Excellence in precision solutions for particle accelerators

- Test and measurement
- High-power amplifiers

ROHDE&SCHWARZ

Your challenge …

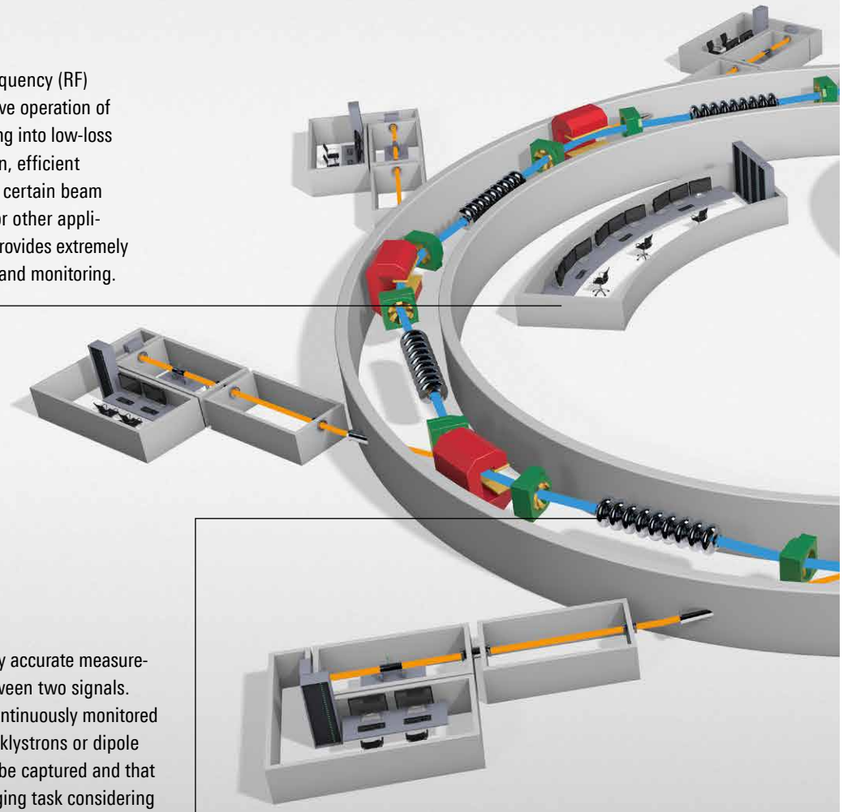
Particle accelerators are a key element in many of today's cutting-edge research areas, including fundamental scientific research or applied disciplines such as materials science or medicine.
All of the particle accelerator's technical components must meet the highest standards – especially when it comes to signal generation, signal amplification and electronic T&M.

This flyer offers a compact overview of Rohde&Schwarz instruments, devices and solutions that are especially suitable for handling particle accelerator requirements. Rohde&Schwarz also offers a wide range of instruments specifically aimed at research applications. For more information on these products, visit our website:

www.rohde-schwarz.com

Beam synchronous timing

Ultralow phase noise microwave and radio frequency (RF) signal sources are vital for efficient and effective operation of any particle accelerator. Whether you are looking into low-loss acceleration, constant energy beam generation, efficient injection (linear to circular) or implementing a certain beam time structure (single, few, multibunch, etc.) or other applications, the R&S®FSWP phase noise analyzer provides extremely high sensitivity for phase noise measurements and monitoring.

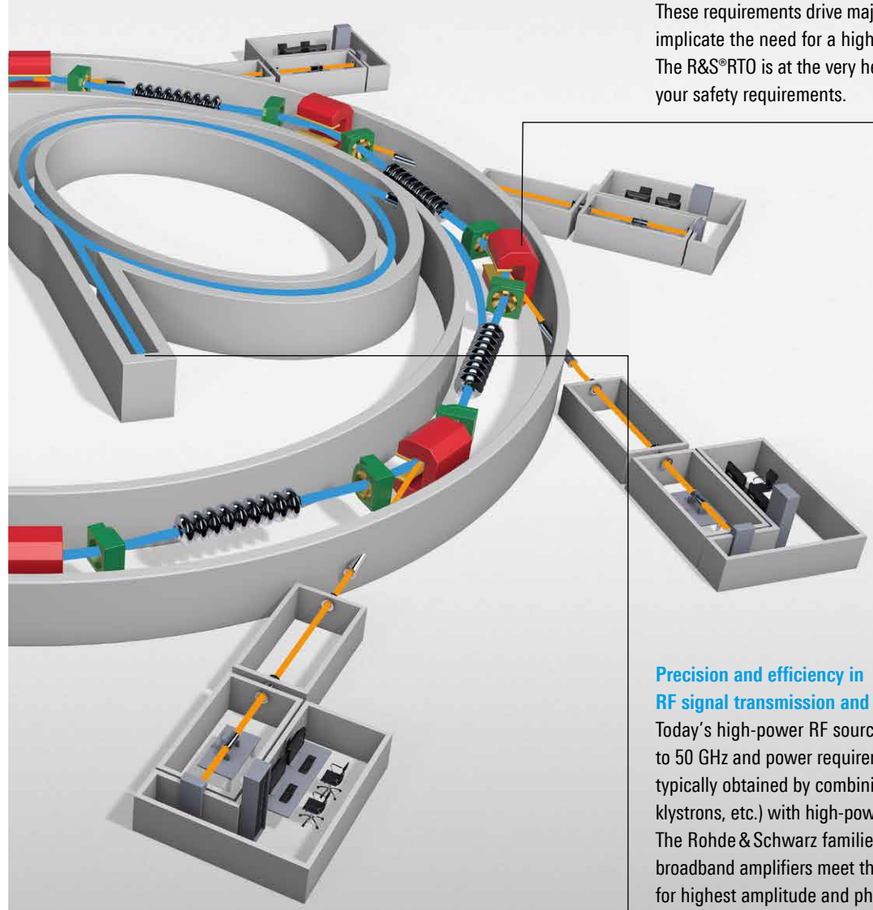


Central beam monitoring

Experiments in accelerator physics demand very accurate measurements of pulse parameters or of the jitter between two signals. For instance, the pulse shape of RF pulses is continuously monitored to prevent damage to any of the accelerator's klystrons or dipole magnets. This requires that every single pulse be captured and that the data be continuously recorded – a challenging task considering that the latest generation of free electron lasers (FEL) increases the pulse rate to 100 Hz. The R&S®RTO allows waveforms to be acquired and downloaded to a PC at rates of up to 100 Hz, ensuring that you do not lose a single pulse.

Beam quality safety interlock system

With the constant need for even higher beam energy and more luminosity, safety requirements become increasingly important and challenging. Even a marginal loss of beam into any part of the accelerator will cause damage, such as rupturing the machine vacuum or destroying one or more dipole magnets, resulting in costly repairs and weeks of downtime. In addition, the continuous top-up operation of synchrotron light sources requires a fully automated injection process.
These requirements drive major changes in the control system and implicate the need for a highly reliable safety interlock system. The R&S®RTO is at the very heart of the system solution to address your safety requirements.



Precision and efficiency in RF signal transmission and amplification

Today's high-power RF sources with frequency ranges from 10 kHz to 50 GHz and power requirements in the 10 kW to 2 MW range are typically obtained by combining a series of vacuum tubes (tetrodes, klystrons, etc.) with high-power VHF/UHF transmitters and amplifiers. The Rohde&Schwarz families of highly efficient transmitters and broadband amplifiers meet these challenges and address the demand for highest amplitude and phase stability, lowest phase noise, top energy efficiency, small footprint and a modular design.

Introduction

With over 80 years of business experience, you can rely on our excellence in high-energy RF signal generation, signal amplification and state-of-the-art test and measurement solutions.

With more than 70 subsidiaries and local representations worldwide, Rohde&Schwarz has built up long-lasting relationships within the global research community. Driven by our own curiosity for technical innovation and research development, we are constantly expanding this relationship network – offering our expertise and cutting-edge solutions to our partners.

And our global presence and widespread service and support network is a decisive benefit when providing local expertise and on-site support. Our global reach and technical expertise makes us a reliable partner in today's international programs and worldwide projects.

Whether your challenge lies in
- Elementary particle research
- Particle therapy applications
- Material characterization

or in providing service in fields such as
- High-energy particle acceleration
- Precise beam forming and monitoring
- Reliable and safe particle storage

Rohde&Schwarz is your reliable long-term partner with proven solutions to address all of these highly sophisticated requirements. Read on to find out what we can do for you.

Oscilloscope

Experiments in accelerator physics, e.g. in synchrotron labs, often require very accurate measurements of pulse parameters or of the jitter between two signals. This data needs to be measured during startup and characterization of the experimental setup as well as during operation for continuous monitoring. For monitoring, the data needs to be stored and downloaded at a high update rate in order to catch every pulse of a free electron laser operating at e.g. 100 Hz. Researchers will appreciate the outstanding accuracy of the R&S®RTO. The low-noise frontend and the 10 Gsample/s single-core monolithic A/D converter offer an effective resolution of > 7 ENOBs for precise measurement data. The 100 ps sampling resolution allows detection of high-frequency signal components. The digital trigger architecture is the key to the low trigger jitter of 1 ps (RMS). The R&S®RTO-B4 oven-controlled crystal oscillator (OCXO) option improves the timebase accuracy to 0.2 ppm, which is important in order to minimize long-term drifts. The R&S®RTO performs measurements fast: 600 000 mask tests/s detect signal deviations faster than ever before. Overall the R&S®RTO is perfect for precise measurements in many accelerator physics lab applications, such as in synchrotrons or free electron lasers.

To summarize: with its excellent signal fidelity, high acquisition rate and the world's first realtime digital trigger system, the R&S®RTO is the instrument of choice for applications in the 600 MHz to 4 GHz class. Customers worldwide rely on the R&S®RTO.

For more information, visit our website to find the following documents
- R&S®RTO product flyer (PD 3607.0946.32)
- Fast download of waveform data with the R&S®RTO digital oscilloscope (PD 3607.2132.92)
- The R&S®RTO in accelerator physics (PD 3606.9740.92)

Key facts
- Continuous beam quality monitoring at 100 Hz
- Safety interlock capability
- RF pulse and acceleration measurement
- Jitter measurement for laser pulses and synchrotron applications
- Trigger distribution accuracy measurements

R&S®RTO digital oscilloscope.

High-power transmitters and amplifiers

The Rohde&Schwarz high-power transmitter and broadband amplifier families address customer demands for highest amplitude and phase stability, lowest phase noise, top energy efficiency, small footprint and a modular design. The R&S®BBA150 broadband amplifier family generates power in the frequency range from 9 kHz to 6 GHz. The compact amplifiers are rugged and feature high availability. The R&S®BBL200 broadband amplifiers are ideal for applications requiring high RF power in the frequency range from 9 kHz to 250 MHz and up to 10 kW.
Originally designed for the latest terrestrial broadcasting requirements, the liquid-cooled R&S®Tx9 high-power transmitter family offers amplifier output powers up to 75 kW, with top energy efficiency and flexibility.

For more information, visit our website to find the following documents
- R&S®THR9 product brochure (PD 3606.8595.12)
- R&S®THU9/THV9 product brochure (PD 5214.5990.12)
- R&S®BBA150 product brochure (PD 3606.7247.12)
- R&S®BBL200 product brochure (PD 3606.9456.12)

Key facts
- 100% mismatch tolerance
- Suitable for amplitude, frequency, phase and pulse modulation
- Worldwide service network and global support for spare parts

Amplifier family	Frequency range	Max. CW output power
R&S®BBA150	9 kHz to 6 GHz	2.5 kW/200 W
R&S®BBL200	9 kHz to 250 MHz	10 kW
R&S®TxR9	87.5 MHz to 108 MHz	60 kW
R&S®TxV9	170 MHz to 254 MHz	32 kW
R&S®TxU9	470 MHz to 862 MHz	75 kW

R&S®BBL200 broadband amplifier.

Phase noise analyzer

The R&S®FSWP phase noise analyzer and VCO tester is the optimum test solution for precision measurement of synthesizers and oscillators like OCXOs, DROs and VCOs. The R&S®FSWP can be easily configured to the needs of the required application, making best use of the instrument's low-noise internal local oscillators with cross-correlation and allowing precise phase noise measurement with a push of a button, even on pulsed sources.

For more information, visit our website to find the following documents
- R&S®FSWP product brochure (PD 3607.2090.12)
- R&S®FSW-K30/R&S®FSWP-K30 noise figure measurement data sheet (PD 5214.6339.22)

Key facts
- Frequency range from 1 MHz to 8/26.5/50 GHz (with external mixers up to 500 GHz)
- High sensitivity for phase noise measurements thanks to cross-correlation and extremely low-noise internal reference sources
  - Typ. –172 dBc (1 Hz) at 1 GHz carrier frequency and 10 kHz offset
  - Typ. –153 dBc (1 Hz) at 10 GHz carrier frequency and 10 kHz offset
- Simultaneous measurement of amplitude noise and phase noise
- Measurement of phase noise on pulsed sources at the push of a button
- Internal source for measuring additive phase noise, including on pulsed signals
- Wide dynamic range for spectrum analysis thanks to low displayed average noise level (DANL) of –156 dBm (1 Hz) (without noise cancellation) and high TOI of typ. 25 dBm
- 80 MHz signal analysis bandwidth
- Total measurement uncertainty:
  - < 0.2 dB up to 3.6 GHz
  - < 0.3 dB up to 8 GHz

R&S®FSWP Phase noise analyzer

Service that adds value

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

About Rohde&Schwarz

The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, radiomonitoring and radiolocation. Founded more than 80 years ago, this independent company has an extensive sales and service network and is present in more than 70 countries. The electronics group is among the world market leaders in its established business fields. The company is headquartered in Munich, Germany. It also has regional headquarters in Singapore and Columbia, Maryland, USA, to manage its operations in these regions.

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

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Data without tolerance limits is not binding | Subject to change

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