R&S®DDF200M
Digital Direction Finder
Radio direction finding on multiple channels

ROHDE&SCHWARZ

Product Brochure | Version 02.01

R&S®DDF200M Digital Direction Finder

At a glance

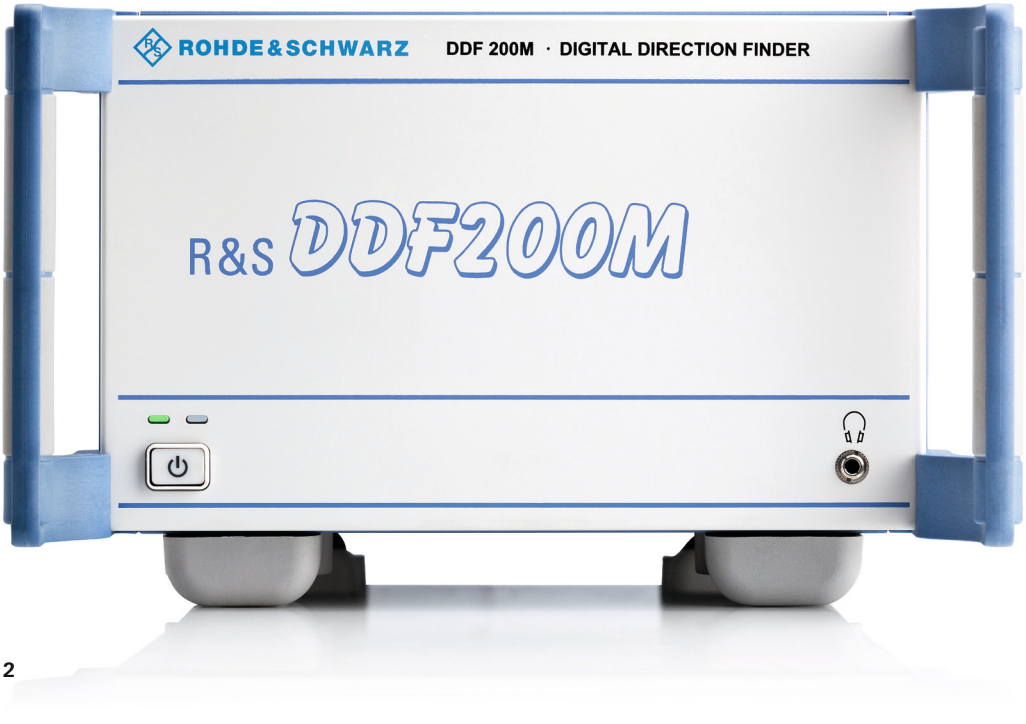
The R&S®DDF200M digital direction finder represents the latest generation of traffic control direction finders. Radio direction finding for maritime traffic control is performed simultaneously on multiple frequency channels using only one direction finder.

The R&S®DDF200M delivers accurate radio direction finding results in vessel traffic control applications. It measures the radio emissions from ships in the maritime VHF range on many frequency channels in parallel. Thanks to the wideband DF technology, the DF performance is equally high on all frequency channels measured. In contrast to traditional traffic control direction finders, which require one DF unit per frequency channel, only one R&S®DDF200M is used to measure all frequency channels required.

The correlative interferometer DF method is used in combination with the wide aperture R&S®ADD090 VHF DF antenna (with nine antenna elements) to provide high DF accuracy, sensitivity and immunity to reflections.

Key facts

- Parallel direction finding on up to 32 maritime channels with the same high DF accuracy and sensitivity on all channels
- Quasi-simultaneous direction finding on additional channels outside the maritime frequency range, e.g. distress channels
- Seamless coverage of a wide frequency range from 118 MHz to 250 MHz (with R&S®ADD090)
- Adaptive interference cancellation (option) in instances where VHF radiocommunications antennas are installed on the same mast as the DF antenna
- Output of results to vessel traffic management systems via a serial interface (option) or TCP/IP interface
- Serial interface compatible with R&S®DDF100M (option)



R&S®DDF200M Digital Direction Finder

Benefits and key features

One direction finder for all frequency channels

- Parallel direction finding on up to 32 maritime channels with the same high DF accuracy and sensitivity on all channels
- Quasi-simultaneous direction finding on additional channels outside the maritime frequency range, e.g. distress channels

▷ page 4

High DF accuracy, sensitivity and immunity to reflections

- Correlative interferometer DF method
- Multi-element wide aperture DF antenna

▷ page 5

Adaptive interference cancellation (option)

- Suppression of interference signal caused by strong adjacent transmitters to enable direction finding
- Installation of DF antenna and maritime radiocommunications antennas on the same mast

▷ page 6

Simple networking and control

- Networking of direction finder, data server and display units via LAN
- Output of results to vessel traffic management systems (VTMS) via TCP/IP or optional serial interface
- Serial interface compatible with R&S®DDF100M (option)
- Powerful R&S®DDF20M-CTL graphical user interface and control software included

▷ page 6

Comprehensive selftest capabilities

- Built-in test and automatic alerts in event of error(s)

▷ page 7

Integrated DF antenna lightning protection

- No impairment of DF accuracy
- DF accuracy specified in data sheets attained even with lightning rod
- No time-consuming calibration after DF antenna installation

▷ page 7

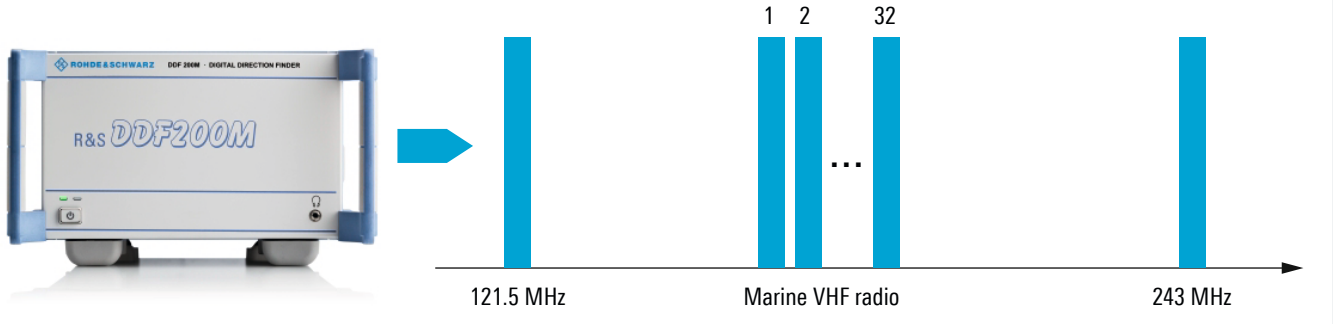
One direction finder for all frequency channels

Conventional fixed frequency direction finders are tuned to a specific frequency and take the bearings of signals on that frequency. If the bearings are taken across multiple frequencies at the same time, which is common in traffic control systems, an appropriately large number of fixed frequency direction finders is required. In contrast to fixed frequency direction finders, wideband direction finders take bearings on many frequencies simultaneously. This is done by using a Fourier transform to divide the frequency spectrum within the realtime bandwidth into channels according to the preselected channel spacing settings. The Fourier transform can be considered a bandpass filter bank where the bandwidth of the bandpass filters is adjustable and each bandpass filter corresponds to a channel. Bearings are then calculated in parallel for all channels. DF accuracy, sensitivity and measurement speed are equally high for all channels measured.

The following operating modes are available on R&S®DDF200M:

- DF0: receive mode on a single frequency channel for audio demodulation (no direction finding)
- DF1: direction finding on a single frequency channel with fast measurement speed (only versions without interference canceller)
- DF2: quasi-simultaneous direction finding on up to four frequency channels
- DF3: direction finding on a single frequency channel with higher sensitivity due to longer measurement time
- DF4: quasi-simultaneous direction finding on up to 32 frequency channels in the maritime VHF range plus additional frequencies outside this range

Principle of operation of the R&S®DDF200M in DF4 operating mode



High DF accuracy, sensitivity and immunity to reflections

Correlative interferometer DF method

The R&S®DDF200M uses the accurate correlative interferometer DF method. With this method, the phase differences between the antenna elements are measured and compared to values stored in a reference table. All phase differences for all azimuth and elevation angles are stored in the reference table. The bearing values are determined by comparing the measured phase differences with the calculated phase differences. The angle with the highest correlation is taken as the bearing of the signal.

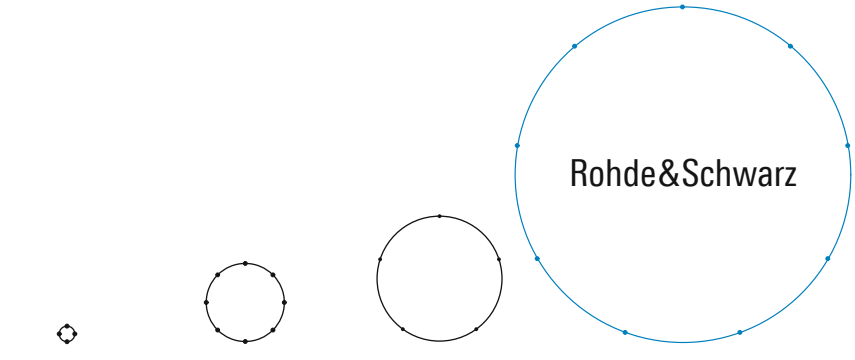
Multi-element wide aperture DF antenna

The correlative interferometer DF method permits the use of wide aperture antennas that are highly immune to reflections and features a high level of DF accuracy and sensitivity. The higher level of DF accuracy and immunity to reflections is particularly evident when compared to conventional Watson-Watt DF methods, which are still used in maritime traffic control applications.

It is generally known that a direction finder's accuracy and sensitivity in a real environment increases with the diameter of the DF antenna. This advantage comes to light only in actual operational environments that include reflections and weak signals. It is not apparent from the specifications, since in the data sheets the instrument and system accuracy are specified for ideal, reflection-free DF antenna environments and strong signals for the purpose of comparison.

The figure shows that the R&S®DDF200M, which features a nine-element array and employs the correlative interferometer DF method, offers by far the largest DF antenna and thus higher accuracy and sensitivity.

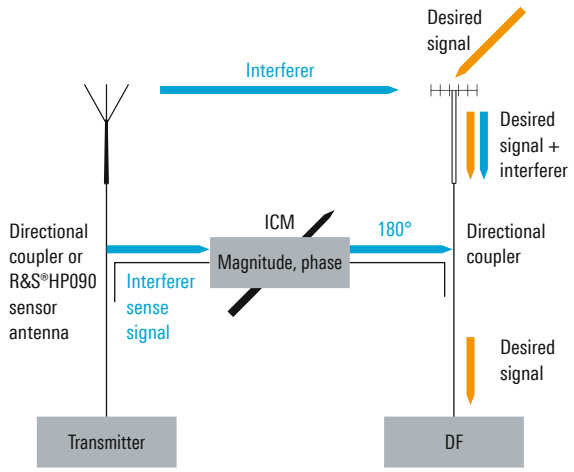
Improvement of DF accuracy as a function of DF antenna aperture



Maximum permissible diameter of the DF antenna relative to the wavelength for unambiguous DF results for up to 50 % environmental reflections

Adaptive interference cancellation (option)

Principle operation of the ICM



In applications where the VHF radiocommunications antennas are installed on the same mast as the DF antenna, the optional adaptive interference canceller module (ICM) serves to suppress these signals to enable direction finding. In contrast to passive filters, the active adaptive filter of the ICM ensures that adjacent-channel interferers are supressed without filtering out large parts of the maritime frequency range.

The figure shows the principle of operation. The interfering signal is sensed via directional couplers, changed in magnitude and phase and added to the DF antenna signals in order to cancel out the interference.

This requires that the high-power signals coming from the VHF radiocommunications transceivers are first routed through the ICM before they are connected to the transmit antenna.

Simple networking and control

Connection to customer-specific vessel traffic management systems is accomplished via LAN (TCP/IP). The open interface for remote control commands in line with the SCPI standard enables system integrators to easily incorporate the DF unit into vessel traffic management systems (VTMS).

Alternatively, the R&S®DDF200M-SE serial interface (option) is available. One major advantage of this option is that the unit becomes backward compatible with the R&S®DDF100M, the predecessor of the R&S®DDF200M. This makes it significantly easier to expand existing systems in the future.

The R&S®DDF20M-CTL graphical user interface and control software can also be used to display results and control the system. Standard PC hardware can be used, which greatly reduces the costs per workstation while increasing flexibility. For example, laptops can be utilized for control and display in systems. The R&S®DDF20M-CTL graphical user interface and control software is also used for maintenance and troubleshooting on site. The R&S®DDF20M-CTL is included with the R&S®DDF200M.

Comprehensive selftest capabilities

Selftest capabilities are particularly important for safety-relevant applications in maritime traffic control. The R&S®DDF200M continuously checks test points in the background during operation and compares the results with the nominal values. If one of these test points is outside the nominal value range, an error message is automatically generated.

R&S®ADD090 VHF DF antenna installed on a mast.

Integrated DF antenna lightning protection

DF antennas for vessel traffic control applications are usually positioned on top of high masts in order to achieve wide coverage. The higher a DF antenna is located, the more likely it will be struck by lightning. This applies especially to areas with frequent thunderstorms.

The R&S®ADD090 VHF DF antenna and the R&S®GX090 antenna network feature built-in, effective lightning protection:

- Integrated lightning rod that prevents lightning from striking the DF antenna from the side
- Massive metal core inside the DF antenna to divert the lightning current to the mast so that the current flows off safely via ground
- Gas arresters at all critical spots prevent voltage peaks (caused by lightning bolts) from destroying the DF antenna circuitry

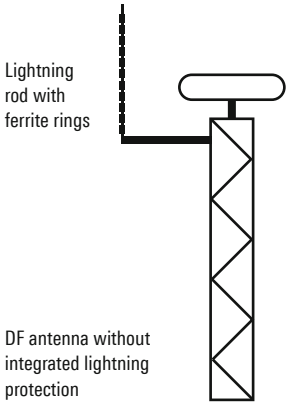
This lightning protection concept was taken into account in development right from the start and does not impair DF accuracy. The DF accuracy specified in the data sheets is attained even with the lightning rod.

Vessel traffic control DF antennas without integrated lightning protection have a lightning rod that is erected next to the DF antenna, which leads to considerable DF errors (especially in the VHF range). Even if this type of lightning rod is lined with ferrite rings and is positioned two meters away from the DF antenna, the DF accuracy is considerably poorer than specified in the data sheet for a reflection-free environment without lightning protection (see table below). At certain frequencies where the lightning rod is in resonance, considerable DF errors of more than 20° can occur. It is not possible to predict precisely how high the DF errors will be and at which frequencies they occur.

If the spacing between the DF antenna and the lightning rod is less than two meters, or if the rod is not thoroughly ferritized, the DF errors to be expected are even significantly higher.

The additional DF errors due to the separate lightning rod can be slightly reduced by calibration. This calibration, however, is very complicated and can correct only some of the DF errors. Even after calibration, additional DF errors in the VHF range can occur at any time.

Lightning protection for antennas



R&S®ADD090 with integrated lightning protection

Comparison of specifications of DF antennas with and without integrated lightning protection

	DF antennas without integrated lightning protection [1]	R&S®ADD090 with integrated lightning protection
Average DF accuracy according to data sheet specifications (reflection-free environment)	1° RMS	1° RMS
Average DF accuracy with lightning protection, 20 MHz to 200 MHz	5° RMS	1° RMS
Additional DF error due to lightning protection	depending on frequency, up to 20°	no additional DF error

[1] Measured with separate lightning rod lined with ferrite rings, 2 m away from antenna.

System components

DF antenna system for vessel traffic control (R&S®ADD090 and R&S®GX090)

The DF antenna system consisting of the R&S®ADD090 VHF DF antenna and the R&S®GX090 antenna network covers the frequency range from 118 MHz to 250 MHz. With a diameter of two meters and a total of nine antenna elements, this DF antenna system offers wide aperture performance (above 150 MHz) and thus high DF accuracy, sensitivity and immunity to reflections. The DF antenna system draws its power from the R&S®DDF200M or the R&S®GX090C combiner network via the control cable. For cable lengths of 100 m or more and systems without interference cancellation, an additional R&S®IN061 power supply is required (included in the cable set).

Antenna cables

To connect the DF antenna to the R&S®DDF200M direction finder, the R&S®DDF91XZ (for systems without ICM) and the R&S®DDF92XZ (for systems with ICM) VHF cable sets are available in many standard lengths.

Special lengths are available on request.

R&S®GX090C and interference canceller module (ICM)

The two DF channels (DF and REF) coming from the R&S®ADD090 VHF DF antenna and the corresponding R&S®GX090 antenna network – a reference signal and a sampled DF signal – are first routed through an ICM. Interfering signals in the frequency range from 150 MHz to 174 MHz coming from transmitters near the DF antenna are reduced to uncritical levels to enable direction finding.

An additional monitoring receiver can be connected to the R&S®GX090C combiner network for monitoring purposes without the need to install additional antenna(s). The reference antenna element from the R&S®ADD090 is used in this case.

R&S®RAMON radiomonitoring software

The R&S®DDF200M comes with the appropriate Windows-based R&S®RAMON radiomonitoring software for operation from a standard PC. R&S®RAMON is used to present the DF results for all measured frequency channels. It also serves as a helpful tool for on-site maintenance and troubleshooting.

System configuration

Configuration without interference cancellation

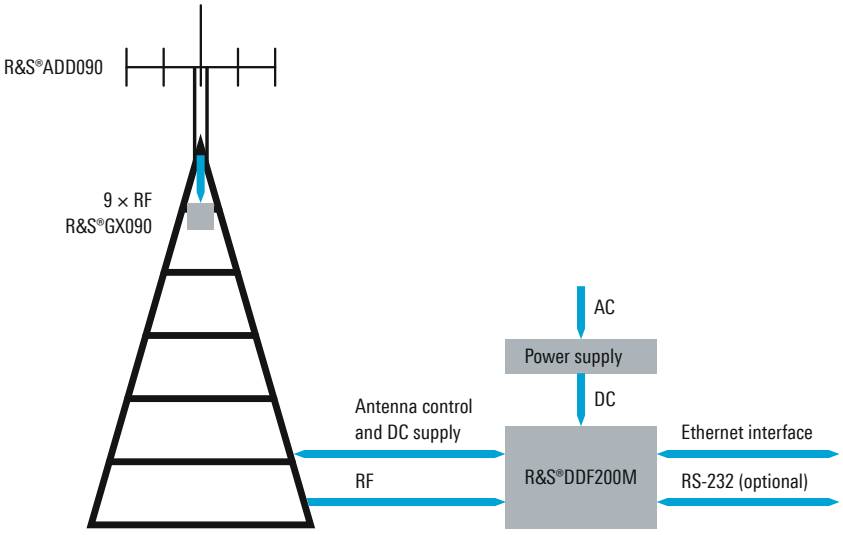
Description	Type	Order No.
Digital Direction Finder	R&S®DDF200M	4073.1002.02
VHF DF Antenna for R&S®DDF200M	R&S®ADD090	4063.7043.02
Antenna Network for R&S®ADD090	R&S®GX090	4063.4844.12
VHF Cable Set, length: 25/50/70/100/150 m	R&S®DDF91XZ	4064.8920.xx
Options		
Serial Interface	R&S®DDF200M-SE	4073.1402.02
Mast Extender	R&S®KM090	4067.5722.02

Configuration with interference cancellation

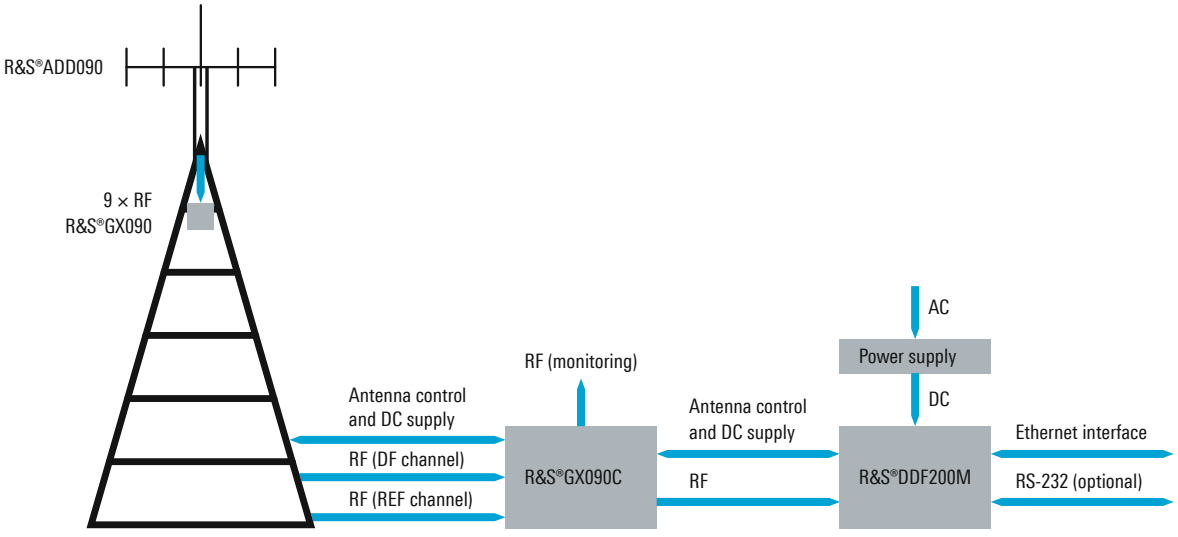
Description	Type	Order No.
Digital Direction Finder	R&S®DDF200M	4073.1002.02
VHF DF Antenna for R&S®DDF200M	R&S®ADD090	4063.7043.02
Antenna Network for R&S®ADD090	R&S®GX090	4063.4844.02
Combiner Network	R&S®GX090C	4063.2641.02
VHF Cable Set, length: 25/50/70/100/150 m	R&S®DDF92XZ	4064.9362.xx
Options		
Serial Interface	R&S®DDF200M-SE	4073.1402.02
Mast Extender	R&S®KM090	4067.5722.02

System configuration

Without interference cancellation



With interference cancellation



Specifications in brief

Specifications in brief		
Frequency range	with R&S®ADD090	118 MHz to 250 MHz
System DF accuracy [1]	with R&S®ADD090, in reflection-free environment, including lightning protection, DF error correction not required	≤ 1° RMS, 0.5° RMS (typ.)
DF method		correlative interferometer
Channel resolution	selectable	200 Hz to 2 MHz (includes 12.5 kHz and 25 kHz)
DF sensitivity	with R&S®ADD090, field strength required for 2° RMS, 15 kHz DF bandwidth, 1 s integration time	5 µV/m
Number of frequency channels in parallel	in the maritime frequency range of 156 MHz to 162 MHz	up to 32 channels
Maximum number of interferers	with interference cancellation	6
Frequency range of the interferers	with interference cancellation	150 MHz to 174 MHz
Interfaces	all DF modes	Ethernet
	optional for DF0, DF1, DF2 and DF3 modes	RS-232
Dimensions	DF unit	½ 19" × 3 HU
	R&S®ADD090 (Ø × H, with lightning protection)	approx. 2.07 m × 2 m (6.79 ft × 6.56 ft)
Weight	R&S®ADD090	approx. 40 kg (88.18 lb)

[1] Measured in reflection-free environment. The RMS error is calculated from the bearings of evenly distributed samples versus azimuth and frequency.

Ordering information

Designation	Type	Order No.
Base unit (including supplied accessories such as power cable, operating manual)		
Digital Direction Finder	R&S®DDF200M	4073.1002.02
Options		
Serial Interface	R&S®DDF200M-SE	4073.1402.02
Documentation of Calibration Values	R&S®DDF200M-DCV	4073.1225.02
System components		
VHF DF Antenna for R&S®DDF200M	R&S®ADD090	4063.7043.02
Antenna Network for R&S®ADD090	R&S®GX090	4063.4844.02
Combiner Network	R&S®GX090C	4063.2641.02
VHF Cable Set for R&S®DDF200M system, without interference canceller	R&S®DDF91XZ	4064.8920.xx [1]
VHF Cable Set for R&S®DDF200M system, with interference canceller	R&S®DDF92XZ	4064.9362.xx [1]
Adapter for R&S®ADD196 for mobile application	R&S®ADD150A	4041.2655.02
Mast Extender	R&S®KM090	4067.5722.02
19" Rack Adapter	R&S®ZZA-T02	1109.4164.00

[1] The DF antenna cable sets are available in various lengths, designated by the last two digits of the order number.

Service options	
Extended Warranty, one/two/three/four year(s)	Please contact your local Rohde&Schwarz sales office.
Extended Warranty with Calibration Coverage, one/two/three/four year(s)	
Extended warranty with accredited calibration coverage, one/two/three/four year(s)	

Service that adds value

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

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Regional contact

- Europe, Africa, Middle East | +49 89 4129 12345
  customersupport@rohde-schwarz.com
- North America | 1 888 TEST RSA (1 888 837 87 72)
  customer.support@rsa.rohde-schwarz.com
- Latin America | +1 410 910 79 88
  customersupport.la@rohde-schwarz.com
- Asia Pacific | +65 65 13 04 88
  customersupport.asia@rohde-schwarz.com
- China | +86 800 810 82 28 | +86 400 650 58 96
  customersupport.china@rohde-schwarz.com

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