State-of-the-art: the German Arme

In 1989, the German Armed Forces (Bundeswehr) contracted Rohde & Schwarz to supply the entire test and measurement equipment for its EMC test center in Greding, one of the largest worldwide. Over the last few years, in close collaboration with the Bundeswehr Technical Center for Information Technology and Electronics (WTD 81), this test center has been completely updated with the latest technology. It relies on an elaborate concept that satisfies even the most challenging demands placed on EMC test centers.

FIG 1 Amplifiers/antenna units detached from the preamplifiers generate field strengths of between 200 V/m and 300 V/m at a distance of 1 m at 40 GHz and with 40 W power.

d Forces' EMC test center

The decisive factors in EMC test centers: flexibility and 100% versatility

EMC tests are indispensable in the development of electronic instruments and systems. In contrast to individual components, complex systems such as vehicles or radar systems can be subjected to EMC tests as complete functional units only at a relatively late stage in their development. In addition, the usually tight development schedules demand quick and flexible adjustment of test schedules, with the consequence that test center capacities are utilized to a constantly varying degree, which makes resource planning very difficult. Moreover, the installed test equipment should be capable of testing a wide variety of equipment.

The EMC test center in the Bundeswehr Technical Center for Information Technology and Electronics (WTD81) in Greding, one of the largest worldwide, is a prime example of flexibility, versatility and usability for fully automatic measurements. As early as 1989, Rohde&Schwarz installed a full range of T&M equipment, and in the last few years the center has been upgraded with the latest technology as part of a modernization and expansion program.

Elaborate design for optimal use of system resources

In every development project, the time schedule and consequently the scheduling of the associated EMC tests are subject to frequent changes. Developers are permanently confronted with the issues of whether equipment under test (EUT) has to be modified, whether the modification can be performed on site, or whether an additional test date is necessary. In many cases, the time required for measurements cannot be precisely defined, which complicates test lab resource planning. State-of-the-art EMC test centers must therefore be designed to ensure maximum and efficient utilization of resources despite the fact that short-term planning of their test capacity is normally not possible.

These requirements formed the basis for the design of the WTD81 EMC test center. A large and a small anechoic chamber and a reverberation chamber are available for measurements. Each test chamber is permanently assigned a control room with a test receiver, signal generator, power meter, EUT monitoring and R&S®EMC32 measurement software from Rohde&Schwarz (FIG 3). Amplifiers with powers of 5 kW and 10 kW for frequencies between 9 kHz and 100 MHz and 2 kW and 5 kW for frequencies between 80 MHz and 1 GHz are provided in a central, shielded amplifier room (FIGs 2 and 4).

The necessary power depends on the test conditions and requirements in each case, e.g. the stipulated test severity, the distance to the EUT, or the antenna used. The maximum available power is not always needed in all chambers. The amplifiers can therefore be assigned as required to the individual test chambers or – for system tests and system calibration – to the load resistors, which ensures efficient

FIG 2 The amplifiers are accommodated in a central, shielded room and can be assigned to the test chambers as required.

measurements using the most suitable amplifiers in each case. Maximum power can also be provided for each test chamber if necessary. The component redundancy offered increases system availability, thus ensuring, for example, that measurements can be performed without restrictions even while maintenance is being carried out.

Uncompromising in terms of safety

An important aspect of planning in which no compromises can be accepted is the safety of the system. The risks associated with EMC measurements are well-known: Not only can an incorrectly connected cable falsify measurement results; if high RF powers are applied, it can also damage or even destroy the test system and the EUT, for example if the electromagnetic field is inadvertently generated in the wrong test chamber.

The test center in Greding has been designed to exclude configuration errors of this kind. This is achieved through fixed RF cabling and automatic relay switching. The status of each power relay is signaled back before the required path is activated. Amplifier assignment from a central location also avoids configuration conflicts. In addition, as part of a completely revised safety concept, the doors of all chambers have been included in the interlock circuit, which also covers and indicates further important parameters of the test system:

- Pressure and temperature of cooling water for the amplifiers
- Temperature in amplifier room
- Final positions of RF relays
- Correct locking of antennas in H and V positions
- Cooling of E/H generators

Safety measures to protect the operating staff include large illuminated displays above the entry doors to the test chambers. Moreover, a safety button is provided that will open the interlock circuit when staff enters a chamber and will keep it open as long as anyone is inside the chamber. Each amplifier is assigned the safety loop of the test chamber to which it is allocated. This makes sure that the correct amplifier is switched off when, for example, a chamber door is opened, and that test operation in the other chambers can continue

FIG 3 Each test chamber is permanently assigned a control room with test receiver, signal generator, power meter, EUT monitoring and measurement software from Rohde & Schwarz.

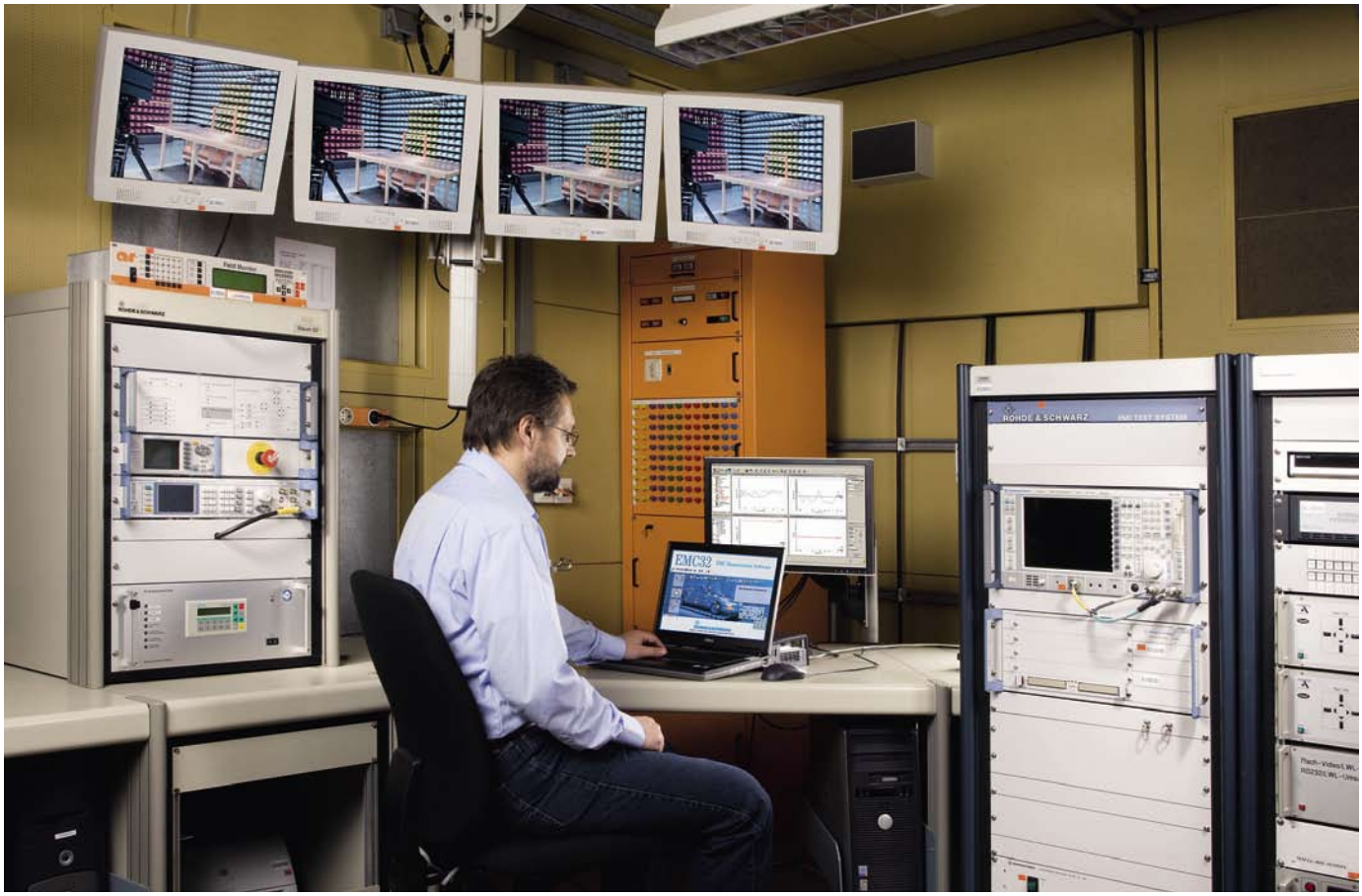

FIG 4 Rack for controlling the amplifier switching in the amplifier room, and in the background the associated RF power switch unit.

FIG 5 Strip line for component tests. The table can be removed, allowing the test configuration to be used also for conducted EMC measurements.

unimpaired. System and safety status messages are output directly at each operator's workplace. In addition, the R&S®EMC32 measurement software from Rohde & Schwarz automatically recognizes the configuration and takes it into account in the measurements. The complete system status, including the status of each individual safety switch, is displayed in detail at a central location, allowing faults to be traced and eliminated rapidly.

Another important prerequisite for the efficient utilization of the test system is fast and flexible function monitoring of a wide variety of EUTs. Due to the complexity of many EUTs, the capabilities of purely visual monitoring are quickly exhausted. In this respect, the EMC test system in Greding offers a wide range of communications options, including the monitoring of complete vehicles via their bus systems. Complex EUTs are frequently equipped with a software-based test environment of their own, via which data can easily be exchanged with the R&S®EMC32 software using TCP/IP. In such cases, the software can determine the immunity to disturbance of various components of an EUT by means of a single measurement.

Field strengths for all requirements

Due to its efficient field generation, the EMC test system is capable of producing a minimum field strength of 200 V/m seamlessly across the entire frequency range from 9 kHz through 40 GHz, which means that it covers all severity levels defined in MIL-STD-461. This also applies to tests on large EUTs and the large measurement distances that have to be observed in such cases.

Below 20 MHz, fields are generated by means of a strip line and E/H generators. The strip line used generates both the electric and magnetic field components with both polarizations, which reflects the conditions prevailing in a real

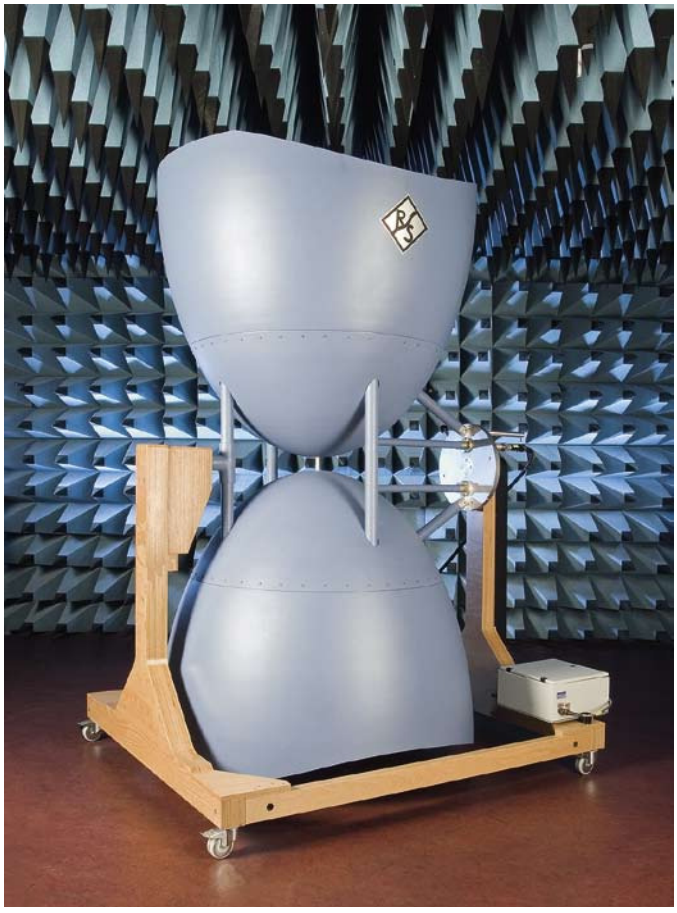

FIG 6 Due to its high efficiency, the R&S®HK5000 broadband dipole from Rohde & Schwarz generates very high field strengths in the range from 20 MHz to 100 MHz.

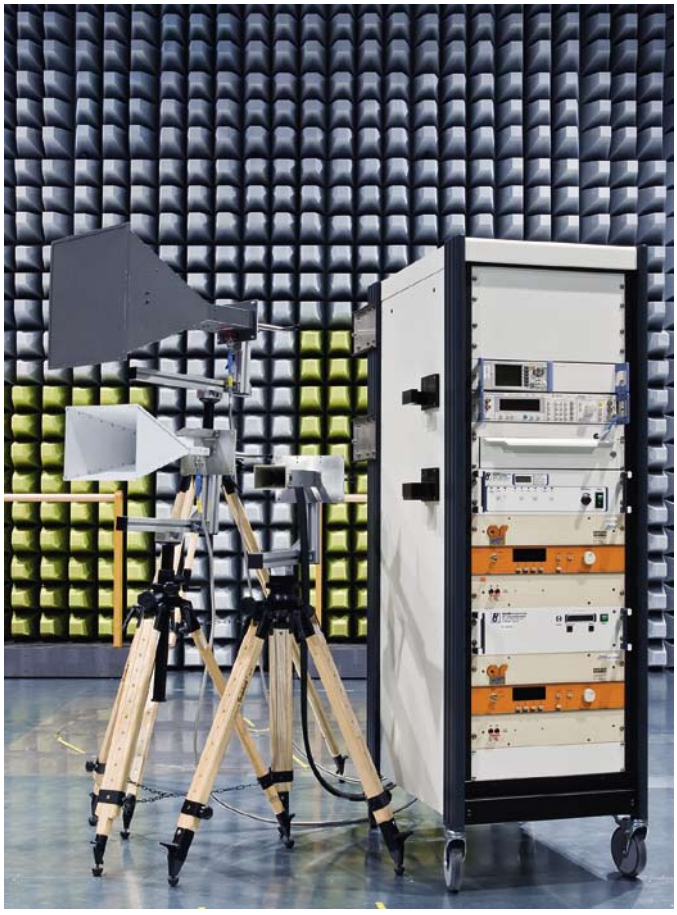

FIG 7 Mobile test systems generate pulsed and non-pulsed fields with strengths of up to 600 V/m in the range up to 18 GHz.

operating environment. The table on which the component under test is placed can be removed and taken together with the component to another location, allowing conducted EMC measurements to be performed using the same test configuration (FIG 5). Above 80 MHz, compact directional LPD antennas with high power-handling capacity are available (FIG 8). The strip line as well as the LPD antennas are tried-and-tested components that have been in use for many years.

The frequency range between 20 MHz and 100 MHz is particularly critical since high field strengths are difficult to achieve here. The EMC test center in Greding uses a specially developed broadband dipole – the R&S®HK5000 – in this range (FIG 6). Compared with the considerably shortened LPD antennas previously used, this dipole not only is much more compact but also requires 50% lower input power. At an input power of up to 10 kW, the R&S®HK5000 produces significantly higher field strengths than the LPD antennas before. The frequency range of interest is thus effectively covered.

A second important aspect is field generation in the microwave range, particularly for measuring the impact of radar equipment in both military and civil environments. Two mobile EMC test systems with amplifiers of 200 W and 500 W, respectively, generate pulsed and non-pulsed fields with strengths of up to 600 V/m for frequencies up to 18 GHz (FIG 7). At 40 GHz, however, high losses of 4.5 dB, i.e. 65% of the output power, occur even with short, flexible waveguides with a length of only 3 m. Lengths in this order are necessary, however, since in the microwave range, not the EUT as a whole is irradiated but only its critical areas. These areas may be located in inaccessible positions, e.g. inside a vehicle. The solution to this problem is to use amplifiers detached from the preamplifiers and operated directly on the antenna (FIG 1). This allows field strengths of between 200 V/m and 300 V/m to be achieved at a distance of 1 m even with a power of 40 W.

Summary

The system concept developed by Rohde & Schwarz in close collaboration with the Bundeswehr Technical Center for Information Technology and Electronics (WTD 81) in Greding combines optimal utilization of system resources and efficient field generation with a high level of automation and high reliability achieved through reproducible test sequences. The system excellently fulfills the exacting quality and flexibility demands placed on a test lab.

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Rohde & Schwarz – the world market leader for EMC test solutions

Rohde & Schwarz provides the full range of EMC test and measurement equipment from a single source. Based on decades of experience and offering a complete product portfolio, Rohde & Schwarz can set up and deliver even large EMC test systems on a turnkey basis. The equipment complies with all international standards both with respect to electrical and mechanical requirements. Available products include:

- Complete, turnkey EMC test centers for measuring electromagnetic interference (EMI) and electromagnetic susceptibility (EMS)
- EMI test receivers and spectrum analyzers for compliance and precompliance measurements
- Comprehensive range of accessories
- Sophisticated EMC measurement software

FIG 8 Above 80 MHz, compact directional LPD antennas are used to generate the required electromagnetic fields.