# TEST & MEASUREMENT REFERENCE GUIDE

ROHDE&SCHWARZ

Make ideas real

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# Rohde & Schwarz is one of the world’s leading manufacturers of electronic T&M and communications equipment

Rohde & Schwarz has driven innovation in RF technology from the very beginning, always pushing the limits of what is technically feasible. We are committed to providing our customers with industry-leading solutions to meet even the most challenging requirements.

# YOUR PARTNER IN TEST AND MEASUREMENT

Rohde & Schwarz is a market-leading supplier in the mobile and wireless communications sector. We offer a comprehensive portfolio of Test and Measurement (T&M) instruments and systems for the development, production and acceptance testing of components and consumer devices. Important T&M markets include the automotive industry, the aerospace & defense sector, all industrial electronics segments as well as research and education. In addition to its established business fields, Rohde & Schwarz is making substantial investments in future technologies such as artificial intelligence, the industrial internet of things (IoT), 6G, cloud solutions and quantum technology.

## About Rohde & Schwarz

Rohde & Schwarz is one of the world's leading manufacturers of T&M, Secure Communications, Monitoring and Network Testing, and Broadcasting equipment. Founded more than 80 years ago, the independent company has an extensive sales and service network with subsidiaries and representatives in more than 70 countries. Incorporated in the United States since 1978, Rohde & Schwarz USA, Inc. has a large team of sales and application engineers throughout North America with regional offices in Maryland, Texas, California, and Oregon. We have a world-class service facility in Columbia, Maryland and our customers can expect extensive after-sales support, including training, free technical support and close personal contact from our engineers out in the field as possible – with the desired quality and performance.

# SIGNAL & SPECTRUM ANALYZERS

Spectrum analyzers are single-channel receivers that measure basic signal amplitude characteristics like carrier level, sidebands and harmonics ranging from as low as 2Hz up to 85GHz.

More advanced models demodulate and measure more complex signals. Wideband signal analysis is required in 5G and WLAN applications, as well as satellite, electronic warfare, and radar applications.

## Frequency Coverage

**“Does the spectrum analyzer have the necessary frequency range to capture your signal of interest?”**

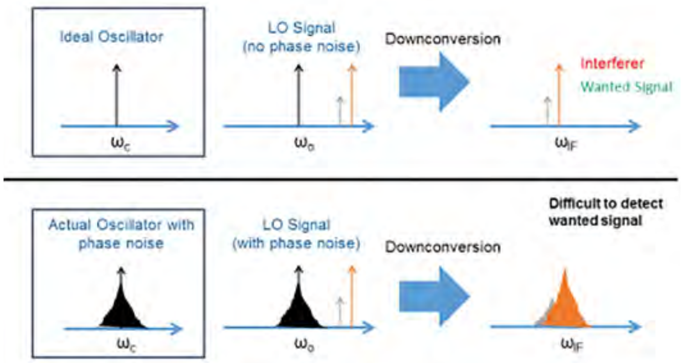
Different measurement applications may require a larger frequency sweep range to evaluate harmonics, spurs and Intermodulation Distortion (IMD) effects in alternate channels (ACPR). This may warrant consideration of a higher bandwidth solution than previously thought to ensure the capture of all potential signals of interest.

Lower ranges also need to be a consideration for those interested in Electromagnetic Compatibility (EMC) applications.

R&S®FSW

## Phase Noise

**"Do you need to perform phase noise measurements on signal sources or make measurements that are sensitive to phase noise?"**

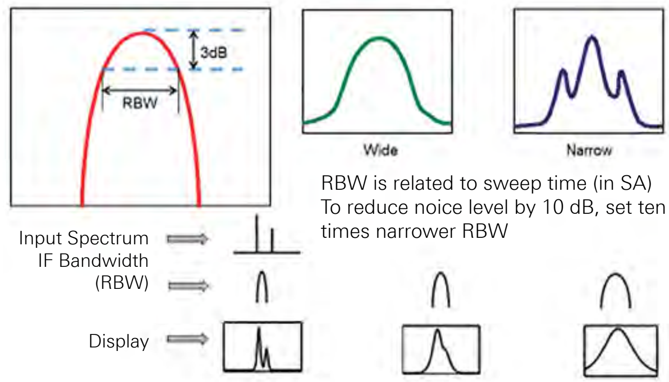



Impact of phase noise on a signal

Phase noise is a key spectrum analyzer parameter which will have an impact on measurements close to the carrier signal. A spectrum analyzer's inherent phase noise will dictate the measurement margin. Additionally, the analyzer's inherent phase noise may adversely impact Error Vector Magnitude (EVM) measurements of digitally-modulated signals.

## Dynamic Range

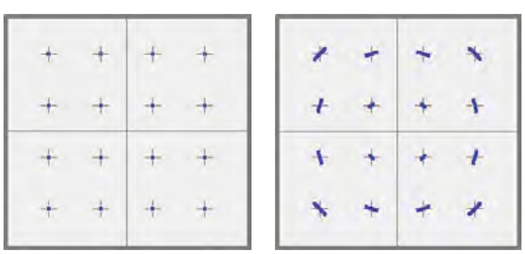
A large range of resolution bandwidth (RBW) settings, coupled with low displayed average noise level (DANL) and high third order intercept (TOI) values, will improve the analyzer's ability to detect weak signals in the presence of strong signals. This is especially important for measurement of spurious emissions ("spurs").




Resolution bandwidth settings impact on signals as displayed on the instrument

## Signal Analysis and Bandwidth for Wireless Standards

**"Does your application require demodulation capability?"**



IQ constellation diagram, 16 QAM in this case (left), as well as phase noise impacts on signal (right)

Some applications may require the ability to measure signals employing amplitude, frequency, and/or phase modulation. Some may also require the ability to measure digitally modulated signals such as those in many of today's wireless standards. Spectrum analyzers offer varying degrees of flexibility for addressing these modulation techniques.

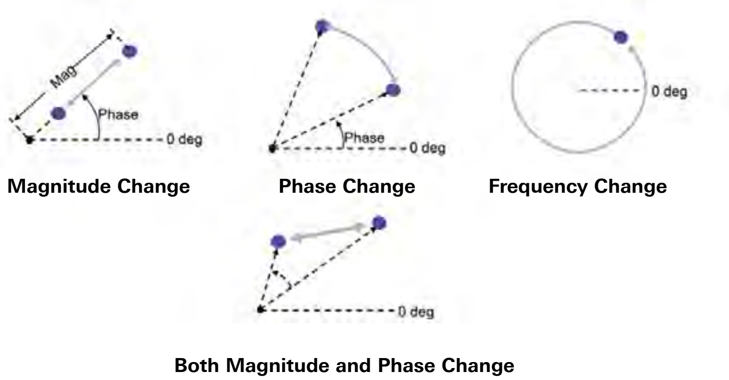
Signal analysis for wireless standards is an important use case for signal anlayzers. The first criteria here is to make sure the instrument has sufficient bandwidth to accomodate the wireless standard being measured. 5G signals can range from 100 MHz to 1 GHz bandwidth (BW) depending on whether carrier aggregation is being used. WLAN signals are up to at lease 320 MHz for WiFi 7.

EVM for 5G FR2 and wireless local-area network (WLAN) / WiFi 7 are leading applications where the highest performance is needed in research & development (R&D) in addition to the bandwidth. To get the best EVM performance all of the performance areas need to be listed: TOI, DANL, and Phase Noise.

## A Flexible Tool for A Broad Range of Applications

The signal generator's wide frequency range, high output power and variety of modulations make it a flexible tool for a broad scope of applications. Signal generators with a minimum frequency of 9 kHz permit applications in Electromagnetic Compatibility or EMC measurements. Frequency coverage up to 67 GHz covers the latest technologies in both the commercial (5G, Wi-Fi, Global navigation satellite system (GNSS), etc), and Aerospace/ Defense (Radar/Electronic Warfare Test (EWT), Satellite) industries. For frequencies above 67 GHz, a range of frequency extension products are available for signal generation well above 100 GHz.

Output power, phase noise, frequency range, and harmonics are the key parameters when it comes to selecting the right analog signal generator. However, many real-world measurements require focus on more than just one aspect simultaneously. This section provides an overview of some of the key signal generation specifications you will need to consider.



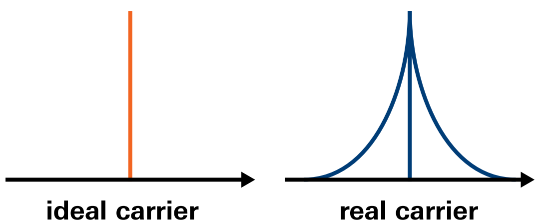

Basic Concept of Digital Modulation

## Analog vs. Vector

One of the most important factors to determine upfront is whether an analog or vector signal generator is best for your application. Analog signal generators have the ability to generate continuous wave (CW) signals or to vary the amplitude, frequency and phase of a signal to create different forms of modulation such as amplitude modulation (AM), frequency modulation (FM) and phase modulation (PM). Modulation formats may also be combined, such as adding FM onto an AM signal. Vector signal generators, on the other hand, have the ability to vary two or more of these modulation types—at the same time.

## Phase Noise

Phase noise is a key aspect of signal quality. A distinction is made between close-in phase noise, phase noise with the typical carrier offset of 10 kHz or 20 kHz, and the behavior far from the carrier, i.e. wideband phase noise with a carrier offset of typically > 10 MHz. With each application having different specifications, it is important to understand your specific phase noise requirements. The R&S®SMA100B leads the industry in phase noise performance, while the mid range SMB family provides good phase noise, at a lower price point.




An ideal carrier would have no phase noise, but a real signal would look like this.

## Highest Output Power

Very high output powers are often required, particularly in the microwave frequency range. This is because at higher frequencies, there is greater attenuation between the generator and device under test. The R&S®SMA100B offers industry leading output power that is more than enough to compensate for these losses. As a result, no external amplifier is required between the signal generator and the device under test. This simplifies the test set up, while also improving the accuracy and repeatability of the measurement.

Equipped with the appropriate options, a 6 GHz instrument generates up to +38 dBm RF output power, and a 20 GHz instrument generates up to +32 dBm in the microwave frequency range. The 40 GHz instrument can deliver +29 dBm at 40 GHz. Even while producing signals with these high power levels, the SMA100B does not compromise signal quality, ensuring the harmonics and non-harmonic effects are extremely low across the entire frequency.

R&S®SMBV100B

## Exceptional Modulation Characteristics

When creating complex RF signals, having enough RF bandwidth is key. All vector signal generators from Rohde & Schwarz lead the way in terms of bandwidth. From the entry level SMCV100B with up to 240 MHz of bandwidth, to the SMW200A with 2 GHz of bandwidth, each of them can create your desired signal, while ensuring it is of the highest quality.

State-of-the-art D/A converters and an excellent RF chain ensure exceptional modulation characteristics. With modern wideband signals, a key parameter to consider is modulation frequency response. The generator needs to have a flat frequency response to ensure that it can accurately, and repeatability create wideband RF signals. With the SMW200A a modulation frequency response of < 0.4 dB (meas.) over 2 GHz bandwidth can be achieved. This ensures that signals are of the highest quality.

## Real-Time Generation of Complex RF Signals

A vector signal generator creates digitally modulated signals (e.g., 5G, W-LAN, etc.) although some generators do it more efficiently than others.
Rohde & Schwarz signal generators create signals internally, in real time. This means as soon as the user configures the signal from the front panel, the generator creates the signal and plays it out.

Not all products do this. They create some signals in real time, but the majority must be created with offline software. Files from the offline software must then be transferred to the generator. This adds an extra step that can become extremely time-consuming when the user wants to continually modify the signals (e.g., when troubleshooting a design).

# VECTOR NETWORK ANALYZERS

## Exceptional Performance, High Value and Reliability

Network analyzers (VNAs) are extensively used in all aspects of RF device design and production test. Rohde & Schwarz offers solutions in the RF, microwave, and mm-wave frequency range, up to 1.1 THz supporting a wide range of application areas.

They are the perfect tool for analyzing the different properties of passive and active components such as filters, amplifiers, mixers, associated subassemblies and multiport modules.

Time domain options also provide unique insights into high speed digital designs.

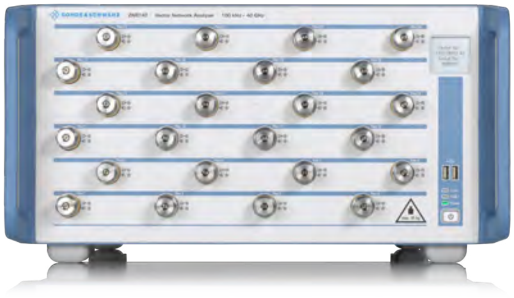
## Dynamic Range / Output Power / IF Bandwidth

Different applications may require certain key performance metrics like dynamic range, which is the maximum measurement range of a VNA. It is limited by the noise floor (at the low end) and output power (at the high end) as well as the IF bandwidth setting of the VNA.

Wide dynamic range is especially important for measuring flters with sharp cutoff transitions, and for achieving fast measurement speed via a wide IF bandwidth setting.

## Multiport

For applications that require device performance characterization over a higher port count, or for parallel test consideration to improve test throughput, Rohde & Schwarz offers multiport solutions up to 40 GHz of bandwidth and 48 ports providing exceptional measurement flexibility.



R&S®ZNBT40

## VNA architecture continues to evolve to meets today's demanding measurements challenges

### Multiple coherent sources in ZNA enable a wide range of applications

- Vector frequency translation measurements
- Intermodulation on mixers and amplifiers
- Embedded LO Group Delay
- Noise Figure
- True Differential and Phase Control
- Active Load Pull
- Simultaneous Measurements on Two Frequencies

### Flexible Test Set Configurations

- Two or Four Port Sets
- Multiple Sources in Two Port Configurations

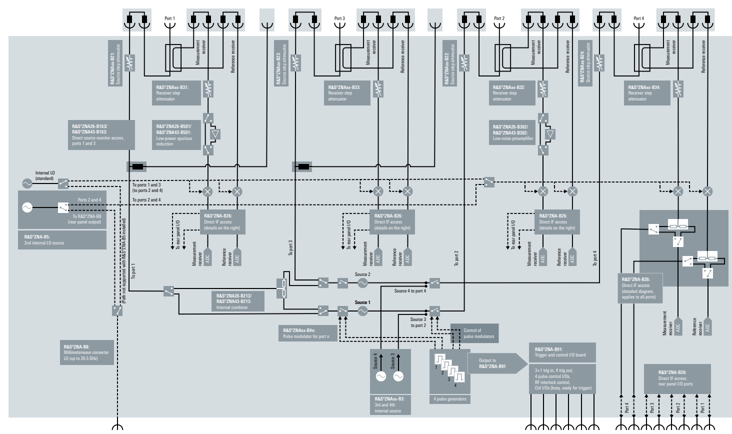
### mmWave Support

- Direct IF Inputs improve measurement accuracy
- Dedicated RF output for LO
- Converter support up to 1.1 THz

### Broadband Sweep to 110 GHz

- Single sweep from 10 MHz to 110 GHz
- Two and Four Port Systems based on ZNA67

R&S®ZNA



ZNAxx-B16 option: Direct source and receiver access (frequency extension down to 100 kHz (R&S®ZNA26 and R&S®ZNA43), supports reversed coupler operation)

R&S®ZNA67EXT

# OSCILLOSCOPES

### Exceptional Signal Integrity, High Value, and Excellent Reliability from 50 MHz to 16 GHz

The Rohde & Schwarz digital oscilloscope portfolio offers options from low cost yet powerful, 50 MHz scopes to full-featured 16 GHz oscilloscopes. Designed by the RF experts at Rohde & Schwarz, all our oscilloscopes feature exceptional signal integrity and excellent reliability.

### Bandwith Selection

Bandwidth selection is typically the most crucial parameter for choosing a scope. Bandwidth is defined as the frequency at which a sine wave is attenuated to -3 dB or is 30% smaller.

Since most signals are not sine waves (they look like square waves), you have to take into account the other frequency components that make up the signal. For example, you can't measure a 1 GHz square wave with a 1 GHz scope. It won't look like a square wave, but rather a sine wave since only the fundamental frequency is captured.

Rule of thumb: The simplest way to determine how much bandwidth you may need is to take 3x to 5x the clock frequency of the signal you want to measure. Generally choosing a higher bandwidth (5x the clock frequency) will give you better signal representation, but obviously the higher the frequency, the more expensive the test solution.

### Sample Rate/Memory Depth

Sample rate and memory depth are directly related. The sample rate is how often the oscilloscope samples and digitizes the waveform, but those samples have to be stored somewhere, which is why memory is important. Since storing waveforms at a faster rate consumes more memory, a deep memory buffer allows you to keep your sample rate high, which also allows you to take advantage of the full bandwidth of the scope.

Rule of thumb: For the sample rate, you typically want it to be 2.5x to 5x or more. the bandwidth of the scope to accurately reproduce the signal. For example, for a 1 GHz scope, you want a sample rate of 2.5GS/s to 5GS/s.

As mentioned, memory depth is directly related to the sample rate. The more memory depth you have, the longer amount of time you can capture at high sample rates.

See the chart on the next page for some examples of time versus sample rates.

R&S®MXO 5

## Update Rate

Although often called “real time” all digital oscilloscopes have “dead time” or “blind time”. Update rate is how fast the scope can trigger on a waveform (basically one screen’s worth of data), process it and then plot it to the display. The faster it can do this, the more likely you are to see infrequent events. Update rate is typically specified in “waveforms per second” or “wfms/s”.

Seek an update rate as fast as possible, but be careful of trading something else off to get it (like memory depth). Update rates >20,000wfms/s help ensure you don’t miss a rare glitch and keep the oscilloscope responsive.

## Vertical Resolution

The vertical resolution, sometimes called “bits,” is the number of buckets, or discrete vertical levels, an oscilloscope can put voltages into for a given sample. When the oscilloscope analog to digital converter (ADC) is sampling the waveform, it doesn’t have an infinite number of levels to put the sample in. It has to choose a level to put that sample in. The more levels it has to choose from, the more precise it can be. An 8-bit scope has 256 levels, a 10-bit scope has 1024, and an 18 bit scope has 262,144 levels. A-16 bit scope has 65,536 levels.

Rule of thumb: Many oscilloscopes utilize an 8-bit ADC. In general, additional vertical resolution (10-bit for example) is most useful for signals where you are trying to see the details of a small signal riding on top of a much larger signal. Without the additional levels, the small signal would be lost in the larger signal. Typically, larger signals are slow and not high in frequency.

## Digital trigger vs Analog trigger

Some oscilloscopes now offer a digital trigger architecture versus the traditional analog trigger circuits. A digital trigger uses the digitized sample points and can make trigger decisions on very small and very fast signal changes. Analog triggers require larger signal changes for edge type triggers and longer time periods for pulse width and timing triggers.

Digital triggers provide the most flexibility. The trigger sensitivity is as little as 0.0001 div and is adjustable to factor in different trigger requirements, for example to avoid false triggering on noise. It is also possible to use the digital trigger to adapt the cutoff frequency only on the trigger path while maintaining the original waveform for viewing and measurements.

## Frequency analysis

Many oscilloscopes now offer an FFT function that converts the time domain waveform into the frequency domain, plotted on a Log scale. In more modern FFT implementations, you can configure the FFT by simply entering typical spectrum analyzer parameters: cen¬ter frequency, span and resolution bandwidth (RBW).

An FFT / Spectrum on an oscilloscope is useful in a number of scenarios including EMI debug, Multi-Channel RF measurements, Power Integrity and embedded RF debug.

Rule of thumb: Check the oscilloscope datasheet for FFT / Spectrum specifications to see if it will meet your RF measurement requirements. Key specifications are FFT update rate (if you are looking for infrequent events, is the update rate fast enough to catch them), sensitivity and dynamic range.

R&S®RTO6

# RF POWER SENSORS


## Get Accurate Results, Faster

Rohde & Schwarz Power Sensors are the most accurate with the least amount of uncertainty, enabling users to quickly make accurate measurements, even at low power levels.

## Selecting the Correct Sensor Type

Choosing the right power sensor type can make all the difference when it comes to getting accurate results. The type of signals and the required measurements greatly influence the sensor choice. Knowing this information is the first step in determining what type of sensor you will need.

Is it a continuous wave (CW) signal? Does the signal have any analog or digital modulation? Or are you trying to characterize a pulsed signal?

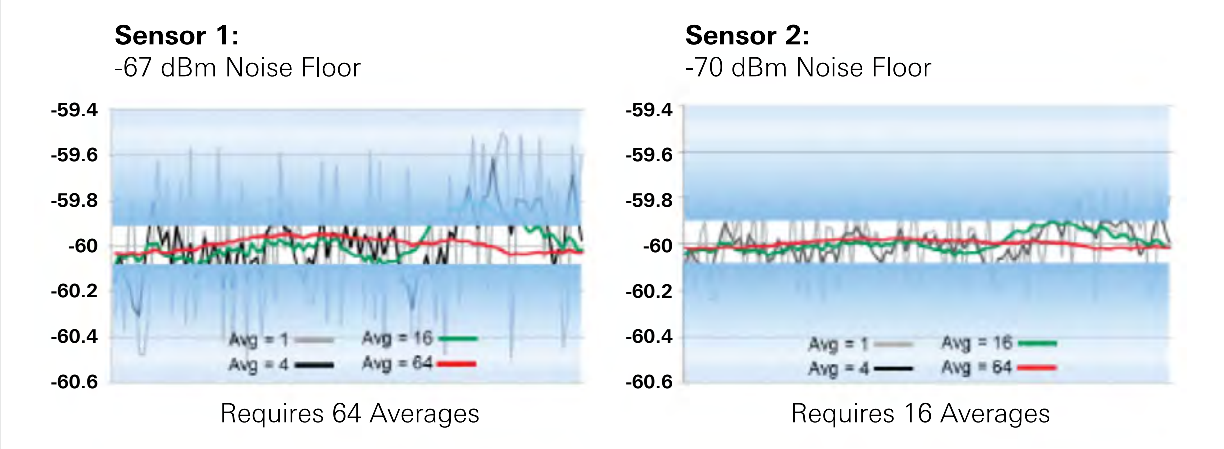
Next, what measurements do you need to make? Average power (CW and/or modulated signals), Time slotted measure-ments, Envelope power versus time, Statistical analysis such as CCDF, CDF and PDF or others?

## Measurement Speed

Power sensor specifications state speed or measure-ment rate. This is not the same as the number of measurements that can be made in a second, but rather the speed at which measurements are made. All sensors have a buffer that stores measurement results. Once this buffer is full, information needs to be sent to the controlling device so the sensor can start making more measurements. The majority of vendors spec sensors this way, however it is good to note that the R&S®NRPxxS and R&S®NRPxxSN families of sensors are the fastest available today, with a measurement/second spec of 50,000, translating into 8,192 measurements in 81.92 msecond. After 8,192 measurements, the buffer is full and the data needs to be transferred to the PC.

## Measurement Accuracy

One of the biggest factors affecting measurement accuracy, especially at low power levels, is the noise floor of the power sensor. As the signal level gets lower, the noise levels inside the sensor start to have more of an effect on the measurement results. This leads to the sensor having to make more measurements to average out the effects of the noise. This can significantly lengthen the time it takes to get results. Using a sensor with the lowest noise floor, minimizes this effect and gives results faster (less averaging is needed as there is less noise).




Two sensors with similar speeds and uncertainty, but one having a lower noise floor, get the same results four times faster.

Dropping the noise floor by 3 dB yields 50% less noise. The R&S®NRPxxS and R&S®NRPxxSN families of sensors have the lowest noise floor on the market at -70 dBm. Let's look at a measurement example to understand the interaction between speed and accuracy. In this example we need to measure a signal that's -60 dBm, with an accuracy of ±0.1 dB. For this measurement, we use two sensors and let us assume that they have the same measurement speed and the same uncertainty specifications.

## Sensor Operation

The power sensor makes all the measurements itself and stores the results onboard, but the user needs some way to control the sensor and get access to the measurement results. There are four ways to operate a power sensor; from a PC by the USB interface, with a traditional power meter, over the Internet with sensors that have an Ethernet connector, or connected to another supporting instrument. Ethernet control

is especially useful when working with remote monitoring sites. It could be a transmission tower out in the field or on top of a building with a power sensor installed and connected to the Ethernet. No need to go to the site to make the measurements, you can just log on from any one of your devices – laptop, mobile phone or tablet, and make measurements in real-time. Many of the leading LAN sensors have a built-in Web server, which greatly simplifies how measurements are made.

# WIRELESS COMMUNICATION TESTERS

R&S®CMX500

## Wireless Device Testing

Rohde & Schwarz has been actively involved since the beginning of the standardization, globalization and testing of wireless technologies.  Test and measurement solutions are developed for applications along the entire value chain – from the building of prototypes to mass manufacturing. Today's wireless devices contain a mixture of wireless technologies including:

- Non-Cellular: Bluetooth, WiFi (WLAN), UWB, Zigbee, LORA
- Cellular IoT: eMTC (CAT-M), NB-IOT (CAT-NB), LTE CAT1/1bis, 5G RedCap
- Cellular: GSM, WCDMA, CDMA, LTE, 5G NR FR1 & FR2
- Digital / Analog Technologies: GNSS (GPS, GALILEO), APCO, DMR, Tetra, AM/FM/PM

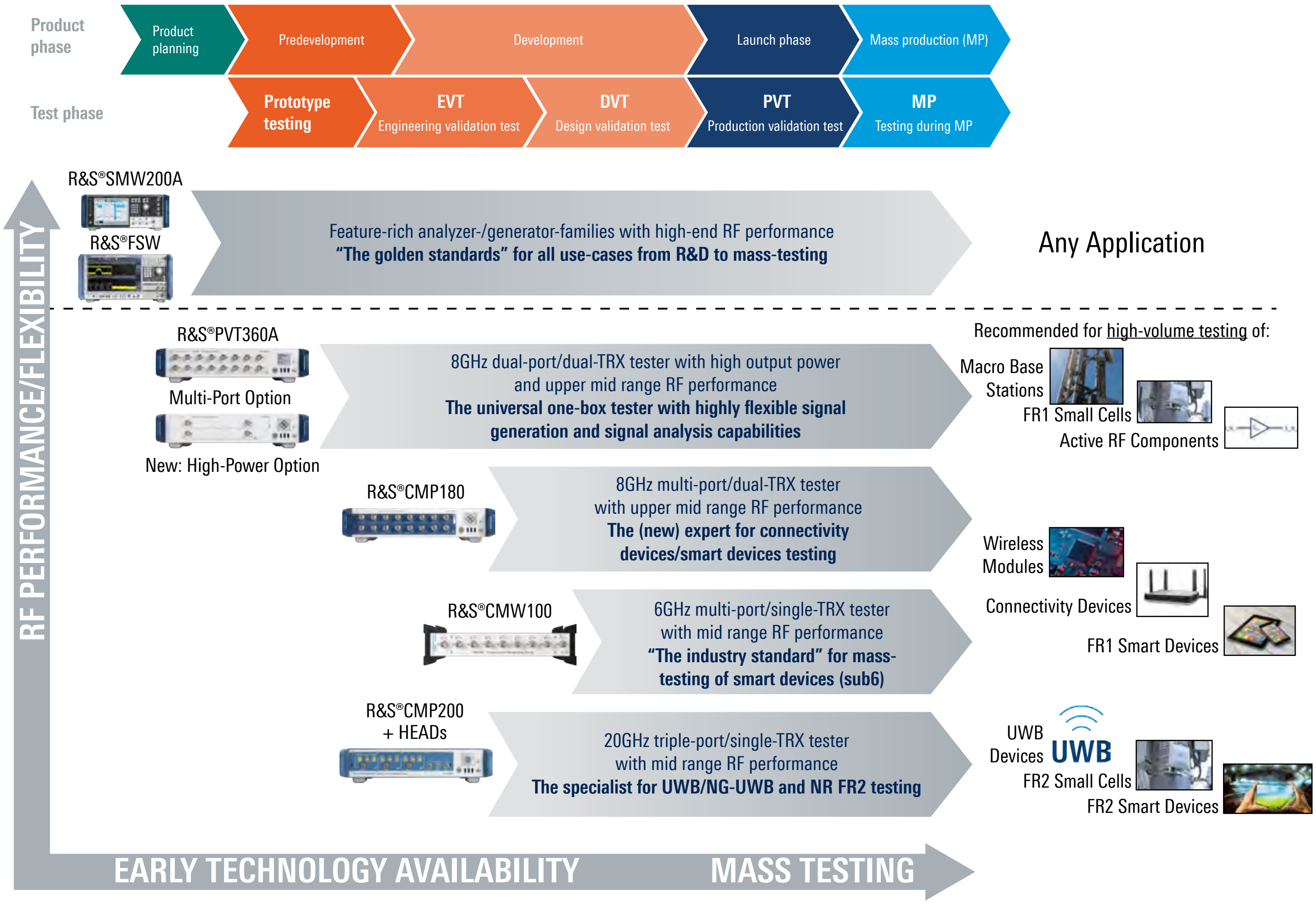
Rohde & Schwarz provides class-leading performance, reliability and innovative solutions, regardless of the wireless technology and customer application.

## One-Box Network Emulators

Device manufacturers, chipset suppliers, network operators, authorized test labs and service/repair centers require signaling network emulators for simulating cellular networks and non-cellular connectivity. This 'signaling solution' includes the physical layer and protocol messages, providing a test environment for voice calls, sending messages, IP data transfer and everything else a device could do on a real-live network.

# ONE-BOX VSA/VSG TESTERS

## VSA/VSG - Product/Portfolio Positioning:




EVT = Engineering Validation Testing | DVT = Device Validation Testing | PVT = Production Validation Testing | MP = Mass Production

One-Box VSA/VSG testers provide turnkey, cost-optimized and easily scalable solutions from device engineering and validation, up through mass production. This sales guide details the key needs and customer personas in R&D, validation and production, the R&S product portfolio and the positioning of our products.

### VSA/VSG - Product/Portfolio Positioning:

The top-class R&S®SMW200A signal generator and R&S®FSW spectrum analyzer remain as the golden solutions for performance and flexibility during technology introductions for R&D. The one-box VSA/VSG testers become applicable when ultra-compact turnkey solutions are required, especially for the high-volume testing that happens during EVT, DVT, PVT and MP product phases. This is where RF performance must still be in the upper-mid-range level, but cost, scalability, and speed matter most.

# PHASE NOISE ANALYZERS

Phase noise in RF and digital components and systems is critical to device performance. In 5G applications, phase noise of Transmit / Receive modules relates to the device data throughput and antenna performance, which relates to cellular operators billable minutes. In Radar applications, phase noise is the driver for performance in the system detecting and resolving targets. In High Speed Serial Data applications, the Jitter performance of clocks and other components relates to the data rates possible, which are ever increasing. Jitter and Phase Noise are very closely related.

Components such as Phased Locked Loops and various Oscillators are directly related to system performance and may have even higher performance demands. Phase noise performance needs to be verified throughout the signal path for components used in systems like these.

## R&S®FSx-K40: Spectrum Analyzer Based Phase Noise Measurements

- Phase noise application based on spectrum analyzers
- General purpose tool: spectrum analysis and signal analysis also possible
- Quick checks of phase noise on components and systems
- Performance varies based on industry leading spectrum analyzers, from -108 dBc/Hz to 137 dBc/Hz at a 10 kHz offset, 1 GHz center frequency

  Phase noise analysis available on the FSW, FSVA3000, FSV3000, and FPL1000 spectrum analyzers

## R&S®FSWP: Industry Leading Performance, Speed, and Versatility

- High end signal and spectrum analyzer and phase noise tester in one box
- Cross correlation for very sensitivity of high amplitude and phase noise measurement in parallel, even on pulsed signals
- Frequency range from 1 MHz up to 50 GHz, 325 GHz with external mixers
- Internal source for measuring residual phase noise on pulsed signals
- SCPI recorder to simplify code generation

## R&S®FSPN: Unrivalled Signal Source Analysis Meets High Speed

- Pure phase noise analyzer and VCO tester with high measurement speed
- Simultaneous measurement of phase noise and amplitude noise
- Frequency range from 1 MHz to 26.5 GHz
- Extremely low-noise internal DC sources for automatic VCO characterization
- Automatic SCPI recoding and 100% compatible with R&S®FSWP

# EMC TESTING SOLUTIONS

From Electromagnetic Compatibility (EMC) precompliance test in the development laboratory, through to full compliance test requiring standard-conformant equipment and procedures, Rohde & Schwarz supply all the necessary EMC test equipment and EMC test automation software for both interference and immunity tests. Much of the required equipment including EMI test receivers, signal generators, broadband amplifiers, antennas, LISN, oscilloscopes, vector-network analyzers, spectrum analyzers and diverse accessories are Rohde & Schwarz own products. Test systems for all relevant EMC standards are carefully assembled from individual components and complete the Rohde & Schwarz EMC portfolio.

## EMI test receivers

R&S EMI test receivers support the full range of commercial, automotive and military EMI Standards from all leading Standard authorities, including IEC, CISPR, CENELEC, ETSI, FCC, ANSI, RTCA and MIL-STD. All the latest amendments including the fast FFT-based time-domain scan that makes testing many times faster than conventional frequency scans, are all supported. The instruments cover all required frequency ranges up to 44 GHz, with frequencies up to 500 GHz supported by external mixers.

## Broadband Amplifiers

R&S broadband amplifiers are innovative solid-state solutions with exceptional RF performance for generating RF power up to 13 kW in the frequency range of 4 kHz to 6 GHz. Designed as very compact amplifiers, at highest power density, they are robust against severest output mismatch while featuring high availability. Their modular structure allows for field proven scalability of systems. Sophisticated switching options for input, output and sample ports will match your needs when it comes to even complex RF systems set-ups.

## EMC test automation software

The nature of executing EMC testing - repetitive procedures, diligently searching for unwanted emissions, stepping through wide frequency and power level ranges - demands automation. R&S EMC automation software provides market-leading standard-conforming functions for both EMI and EMS test procedures. The full range of commercial, automotive and military EMC standards from all leading standard authorities are supported, including IEC, CISPR, CENELEC, ETSI, FCC, ANSI, RTCA and MIL-STD.

**R&S®OSP220**
2 HU with status display and 3x front and 3x rear module slots

**R&S®OSP230**
2 HU with touchscreen and 2x front and 3x rear module slots

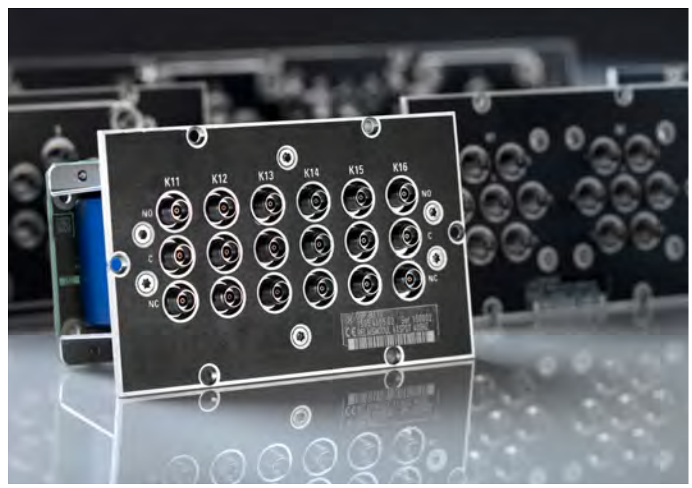
**R&S®OSP-B200S2**
2x module slots

**R&S®OSP320**
3 HU with status display and 5x front and 5x rear module slots (optional double-width touchscreen module)

New technologies such as 5G, radar and other applications call for very fast and often precisely defined switching times between measuring instruments and antennas and between the DUT ports in development and production.

The modular R&S®OSP open switch and control platform can be used to perform RF switch and control tasks quickly and easily. The latest R&S®OSP generation comes with an extended range of modules, allowing an even wider variety of RF wiring configurations to be implemented.

The R&S®OSP switch and control units can be controlled via Ethernet. Multiple units can be combined into a primary/secondary system setup via LAN. Manual control via touchscreen or an external monitor and a keyboard and mouse is also possible.




Wide range of RF Switch Modules up to 67 GHz

## Radiated Testing & Shield Boxes/Chambers

Rohde & Schwarz is a one-stop-shop for a full range of radiated testing. Our solutions are designed to support the latest technologies, to be futureproof and with ease of use in mind. Our reliable solutions are complemented by a global support network of skilled technicians and customer care personnel.

Radiated testing has become more important due to the highly integrated nature of today's wireless devices. In the past, discrete components or subsystems could be tested with RF cables connected directly to the device. While in some cases this may still be possible, many products now have antennas integrated directly into their design making it no longer possible to connect an RF cable.

Shielded boxes or chambers are often required to isolate the wireless device from real-world signals so that a connection can be established between the DUT and the test equipment, shielding effectiveness and supported frequency range are key performance metrics used when choosing a solution.

Standards organizations have defined Over-the-Air (OTA) test methodologies and performance metrics for verifying the transmitter power and receiver sensitivity of a device in three dimensions. The device under test is mounted on a multi-axis gimbal that enables Total Radiated Tx Power (TRP) and Total Isotropic Rx Sensitivity (TIS) measurements.

## High-Frequency (5G FR2 mmW) Testing in Compact Antenna Test Range (CATR)

5G FR2 uses frequencies in the 24-50GHz mmW range requiring the use of mmW antenna arrays to focus RF beams (beamforming) to increase the signal range and to overcome the high path loss. As a result, 5G FR2 mmW testing is typically performed in a radiated environment.

Many types of RF measurements must be performed in the far-field, where you have a nearly constant phase and magnitude of signals. Achieving this far-field distance can be problematic due to the high path loss at mmW frequencies, to overcome this problem the compact antenna test range (CATR) technology is used to create a far-field environment in a compact test environment. R&S offers CATR solutions that are both portable and flexible enough to test devices with antenna arrays up to 40cm in diameter and 18kg weight.


R&S®LCX200 and MFIA Impedance Analyzer

## Impedance Parameters Measurement

An LCR meter measures impedance parameters (inductance, capacitance and resistance) of an electronic component. Benchtop LCR meters typically have selectable test frequencies of more than 100 kHz to create data points at multiple spot frequencies. They often include options to superimpose a DC voltage or current on the AC measuring signal.

In addition, benchtop meters allow the usage of special fixtures to measure Surface Mount Device (SMD) components, air-core coils or transformers. Often used in a general capacity, components used in development can be validated and tested both incoming and for variation between parts.

With fast measurements that shorten test times, and binning interfaces to control a handler/sorter, LCR Bridge/ Meters can also be used in production facilities.

## All-in-one. The compact class, that has it all.

The R&S®NPA series of single phase power analyzers is a comprehensive range of compact testers meticulously designed for AC/DC load or standby current characterization with fundamental accuracy of 0.05% and low current measurement down to 5 milliamps. Unlike other competitors on the market, these analyzers:

- Require no additional tools for graphical analysis and compliance testing.
- Provide numerical displays of 26 critical parameters.
- Feature an auto-range function to enhance testing efficiency.
- Offer a fast display update rate of 100 milliseconds for short tact times.
- Incorporate frequency and adaptive filter capabilities to eliminate unnecessary noise and ensure smooth and accurate results.

The R&S®NPA seamlessly integrates all essential and remote control functions necessary for electric device research and development, production lines and quality assurance testing.

R&S®NPA

# POWER SUPPLIES

## A High Channel Count in a Compact Package

A variable DC power supply appears to be a straightforward device. But it has to reliably deliver stable, precise, clean voltage and current, no matter its load. Resistive, capacitive, inductive, low- or high-impedance, stable or variable.

Selecting the right power supply for your application requires an understanding of how they are specified.

The most important questions to have answered are covered in the following four sections.

## Number of Channels

### How many channels are needed? How many DUTs need to be powered?

Depending on the application and needs you can select a power supply unit with 1, 2, 3 or 4 channels.


R&S®NGE100B

## Output Power

### How much power does the device need?

The maximum power is determined by the maximum voltage and current demanded by the device. Is there a need for all of the power to be bundled to achieve higher current output? This is called parallel operation mode. Is there a need to combine channels to a higher maximum combined output voltage? This is called serial operation mode.

## Modulation and Arbitrary Functionality

### Is a function-variable output level necessary? If so, at which speed?

With a power supply, it is possible to define functions to vary the output voltage level over time. This can also be described as time/current flow or time/voltage curve that is freely programmable by channel. Some are programmable with an arbitrary sequence remotely or on the instrument.

## Protection

### If an overvoltage event occurs, the user can configure the response of each channel independently.

In some scenarios it is necessary to shut down one channel and leave another one active. For instance, to let a fan continue running while all other channels are switched off. Some instruments, such as the R&S®NGE100, allow for independent overvoltage, overcurrent, and overpower protection.

Users can link channels so that all linked channels are switched off if one channel hits its limit.

Even the delay time of the electronic fuses can be set to prevent switch-off due to short current spikes.

# SOURCE MEASURE UNITS (SMU)


## Source, Sink and Measure

A standard power supply is a one quadrant architecture with only the ability to source power. Power supplies that include the ability to sink voltage or current are commonly described as electronic loads.

SMUs combine power delivery, electronic load, and high-speed precise measurement capability into one device. SMUs are catagorized into two and four quadrant architectures.

## Two Quadrants: Operates as Source and Sink

The two-quadrant architecture of this source measure unit allows it to function both as a source and a sink and simulate batteries or loads. The source measure unit automatically switches from source mode to sink mode. As soon as the externally applied voltage exceeds the set nominal voltage, current flows into the instrument. This is indicated by a negative current reading.

## Battery Simulation

Real batteries show different characteristics depending on the type of battery and its charging condition. Capacity, open circuit voltage (Voc) and equivalent series resistance (ESR) are important battery characteristics that depend on its state of charge (SoC). The R&S®NGU-K106 option allows users to simulate the behavior of batteries under different charging conditions, e.g. when powering a DUT.

When battery-operated devices have to be optimized for lifecycle, the discharging behavior of the battery type needs to be considered. The battery simulator function of the R&S®NGU201 makes it possible to simulate the real battery output performance.

The charging behavior of a battery can also be simulated. This is particularly important when designing battery chargers. In this application, the R&S®NGU201 source measure unit is used in sink mode.

Both cases provide dynamic simulation, meaning Voc, ESR and SoC change according to charging/discharging conditions like a real battery. The state of charge is shown graphically.

## Four Quadrants: Source or Sink Operation with Arbitrary Polarity

With its four-quadrant architecture, the R&S®NGU401 can supply positive or negative voltages or currents and can act as a source or sink in both polarities. This enables tasks such as measuring the forward and reverse characteristics of semiconductor devices in a single test operation without having to make changes to the circuit.

The power supply automatically switches from source mode to sink mode. When the applied external voltage exceeds the set output voltage, current flows into the device. This is indicated by the opposite sign for current measurement.

# PRODUCT SERVICES AND SYSTEM SUPPORT

Rohde & Schwarz offers customers reliable, local service to ensure optimal product reliability. We support you through all phases of the product life cycle and stand by you with an extensive and constantly growing portfolio of services that can be tailored to your specific needs.

### Calibration Services

The scope and efficiency of our measurements are unequaled. You have chosen technologically leading products, and we ensure the total functionality and accuracy of your valuable T&M instruments for years to come.

### Repair Services

Our products are among the most reliable on the market. But even the best instruments may over time deviate from their optimal performance and require adjustment or repairs. If they ever do need to be repaired, quick and smooth handling is required.

### On-site Services

Downtime is a major cost factor to avoid. That's why we do everything we can to minimize the time your instruments have to be offline for calibration - all without time-consuming logistics effort. Precision is not a question of location or the manufacturer. We come to you.

### Extended Warranty

To enable you to benefit from the functionality of your equipment for many years, we offer tailored services to include with your new equipment purchase or warrantied product. Our concepts keep you safe.

### Service Contracts

Continue to benefit after the end of warranty with our attractive service contracts. Perfect protection at all times.

### Cybersecurity Services

Rohde & Schwarz Cybersecurity offers you comprehensive security services based on many years of expertise in high-security.

# TEST & MEASUREMENT PRODUCT GUIDE

## Available for download and print


Get our new T&M product guide for a complete overview of our portfolio, specifications and product models from Rohde & Schwarz. We offer a broad range of instruments to meet both your everyday needs and your most challenging requirements. Learn more about what's possible when faced with tomorrow's challenges today and prepare for what's next!

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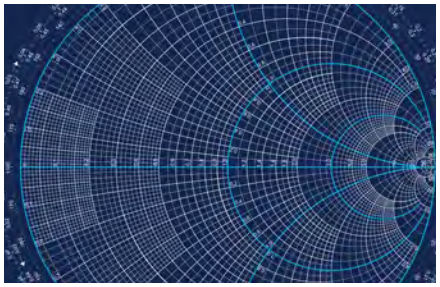
# EVERYTHING TEST

## Educational series

Join us for a complimentary six-track educational series that will improve your understanding of basic test and measurement concepts, techniques, and instrument optimization across a wide range of applications.



RF Fundamentals

Test & Measurement Fundamentals

RF Component Testing

Digital Design & Test

Intro to EMC Testing

Intro to Power Electronics

Automotive Testing

Mastering EVM

Understanding Coexistence Testing

Understanding Noise Figure

Understanding Phase Noise

**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.

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