R&S®DDF1GTX
High-Speed Scanning HF Direction Finder

Extremely fast and accurate direction finding

ROHDE&SCHWARZ

Product Brochure | Version 04.00

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At a glance

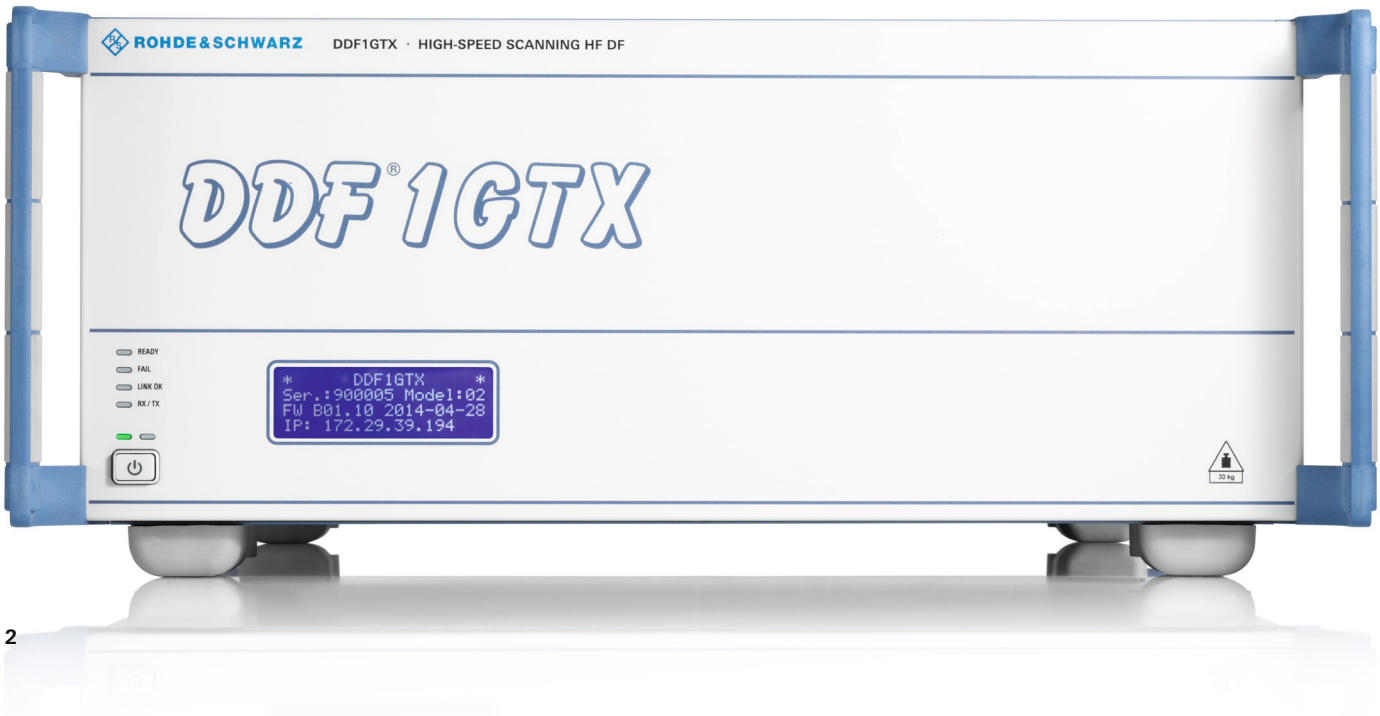
The R&S®DDF1GTX high-speed scanning HF direction finder allows parallel direction finding of all signals across the entire HF range, ensuring the fastest speed while delivering outstanding DF accuracy, sensitivity and immunity to reflections. The optional super-resolution DF method in conjunction with the optional beamforming [1] makes the direction finder ideal for complex signal scenarios.

[1] Available on request.

The R&S®DDF1GTX offers up to 10 coherent receive channels with exceptionally high linearity and sensitivity, permitting parallel sampling of all antenna elements of the DF antenna. In conjunction with a realtime bandwidth of 30 MHz, the direction finder makes it possible to measure all signals across the entire HF range in just one test step.

In receive mode, the receive channels can be aligned to a specific signal using optional beamforming. This significantly increases the signal-to-noise (S/N) ratio and suppresses co-channel interference.

For fast, automatic location of frequency-agile signals, multiple R&S®DDF1GTX direction finders can be operated in synchronized DF mode in conjunction with an optional, automatic preclassifier. The R&S®DDF1GTX complies with all relevant ITU recommendations and can be enhanced with an option to include ITU-compliant measurements.



Key facts

- Fastest DF measurement speed thanks to N-channel architecture and 30 MHz realtime bandwidth
- Superior DF accuracy, sensitivity and immunity to reflections due to N-channel architecture with parallel sampling of all antenna elements and 30 MHz realtime bandwidth
- Maximum sensitivity and suppression of co-channel interference in receive mode using the optional beamforming [1)]
- Super-resolution DF method (optional)
- Complies with all relevant ITU recommendations; ITU-compliant measurements available as an option

Benefits

Fastest scan speed and highest probability of intercept

The R&S®DDF1GTX offers up to 10 coherent receive channels for parallel sampling of all antenna elements of the DF antenna. Parallel sampling eliminates the need for switching between the individual antenna elements. In conjunction with a realtime bandwidth of 30 MHz, the direction finder makes it possible to measure all signals across the entire HF range in just one test step. Bearings of short-duration burst signals and fast, frequency-agile transmitters operating at unknown frequencies are taken with the highest possible probability of intercept.

Rear view.

Powerful hardware developed by Rohde&Schwarz

In-house development and manufacture of all DF system components, including the DF antenna

All components of an R&S®DDF1GTX based DF system are developed and manufactured by Rohde&Schwarz, ensuring outstanding performance and quick implementation of technical innovations. Particularly for DF antennas, recent years have seen major improvements, such as active/passive switchover developed and launched by Rohde&Schwarz.

Rohde&Schwarz benefits from its many years of experience in the development and production of antennas, receivers and digital signal processing equipment.

Signal processing at maximum speed based on powerful FPGAs

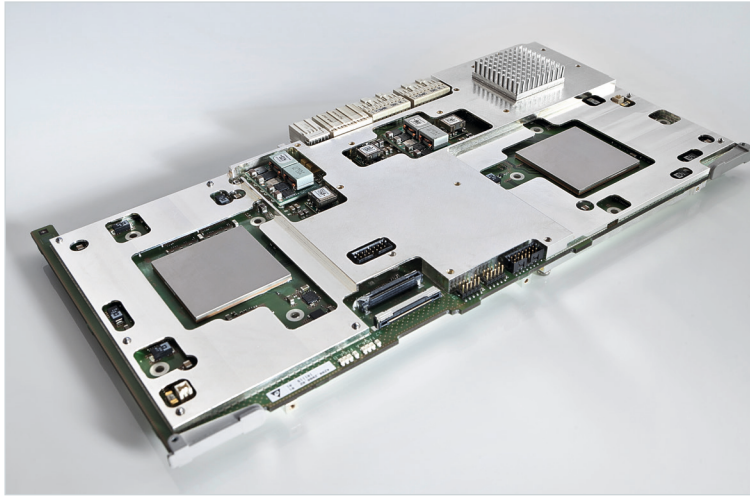
The large number of powerful field programmable gate arrays (FPGA) employed in the R&S®DDF1GTX delivers above-average signal processing speed. FPGAs are much more powerful than the digital signal processors (DSP) and PC processors used in many competitor products. The FPGAs employed in the R&S®DDF1GTX are the most powerful models currently available on the market.

High immunity to strong signals thanks to sophisticated preselection

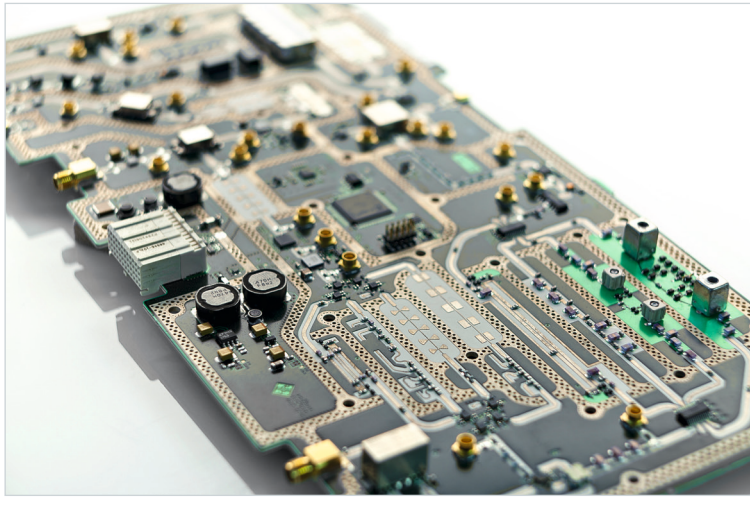
Apart from wanted signals, a spectrum usually contains strong, out-of-band signals, such as those from communications and radio broadcast transmitters. In order not to impair DF results, these signals must be sufficiently suppressed by preselection. The R&S®DDF1GTX is equipped with sophisticated preselectors developed by Rohde&Schwarz, backed by decades of experience. The preselection functionality implemented in the R&S®DDF1GTX goes far beyond ITU recommendations and leads to very high immunity to strong signals.

Superior frequency accuracy and stability

The reference oscillator in the R&S®DDF1GTX is synchronized to the pulse-per-second (PPS) signal from the GPS. This results in exceptional frequency measurement accuracy and stability – significantly better than that of typical reference oscillators without GPS synchronization. Plus, the R&S®DDFGTX-TS time synchronization option significantly improves time synchronization accuracy when multiple R&S®DDF1GTX direction finders are used within a radiolocation network.



Module with powerful FPGA for high-speed signal processing.



High-performance preselection with bandpass and tracking filters.

Innovative DF antenna technology

Extra-large antenna aperture

The R&S®ADD011SRX N-channel super-resolution HF DF antenna (model .1x) consists of two antenna arrays arranged in concentric circles with diameters of 150 m and 50 m. Each antenna array offers a particularly large aperture for its specific frequency range. This architecture provides exceptionally high DF accuracy, sensitivity and immunity to reflections for the entire DF system.

Due to the circular arrangement of the antenna arrays, the R&S®ADD011SRX offers the same high DF accuracy, sensitivity and immunity to reflections for every angle of incidence. By contrast, with an L-shaped arrangement of antenna arrays as used by competitors, the DF accuracy, sensitivity and immunity to reflections vary with the angle of incidence.

Crossed-loop antenna element of the R&S®ADD011SRX N-channel HF DF antenna.

Connection to non Rohde&Schwarz HF DF antennas

In addition to operation with the R&S®ADD011SRX N-channel super-resolution HF DF antenna, the R&S®DDF1GTX can also be configured for operation with selected non Rohde&Schwarz correlative interferometer HF DF antenna elements forming a circular array. This requires the R&S®DDF1GTX-CU option. Whether a non Rohde&Schwarz HF DF antenna can be connected has to be checked in advance, i.e. prior to ordering the R&S®DDF1GTX.

The R&S®DDF1GTX-CU option can also be used to compensate for non-equidistant antenna elements arranged in a circle.

Active/passive switchover with just one 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 immunity to strong signals provided by passive DF antennas. The R&S®ADD011SRX N-channel super-resolution HF DF antenna makes it possible for the first time to bypass the active circuitry of the antenna elements. The user can switch the active elements to passive mode with a single mouse click. The R&S®ADD011SRX combines the advantages of both methods without their disadvantages. [1)]

[1)] For details, see R&S®ADDx multichannel DF antennas product brochure (PD 0758.1106.12).

Exceptionally high detection sensitivity

Keeping the noise floor as low as possible is the prerequisite for detecting weak signals in the spectrum. The R&S®DDF1GTX offers an exceptionally low noise floor, allowing even extremely weak signals to be detected. This is mainly attributable to the direction finder's low inherent digital noise and the high, adjustable channel resolution combined with low-noise analog preselection.

Particularly low inherent digital noise through use of high bit depth in digital signal processing

In addition to the noise generated by the receiver's analog preselection, the displayed noise floor is determined by the direction finder's inherent digital noise. This in turn is the result of the limited bit depth and the accompanying rounding errors in digital signal processing. The high bit depth used in the R&S®DDF1GTX ensures that the inherent digital noise remains below average.

Particularly high adjustable channel resolution

As channel resolution increases, the noise floor decreases, since less noise is present per channel. Conventional HF direction finders typically offer a maximum channel resolution of approximately 100 Hz. The R&S®DDF1GTX, by contrast, offers a maximum channel resolution of 10 Hz, i.e. resolution improved by a factor of ten. This means that the R&S®DDF1GTX noise floor is 10 dB lower than that of conventional HF direction finders. As a result, weak signals that would otherwise be lost in noise become visible in the spectrum (see screenshots).

Accurate and reliable location of short-duration signals

Synchronization of multiple R&S®DDF1GTX for time-synchronized DF scan mode

Thanks to its high realtime bandwidth and N-channel architecture, the R&S®DDF1GTX provides outstanding DF scan speed and high probability of intercept for short-duration signals. Another prerequisite for locating these signals is the use of at least two direction finders that deliver a bearing. For short-duration signals, the DF scan operation must therefore be time-synchronized to ensure that all direction finders in a radiolocation network take bearings on the same frequency at the same time.

In the case of the R&S®DDF1GTX, this is achieved by means of the R&S®DDFGTX-TS time synchronization option, which synchronizes the start time for the measurements to the pulse-per-second (PPS) signal from the GPS.

Integrated GPS module as a high-precision time and frequency reference

The R&S®DDF1GTX includes as standard an integrated, high-precision GPS module as a time and frequency reference. This provides exceptionally high frequency and time stamp accuracy. Time-synchronous DF scan operation available with the R&S®DDFGTX-TS time synchronization option utilizes this high-precision timebase.

Optional preclassifier for detecting LPI signals and summarizing individual DF results into a condensed result

Only a specific portion of the signals received by the DF antenna is of interest in practical applications. The R&S®DDFGTX-CL preclassifier option automatically separates specific LPI signals, such as frequency hopping, chirp and burst signals, from conventional signals. The individual DF results of an emission are automatically averaged and summarized to give a condensed result. This procedure enhances radiolocation accuracy and minimizes the amount of data to be transferred between the DF stations in a radiolocation network.

Wideband super-resolution

Direction finding for co-channel signals

Conventional DF methods are based on the assumption that a specific frequency is occupied exclusively by a single transmitter. However, if additional transmitters are operating on the same frequency, direction finding may be impaired – a problem referred to as co-channel interference. In this case, the DF result depends on the ratio of the transmitter levels. If one of the transmitters is clearly stronger than the others, its bearing is displayed with a slight error. If the transmitters have similar levels, the DF result is usually incorrect. This applies equally to all conventional DF methods, including correlative interferometer, Doppler and Watson-Watt.

Co-channel interference is regularly seen in practice:

- In the HF range, propagation conditions are continuously changing. Emissions may sometimes travel much farther than originally planned and therefore be received in areas where a different station transmits on the same frequency
- Defective electronic equipment may produce electromagnetic interference on a frequency that is also used by transmitters
- Sometimes, specific transmitters are intentionally jammed. In this case, an interfering signal is sent on the same frequency

Optional wideband super-resolution

To take the bearings of co-channel signals, the R&S®DDF1GTX can be enhanced with the R&S®DDF-GTX-SR super-resolution option to add to the DF methods already offered by the direction finder. When equipped with the R&S®DDFGTX-SR option, the direction finder can resolve a wave field with multiple signals present on the same frequency. The number, angle of incidence, receive level and DF quality of the signals are precisely calculated and displayed. The R&S®DDFGTX-SR option makes it possible to take the bearings of up to five different signals on the same frequency in parallel. The actually achievable performance depends, among other factors, on the angles of incidence and S/N ratios of the signals.

R&S®DDFGTX-SR can be used either on a single frequency channel, or simultaneously on up to 1000 adjacent frequency channels within the realtime bandwidth (wideband super-resolution), delivering equally high performance for all channels.

Maximum performance

Thanks to the N-channel architecture with parallel sampling of all DF antenna elements, the R&S®DDFGTX-SR option offers the highest possible performance in terms of selectivity for the co-channel signals, minimum signal duration and reliability of the estimated number of waves.

Reliable estimation of the number of waves is an important prerequisite when using super-resolution DF methods in automated measurements. This estimation provides information about the number of the signals involved. The R&S®DDFGTX-SR option employs an improved method for estimating the number of waves. This method contributes significantly to the excellent performance of the R&S®DDF1GTX in super-resolution mode.

Effective measurements in line with ITU recommendations

The R&S®DDF1GTX meets, and in many cases clearly surpasses, the ITU recommendations for direction finders and monitoring receivers. For example, the R&S®DDF1GTX receiver offers large-signal immunity clearly better than the minimum values recommended by ITU (higher intercept points, lower phase noise).

Option for ITU-compliant measurements on signal parameters for AM, FM and PM-modulated signals

The R&S®DDF1GTX-IM option can be used to perform ITU compliant measurements on signal parameters for AM, FM and PM-modulated signals. The modulation index, occupied bandwidth and phase deviation can be determined. The minimum, maximum and average values over a user-defined measurement period are displayed. The R&S®DDF1GTX-IM option covers the following ITU recommendations:

- ITU-R SM.377 (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)

For offline measurements on 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 (requires additional PC).

The R&S®DDF1GTX fulfills the following ITU hardware recommendations:

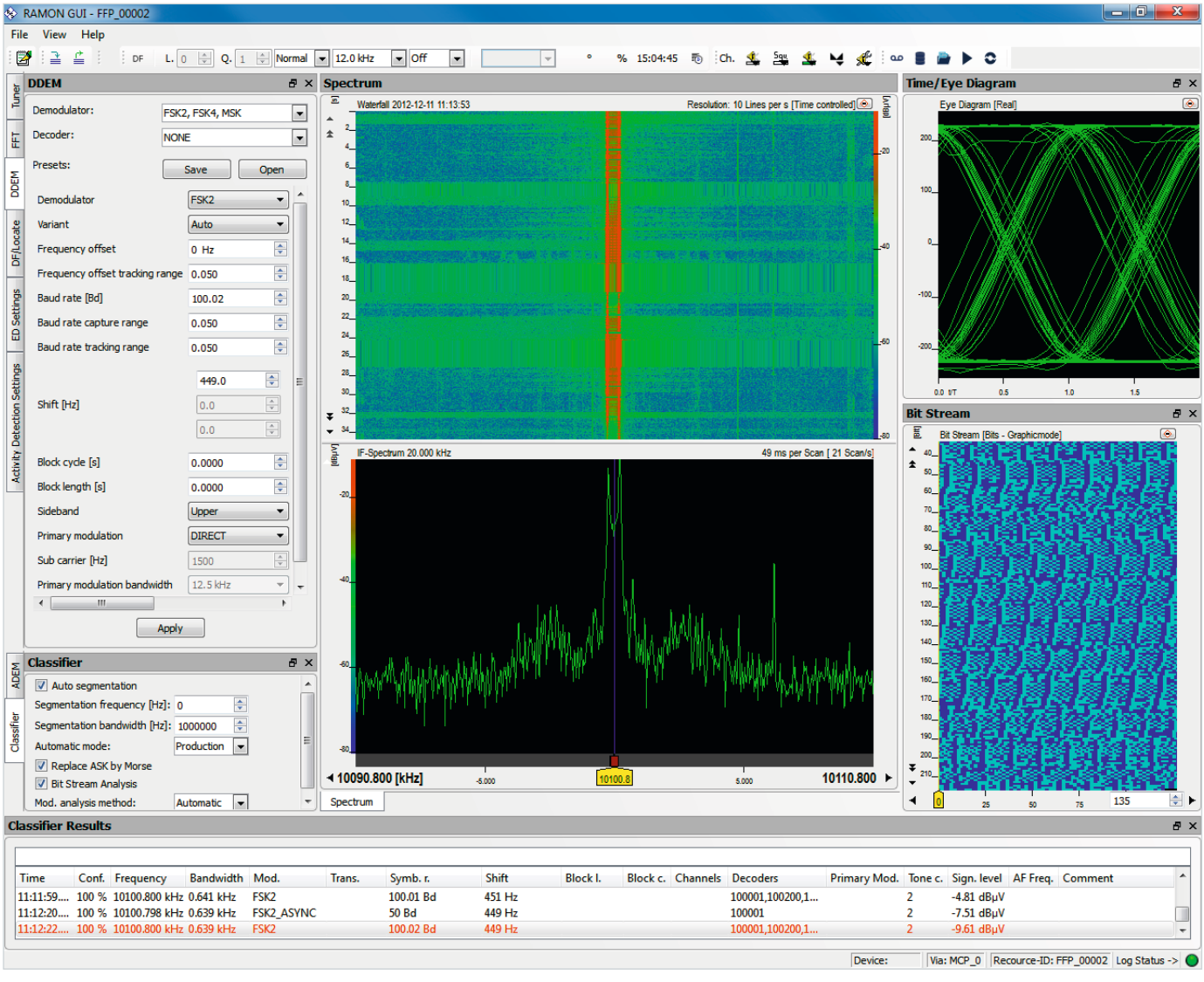
- ITU-R SM.1836 (measurements of IF filter edge steepness)
- ITU-R SM.1837 (IP3 measurements)
- ITU-R SM.1838 (noise figure measurements)
- ITU-R SM.1840 (sensitivity measurements)

Signal analysis in parallel with direction finding

Output of I/Q data for parallel signal analysis with R&S®CA120

The R&S®DDF1GTX can demodulate signals within the realtime bandwith and output the I/Q data for signal analysis while in wideband DF mode. The signals can then be analyzed and classified using the R&S®CA120 multichannel signal analysis software.

R&S®CA120 multichannel signal analysis software.



Specifications in brief

Specifications in brief		
Frequency range	base unit	300 kHz to 30 MHz
DF method	base unit	correlative interferometer (CI mode)
	with R&S®DDFGTX-SR option	wideband super-resolution (SR mode)
Number of coherent measurement channels		10
Instrument DF accuracy		typ. 0.2° RMS
System DF accuracy [1]	with R&S®ADD011SRX (model .1x)	typ. 0.5° RMS
Realtime bandwidth	adjustable	up to 30 MHz
DF sensitivity		on request
Instrument DF sensitivity	100 Hz channel spacing, 2 MHz < f ≤ 30 MHz	typ. –147 dBm
DF scan speed [2]	100 % channel occupancy, CI mode, normal selectivity, in line with Report ITU-R SM.2125	
	1.25 kHz channel spacing	> 35 GHz/s
Processing speed [2]	CI mode	up to 28 000 000 channels/s
Minimum signal duration	for single burst signal, 95 % POI, normal selectivity, in line with Report ITU-R SM.2125	40 µs
Preselection	highpass/lowpass filters per measurement channel	10, switchable
Frequency resolution (channel spacing)	adjustable, depends on realtime bandwidth setting	up to 10 Hz
Dynamic range	depends on realtime bandwidth and channel spacing setting (incl. AGC)	up to 173 dB

[1] Measurement in reflection-free environment. The RMS error is calculated from the bearings of evenly distributed samples versus azimuth and frequency according to ITU-R SM.2125.

[2] DF scan range narrower than realtime bandwidth.

Ordering information

Designation	Type	Order No.
High-speed scanning HF direction finder	R&S®DDF1GTX	4200.0008.02
Options		
Super resolution	R&S®DDFGTX-SR	4200.3607.02
ITU measurement software	R&S®DDFGTX-IM	4200.3688.02
Time synchronization	R&S®DDFGTX-TS	4200.3620.02
Single station locator for HF	R&S®DDF-SSL	3020.8864.02
Preclassification	R&S®DDFGTX-CL	3025.2935.02
Multichannel server	R&S®DDFGTX-MC	3025.2929.02
DIGIQ interface [1]	R&S®DDFGTX-DIQ	4200.3707.02
Adaptation to customer specific HF DF antennas	R&S®DDFGTX-CU	4200.4026.02
Documentation of test results (final test in the factory)	R&S®DDFGTX-DCV	4200.3765.02
External accessories		
N-channel SR DF antenna, circular array with 100 m diameter [1]	R&S®ADD011SRX	4200.5000.05
N-channel SR DF antenna, two concentric circular arrays with 50 m and 150 m diameter [1]	R&S®ADD011SRX	4200.5000.15
N-channel SR DF antenna, circular array with 50 m diameter [1]	R&S®ADD011SRX	4200.5000.25
N-channel antenna cable set [1] (xx = length: 2/5/30/250 m)	R&S®DDFNC-1	4101.4006.xx
DF antennas and accessories: see R&S®ADDx multichannel DF antennas product brochure, PD 0758.1106.12		

[1] Available on request.

Service that adds value

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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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