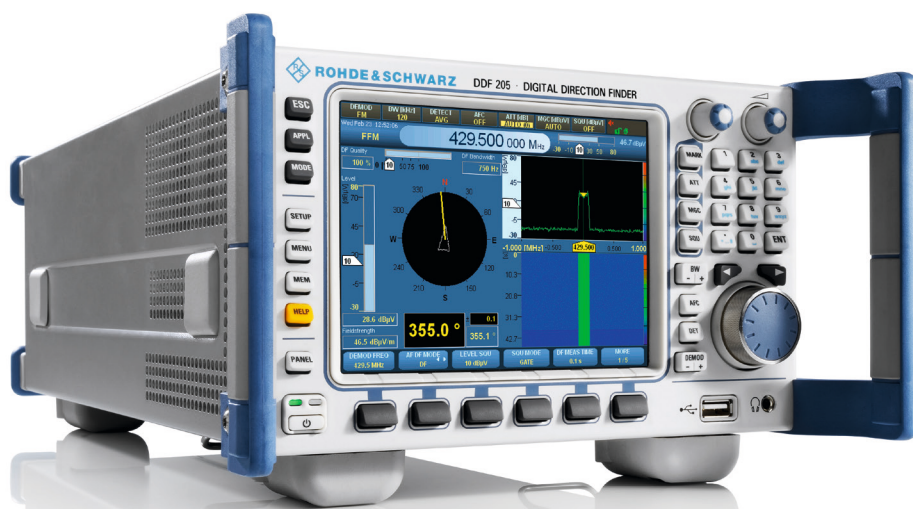


R&S® DDF205

Digital Direction Finder

Accurate direction finding in a compact unit



R&S® DDF205

Digital Direction Finder

At a glance

The R&S® DDF205 combines the new, highly integrated R&S® EB500 monitoring receiver with the accurate correlative interferometer DF method. This unique combination performs precise radio direction finding though it is compact and has low power consumption. Featuring wideband DF antennas and the ability to be powered from a DC source, the R&S® DDF205 is also ideal for mobile applications.

Due to the use of wide-aperture DF antennas and a very large number of antenna elements, the correlative interferometer DF method offers a high degree of accuracy and outstanding immunity to reflections at an excellent price/performance ratio.

The R&S® DDF205 fulfills all ITU recommendations for direction finders and receivers and can be extended with an option to include a comprehensive range of ITU-compliant measurement methods.

Key facts

- Tried and tested technology used by 24 regulatory authorities worldwide
- High-precision DF method at an excellent price/performance ratio (patented method)
- Reliable DF results even in difficult environments (e.g. in urban areas with up to 50% reflection)
- Compact dimensions and low power consumption

R&S® DDF205 without front panel control.



R&S® DDF205

Digital Direction Finder

Benefits and key features

Extended applications

- Fast spectrum monitoring with scan speeds of up to 12 GHz/s
- Display and demodulation of signals with up to 20 MHz bandwidth
- Wideband DF antennas and DC power supply capability for mobile operation
- Parallel monitoring and demodulation of one plus three signals within realtime bandwidth
- Online signal analysis with live streaming over LAN interface, e.g. with R&S®CA100 and suitable options
 - Signal analysis and classification
 - Detection of modulation mode and transmission quality (eye diagram)
 - Extraction of signal content using bitstream analysis
- Offline signal analysis of recordings

▷ [page 4](#)

Fast and reliable radiolocation due to high DF accuracy

- Use of high-precision correlative interferometer DF method
- Higher immunity to reflections due to DF antennas with a very large number of antenna elements

▷ [page 7](#)

Innovative DF antennas

- Active/passive switchover with just a mouse click
- Exceptionally high DF sensitivity
- Integrated, extendible lightning protection
- Easy replacement of DF antennas

▷ [page 8](#)

Effective measurements in line with ITU recommendations

The R&S®DDF205 fulfills all ITU recommendations for direction finders and receivers:

- Option for comprehensive, ITU-compliant measurement methods including, for example:
 - Frequency and frequency offset, field strength, modulation, spectrum occupancy and bandwidth
 - Offline measurements on digitally modulated signals using the R&S®CA100IS software and suitable options (in line with ITU recommendation SM1600)

▷ [page 9](#)

Direction finding up to 6 GHz

- Fast, effective interference detection

▷ [page 10](#)

High-resolution IF spectrum

- All details visible in DF mode

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Extended applications

Due to the extensive functionality of the R&S®EB500 monitoring receiver, the R&S®DDF205 offers more standard features than a conventional direction finder.

Fast spectrum monitoring with scan speeds of up to 12 GHz/s

The R&S®DDF205 can be equipped with the high-speed R&S®DDF205-PS panorama scan as an option. This enables fast scanning at speeds of up to 12 GHz/s to obtain a quick overview of the spectrum. A signal detected during the panorama scan can be transferred to DF mode by pressing a key.

Display and demodulation of signals with up to 20 MHz bandwidth

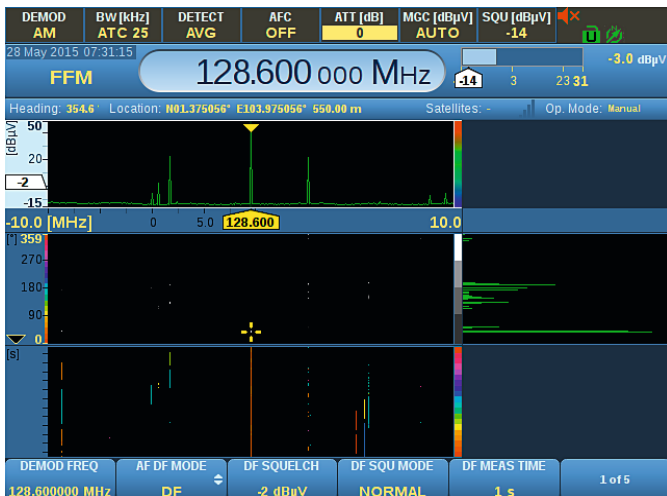
The R&S®DDF205 fully displays signals up to a bandwidth of 20 MHz in the IF spectrum display. This allows very detailed investigation of any signal with high resolution. Even events with extremely short durations can be reliably detected in this mode.

The R&S®DDF205 demodulates signals with a bandwidth of up to 20 MHz.

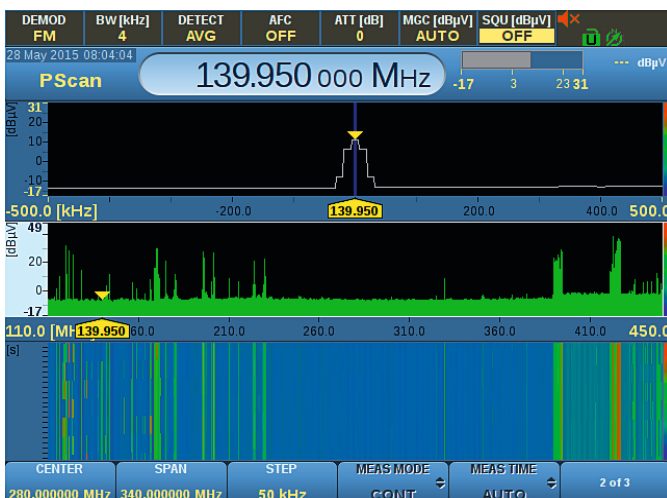
Wideband DF antennas and DC power supply capability for mobile operation

The R&S®DDF205 features compact dimensions and wideband DF antennas for the entire VHF/UHF range. Plus, it can be powered from a DC source, e.g. a vehicle battery. These characteristics make the R&S®DDF205 ideal for mobile applications.

Graphical user interface with 20 MHz realtime bandwidth.



Graphical user interface with fast spectral scan for quick overview of the spectrum beyond realtime bandwidth.



Parallel monitoring and demodulation of one plus three signals within realtime bandwidth

Equipped with the R&S®DDF205-DDC option, the R&S®DDF205 offers three parallel demodulation channels in addition to the demodulation path included in the base unit.

The demodulation path included in the base unit has a maximum bandwidth of 20 MHz; the three additional paths provide a maximum of 1 MHz each. When the R&S®DDF205-DDC option is installed, users have four independent software receivers in a single instrument.

The demodulated information from all four channels is processed as separate data streams via the LAN interface, e.g. as a *.wav data stream for audio data or as I/Q base-band data for analysis.

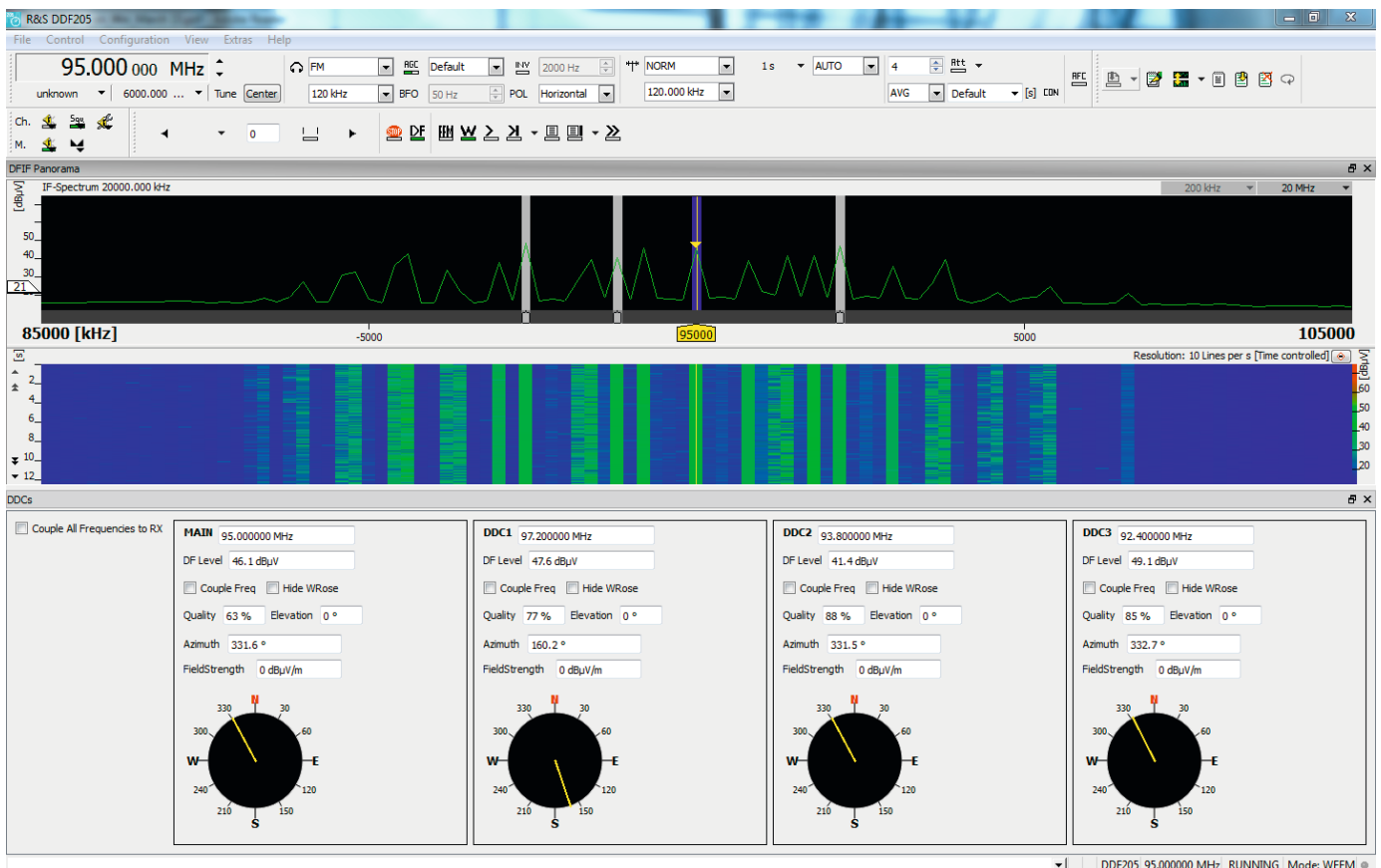
The four demodulation channels can be placed anywhere within the selected realtime bandwidth and separately parameterized. Settable parameters include:

- Center frequency
- Bandwidth
- Demodulation mode
- Squelch value

Using the DDC function, users can process four signals in parallel and check for content or absence of interference.

Additionally, the R&S®DDF205-Control software displays the DF results for each DDC on top of the main channel. For clear audio, the direction finder can be switched from DF mode to receive mode by means of a mouse click.

DF results displayed on R&S®DDF205-Control GUI for main and each DDC channel.



Online signal analysis with live streaming over LAN interface

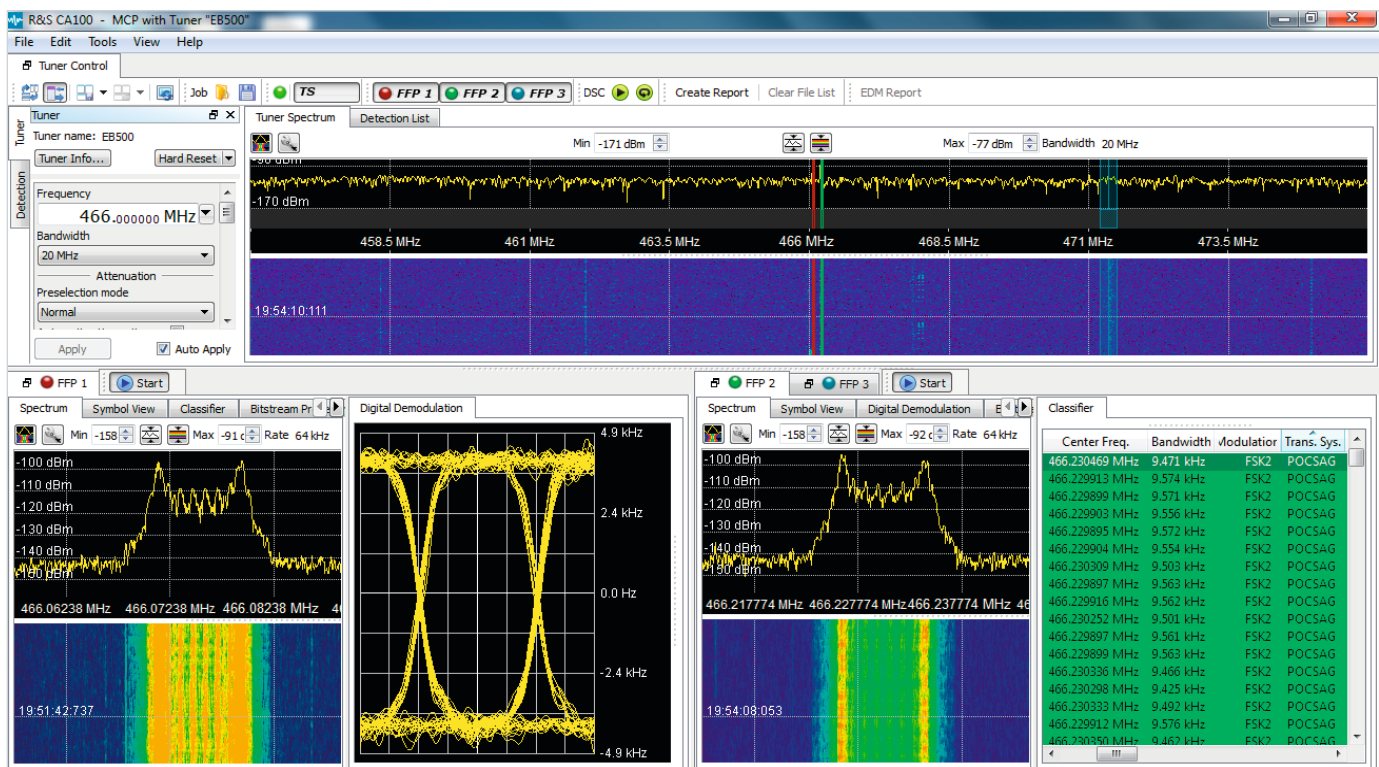
The R&S®DDF205 provides a continuous I/Q baseband data stream for online analysis of a max. 1 MHz signal channel over the 1 Gbit LAN interface. The R&S®CA100 software uses this data stream to analyze and classify the signal on an external PC. It recognizes modulation modes and displays transmission quality in an eye diagram. Bit-stream analysis allows users to extract the message content from the received signal.

If the monitoring receiver is equipped with DDCs (R&S®DDF205-DDC option), the R&S®CA100 software can process up to three signals in parallel.

Offline signal analysis of recordings

The R&S®CA100 software can save data packets on a PC's hard disk for later detailed offline analysis. Complex signal forms are examined under different conditions to obtain more detailed analysis results.

Online and offline signal analysis, from eye diagram to message content.



Fast and reliable radiolocation due to high DF accuracy

Use of high-precision correlative interferometer DF method

In the VHF/UHF/SHF range, the R&S®DDF205 uses the correlative interferometer DF method. In contrast to other direction finders using simple amplitude comparison methods, the R&S®DDF205 therefore offers significantly higher DF accuracy up to class A in line with ITU recommendations.

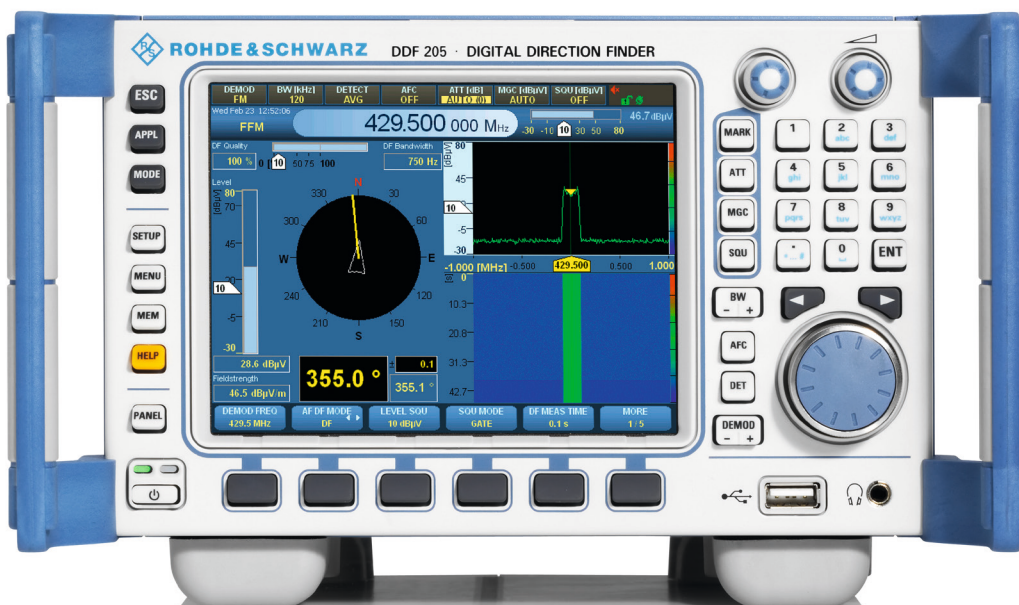
This high DF accuracy relies on the precise measurement of the phase angles between the reference antenna element and the other elements. Measuring the phase difference between two signals normally requires two coherent receive paths. For this reason, most interferometer direction finders on the market use at least two receivers. With the R&S®DDF205, the two receive paths are coherently linked in the DF antenna using a patented method from Rohde&Schwarz.¹⁾

Higher immunity to reflections due to DF antennas with a very large number of antenna elements

Due to multipath propagation (especially in urban areas), not only the direct wave but also reflections arrive at the DF antenna. The R&S®ADDx DF antennas offer higher immunity to such reflections than most other commercially available antennas, since they feature an exceptionally large number of antenna elements. Virtually all Rohde&Schwarz DF antennas use nine antenna elements in the VHF/UHF range, or eight in the UHF/SHF range, while commercially available DF antennas typically have only five. The Rohde&Schwarz antennas were designed to provide stable bearings even with a 50% share of reflections.¹⁾

¹⁾ For details, see page 15.

R&S®DDF205 with front panel control.



Innovative DF antennas

Active/passive switchover with just a mouse click

Up until now, users have had to decide what is more important to them: the higher sensitivity offered by active DF antennas or the higher immunity to strong signals provided by passive DF antennas.

The R&S®ADD196/197/295 DF antenna for the first time makes it possible to bypass the active circuitry of the antenna elements. The user can switch the active elements to passive mode by a simple mouse click. This DF antenna thus offers the advantages of both methods. ¹⁾

Exceptionally high DF sensitivity

The antenna elements of the R&S®ADD196, R&S®ADD197 (vertical polarization) and R&S®ADD295 DF antennas are equipped with PIN diodes, allowing the electrically active structure to change very quickly in the VHF/UHF range. As a result, these elements are always optimally adapted to the receive frequency and offer exceptionally high sensitivity. ¹⁾

Integrated, extendible lightning protection

All installed Rohde&Schwarz DF antennas that are at risk of being struck by lightning have built-in effective, extendible lightning protection. The lightning protection concept was taken into account in development right from the start and does not impair the DF accuracy. ¹⁾

Easy replacement of DF antennas

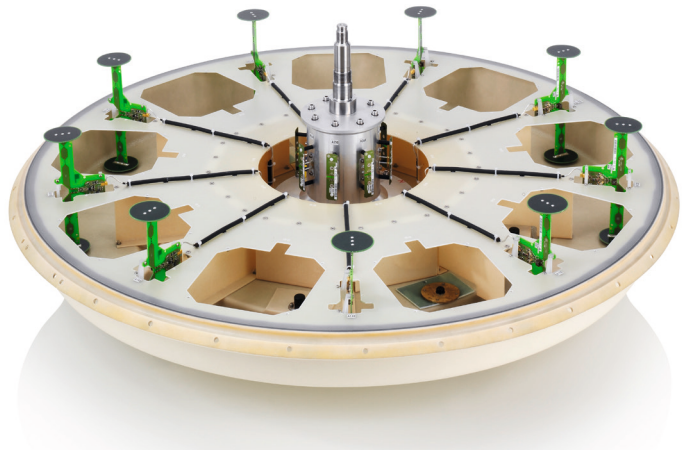
Unlike other commercially available antennas, DF antennas from Rohde&Schwarz do not need to be individually calibrated. The precisely manufactured R&S®ADDx DF antennas behave exactly as predicted in theory. A DF antenna from Rohde&Schwarz can be replaced with the same model without having to manage new calibration data and store it in the direction finder. ¹⁾

¹⁾ For details, see page 18.

R&S®ADD196 VHF/UHF DF antenna
with integrated lightning protection.



R&S®ADD295 broadband VHF/UHF DF antenna.



Effective measurements in line with ITU recommendations

Option for comprehensive, ITU-compliant measurement methods

The R&S®DDF205-IM option enables ITU-compliant measurements of signal parameters for AM, FM and PM modulated signals. The modulation index, occupied bandwidth and phase deviation can be determined, for example. The minimum, maximum and average values over a user-defined measurement period are displayed.

The R&S®DDF205-IM option covers the following ITU recommendations:

- ITU-R SM.377 (frequency and frequency offset measurements)¹⁾
- ITU-R SM.378 (field strength measurements)
- ITU-R SM.328 (bandwidth measurements)
- ITU-R SM.443 (bandwidth measurements)
- ITU-R SM.1880 (determination of spectral occupancy, with remote control PC and R&S®ARGUS software package)

Offline measurements on digitally modulated signals using the R&S®CA100IS software and suitable options

For offline measurement of digitally modulated signals in line with ITU-R SM.1600, the R&S®CA100IS option can be added to the R&S®CA100 software solution. For signal processing with the R&S®CA100, an additional PC is required.

The R&S®DDF205 fulfills the following ITU hardware recommendations:

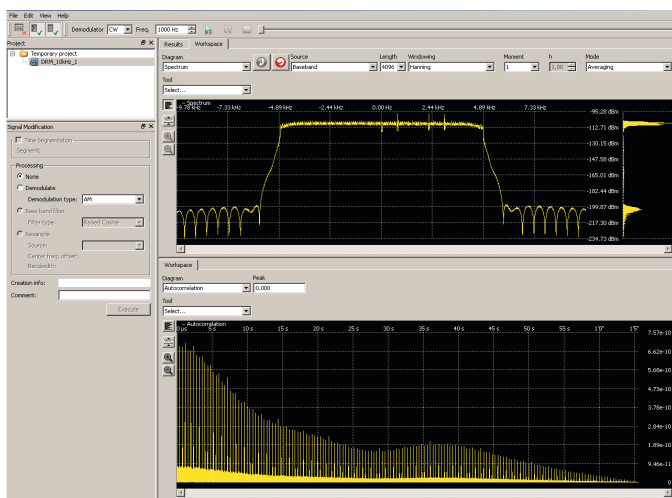
- ITU-R SM.1836 (measurements of IF filter edge steepness)
- ITU-R SM.1837 (IP3 measurements)
- ITU-R SM.1838 (noise figure measurements)
- ITU-R SM.1840 (sensitivity measurements)

¹⁾ Depending on the application, an external reference frequency with higher accuracy may be required, e.g. a GPS reference frequency.

Modulation and bandwidth measurement results at a glance.



Offline measurement of a Digital Radio Mondiale (DRM) signal in line with ITU-R SM.1600.



Direction finding up to 6 GHz

Fast, effective interference detection

Together with the new R&S®DDF205-FE option and the R&S®ADD075 DF antenna, the R&S®DDF205 delivers accurate DF results up to 6 GHz. Until now, this has been possible only up to 3 GHz. For the first time, bearings can now be taken on transmitters up to 6 GHz, for example in the frequency ranges of the following services:

- WLAN
- WiMAX™
- Microwave links

Locating target transmitters previously required the use of rotatable directional antennas, which have disadvantages regarding manageability and measurement speed. The R&S®DDF205 immediately displays the bearing, significantly simplifying direction finding during a test drive. The high DF accuracy and immunity to reflections in the VHF/UHF range are also achieved in the SHF range.

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R&S®ADD075 UHF/SHF DF antenna.



R&S®ADD207 compact DF antenna with
R&S®ADD17XZ3 vehicle adapter.



High-resolution IF spectrum

All details visible in DF mode

In order to get stable and accurate DF results, a sufficiently wide DF bandwidth is required, i.e. the DF bandwidth should be similar to the signal bandwidth. Typically, this results in a coarse spectrum resolution. In many applications, a much finer channel resolution in the IF spectrum is required in order to see details in the spectrum that are not visible otherwise. Now the R&S®DDF205 offers both in parallel: an IF spectrum with fine resolution for spectrum display and a DF spectrum with coarse resolution for direction finding (see screenshot). Both resolutions can be set independently.

WCDMA signal measured with a DF bandwidth of 2 MHz and displayed at high resolution.



System components

DF antennas for the R&S®DDF205

The R&S®DDF205 can be operated with all R&S®ADDx single-channel DF antennas (see table). For details, see the R&S®ADDx single-channel DF antennas product brochure (PD 3606.8295.12) and data sheet (PD 3606.8295.22).

System requirements

If the R&S®DDF205 is ordered without front panel control, a standard PC is required to control the direction finder.

Ethernet interfaces for remote control and data transmission

The base unit is equipped with one 1 Gbit LAN interfaces to control the R&S®DDF205 from a remote operator workstation and to output measurement results. System and analysis software packages from Rohde&Schwarz, such as R&S®ARGUS, R&S®RAMON and R&S®CA100, access this interface to utilize all receiver and direction finder functions.

The open interface description for remote control commands (in line with the SCPI standard) and the output data formats enable external system integrators to incorporate the R&S®DDF205 into third-party software solutions.

DC operation (e.g. on vehicle battery)

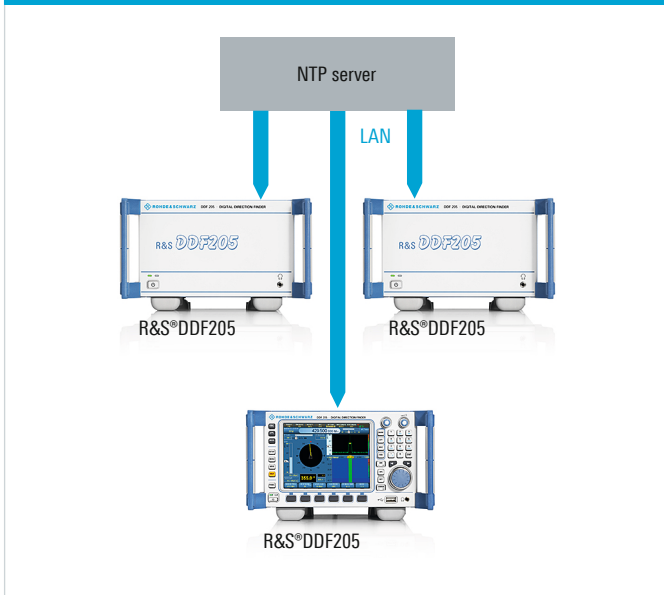
The R&S®DDF205 receives its power directly from a DC power source, such as a vehicle battery. Thanks to its wide input voltage range, the direction finder can be operated on vehicle battery, even with all options installed. An optional DC power cable (R&S®EB500-DCC option) is installed directly on the direction finder, eliminating the need for additional space in vehicles.

DC port for connecting the R&S®DDF205 to the vehicle's on-board power supply



DF antenna	Frequency range	Application
R&S®ADD119	300 kHz to 30 MHz	mobile
R&S®ADD107	20 MHz to 1.3 GHz	mobile and portable
R&S®ADD207	690 MHz to 6 GHz	mobile and portable
R&S®ADD307	20 MHz to 690 MHz	portable
R&S®ADD196	20 MHz to 1.3 GHz	mobile and stationary
R&S®ADD197	20 MHz to 1.3 GHz	mobile and stationary
R&S®ADD071	1.3 GHz to 3 GHz	mobile and stationary
R&S®ADD075	1.3 GHz to 8.2 GHz	mobile and stationary
R&S®ADD295	20 MHz to 3 GHz	mobile and stationary
R&S®ADD175	690 MHz to 2.7 GHz	mobile and portable
Discontinued antennas		
R&S®ADD190	20 MHz to 1.3 GHz	mobile and stationary
R&S®ADD195	20 MHz to 1.3 GHz	mobile and stationary

An NTP server distributes time and date information to the receivers in the system via a network connection



R&S®EB5-EGT external GPS module.



Detailed display of GPS data and GPS operating mode.



System time synchronization using NTP server

An NTP server distributes the system time to all devices in the networked system. Synchronization takes place automatically every time the R&S®DDF205 starts up, or can be manually triggered by an SCPI command issued by the user or a software application running on the network. The internal device time and date are synchronized to the received NTP time. The accuracy depends on the quality of the NTP server and LAN infrastructure and is typically in the millisecond range. Cyclic synchronization of device time and date prevents drifting differences in the internal time references of multiple devices in the network.

The synchronized timebase makes it easier to compare measurement results received by different stations (e.g. spectrum, audio). As a result, it is possible to identify and assign results with identical timestamps. It is also possible to document when a specific signal, e.g. an interfering signal, was received.

TDOA ready with high-accuracy timestamps and GPS synchronization of frequency and time

The R&S®DDF205 system time can be set and synchronized via the external GPS module’s NMEA protocol. GPS information, e.g. position and date, is available at the LAN interface.

The internal R&S®DDF205 10 MHz reference frequency is synchronized using a pulse per second (PPS) signal from the GPS module. The GPS module significantly improves the accuracy of the internal reference frequency to fulfill all ITU frequency accuracy requirements ($\leq 1 \times 10^{-9}$) for radiomonitoring receivers:

- Typ. 1×10^{-11} (with external GPS module, R&S®EB5-EGT option)

The receiver’s high-accuracy timestamp in the I/Q output data stream is also derived from the information in the GPS module. The accuracy of the timestamp is in the nanosecond range (with external GPS module, R&S®EB5-EGT option).

The timestamps in the I/Q baseband data stream of the R&S®DDF205 permit TDOA¹⁾ applications via LAN. The R&S®DDF205 functions as a receiving node in the sensor network. Time accuracy depends on the receiver’s antenna input and is independent of the receiver settings, which significantly simplifies the setup of correction tables for a TDOA system. The tables only need to contain system parts such as antennas, cable lengths and signal distribution, and not all receiver settings. This greatly simplifies the TDOA system integrator’s job.

¹⁾ TDOA: time difference of arrival.

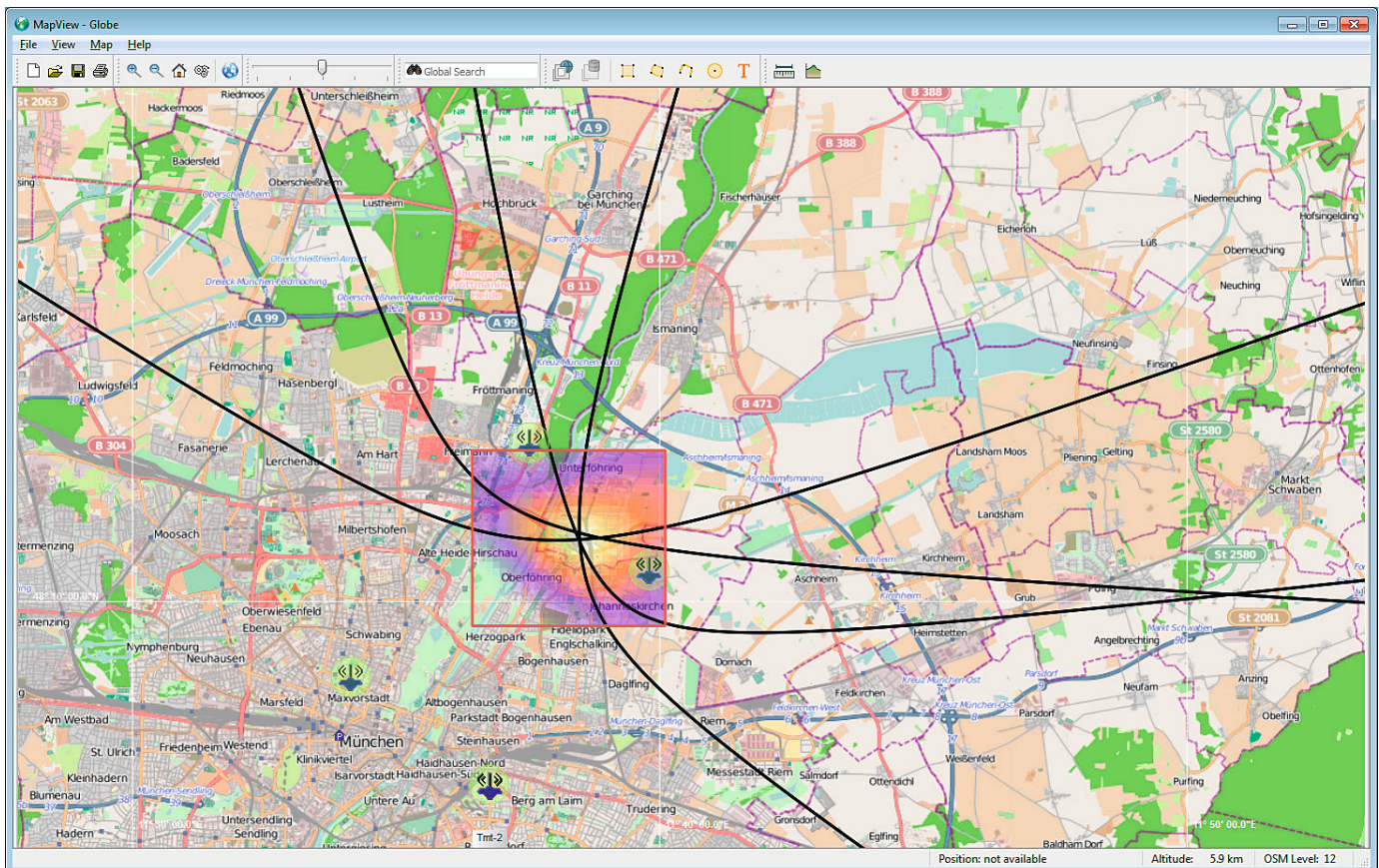
The time accuracy in the baseband data stream (when using the external GPS module) leads to extremely reliable radiolocation results in the TDOA network.

R&S®ARGUS and R&S®RAMON system software

In addition to front panel control, the R&S®DDF205 can also be controlled via the R&S®ARGUS and R&S®RAMON system software. This permits integration of the direction finder into systems.

The R&S®DDF205 comes with appropriate R&S®RAMON control software for operating the R&S®DDF205 from a standard PC. The control interface is accessible to users, which allows operation of the R&S®DDF205 using customer-specific software.

R&S®ARGUS locating a transmitter using TDOA.



Technical background

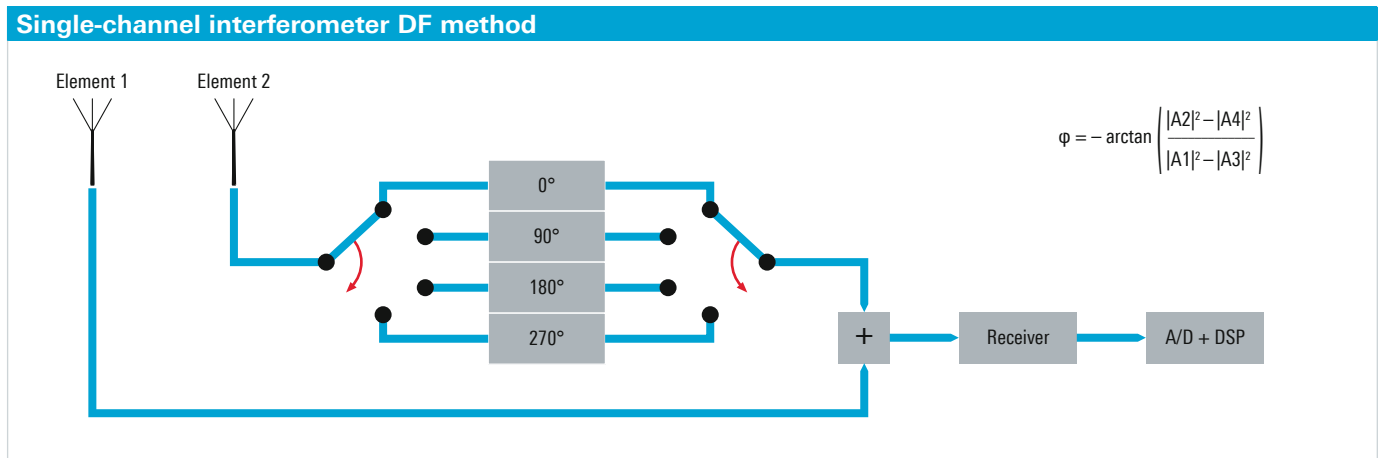
Single-channel interferometer DF method

The correlative interferometer DF method is based on measuring the phase differences between several antenna elements of a DF antenna. To measure the phase angle φ between the signals of two antenna elements by means of a single receiver, a patented method from Rohde&Schwarz is used.

With this method, the phase of one of the two signals is shifted in four steps ($0^\circ/90^\circ/180^\circ/270^\circ$) in the quadrature multiplexer and then added to the second signal. The receiver measures the amplitude of the sum signal after each phase shift. Inserting the four amplitude values obtained ($A1/A2/A3/A4$) into the formula (see diagram) yields the phase angle φ between the two signals. This measurement is performed for each antenna element.

Most interferometer direction finders on the market use at least two receivers. The two receive paths must be in phase and calibrated accordingly, since otherwise the measurement time will be significantly extended. Moreover, the local oscillator signals need to be multiplied and distributed in phase. This means that more hardware is necessary than with a single-channel interferometer direction finder: an additional receive path, hardware for in phase multiplication and distribution of the local oscillator signals, a calibration signal generator, calibration signal distribution and an additional cable to the DF antenna for the calibration signal.

With the R&S®DDF205, the two receive paths are coherently linked in the DF antenna using a patented method from Rohde&Schwarz. As a result, the single-channel interferometer DF method provides the same DF accuracy and immunity to reflections as direction finders with two or more receive paths – without requiring additional hardware.



Multi-element DF antennas

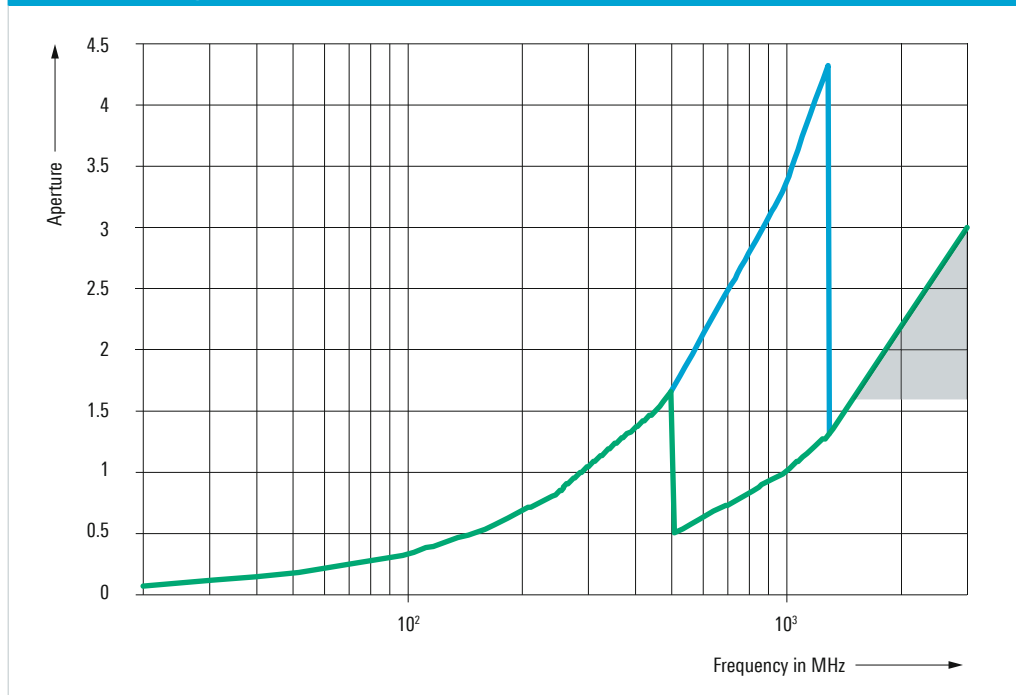
Due to multipath propagation (especially in urban areas), not only the direct wave but also reflections arrive at the DF antenna. Immunity to reflections is influenced to a large extent by the number of antenna elements in a DF antenna. Virtually all R&S®ADDx DF antennas comprise nine antenna elements for the VHF/UHF range, or eight for the UHF/SHF range. These DF antennas were designed to provide stable bearings even with a 50% share of reflections. If only five antenna elements are used (as is the case with typical commercially available antennas), substantial DF errors can be expected in certain frequency ranges (see gray area in diagram).

The aperture of a DF antenna (diameter/wavelength) can be considerably enlarged by increasing the number of antenna elements. The distance between two adjacent antenna elements of a DF antenna is to be selected such that unambiguous phase differences are obtained between the antenna elements at the highest operating frequency and for all possible combinations of direct and reflected waves. Commercially available five-element DF antennas therefore have a much smaller aperture than DF antennas with nine elements across wide frequency ranges.

The aperture of a DF antenna is crucial to the efficiency of a direction finder. The wider the DF antenna's aperture, the higher the DF accuracy and sensitivity as well as the immunity to reflections (see ITU SMH 2002, section 4.7.1.1.3).

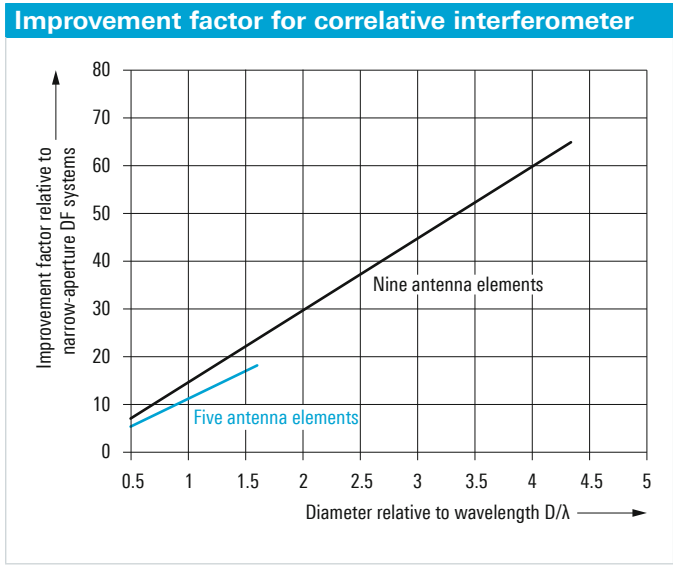
This advantage is not apparent from the specifications. For the purpose of comparison, data sheets always specify instrument and system accuracy based on ideal, reflection-free DF antenna environments and strong signals.

Comparison of aperture of commercially available five-element DF antennas (green) with that of Rohde&Schwarz DF antennas (blue)

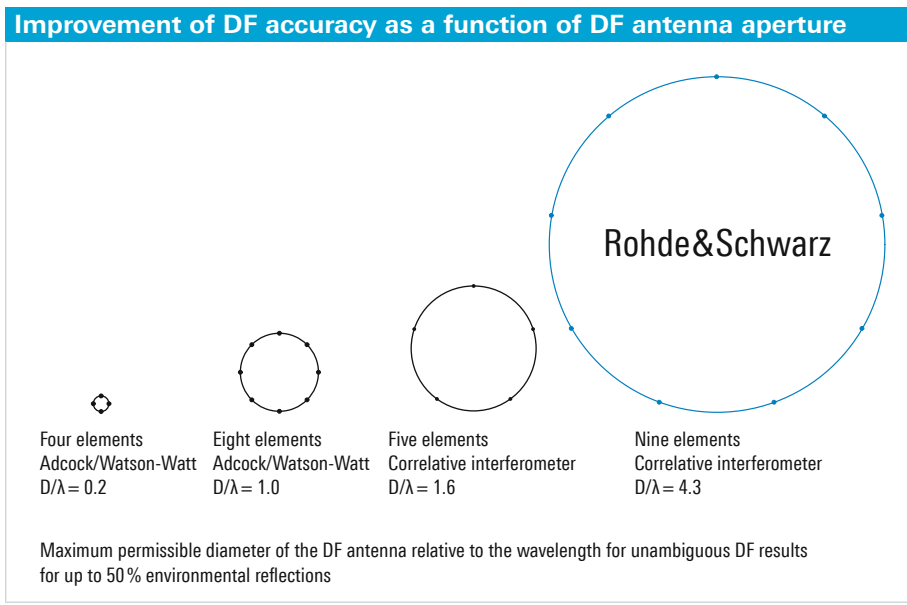


DF antennas using nine elements and the correlative interferometer DF method offer by far the widest aperture and therefore enhanced accuracy and sensitivity (see top figure). As a result, they have a considerably greater improvement factor compared with small-base DF antennas, such as antennas containing only five elements, for example.

The considerably higher immunity to reflections offered by DF antennas with nine elements (compared with five-element DF antennas) can be mathematically proven by simulating the DF antennas in a two-wave field (direct wave and reflected wave). First, the DF values that a DF antenna in a two-wave field would produce are calculated one after the other, the field strength of the direct wave being twice as high as that of the reflected wave. Since the DF error depends on the frequency, the angle of incidence and the phase angle of the reflected wave, all possible combinations of these parameters are simulated. Then the RMS value is determined from the individual DF errors.



The table below shows that DF antennas with nine elements provide considerably higher DF accuracy than commercially available five-element DF antennas. It is assumed that the five-element DF antennas exhibit a system DF accuracy of 1° RMS in a reflection-free environment. Since the Rohde & Schwarz DF antennas use eight elements for direction finding in the frequency range above 1.3 GHz, an eight-element DF antenna is simulated in this frequency range.



Average DF error of different DF antennas in a two-wave field			
	Frequency ranges	DF antenna diameter	DF accuracy in two-wave field (approx.)
Rohde & Schwarz DF antennas	20 MHz to 1.3 GHz	1 m	1.7° RMS
	1.3 GHz to 3 GHz	0.3 m	2.2° RMS
Commercially available five-element DF antennas	20 MHz to 500 MHz	1 m	6.1° RMS
	500 MHz to 3 GHz	0.3 m	10° RMS

Active/passive switchover with just a mouse click

The number of radio services and transmitters is continuously growing, resulting in an increasing cumulative load on the antenna input and the receiver input. Especially digital broadcasting services such as DVB-T and DAB with their high bandwidths represent a growing challenge to the linearity of antennas and receivers. The problem may intensify if the DF antenna is in the vicinity of strong transmitters – which, particularly in urban areas, can hardly be avoided.

If the number of strong signals becomes too high, intermodulation products may become visible in the spectrum. In the worst case, they would mask signals of interest and make it impossible to take bearings.

Most DF antennas from Rohde&Schwarz are equipped with active antenna elements, which provide significantly higher sensitivity than passive elements – and also have compact dimensions. Although extremely linear, active antenna circuitry with top-quality components is used, very strong signals may cause intermodulation.

Passive antennas provide significantly higher linearity and therefore generate virtually no intermodulation products; however, they are either less sensitive or considerably larger than active antennas. In applications where only compact antennas can be used, passive DF antennas are substantially less sensitive in the VHF and the lower UHF range than active models.

Up until now, users have had to decide what is more important to them: the higher sensitivity offered by active DF antennas or the higher immunity to strong signals provided by passive DF antennas.

The R&S®ADD196/197/295 for the first time makes it possible to bypass the active circuitry of the antenna elements. The user can switch the active elements to passive mode by a simple mouse click. This DF antenna thus offers the advantages of both methods.

Exceptionally high DF sensitivity

For DF antenna elements to exhibit good receive characteristics, adaptation to the subsequent stage must be optimized and coupling to the adjacent elements minimized. These requirements can best be met over a wide frequency range by using configurable antenna structures:

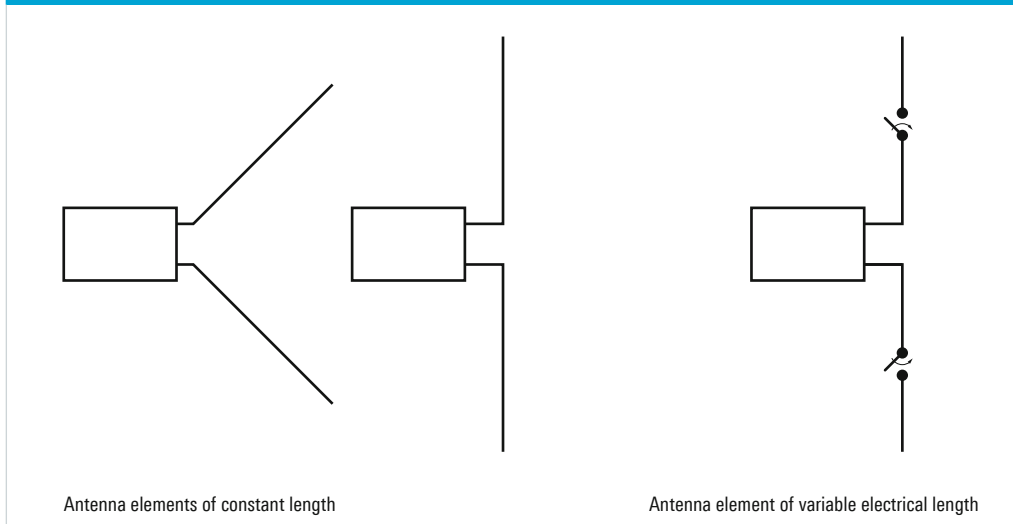
- At low frequencies, configuration of antenna element for maximum electrical length
- At high frequencies, selection of the most effective antenna length to achieve the best possible compromise between decoupled receive power and impact on the directional pattern due to mutual coupling

Optimal results are achieved using electric switches that connect or disconnect parts of the antenna element (see figure, right).

The antenna elements of the R&S®ADD196, R&S®ADD197 (vertical polarization) and R&S®ADD295 DF antennas are equipped with PIN diodes, allowing the electrically active structure to change very quickly in the VHF/UHF range. As a result, these elements are always optimally adapted to the receive frequency and offer exceptionally high sensitivity.

Commercially available DF antennas that cover a very wide frequency range with antenna elements of constant length (see figure, left) are usually optimized for the UHF range and are considerably less sensitive in the VHF range than the Rohde&Schwarz models with variable electrical length.

Antenna structures



Integrated, extendible lightning protection

DF antennas for the VHF/UHF/SHF range are usually positioned as high as possible 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.

All installed Rohde & Schwarz DF antennas that are at risk of being struck by lightning feature built-in, effective lightning protection up to an installation height of 20 m:

- 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 via the ground
- Gas arresters at all critical spots prevent voltage peaks (caused by lightning bolts) from destroying the DF antenna circuitry

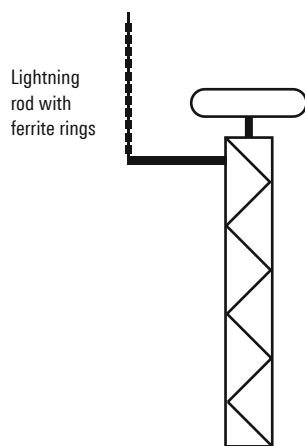
This lightning protection concept was taken into account in development right from the start and does not impair DF accuracy. As a result, the DF accuracy specified in the data sheets is attained even with the lightning rod.

Commercially available DF antennas without integrated lightning protection have a lightning rod that is mounted 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, DF accuracy is considerably poorer than that specified in the data sheet for a reflection-free environment (see table on page 20). 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.

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

The additional DF errors due to the separate lightning rod can be reduced by calibration – which is, however, very complicated and can correct only part of the DF errors. But even after calibration, additional DF errors can occur at any time in the VHF range.

Lightning protection for antennas



DF antenna without integrated lightning protection



R&S®ADD197 with integrated lightning protection

For the R&S®ADD196, R&S®ADD197 and R&S®ADD295 DF antennas, the R&S®ADD-LP extended lightning protection is available as an option. It is recommended for installation heights of more than 20 m above ground (e.g. masts > 20 m, tall buildings, mountaintops). The figure shows the extended lightning protection, which consists of two crossed lightning rods that protrude laterally beyond the DF antenna to provide an especially high level of protection against lightning striking from the side.

Easy replacement of DF antennas

Unlike other commercially available antennas, DF antennas from Rohde&Schwarz do not need to be individually calibrated. The precisely manufactured R&S®ADDx DF antennas behave exactly as predicted in theory. They provide the high DF accuracy specified in the data sheet without subsequent correction by means of individual factory calibration.

Rohde&Schwarz strives to avoid individual calibration of DF antennas already at the development stage by implementing the following:

- High decoupling from interference (e.g. from cables)
- High common-mode rejection
- Minimal mutual coupling between antenna elements

A DF antenna from Rohde&Schwarz can be replaced with the same model without having to manage new calibration data and store it in the direction finder.

R&S®ADD197 with R&S®ADD-LP.



Comparison of specifications of DF antennas with and without integrated lightning protection		
	DF antennas without integrated lightning protection ¹⁾	Rohde & Schwarz DF antennas with integrated lightning protection (example: R&S®ADD196)
Average DF accuracy according to data sheet specifications (reflection-free environment)	1° RMS	1° RMS (2° RMS for f < 80 MHz)
Average DF accuracy with lightning protection, 20 MHz to 200 MHz	5° RMS	1° RMS (2° RMS for f < 80 MHz)
Average DF accuracy with lightning protection, > 200 MHz	2° RMS	1° RMS
Additional DF error due to lightning protection	depends on frequency, up to 20°	no additional DF error

¹⁾ Measurement with separate lightning rod, lined with ferrite rings, 2 m away from antenna.

Applications

Mobile radiomonitoring and radiolocation

The R&S®DDF205 is optimally suited for integration into vehicles:

- High integration density: compact dimensions of only three height units with ½ 19" width
- Flexible power supply: powering from AC source with power supply (included) or by direct connection to DC source
- Front panel control: alternatively, operation via front panel without using a PC
- Wideband DF antenna available as an option: coverage of entire VHF/UHF range with the R&S®ADD295

The DF and monitoring antennas connected to the R&S®DDF205 have a decisive impact on its performance. In this area, Rohde & Schwarz offers solutions that meet the specific requirements of mobile radiomonitoring and radiolocation.

R&S®ADD295 VHF/UHF wideband DF antenna

Previously, two DF antennas were required in order to cover the entire VHF/UHF range. This resulted in additional reflection, particularly with systems mounted on vehicle roofs. The R&S®ADD295 solves the problem. It covers the entire VHF/UHF range with two antennas in the form of concentric circles of dipoles nested in one another. This solution takes up only half the space on the vehicle roof.

R&S®ADD295.



Stationary radiomonitoring and radiolocation up to 6 GHz

The R&S®DDF205, together with the R&S®ADD197 and R&S®ADD075 DF antennas, forms an extremely powerful stationary DF system for radiomonitoring and radiolocation up to 6 GHz in line with ITU recommendations.

The R&S®ADD197 DF antenna for the VHF/UHF range now makes it possible to take accurate bearings also on all horizontally polarized transmitters. This solves a number of problems, and at the same time opens up new applications:

- Illegal TV and broadcast transmitters equipped with horizontally polarized antennas on masts are in operation in some countries. Locating such transmitters using vertically polarized DF antennas and triangulation is not possible
- Defective transmit and receive systems using horizontally polarized antennas can be located with significantly higher reliability
- Public TV and broadcast transmitters can be used to align the direction finder to north and check its functionality. These transmitters are ideally suited for this purpose as they permanently broadcast a powerful and undisturbed signal from a known location. DF accuracy and north alignment can thus be conveniently checked

Any combination of an R&S®ADD071 UHF or R&S®ADD075 UHF/SHF DF antenna with an R&S®ADD196, R&S®ADD197 or R&S®ADD295 VHF/UHF DF antenna is possible. The two antennas can be connected to the R&S®DDF205 by means of a single R&S®DDF1C-x DF antenna cable set if they are installed one above the other and connected to each other using the appropriate R&S®DDF1CX connecting cable set (see photo).

Together with the R&S®DDF205-IM option, a radio-monitoring and radiolocation system is created that delivers reproducible and reliable results in line with ITU recommendations.

Antenna system consisting of the R&S®ADD071 (bottom) and the R&S®ADD197 (top).



Options

R&S®DDF205-HF HF frequency range extension

The R&S®DDF205-HF option extends the frequency range of the R&S®DDF205 downward. The lower frequency limit depends on the operating mode:

- DF mode: 300 kHz
- Receive mode: 8 kHz

To use this option, DF and/or receiving antennas for the extended frequency range are additionally required.

R&S®DDF205-FE SHF frequency range extension

The R&S®DDF205-FE option extends the upward frequency range of the R&S®DDF205 up to 6 GHz.

To use this option, DF and/or receiving antennas for extended frequency range are additionally required.

R&S®DDF205-PS panorama scan

When equipped with the R&S®DDF205-PS option, the R&S®DDF205 traverses a user-defined frequency range at maximum speed (without direction finding). This provides the user with a quick overview of the spectrum occupancy. Any changes caused by illegal radio services, interference sources, temporary emissions, etc., can be recognized immediately. The marker function can be used to take a bearing of the target signal and demodulate and analyze it.

The resolution for the FFT computation can be set to match the channel spacing used by various radio services. This FFT scan provides fast scan rates at narrow resolution bandwidths and consequently high sensitivity.

R&S®DDF205-IM ITU measurement software

The R&S®DDF205-IM option adds a comprehensive range of ITU-compliant measurement methods. These include:

- ITU-R SM.377¹⁾ (frequency and frequency offset measurements)
- ITU-R SM.378 (field strength measurements)
- ITU-R SM.328 (determination of modulation modes)
- ITU-R SM.443 (bandwidth measurements)
- ITU-R SM.1880 (determination of spectral occupancy, with remote control PC and R&S®ARGUS software package)

To use this option in line with ITU recommendations, we recommend that suitable receiving antennas be provided.

¹⁾ Depending on the application, an external reference frequency with higher accuracy may be required, e.g. a GPS reference frequency.

R&S®DDF205-COR DF error correction

The R&S®DDF205-COR option enables the R&S®DDF205 to correct errors through the use of comparison tables.

Especially in mobile DF applications, DF accuracy may be degraded due to vehicle reflections. DF accuracy can be significantly improved by applying appropriate DF error correction. For this purpose, the DF vehicle is exposed to test signals applied in 10° steps from all directions across the entire frequency range. With the resulting DF values, correction tables are generated and loaded into the R&S®DDF205 memory. By using this approach, many DF errors are rectified.

On request, DF vehicles are also measured on a turntable.

R&S®DDF205-WDF wideband direction finding

The R&S®DDF205-WDF option allows wideband direction finding for all signals in a frequency range up to 20 MHz with selectable resolution. DF values are calculated and displayed simultaneously for all signals above the level threshold. Wideband direction finding includes:

- Calculation and display of DF values simultaneously for all frequency channels used in:
 - Aeronautical and maritime frequency bands
 - FM broadcasting
- DF measurements on signals with large bandwidths (e.g. DAB and DVB-T) and high channel resolution, display of DF results as an average of many individual DF values in a histogram, compensation of frequency-dependent bearing fluctuations
- Reliable DF measurements on frequency agile transmitters (frequency hoppers and chirp transmitters) with hop rates up to 100 hops/s

R&S®DDF205-DCV measurements results

- Documentation of calibration values

R&S®DDF205-DDC digital downconverter

The R&S®DDF205-DDC option transforms the R&S®DDF205 digital direction finder into a multichannel receiver with a total of four demodulation channels, which can be allocated to any frequency within the realtime bandwidth. The demodulation channels can be parameterized independently of each other (demodulation mode, level squelch, etc.). Demodulated data can be stored internally, and is also available at the Ethernet interface.

R&S®DDF205-SL selective call analysis

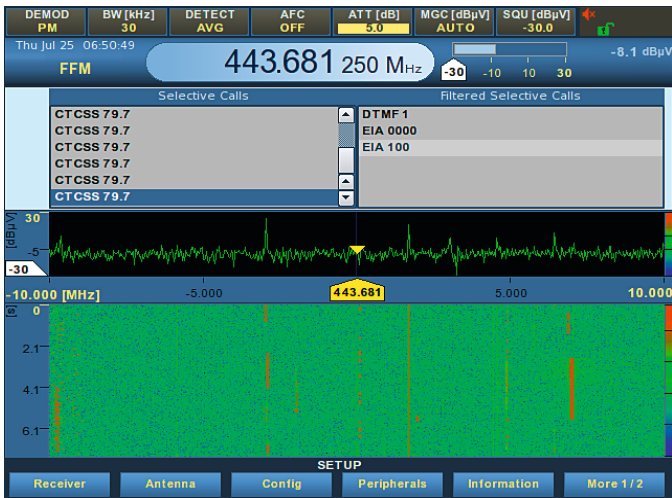
The R&S®DDF205-SL option allows the decoding of diverse selective call methods and the demodulation of pagers.

The following selective call methods are supported: CCIR1, CCIR7, CCITT, EEA, EIA, EURO, DCS, DTMF, CTCSS, NATEL, VDEW, ZVEI1, ZVEI2. Results are shown on the display of the direction finder or on the external control PC.

R&S®DDF205-IR internal recording

For detailed evaluation of detected signals, a given spectral/waterfall scenario must be recorded (e.g. on a connected USB flash drive) to be able to replay the information later in the direction finder (R&S®DDF205-IR option). The R&S®DDF205-IR internal recording option is available for direction finders with front panel operation (model .03) or for external R&S®DDF205 GUI software.

Display of detected selective call standards in an overview list (left column); filtering by relevance possible (right column).



The positions recorded during a drive test (including the bearing, if applicable) are shown on a map.



R&S®DDF205-Map map display

When GPS information is present in the direction finder, DF results can now be shown on the display with the R&S®DDF205-Map option on a digital map on the front panel. Users can download these maps using the R&S®OpenStreetMapWizard (OSMWizard). The R&S®DDF205-Map option is available for direction finders with front panel operation (model .03) or for external R&S®DDF205 GUI software

OpenStreetMap (OSM)

OpenStreetMap (OSM) is a user-editable world map that is available at the following Internet address:
<http://www.openstreetmap.org/>

OSM is a wiki project in which users can participate by uploading and editing geographical information such as GPS tracking data or the course of a road or river. This world map is growing daily.

OpenStreetMap data can be used freely under the terms of the Creative Commons Attribution-ShareAlike 2.0 license.

Specifications in brief

Specifications in brief		
Frequency range, DF mode		
Frequency range	base unit	20 MHz to 3 GHz
	with R&S®DDF205-HF option	300 kHz to 3 GHz
	with R&S®DDF205-FE option	20 MHz to 6 GHz
	with R&S®DDF205-HF and R&S®DDF205-FE options	300 kHz to 6 GHz
Frequency range, receive mode		
Frequency range	base unit	20 MHz to 3.6 GHz
	with R&S®DDF205-HF option	8 kHz to 3.6 GHz
	with R&S®DDF205-FE option	20 MHz to 6 GHz
	with R&S®DDF205-HF and R&S®DDF205-FE options	8 kHz to 6 GHz
DF mode		
DF method	VHF/UHF/SHF	correlative interferometer
	HF	Watson-Watt
System DF accuracy ¹⁾	depends on DF antenna (i.e. R&S®ADD119, R&S®ADD196 and R&S®ADD075), in reflection-free environment, with lightning protection, in line with report ITU-R SM.2125 (limited to one modulation type) and recommendation ITU-R SM.854	
	300 kHz to 30 MHz	≤ 2° RMS
	20 MHz to 80 MHz	typ. 1° RMS
	80 MHz to 1.3 GHz	typ. 0.5° RMS
	1.3 GHz to 6 GHz	typ. 1° RMS
System DF sensitivity	depends on DF antenna (i.e. R&S®ADD119, R&S®ADD196 and R&S®ADD075), for 5° RMS DF fluctuation, 5 s integration time and 250 Hz (HF)/600 Hz (VHF/UHF/SHF) DF bandwidth, in line with report ITU-R SM.2125	
	300 kHz to 80 MHz	typ. 14 µV/m to 4 µV/m
	80 MHz to 1.3 GHz	typ. 1 µV/m
	1.3 GHz to 6 GHz	typ. 2 µV/m
Realtime bandwidth for wideband direction finding	with R&S®DDF205-WDF option	up to 20 MHz
Minimum signal duration	for single-burst signals, in line with report ITU-R SM.2125	
	VHF/UHF/SHF	1 ms
	HF	2 ms
Receive mode		
Analysis bandwidth		up to 20 MHz
Demodulation bandwidth		up to 20 MHz
Scan speed	with R&S®DDF205-PS option	up to 12 GHz/s

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

For data sheet, see 5214.3723.22

For R&S®ADDx single-channel DF antennas product brochure and data sheet, see PD 3606.8295.12 and PD 3606.8295.22 and www.rohde-schwarz.com

Ordering information

Designation	Type	Order No.
Base unit		
(including supplied accessories such as power cable, operating manual)		
Digital Direction Finder, without front panel control	R&S®DDF205	4073.0006.02
Digital Direction Finder, with front panel control	R&S®DDF205	4073.0006.03
Options		
HF Frequency Range Extension	R&S®DDF205-HF	4072.8003.03
SHF Frequency Range Extension	R&S®DDF205-FE	4072.9300.03
Panorama Scan	R&S®DDF205-PS	4072.9200.03
ITU Measurement Software	R&S®DDF205-IM	4072.9100.03
Internal Recording	R&S®DDF205-IR	4072.9551.03
Map Display	R&S®DDF205-Map	4072.9451.03
Digital Downconverter	R&S®DDF205-DDC	4072.9500.03
DF Error Correction	R&S®DDF205-COR	4072.9600.03
Wideband Direction Finding	R&S®DDF205-WDF	4072.9651.03
Selective Call Analysis	R&S®DDF205-SL	4072.9800.03
Documentation of Calibration Values	R&S®DDF205-DCV	4072.8403.03
Analysis of Signal Scenarios in line with ITU-R SM.1600 (requires R&S®CA100 PC-based signal analysis and signal processing software)	R&S®CA100IS	4102.0210.02
External accessories		
Compact VHF/UHF DF Antenna	R&S®ADD107	4090.7005.02
Compact UHF/SHF DF Antenna	R&S®ADD207	4096.0002.02
Collapsible VHF/UHF DF Antenna	R&S®ADD307	4098.2002.07
HF DF Antenna	R&S®ADD119	4053.6509.02
VHF/UHF DF Antenna	R&S®ADD196	4077.3000.12
Dual Polarized VHF/UHF DF Antenna	R&S®ADD197	4068.1450.12
Broadband VHF/UHF DF Antenna	R&S®ADD295	4070.9002.12
UHF DF Antenna	R&S®ADD175	4079.4003.02
UHF DF Antenna	R&S®ADD071	4043.6006.02
UHF/SHF DF Antenna	R&S®ADD075	4069.6603.12
DF Antenna Cable Set for single-channel direction finders, frequency range 0.3 MHz to 1.3 GHz	R&S®DDF1C-1	4077.6009.xx ¹⁾
DF Antenna Cable Set for single-channel direction finders, frequency range 0.3 MHz to 3 GHz	R&S®DDF1C-5	4077.7005.xx ¹⁾
DF Antenna Cable Set for single-channel direction finders, frequency range 0.3 MHz to 6 GHz	R&S®DDF1C-7	4077.8001.xx ¹⁾
Interconnection Cable Set for the R&S®ADD075	R&S®DDF1CX	4077.8801.10
Interconnection Cable Set for the R&S®ADD071	R&S®DDF1CX	4077.8801.15
Extended Lightning Protection	R&S®ADD-LP	4069.6010.02
Mast Adapter	R&S®ADD150A	4041.2655.02
Mast Adapter for the R&S®ADD175	R&S®ADD17XZ2	4079.5000.02
Mast Adapter for the R&S®ADD075	R&S®ADD07XZB	4069.7300.02
Antenna Adapter, with cable outlet	R&S®ADD071Z	4043.7002.02
Antenna Adapter, without cable inlet/flange	R&S®ADD071Z	4043.7002.03
Antenna Adapter for the R&S®ADD075	R&S®ADD07XZT	4069.7200.02

Designation	Type	Order No.
Tripod with Adapter	R&S®ADD1XTP	4063.4409.02
Vehicle Adapter	R&S®AP502Z1	0515.1419.02
Vehicle Adapter with Magnet Mount	R&S®ADD17XZ3	4090.8801.02
Antenna Cable Set without Converter, length: 5 m	R&S®ADD17XZ4	4090.8730.02
Wooden Tripod	R&S®ADD17XZ6	4090.8860.02
Electronic Compass	R&S®GH150	4041.8501.02
GPS Navigator/GPS Receiver	R&S®GINA	4055.6906.05
19" Rack Adapter (1 × R&S®DDF205 + 1 × blind plate)	R&S®ZZA-T02	1109.4164.00
DC Power Cable	R&S®EB500-DCC	4072.7036.00
External GPS Module	R&S®EB5-EGT	4073.2009.02

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 year	R&S®WE1	Please contact your local Rohde & Schwarz sales office.
Extended Warranty, two years	R&S®WE2	
Extended Warranty, three years	R&S®WE3	
Extended Warranty, four years	R&S®WE4	
Extended Warranty with Calibration Coverage, one year	R&S®CW1	
Extended Warranty with Calibration Coverage, two years	R&S®CW2	
Extended Warranty with Calibration Coverage, three years	R&S®CW3	
Extended Warranty with Calibration Coverage, four years	R&S®CW4	

Your local Rohde & Schwarz expert will help you determine the optimum solution for your requirements. To find your nearest Rohde & Schwarz representative, visit www.sales.rohde-schwarz.com

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

Rohde & Schwarz GmbH & Co. KG

www.rohde-schwarz.com

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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R&S®DDF205 Digital Direction Finder

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