R&S®DDF04E
Digital Direction Finder for Traffic Control

Radio direction finding on multiple channels

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Radiomonitoring & Radiolocation

Data Sheet | 01.00

R&S®DDF04E Digital Direction Finder for Traffic Control

At a glance

The R&S®DDF04E represents the new generation of traffic control direction finders. Radio direction finding for air and maritime traffic control is performed simultaneously on multiple frequency channels using only one direction finder.

The new R&S®DDF04E digital direction finder is used in traffic control systems to take the bearings of multiple aircrafts or ships simultaneously using only one direction finder. The use of a wide-aperture DF antenna with nine antenna elements, in combination with the correlative interferometer DF method, provides high DF accuracy, sensitivity and outstanding immunity to reflections. The R&S®DDF04E features wideband functionality. Direction finding can therefore take place on as many as 32 channels (optional) simultaneously with the same high level of performance. The direction finder contains control software for the flexible management of the frequency channels.

Key facts

- Parallel direction finding on up to 32 channels (optional) with the same high level of DF accuracy and sensitivity on all channels
- Seamless coverage of a wide frequency range from 100 MHz to 450 MHz with only one DF antenna
- Future-ready due to simple change of the receive frequency and number of channels via the control software, as well as due to the forthcoming 8.33 kHz channel spacing that is already integrated
- Standard PCs, monitors and network technology for control and display
- Flexible networking of direction finder, data server and display units via Ethernet
- Output of results on radar displays and in traffic management systems via an RS-232-C or TCP/IP interface

R&S®DDF04E Digital Direction Finder for Traffic Control

Benefits and key features

One direction finder for all frequency channels with high DF accuracy and sensitivity

- Parallel direction finding on multiple frequency channels with only one direction finder
- The base unit features four user-configurable frequency channels and is optionally expandable to 32 channels
- DF accuracy and measurement speed are equally high for all frequency channels
- The R&S®DDF04E meets the requirements of the DFS Deutsche Flugsicherung GmbH (company responsible for air traffic control in Germany) and the recommendations of the ICAO and the ITU
- The R&S®ADD050SR DF antenna, a wide-aperture system with nine antenna elements, features a high level of DF accuracy and sensitivity and outstanding immunity to reflections
- Excellent large-signal immunity due to sophisticated preselection and extremely linear receivers

▷ page 4

Wide frequency range with only one DF antenna: flexible and ready for future needs

- Wide frequency range from 100 MHz to 450 MHz for simultaneously monitoring all important distress frequencies
- Coverage of the entire frequency range with only one R&S®ADD050SR wide-aperture antenna
- R&S®ADD153SR compact DF antenna for mobile applications
- The forthcoming 8.33 kHz channel spacing for digital aeronautical radio is already integrated
- The frequencies of the channels being monitored can be changed via mouse click
- The number of channels being monitored can be increased by enabling a software option (additional hardware may be required for suppressing ground transmitter signals)

▷ page 5

Simple networking and control

- Networking of direction finder, data server and display units via LAN
- Output of DF results on radar displays via RS-232-C or TCP/IP interfaces
- Standard PCs, monitors and network technology for data distribution, control and display

▷ page 6

Comprehensive selftest capabilities

- Built-in test including permanent monitoring of more than 170 test points in the background and automatic generation of error messages
- Integrated antenna radiator test to check the functionality of all DF antenna elements
- Comprehensive R&S®DDF-SK service kit (option) for effective on-site troubleshooting

▷ page 6

One direction finder for all frequency channels with high DF accuracy and sensitivity

Conventional DF systems for traffic control consist of multiple DF plug-in modules connected to the same DF antenna. Each of these plug-in modules is a full-fledged fixed-frequency direction finder, i.e. it is tuned to a specific frequency.

In contrast, state-of-the-art digital wideband direction finders such as the R&S®DDF04E are fast enough to process a multitude of frequency channels simultaneously. Up to 32 (optional) frequency channels can be processed with a single direction finder at speeds that permit the DF quality of each individual channel to match that of a discrete DF plug-in module without requiring extensive hardware. The R&S®DDF04E receiver characteristics such as large signal immunity, selectivity and sensitivity are even better than those of conventional DF plug-in modules. The R&S®DDF04E thus not only meets, but in most cases clearly exceeds, all ITU recommendations regarding direction finders and monitoring receivers.

The R&S®DDF04E uses the correlative interferometer DF method. This DF method is based on measuring the phase differences between the antenna elements of a circular-array DF antenna, permitting the use of wide-aperture antennas that are highly immune to reflections and feature 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.

The R&S®DDF04E meets the stringent requirements of the DFS Deutsche Flugsicherung GmbH and the recommendations of the ICAO and the ITU. Due to the parallel wideband signal processing, this high level of DF quality is available on all channels.

Wide frequency range with only one DF antenna: flexible and ready for future needs

The wide frequency range of the R&S®DDF04E, from 100 MHz to 450 MHz, is unique. This means bearings can be taken on all distress frequencies in the VHF/UHF range at the same time, independent of the traffic control frequency range.

A single DF antenna with nine antenna elements covers the entire frequency range for stationary, mobile or semi-mobile applications. This represents another advantage of the DF method employed by the R&S®DDF04E. To cover a comparably wide frequency range, conventional traffic control direction finders that use the Doppler DF method require at least two circular arrays including a total of more than 30 antenna elements.

Due to the wideband DF functionality of the R&S®DDF04E, the receive frequencies of the channels being monitored can be changed via the graphical user interface. The number of frequency channels can be increased by enabling the R&S®DDF04E-4C software option. This allows the R&S®DDF04E to take the bearings on up to 32 frequency channels simultaneously.

With the introduction of digital aeronautical radio, DF systems used for air traffic control must be adapted as well since the channel spacing will shift from 25 kHz to 8.33 kHz. In this case, conventional fixed-frequency DF plug-in modules require a hardware modification by the manufacturer in order to replace the intermediate frequency (IF) filter. Since the R&S®DDF04E uses digital IF signal processing, the channel spacing can be changed via mouse click via the graphical user interface in the operating software.

Simple networking and control plus comprehensive selftest capabilities

Standard PCs are used to control the R&S®DDF04E and display the results. This drastically reduces the costs per workstation while increasing flexibility. For example, tablet PCs can serve as a display, or laptops can be utilized for control and display in mobile systems.

The R&S®DDF04E and the PCs (control PC and DF server) are networked via LAN. Standard network products can be used for this purpose.

Connection to customer-specific traffic management systems and/or radar displays is also accomplished via LAN (TCP/IP). Alternatively, RS-232-C interfaces are available for connecting radar displays.

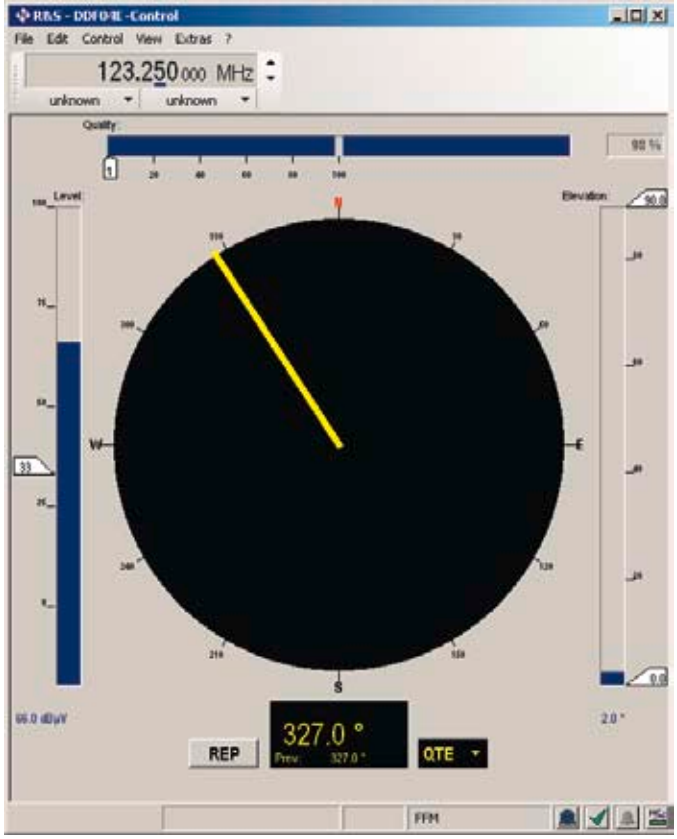
Control information for ground transmitter suppression is first converted to TCP/IP by means of one or several converters. The data can then be queried by the R&S®DDF04E via the network.

Selftest capabilities are particularly important for safety-relevant applications such as air and maritime traffic control. The R&S®DDF04E continuously checks more than 170 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.

All DF antenna elements can be checked for proper functionality using the graphical user interface.

The R&S®DDF-SK service kit is recommended for effective troubleshooting. In addition to a wide range of accessories, the service kit also contains the R&S®ZT660 antenna simulation. With this tool, users can check the functionality of the R&S®DDF04E without having to connect a DF antenna.

Graphical user interface of the R&S®DDF04E.



Technologies

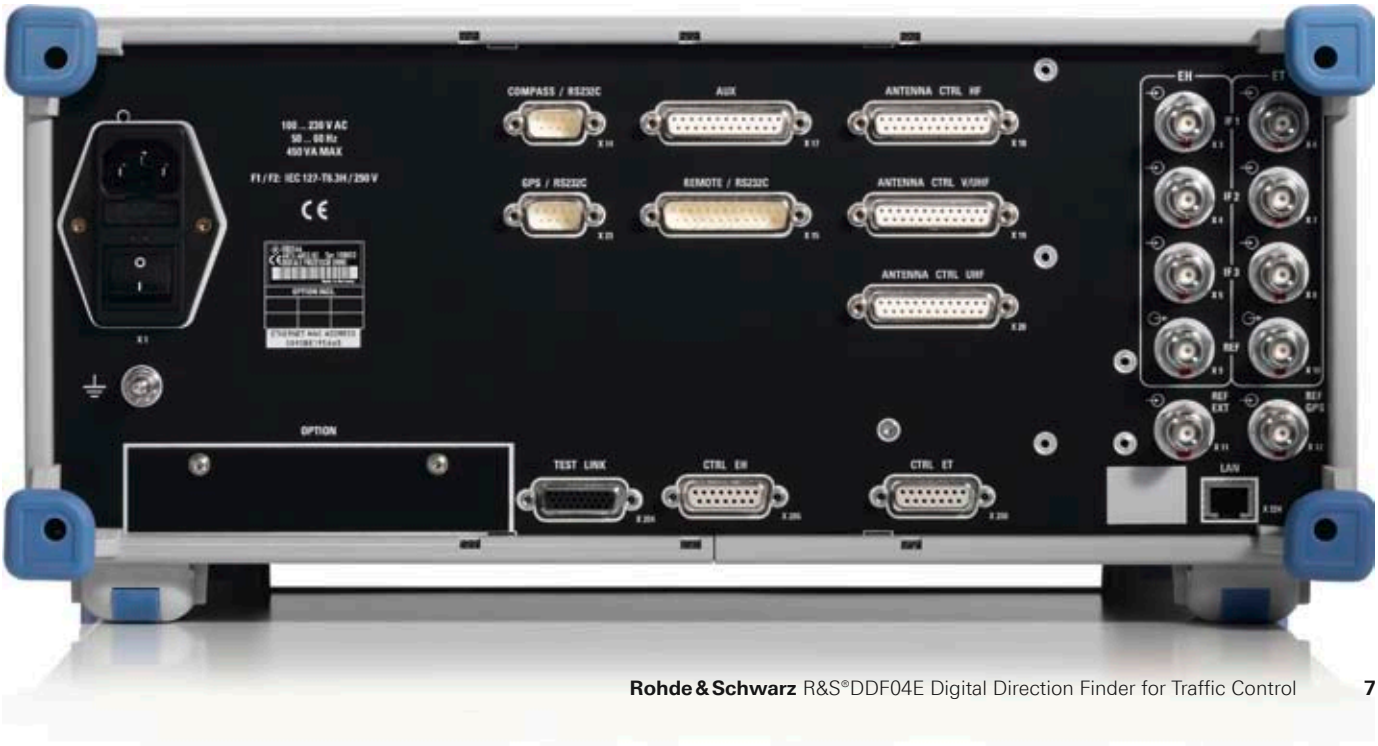
Digital wideband direction finding

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 the bearings on many frequencies simultaneously. To do this, the frequency spectrum within the realtime bandwidth is divided into channels according to the preselected channel spacing settings by using a Fourier transform. 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.

The bearings are calculated using the correlative interferometer method. With this DF 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.

This method of calculating bearings in parallel for multiple channels makes DF accuracy, sensitivity and measurement speed equally high for all channels.



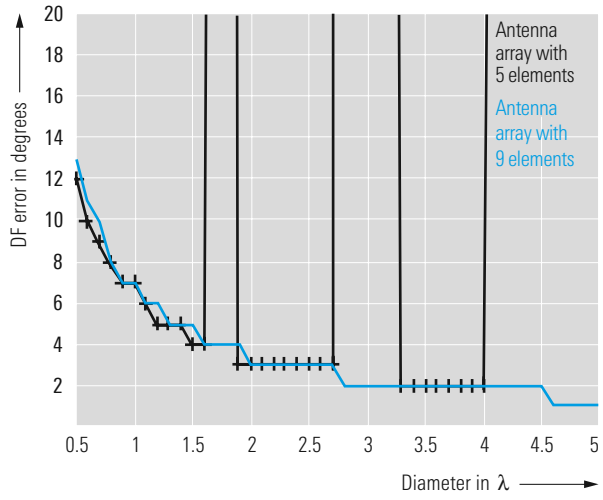
Multi-element DF antennas

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 an actual operational environment that includes 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.

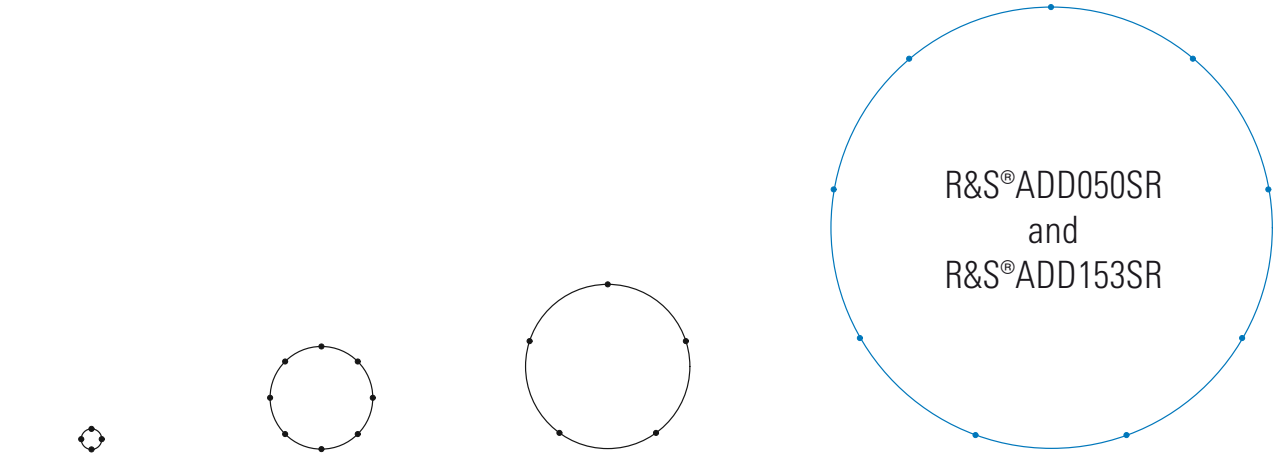
The figure below shows that the R&S®DDF04E, featuring a nine-element array and employing the correlative interferometer DF method, offers by far the largest DF antenna and thus higher accuracy and sensitivity.

Reflections can impair DF accuracy. Depending on their design, some DF antennas can handle reflections better than others. The R&S®DDF04E was designed to provide accurate bearings even with a 50 % share of incoming signal reflections. This high immunity to reflections is achieved by employing a large number of antenna elements. If only five antenna elements are used for instance, a 50 % share of reflections can produce DF errors in the order of 100° over wide frequency ranges. The diagram opposite shows that at specific wavelengths, a five-element antenna array produces significantly higher DF error rates than a nine-element antenna array.

Comparison of DF antennas in a two-wave field



Maximum DF antenna aperture at 50 % of reflections



4 elements
Adcock/Watson-Watt
D/λ = 0.2

8 elements
Adcock/Watson-Watt
D/λ = 1.0

5 elements
Correlative interferometer
D/λ = 1.6

9 elements
R&S®DDF04E correlative interferometer
D/λ = 4.3

System configuration

DF antenna for stationary and semi-mobile applications: R&S®ADD050SR

The R&S®ADD050SR wide-aperture DF antenna covers the entire frequency range of the R&S®DDF04E, from 100 MHz to 450 MHz. With a diameter of three meters and a total of nine antenna elements, the R&S®ADD050SR offers high DF accuracy and sensitivity plus outstanding immunity to reflections.

DF antenna for mobile applications: R&S®ADD153SR

The R&S®ADD153SR mobile DF antenna also covers the entire frequency range of the R&S®DDF04E, from 100 MHz to 450 MHz. Due to its compact dimensions, the R&S®ADD153SR is optimized for mobile applications. A radome protects the antenna elements against the effects of weather.

For installation on a mast, the R&S®ADD150A mast adapter is recommended.

A semi-mobile mast (R&S®KM225) is available in different heights (approx. 1.6 m/3.3 m/5 m) for the R&S®ADD153SR mobile DF antenna. This mast is optimized for fast and easy setup. Masts with a height of approx. 5 m should additionally be secured with R&S®KM225AS guy ropes.

R&S®ADD050SR wide-aperture DF antenna.

R&S®ADD153SR mobile DF antenna.

Supplemental lightning protection

The R&S®ADD050SR and R&S®ADD153SR DF antennas are delivered with a lightning rod as standard. This rod safely diverts lightning strikes and in most cases prevents damage to the DF antenna. However, the higher a DF antenna is installed above ground, the higher the likelihood that the lightning will not strike the rod, but the side of the DF antenna, causing severe damage. For this reason, the R&S®ADD-LP supplemental lightning protection is recommended for installation heights of more than 30 meters above ground (masts higher than 30 meters, high buildings, mountain tops, etc.). The R&S®ADD-LP consists of two crossed lightning rods that in most cases prevent lateral impacts since the rods project beyond the DF antenna.

Antenna cables

To connect the DF antenna to the R&S®DDF04E direction finder, the R&S®DDF5xZ cable set is available in many standard lengths. This cable set consists of four coaxial RF cables and one control cable.

Special lengths are available on request.

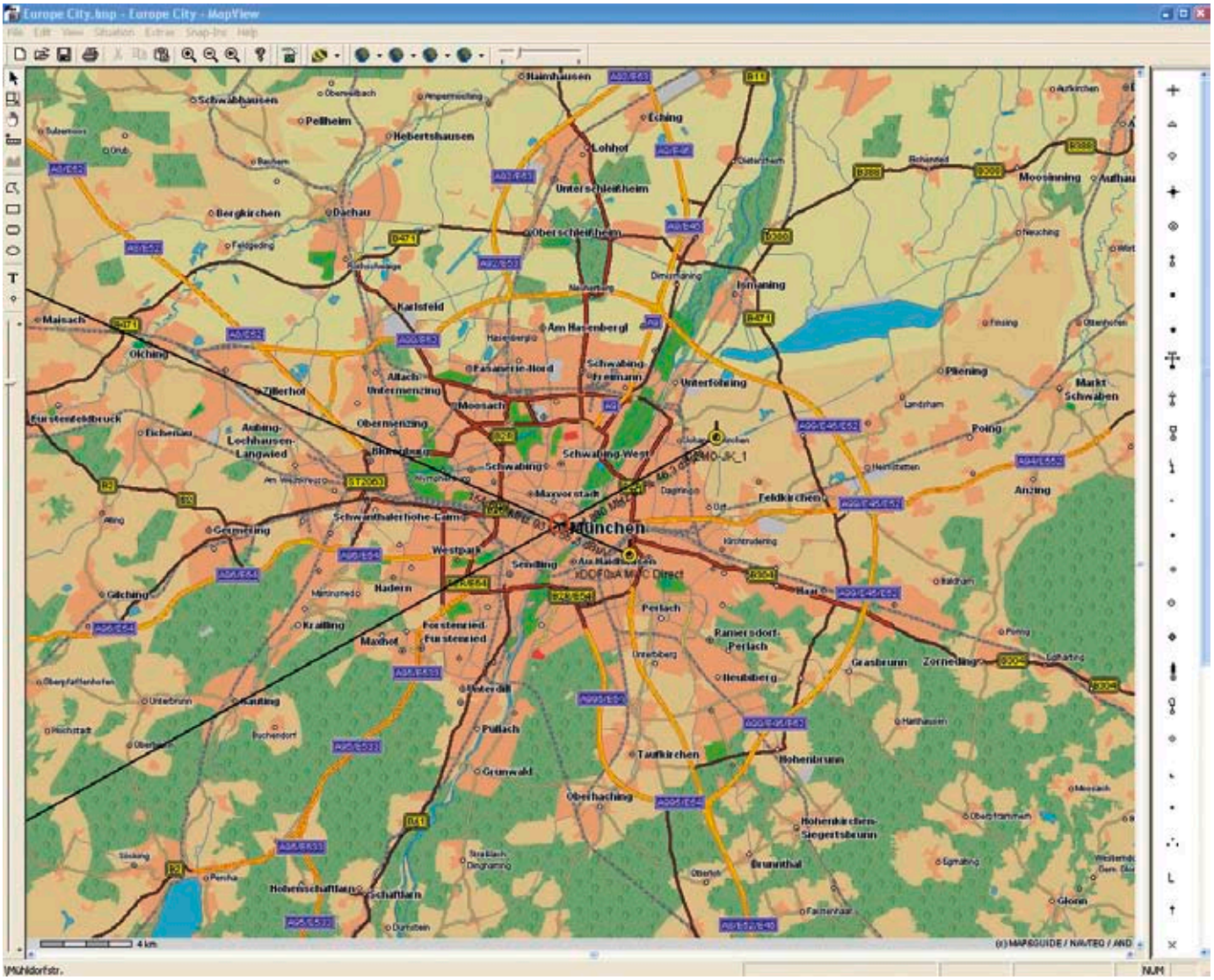
R&S®ADD-LP supplemental lightning protection (mounted on an R&S®ADD153SR).

System components

The R&S®DDF04E can also be controlled via the R&S®RAMON system software. This permits integration of the R&S®DDF04E into radiolocation systems.

The figure below shows radiolocation of a transmitter using two R&S®DDF04E direction finders. R&S®RAMON software modules are used to calculate location results and integrate the two direction finders into the radiolocation system. The map display is generated by the R&S®MapView geographic information software.

Locating a transmitter using two R&S®DDF04E direction finders and R&S®RAMON software.



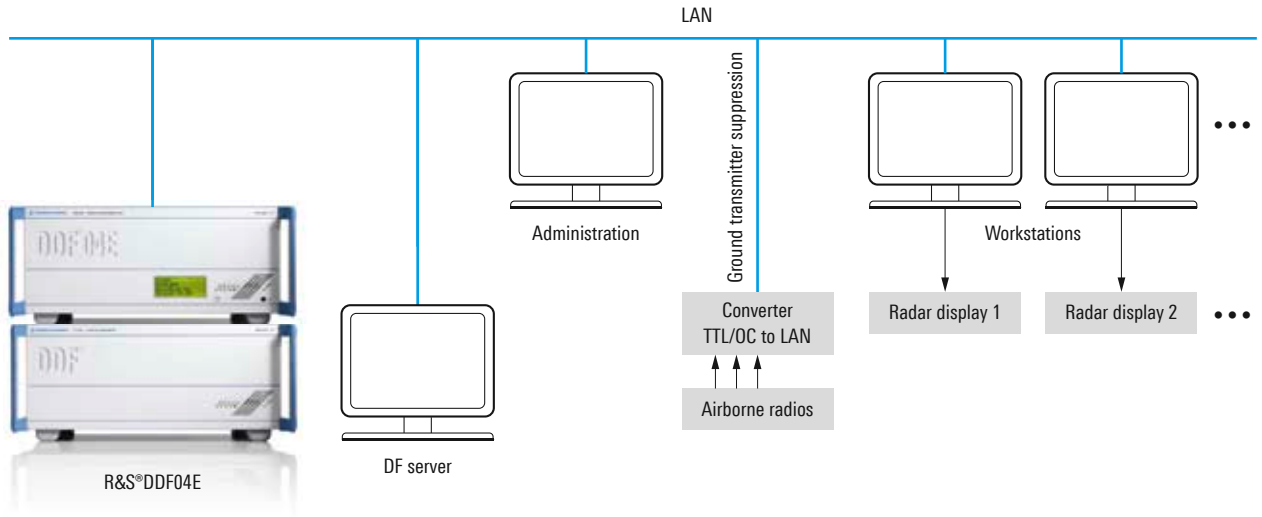
Application example
Air traffic control

In air traffic control applications, the R&S®DDF04E is typically deployed at mid-sized or large airports for taking the bearings of air traffic control communications. With the R&S®DDF04E-4C option, the R&S®DDF04E can be expanded to support the required number of frequency channels. Even large airports with up to 32 frequency channels can be equipped in this manner. Along with the traffic control frequency channels, multiple distress frequencies can be permanently monitored and bearings can be taken when activity is detected.

Another key advantage of the R&S®DDF04E is its readiness to meet future air traffic control requirements. The forthcoming 8.33 kHz channel spacing for digital aeronautical radio is already integrated. In addition, the frequencies of the channels being monitored can be changed via mouse click. The number of channels being monitored can be increased by enabling the corresponding software (additional hardware may be required for ground transmitter suppression).

To mask emissions from the air traffic control's own radiocommunications system, the R&S®DDF04E can suppress ground transmitter signals by blocking selective channels (see block diagram below).

Typical air traffic control setup with the R&S®DDF04E



Application example
Maritime traffic control

The R&S®DDF04E is also used at seaports for monitoring and controlling maritime traffic. Using the R&S®DDF04E-4C option, the bearings of four ships, for example, can be taken quasi-simultaneously. At the same time, all important VHF/UHF distress frequencies can be monitored:

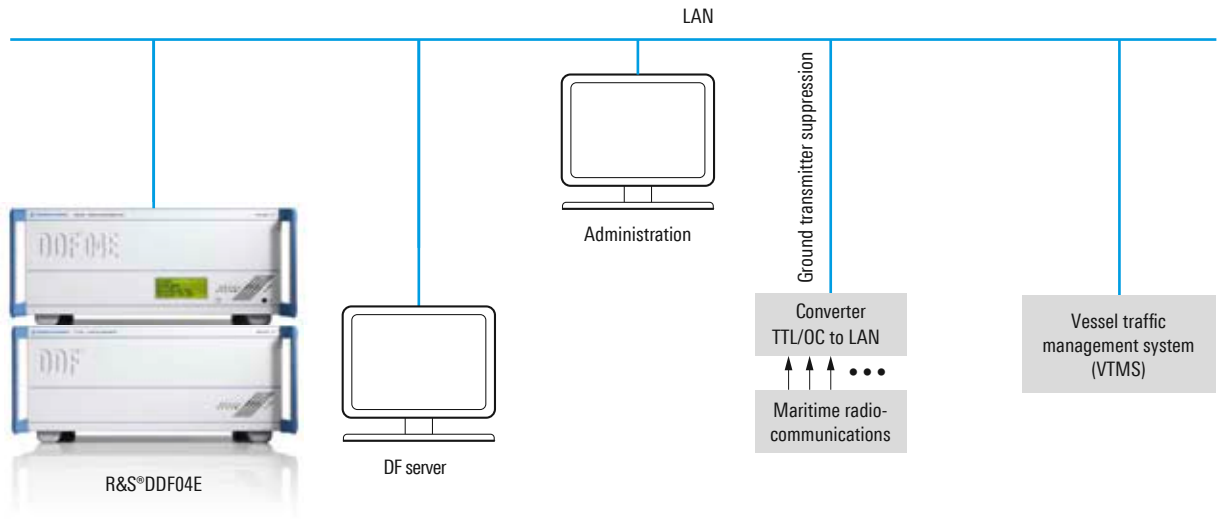
- Maritime radio distress frequency: 156.8 MHz
- International distress frequency: 121.5 MHz
- EPIRB distress frequency: 406 MHz
- Military distress frequency: 243 MHz

As illustrated in the block diagram, all DF results for each active frequency channel are first processed by the DF server and then output via the Ethernet interface. The R&S®DDF04E is thus optimized for integration into the vessel traffic management system (VTMS). The R&S®DDF04E also features a graphical user interface so that it can be controlled with standard PCs and laptops.

All of the above distress frequencies are monitored in parallel. For maximum reliability and safety, the probability of intercept is not affected by the degree of occupancy of the remaining channels. In this example, the R&S®DDF04E would still reliably take the bearing of a distress call on channel 16, even if all remaining channels were occupied with maritime radio traffic or distress calls.

To mask emissions from the traffic control's own radiocommunications system, the R&S®DDF04E can suppress ground transmitter signals by blocking selective channels (see block diagram below).

Typical maritime traffic control setup with the R&S®DDF04E



Specifications

Base unit		
Frequency range		100 MHz to 450 MHz
DF method		correlative interferometer
DF accuracy [1]	with R&S®ADD050SR wide-aperture DF antenna	1° rms, typ. 0.5° rms
	with R&S®ADD153SR mobile DF antenna	1° rms
DF sensitivity [2]	2° rms bearing fluctuation 25 kHz channel spacing 1 s integration time	5 µV/m
Minimum signal duration [2]		100 ms
Number of frequency channels	base unit	4 frequency channels
	with R&S®DDF04E-4C option, multiple installations possible	4 additional channels per option enabled, to yield max. 12 channels in total (up to 32 channels upon request)
Channel spacing	selectable	25 kHz or 8.33 kHz
Linearity	second-order intercept (SOI)	typ. 63 dBm
	third-order intercept (TOI)	typ. 28 dBm
Intermodulation-free dynamic range	in-band, bandwidth 7.5 kHz	typ. 85 dB
Phase noise	at 10 kHz carrier offset	typ. –120 dBc/Hz
Image frequency rejection		typ. 110 dB
IF rejection		typ. 110 dB
Operating temperature range	outdoors (DF antennas, cable set)	–40 °C to +55 °C
	indoors	–10 °C to +55 °C
Storage temperature range		–40 °C to +70 °C
Humidity	cyclic test at 25 °C/35 °C, EN 60068-2-30	max. 95 %
Installation altitude		max. 3000 m above sea level
Power supply		100 V to 230 V AC, +10 %/–15 %, 47 Hz to 63 Hz
Dimensions (approx.)	direction finder	19" × 8 HU
	R&S®ADD050SR DF antenna with lightning rod	3 m diameter × 3 m height (118.1 in diameter × 118.1 in height)
	R&S®ADD153SR DF antenna with lightning rod	1.1 m diameter × 1.3 m height (43.3 in diameter × 51.2 in height)
Weight (approx.)	direction finder	33 kg (72.75 lb)
	R&S®ADD050SR DF antenna with lightning rod	70 kg (154.32 lb)
	R&S®ADD153SR DF antenna with lightning rod	30 kg (66.14 lb)
Wind load	R&S®ADD050SR DF antenna without ice deposit with 30 mm radial ice deposit	 200 km/h: 1520 N/217 mm 180 km/h: 3400 N/221 mm
	R&S®ADD153SR DF antenna without ice deposit with 30 mm radial ice deposit	 200 km/h: 270 N/189 mm 180 km/h: 530 N/192 mm

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

[2] The value depends on the number of frequency channels to be monitored. The specified value is based on an example with eight frequency channels in the civil air traffic control band.

System requirements

Standard PCs, or where appropriate laptops, are used to control the R&S®DDF04E and display results.

The R&S®DDF04E connects to the control and display PCs via Ethernet/LAN, enabling the use of standard network technology.

Ordering information

Designation	Type	Order No.
Base unit (including control software and supplied accessories such as power cable, manual, etc.)		
Digital Direction Finder for Traffic Control	R&S®DDF04E	4076.3006.02
Software option (typically firmware)		
Four-Channel Expansion	R&S®DDF04E-4C	4076.3406.02
System components		
VHF/UHF DF Antenna	R&S®ADD050SR	4071.7003.02
VHF/UHF Compact DF Antenna	R&S®ADD153SR	4071.6007.02
DF Antenna Cable Set, available in different lengths	R&S®DDF5xZ	4064.6728.xx
Lightning Protection	R&S®ADD-LP	4069.6010.02
Mast Adapter for compact VHF/UHF DF antenna, color: light ivory	R&S®ADD150A	4041.2655.02
Electronic Compass	R&S®GH150	4041.8501.02
GPS Navigator/GPS Receiver with integrated inertial navigation function (with GPS antenna)	R&S®GINA	4055.6906.04
Mast for R&S®ADD153SR, hot-galvanized steel, length: 1.65 m	R&S®KM225M3	4036.5508.02
Mast Extension for R&S®ADD153SR, hot-galvanized steel, length: 1.65 m	R&S®KM225M4	4036.0758.02
Mast Guying, consisting of three guy ropes	R&S®KM225AS	4034.9706.02

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About Rohde&Schwarz

Rohde&Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde&Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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*0.14 €/min within German wireline network; rates may vary in other networks (wireline and mobile) and countries.