New concept for communications and intercept antennas on ships

Even on large floating military platforms there is limited space for all the antennas that are required for communications, navigation and intelligence as well as for weapons and radar warning systems. Antenna systems must be individually optimized in terms of frequency range and radiation pattern since the critical applications they support cannot tolerate performance trade-offs. Extensive studies by Rohde&Schwarz on behalf of the German navy targeted at solving such challenging problems delivered results that have now been transformed into innovative products.

Antenna systems — where less can be more

The demand for communications lines as well as additional antenna-based applications on board ships is growing, and this trend is expected to continue in the future. Mechanical designers are faced with difficult challenges as they have to arrange all the antennas at optimum positions and avoid performance trade-offs despite space constraints. The level of expertise required for mechanical design and placement is very high since the antennas must not be negatively impacted by the ship's structures or adjacent antennas and they must avoid interfering with one another. The consequences could be fatal, and the affected communications systems would experience a loss of efficiency. For example, the circularity in the pattern of antennas that are otherwise omnidirectional could be degraded or their vertical radiation pattern could exhibit an unfavorable change. This would shift the main lobe, decrease the antenna gain in the relevant direction and possibly even cause nulls to appear at certain azimuth and elevation angles. As a result, it would practically be impossible to meet special military requirements (STANAG), e.g. for omnidirectional coverage for communications links.

Rohde&Schwarz has long worked to overcome this challenging problem and has developed solutions as part of its extensive studies on behalf of the German navy. The theoretical results generated by these research activities have now been transformed into products including innovative communications antennas and a highly integrated DF and monitoring antenna system. All the new systems require significantly less individual antennas and perfectly meet the complex and growing technical requirements for equipment used on board ships.

New concept eliminates antenna overcrowding on ships

In addition to the requirement for absolute circularity in the pattern, the product design description also wanted Rohde&Schwarz to optimize the elevation radiation pattern. Frequently, the radiation patterns of conventional antennas deteriorate by developing side lobes except in the case of narrowband antenna models. The gain in the direction of the horizon exhibits a sizable drop. As a result, the main lobe does not cover the horizon. Nulls can interrupt communications – a problem that must be strictly avoided during communications with approaching aircraft.

The impressive radiation patterns of the new R&S®AD066FW broadband VHF/UHF communications antenna (Fig. 1) demonstrate what advanced antenna design can achieve. The antenna operates across an extremely wide frequency range from 118 MHz to 453 MHz. Highlight: The antenna is made up of circularly arranged individual radiators that are interconnected into a beam forming network (BFN). This clever design delivers outstanding circularity in the radiation pattern of typically ±0.6 dB and enables usage as a multiple link antenna. Multiple VHF and UHF radio lines (or even all radio lines as a function of the radio concept) on board the ship are connected to an antenna and operated simultaneously (Fig. 2). This significantly reduces the number of antennas required on ships and also reduces the variety of problems associated with antenna interactions.

In order to achieve the decoupling between the transmit and receive paths that is necessary for proper reception, it is recommended to use a second (identical) antenna arranged above the first antenna. Due to the design-driven optimization of the mast decoupling achieved with the R&S®AD066FW, impressive isolation figures of 40 dB or more are possible even when the antennas are stacked directly. The antenna's modular design allows adaptation to a wide variety of mast diameters with comparable electrical

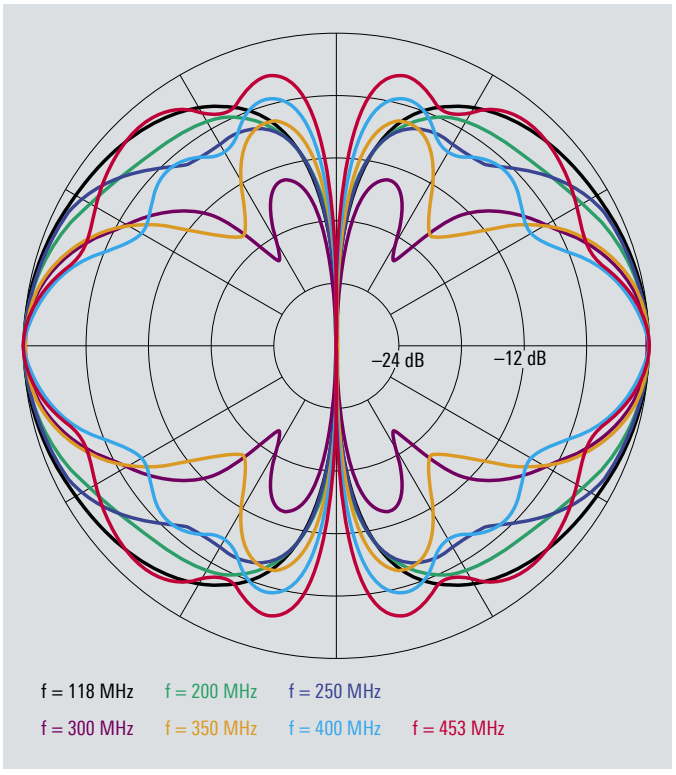

Fig. 1 New R&S®AD066FW broadband VHF/UHF communications antenna with vertical patterns (relative electric field strength).

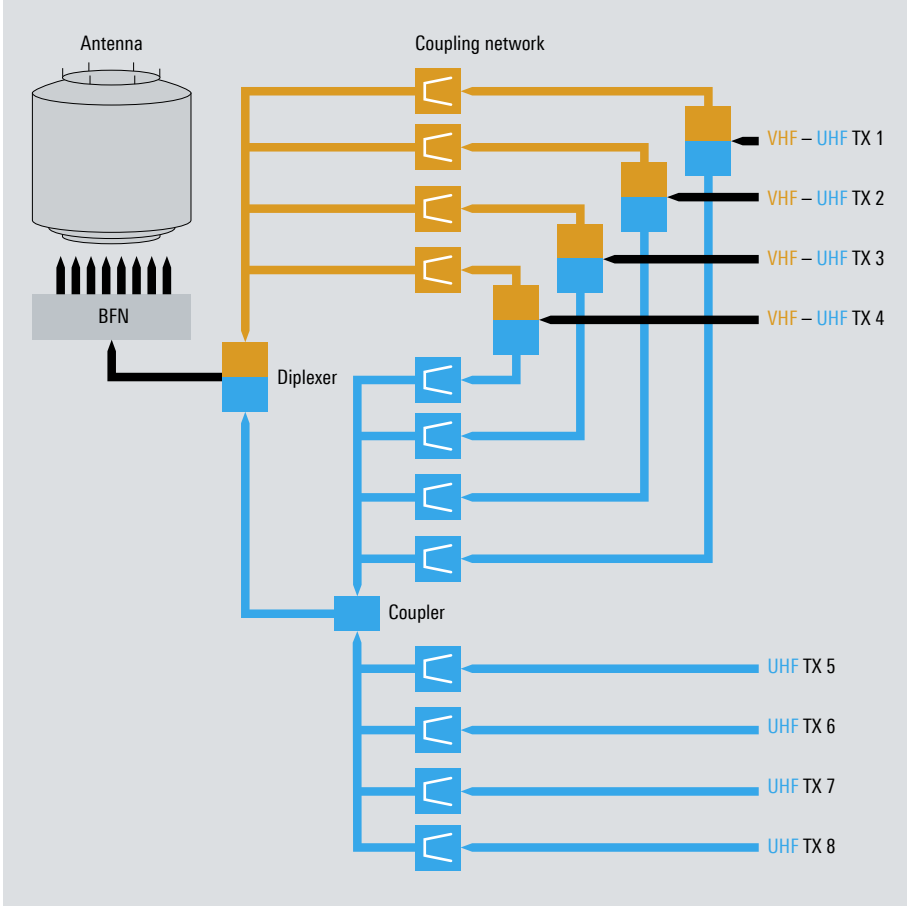

Fig. 2 Basic principle of a multiple link antenna with beam forming network on eight radio lines.

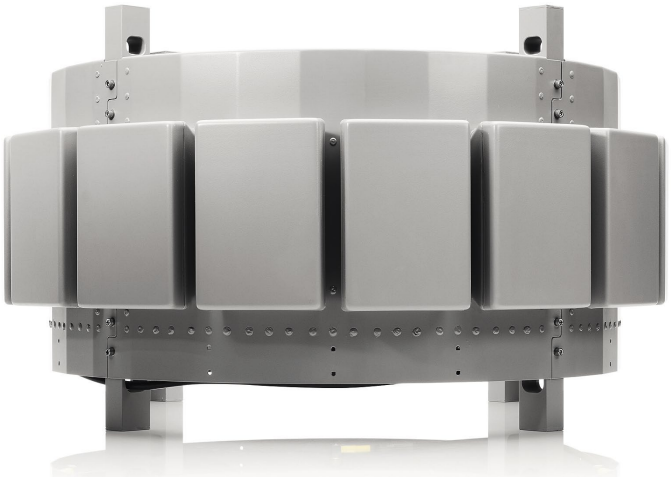

Fig. 3 The R&S®AD016M broadband communications antenna operates in the frequency range from 960 MHz to 1220 MHz and is ideal for applications involving the LINK 16 data radio standard. Due to its stackability, the top of the mast is free for other sensors.

specifications. The detached, exchangeable BFN improves stackability and simplifies maintenance.

Another advantage of this antenna design is that mounting is possible even in an exposed position using a suitably dimensioned mast. An appropriate mast, which can ideally be extended up to the highest point of the ship, can accommodate additional transmit antennas or sensors both below and above the R&S®AD066FW so their performance can benefit from the "panoramic view" available there. For example, this might be tactical data link (TDL) antennas and especially the R&S®AD016M broadband communications antenna (Fig. 3). This antenna is also new and has a design similar to the R&S®AD066FW.

The R&S®AD016M operates in the frequency range from 960 MHz to 1220 MHz and is ideal for applications involving the LINK 16 data radio standard. Due to the stackability, this application does not require a separate mast or mounting on a cross-arm that would invariably impact the circularity of the radiation pattern. Moreover, the top of the mast is left free for other additions — a basic requirement for innovative new antenna concepts. Why? The top of the mast is reserved for antennas that by necessity must be placed at the highest point on the ship such as sensors for sensitive intelligence systems.

Space-saving: a highly integrated antenna system

Rohde&Schwarz has developed equipment and antennas for intelligence systems for decades now. Since these systems are expected to cover constantly expanding frequency ranges, optimized antenna systems with sensors for widely diverse frequency bands are growing in importance. Rohde&Schwarz has taken this requirement into account with a new, highly integrated DF and monitoring antenna system: The R&S®ACD001 integrated C/R-ESM antenna system (Fig. 4) covers the frequency range from 1 MHz to 18 GHz and can be extended up to 40 GHz with an option that can be integrated into the system. Ideally, the antenna system should be positioned at the top of a mast. In systems with digital direction finders, receivers and signal analyzers from Rohde&Schwarz, outstanding overall performance can be achieved.

The key facts of the R&S®ACD001 are as follows:

- Reception of signals with vertical, horizontal and circular polarization
- Omnidirectional and directional radiation patterns simultaneously over entire frequency range
- Usable as DF and monitoring antenna
- Effective lightning protection (mandatory due to positioning at top of mast)
- Outstanding EMC shielding (e.g. in case of exposure to radar signals)

Fig. 4 R&S®ACD001 integrated C/R-ESM antenna system for the frequency range from 1 MHz to 18 (40) GHz.

The R&S®ACD001 antenna system can be used independently or in combination with the stackable antennas presented here. By choosing the appropriate antennas and placing them carefully on the ship, it is possible to meet many requirements despite inherent space constraints. Fig. 5 gives an example of the design of a compact mast structure and how to place such high-performance antenna arrays on ships.

All antennas from Rohde&Schwarz are built to withstand extreme ambient conditions since the exposed position due to RF-related reasons demands a high level of shock resistance and high immunity to electric discharge. Their radar cross-section has been minimized in order to best limit the exposure to enemy reconnaissance.

Overview of other innovative products

In order to satisfy increased environmental requirements, Rohde&Schwarz has improved its existing portfolio of conventional ship antennas in parallel with the development of new "integrated antennas". The antennas listed below were specially designed for ship applications and are optimized for top RF performance, low weight and small dimensions.

A good example is the slender R&S®AD066ST UHF omnidirectional antenna with its very rugged mechanical design (Fig. 6). It is ideal for frequency-agile communications systems in the frequency range from 225 MHz to 400 MHz that demand a high level of decoupling between the transmit and receive paths.

Fig. 5 Sample design of a mast structure with possible arrangement on board ships.

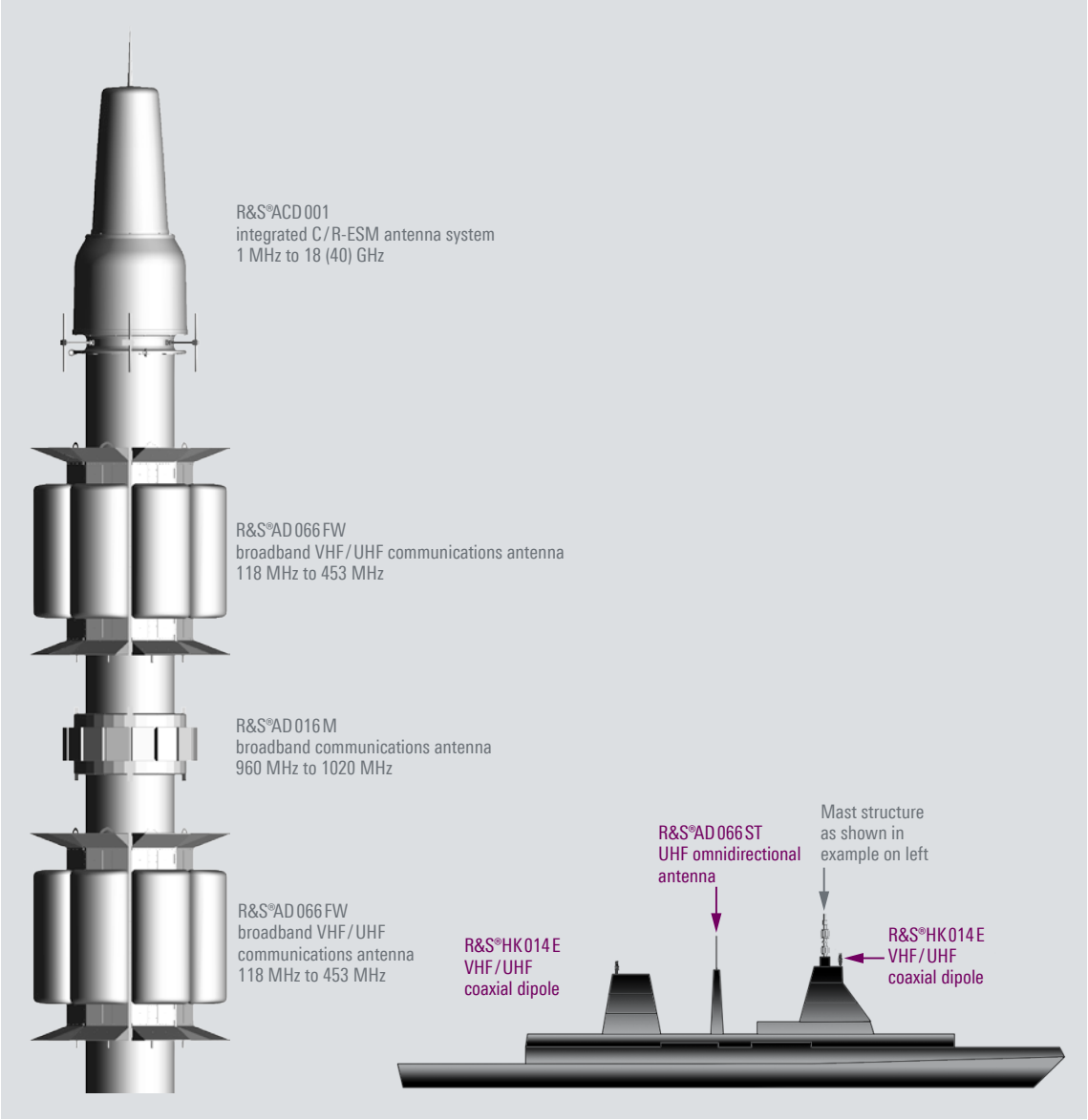

Fig. 6 R&S®AD066ST UHF omnidirectional antenna.

The new R&S®AD033V3 UHF omnidirectional antenna (Fig. 7) uses a similar approach as the R&S®AD066FW broadband VHF/UHF communications antenna (Fig. 1). Except for the frequency range (UHF only; 225 MHz to 450 MHz), it has comparable properties but is smaller and lighter.

Even the R&S®HK014 omnidirectional VHF/UHF coaxial dipole, which is very broadband with respect to its size and has been successfully used for decades in various civil and military applications, has undergone reworking to meet increased environmental requirements. The result is the R&S®HK014E VHF/UHF coaxial dipole (Fig. 8), which also features improved RF figures and a more favorable radiation pattern.

The new R&S®AD016MC compact broadband transmit antenna (Fig. 9) can be used as an alternative to the R&S®AD016M broadband communications antenna in cases where no stacking is required. Despite the same power handling capacity, it is significantly more compact and lightweight than the R&S®AD016M. Its wide frequency range from 800 MHz to 8000 MHz also allows it to be used with other services besides LINK 16.

Fig. 8 The R&S®HK014E VHF/UHF coaxial dipole features improved RF figures and a more favorable radiation pattern.

Summary

The Rohde&Schwarz portfolio of individual antennas and antenna systems for use on board ships has been significantly expanded and reworked. This allows antenna implementations to satisfy extremely demanding electrical and mechanical requirements while taking individual customer requirements into account.

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Fig. 7 R&S®AD033V3 UHF omnidirectional antenna for 225 MHz to 450 MHz.

Fig. 9 The R&S®AD016MC compact broadband transmit antenna with its wide frequency range from 800 MHz to 8000 MHz can also be used with other services besides LINK 16.