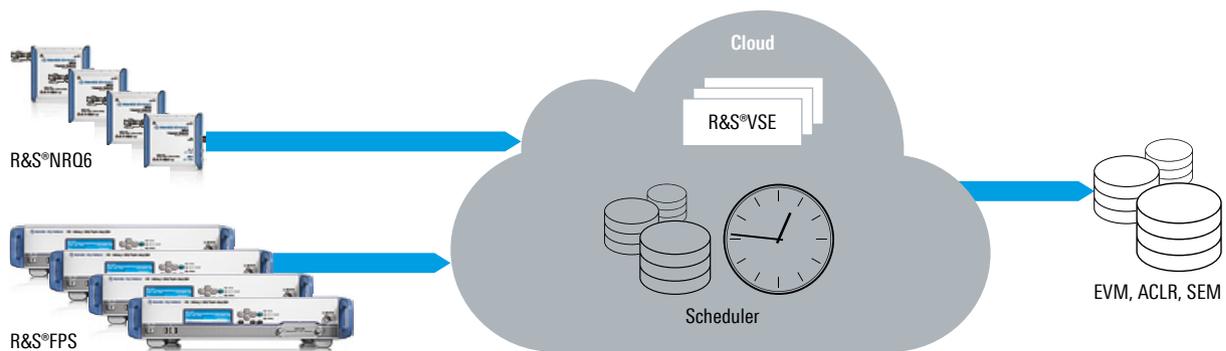
The R&S®SGMA family of vector signal generators (i.e. R&S®SGT100A, R&S®SGS100A and R&S®SGU100A) and the R&S®FPS signal and spectrum analyzer have been developed with both size and test speed in mind, without compromising on performance. The result – significantly reduced test time and floor space, making them the ideal instruments for production environments. For power level calibration, the R&S®NRQ6 offers a compact solution for fast, highly accurate frequency selective power sensing and I/Q data capturing in a single instrument.

To further increase test efficiency and flexibility, Rohde & Schwarz offers cloud-based approaches, especially for production solutions. These solutions separate data collection from data analysis, allowing independent scaling of both processes to accommodate different requirements. The instruments (e.g. R&S®FPS and/or R&S®NRQ6) perform the measurements directly on the DUT and send the data to the R&S®VSE application in the cloud or on an edge server, which performs the calculations and data analysis. This approach leverages the advantages of a cutting-edge, scalable and upgradable processing environment to achieve significant speed and flexibility benefits in production environments.



The R&S®SGMA family of compact vector signal generators and the R&S®FPS signal and spectrum analyzer are optimized for speed, without compromise on performance, making them ideal for production environments.

## Cloud-based base station testing with the R&S®FPS, R&S®NRQ6 and R&S®VSE



Cloud-based approaches for testing in production environments can be implemented with solutions from Rohde & Schwarz, helping to further increase test efficiency and flexibility.

# 5G application software at a glance

| For standards                        |   |   |   |
|--------------------------------------|---|---|---|
|                                      | 5G NR   | Verizon 5GTF                                      | Custom OFDM                                 |
| <b>Vector signal generators</b>      |   |   |   |
| R&S®SMW200A                          | -K144 option,<br>-K444 option <sup>1)</sup>       | -K118 option,<br>-K418 option <sup>1)</sup>       | -K114 option,<br>-K414 option <sup>1)</sup> |
| R&S®SMBV100B                         | -K144 option,<br>-K444 option <sup>1)</sup>       | -K118 option,<br>-K418 option <sup>1)</sup>       | -K114 option,<br>-K414 option <sup>1)</sup> |
| R&S®SGT100A                          | -K444 option <sup>1)</sup>                        | -K418 option <sup>1)</sup>                        | -K414 option <sup>1)</sup>                  |
| <b>Signal and spectrum analyzers</b> |   |   |   |
| R&S®FSW                              | -K144 option (downlink),<br>-K145 option (uplink) | -K118 option (downlink),<br>-K119 option (uplink) | R&S®VSE-K96 option <sup>2)</sup>            |
| R&S®FSVA                             | R&S®VSE-K144 option <sup>2)</sup>                 | –   | R&S®VSE-K96 option <sup>2)</sup>            |
| R&S®FPS                              | R&S®VSE-K144 option <sup>2)</sup>                 | -K118 option (downlink)                           | R&S®VSE-K96 option <sup>2)</sup>            |

<sup>1)</sup> Using R&S®WinIQSIM2™ PC software

<sup>2)</sup> Using R&S®VSE vector signal explorer software.

| Other applications                   |                       |                              |  |
|--------------------------------------|-----------------------|------------------------------|--|
|                                      | Digital predistortion | Amplifier/DPD measurements   | User-defined frequency response correction |
| <b>Vector signal generators</b>      |                       |                              |  |
| R&S®SMW200A                          | -K541 option          | –                            | -K544 option                               |
| R&S®SMBV100B                         | -K541 option          | –                            | -K544 option                               |
| R&S®SGT100A                          | -K541 option          | –                            | –  |
| <b>Signal and spectrum analyzers</b> |                       |                              |  |
| R&S®FSW                              | –                     | -K18 option,<br>-K18D option | -K544 option                               |
| R&S®FSVA                             | –                     | –                            | –  |
| R&S®FPS                              | –                     | -K18 option,<br>-K18D option | –  |

For further information concerning Rohde&Schwarz 5G solutions and educational material, visit [www.rohde-schwarz.com/5G](http://www.rohde-schwarz.com/5G)



# From pre-sale to service. At your doorstep.

The Rohde&Schwarz network in over 70 countries ensures optimum on-site support by highly qualified experts. User risks are reduced to a minimum at all stages of the project:

- ▮ Solution finding/purchase
- ▮ Technical startup/application development/integration
- ▮ Training
- ▮ Operation/calibration/repair



## Service that adds value

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

## Rohde & Schwarz

The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, 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

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

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