



# Electromagnetic Compatibility of Radio Systems for Cars

Special reprint from  
Automobiltechnischen Zeitschrift (ATZ)

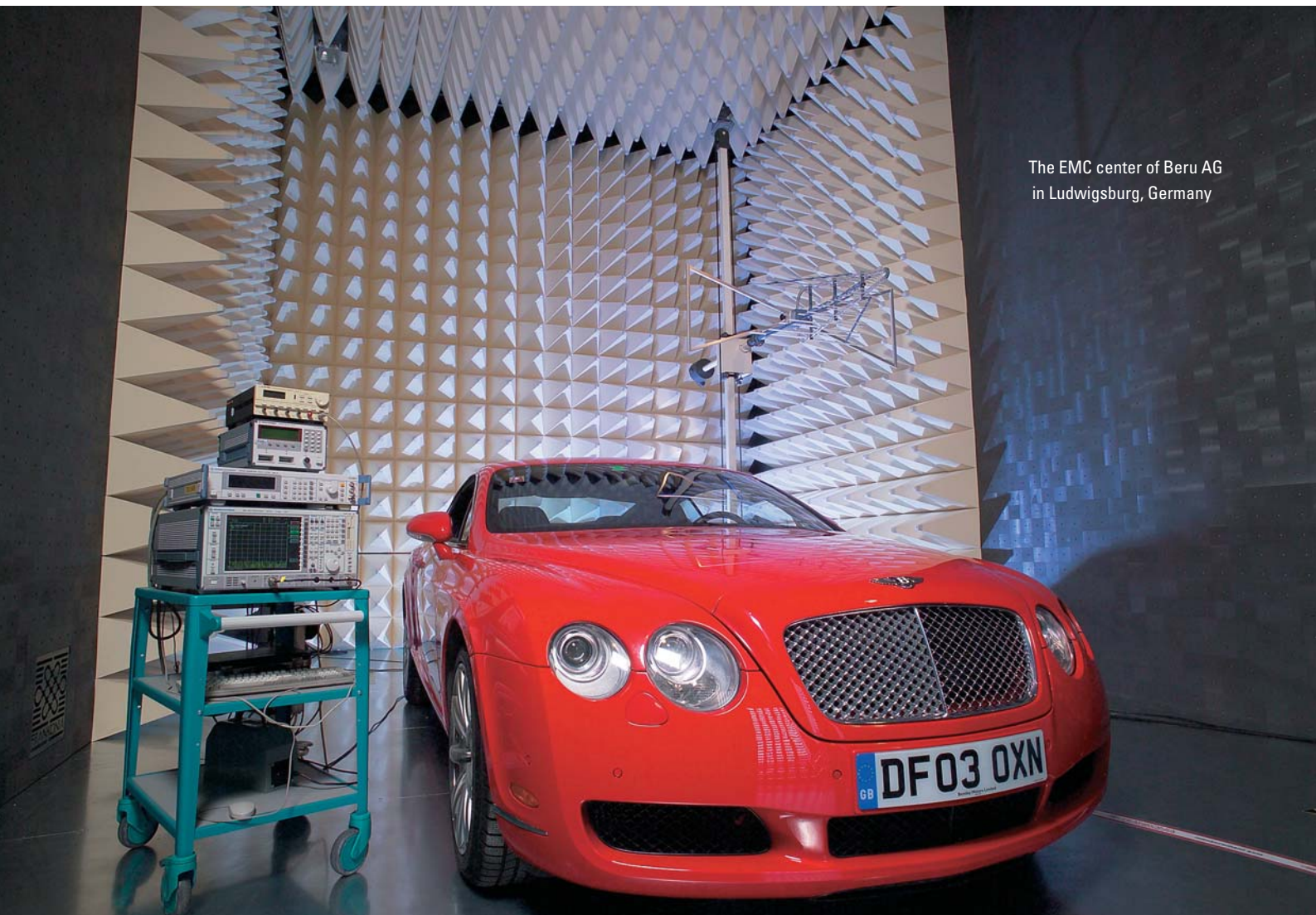
The specialist for  
ignition, diesel cold start,  
electronics and sensorics



# Electromagnetic Compatibility of Radio Systems for Cars

The increasing number of electrical and electronic components in the car has a considerable influence on its safety and environmental compatibility. The legal standards that have to be observed as a result are laid down in the recently modified, so-called Automotive EMC Directive. However, radio systems especially are subject to yet more requirements such as the R&TTE Directive. Using the example of the tire-pressure control system TSS from Beru AG it is explained how manufacturers have so far been obliged to handle these somewhat contradictory specifications and how they have been co-operating in respect of the licensing requirements with the various authorities involved. Now the procedure, tolerated to date, has been transferred to a new Directive.

The EMC center of Beru AG  
in Ludwigsburg, Germany



## 1 Introduction

In modern motor vehicles electrical and electronic components are playing an increasingly more important role. They also include a growing number of radio systems which improve the functionality, safety or luxury features of a car; for example, radio-based systems for central locking, car phone, distance warning device or even the tire-pressure control system TSS (Tire Safety System) developed by Beru AG and already supplied on many vehicles.

However, before one of these systems finds a legal route into the vehicle, each and every one of its modules has to pass extensive validation checks in order to receive an acceptance from the vehicle manufacturer for fitting into the vehicle. Apart from the usual quality checks and service life tests, these also include environmental checks and tests of electromagnetic compatibility (EMC).

In addition, completely irrespective of the specifications of the vehicle manufacturers and suppliers, the legislature stipulates that vehicles and the systems and components they contain go through a regulated type approval process, **Figure 1**. The aim of this is that only those vehicles can be involved in traffic, which, in terms of safety and environmental relevance, comply with the defined, statutory minimum standards.

## 2 Electromagnetic Compatibility

Due to the growing number of electronic components on the one hand and their networking via bus systems in the motor vehicle on the other, in recent years EMC has gained substantially in relevance. What is fundamentally important here is that an electronic component

- must not be sensitive to influences acting from outside under all specified operating conditions
- must not influence other electrical systems
- must permit radio reception without interference during its operation – both in the car itself and in its environment.

As, by virtue of their function, vehicles are not operated in a stationary position, the environmental conditions for the components change constantly, a fact, which makes it difficult to guarantee EMC. If, in the past, relatively simple interference protection measures such as passive filters or shielding (if necessary even retro-fitted), were sufficient, today, due to the complexity of the overall systems, adequate EMC measures must be considered right from the component and wiring design stage.

Both the increasing number of different stationary radio devices (for example transmitting/receiving facilities for cellular radio) and the communications systems (for example car phone / mobile phone, dynamic navigation facilities, TV reception and Bluetooth notebook applications) increasingly being used in the car itself place a special challenge on developers.

### 2.1 Relevant Standards

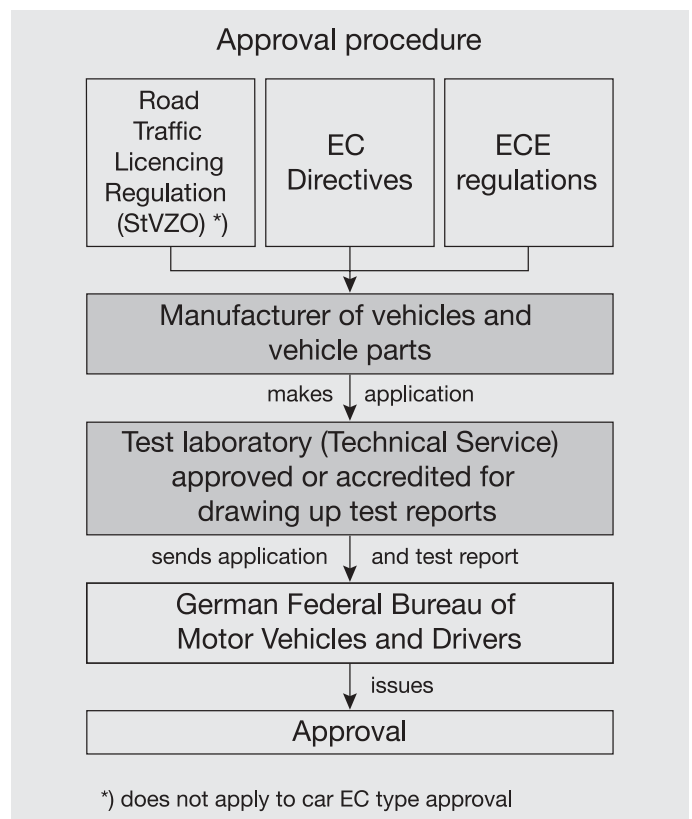
The EMC measurement methods specified for these are established in numerous national and international standards. In terms of radio interferences the following two standards are relevant:

- IEC/CISPR 12 (Limits and Methods of Measurement of Radio Interference Characteristics of Vehicles, Motor Boats and Spark-ignited Engine-driven Devices)
- IEC/CISPR 25 (Limits and Methods of Measurement of Radio Disturbance Characteristics for the Protection of Receivers Used On-board Vehicles)

The necessary interference immunity is described by the following ISO standards:

- ISO 7637 (Road Vehicles – Electrical Disturbance by Conducting and Coupling – Part 1 to 3)
- ISO 10605 (Road vehicles – Electrical Disturbance from Electrostatic Discharges)

**Figure 1:** Diagrammatic sequence of the approval process for motor vehicle components requiring approval (\* not relevant for car EC type approval)



## The authors



Dipl.-Ing. Hans Houben is Head of Development at Beru AG in Ludwigsburg.



Dipl.-Ing. (FH) Zlatan Saric is an employee in the EMC Technical Department, responsible for radio licenses of the TSS at Beru AG in Ludwigsburg.



Dipl.-Ing. (FH) Joachim Scheyhing heads the EMC Technical Department at Beru AG in Ludwigsburg.



Matthias Wöhr is Head of the Technical Services Department (EMC, engine testing, documentation) within the Development Division at Beru AG in Ludwigsburg.

- ISO 11451 (Road Vehicles – Electrical Disturbances by Narrow-band Radiated Electromagnetic Energy – Vehicles Test Methods – Part 1 to 4)
- ISO 11452 (Road Vehicles – Electrical Disturbances by Narrow-band Radiated Electromagnetic Energy – Component Test Methods – Part 1 to 7).

The requirements that must be met with regard to EMC are laid down in the so-called “Automotive EMC Directive”. In the Official Journal of the European Union this Automotive EMC Directive, currently still valid, can be found under the designation 72/245/EEC [1], adapted by 95/54/EC [2], under the Official Journal number L266 (<http://europa.eu.int/eur-lex/lex/de/index.htm>).

## 2.2 Special Problems Caused by Two Directives

For radio systems used in the car, however, yet more requirements apply, which are not covered by the above Automotive EMC Directive. Such systems also fall under the “Radio Equipment and Telecommunications Terminal Equipment and the Mutual Recognition of their Conformity” – known in short as the R&TTE Directive [4].

This European Directive was converted into German law by the national act FTEG (Radio Equipment and Telecommunications Terminal Equipment Act). The directive was published on 7 April 1999 in the Official Journal L 91/1999 of the European Community, giving it legal validity. The EEA and EFTA countries and the accession candidates are also applying it (<http://europa.eu.int/eur-lex/lex/de/index.htm>).

Since 8 April 2001 every radio device put into circulation within the EU has had to satisfy the requirements of the R&TTE Directive. Only if the product complies with all the requirements outlined in it, is it allowed to be given the CE mark and then sold and used in the European Economic Area.

As the Beru TSS tire pressure control system is built into motor vehicles, it clearly falls under the Automotive EMC Directive; due to its radio components. However, it is subject to the R&TTE Directive as well.

The Automotive EMC Directive in force to date, however, pays only scant regard or no regard at all to the special interests of a radio system. Thus, for example, no account is taken of the desired emission of a RF transmitter (radio frequency) and its spurious emission or the protection of the reception band during radiated immunity tests. In principle, therefore, all radio devices contravene the Automotive EMC Directive.

This is why special measures or individual agreements are necessary so that during



**Figure 2:** Components of the radio-based Beru tire pressure control system TSS; from left: trigger transmitter, control unit, wheel electronic device, digital antenna

the type approval procedure radio systems do not emerge with a negative result. This would be the case for example with a receiver, which logically cannot exhibit any disturbance resistance in its reception channel as defined by the standard. Already in the past, thanks to intensive collaboration with the Federal Motor Transport Authority (KBA), Beru AG has found a practicable procedure for overcoming the possible licensing hurdles in radio systems built into motor vehicles.

## 3 Features of the Tire-Pressure Control System

Beru AG’s TSS tire-pressure control system has the following features [5–7]:

- permanent monitoring of tire pressure
- early warning in the event of pressure loss and puncture
- avoidance of errors in inflating tires
- automatic individual wheel detection and locating of wheels.

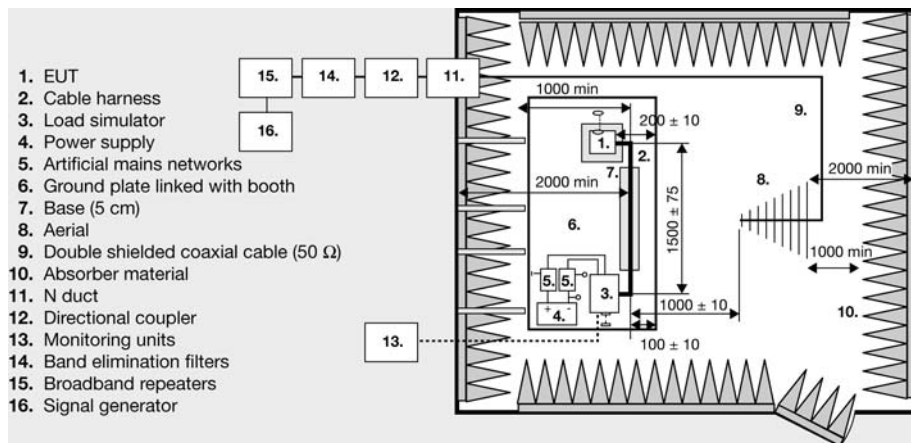
To perform these functions, the system has a battery-powered wheel electronic device that measures pressure and temperature at short intervals in the interior of the tires. Together with a unique identification code of

the wheel electronic device and details of the remaining life of the battery, these values are transmitted in so-called data telegrams by radio to an antenna with integrated RF receiver. The antenna converts the RF signals using microcontrollers into digital data and then forwards it via a LIN bus to a central control unit. The control unit then analyzes the data and decides whether the driver has to be informed of faults. **Figure 2** shows the components of the TSS.

## 4 Differences between the Directives Automotive EMC and R&TTE

Both the Automotive EMC Directive and the R&TTE Directive are so-called vertical directives. This means that, as separate directives, they establish the protection requirements of a special type of product so comprehensively that, in general, the use of other directives is unnecessary for corresponding products. The basic requirements of the R&TTE Directive here apply to the following points:

- the protection of the health of the user and other persons
  - the protection of the components with regard to electromagnetic compatibility.
- The R&TTE Directive is worded in accor-



**Figure 3:** Radiated immunity test in the absorber chamber; band elimination filters integrated into test domain; suppression of amplifier noise and guarantee of the signal-to-noise distance ratio

dance with the so-called New Approach. This means that it is structured in such a way that it regulates the general requirements but the technical details are described in harmonized standards. Taking the example TSS, the harmonized standards to be used are:

- ETSI EN 301 489-1 (general EMC requirements for radio equipment)
- ETSI EN 300 220-1 (radio equipment in the frequency range from 25 to 1000 MHz with transmitting powers of up to 500 mW)
- ETSI EN 300 330-1 (radio equipment in the frequency range from 9 kHz to 25 MHz)
- DIN EN 60950-1 (equipment of information technology security.)

Relevant extracts from the standards can be found on the Internet at the following link: <http://www.europa.eu.int/comm/enterprise/newapproach/standardization/harmstds/reflist/radiotte.html>.

#### 4.1 Radiated Immunity Tests of Electronic Sub-Assemblies

In radiated immunity tests, with the aid of broadband power amplifiers and their associated transmitting antennae an electrical field is produced to which the electronic sub-assemblies (EsA) are exposed. During the test the perfect operation of the EsA must be guaranteed. Broadband amplifiers inherent-

ly produce a broadband noise level and spurious emission, which can adversely affect the reception band of a receiver.

Nevertheless, in order to permit operation before the actual test, so-called band elimination filters are connected into the test path, see **Figure 3** and **Figure 4**. These ensure that the reception band of the receiver remains free of these disturbances.

In addition, in accordance with R&TTE-RL 1999/5/EC [4] a guard band is set up. Within this band there is no need to impact on the disturbance field, because adequate radiated immunity can only be achieved outside the respective reception band since, for physical reasons, receivers cannot exhibit any disturbance resistance in their respective reception band.

The EMC Center of Beru AG, equipped with appropriate band elimination filters, which are specially adapted to the product tire-pressure control system with its transmitter and receiving units and with the ability to set up the required guard bands, is thus in a position, even before the introduction of the type approval procedure, to carry out in-house tests in accordance with the demands of the Automotive EMC and R&TTE Directives. The following agreements have been reached for radio components:

- inspection level 30 V/m in accordance with Automotive EMC Directive 95/54/EC
- guard band  $\pm 21.69$  MHz at 433.92 MHz in

accordance with R&TTE Directive 1999/5/EC.

**Figure 5** shows the corresponding measurement diagrams.

#### 4.2 Radiated Emission Tests of Electronic Sub-Assemblies

In contrast to radiated immunity tests, in a radiated emission (RE) test using a measurement antenna at a defined distance from the EsA, the electromagnetic fields emanating from it are measured. The levels determined in the process are not allowed to exceed certain limit values. Often, the operating frequencies of transmitters (for example, the wheel electronics built into the tire) designed to produce radio signals – plus the spurious emission which always occur with them – are assessed using the EMC limit values of the Automotive EMC Directive.

In general the necessary levels for radio transmission are above the RE limit values of the Automotive EMV Directive. Up to now, by arrangement with the KBA, the R&TTE Directive has applied as an alternative. Similarly to the radiated immunity test, one or several frequency bands are omitted. This means that all frequencies that are used to transmit information not involving wires, but emitted via a transmitting antenna, are exempted from the RE tests (see Photo 6). These frequencies – and their spurious emission – are assessed with regard to their transmitting power and their effective use of the frequency spectrum exclusively in accordance with the R&TTE Directive.

#### 5 Implementation in the Beru EMC Center

The growing proportion of electronics in all product sectors of Beru AG means the company-own EMC Center is being permanently upgraded and continually innovated. This is because products from the manufacturing range, not directly associated with electronics (for example ignition coils), are now equipped with complex integrated electronics. You can therefore find ignition coils in the EMC Center again in the same way as PTC interior heaters or ISS diesel instant start systems. For the particular interests of these high current consumers, the transient test equipment of the EMC Center was specially designed for tests in accordance with the Standard DIN ISO 7637, in order to be able to carry peak currents of up to 200 A.

To be able to continue to satisfy equally the requirements of the vehicle manufacturers and the type approval authorities, the Beru EMC Center is very well equipped with appropriate test assemblies (see Photo 7 and



**Figure 4:** Radiated immunity test on a wheel electronic device

Photo 8), RF and microwave broadband amplifiers, measurement antennae, a separate shielded chamber for ESD (electrostatic discharge) investigations and many other items of test equipment.

With the high level of technical provision and expertise in respect of the various testing

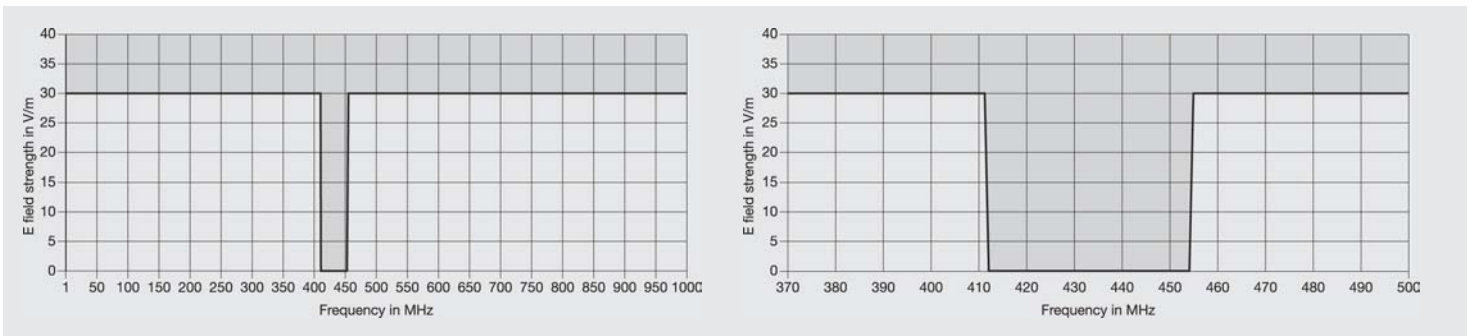
and licensing procedures existing in the EMC Center not only for Europe but also for the markets of the USA, Canada and Asia, extensive investigations can be carried out with a view to applying successfully for a license for radio systems such as the tire-pressure control system in the respective target countries.

**6 Summary**

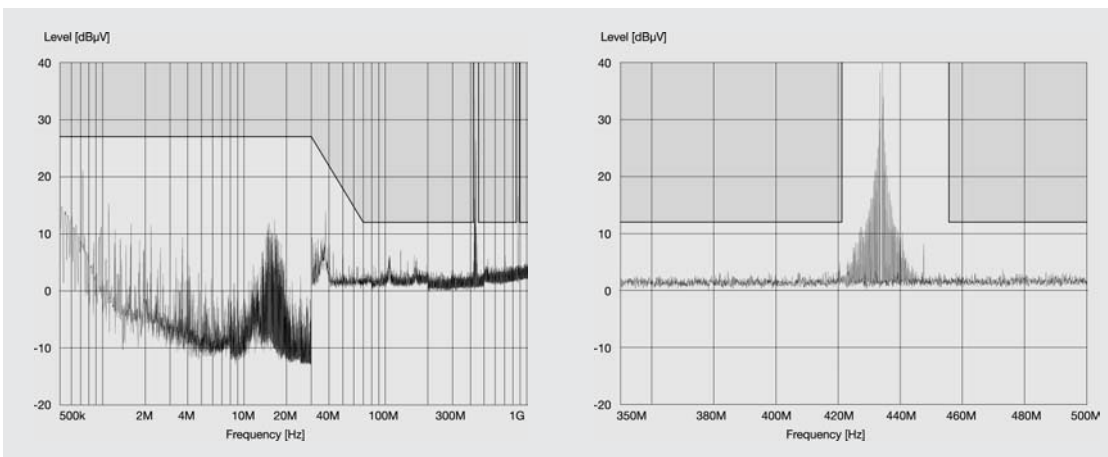
The uncertainties in dealing with radio systems installed in the motor vehicle with regard to Directive 95/54/EC (Automotive EMC Directive) can only be solved if, as a manufacturer of products concerned, you co-operate closely with the authorities right from the initial stages of development. Thanks to this co-operation, it proved possible in the described example “tire-pressure control system” to develop a procedure acceptable to all parties enabling definite decisions to be made where type approval procedures are concerned.

In the meantime a new directive has been issued. It makes the individual arrangements between manufacturer and Federal Motor Transport Authority (KBA) or other European licensing authorities, which have been necessary to date, largely superfluous and as a result gives component suppliers the necessary legal security.

This new “Commission Directive 2004/104/EC of 14 October 2004, for adapting Council Directive 72/245/EEC on the radio interference suppression (electromagnetic compatibility) of motor vehicles to technical progress and for amending Council Direc-



**Figure 5:** Inspection level 30 V/m as laid down in Directive 95/54/EC taking into account a guard band specified in Directive 1999/5/EC (left) and section of the relevant range (right)



**Figure 6:** Transmitter with center frequency of 433.92 MHz; the omitted frequency range for the transmitter is as laid down in R&TTE Directive 433.92 ± 21.69 MHz (left); section of the relevant range (right)

tive 70/156/EEC on aligning the legal provisions of the member states governing the operating license of motor vehicles and motor vehicle trailers” takes account of the rapid progress in radio and communications technology in recent years and is correspondingly adapted [3]. Among other things, the radio systems used in the car are now also taken into account.

The exemptions recorded in it very strongly reflect what Beru AG had already worked out jointly with the Federal Motor Transport Authority before the appearance of the new directive. This new Automotive EMC Directive can be found in the Official Journal of the European Union under Official Journal number L337 [3].

The current Directive 95/54/EC is only applicable until 1 January 2006. From this time though, type approval procedures may only be carried out and issued in accordance with the new Directive 2004/104/EC.

## References

- [1] Directive 72/245/EEC of 20 June 1972 for aligning the legal provisions of the member states governing the radio interference suppression of motor vehicle engines with spark ignition
- [2] Directive 95/54/EC of the Commission of 31 October 1995 for adapting Directive 72/245/EEC of 20 June 1972 on aligning the legal provisions of the member states governing the radio interference suppression of motor vehicle engines with spark ignition to technical progress and on amending Council Directive 70/156/EEC for aligning the legal provisions of the member states governing the operating license of motor vehicles and motor vehicle trailers. Link: <http://europa.eu.int/eur-lex/LexUriServ/LexUriServ.do?uri=celex:31995L0054:de:html>
- [3] Directive 2004/104/EC of 14 October 2004 for adapting Council Directive 72/245/EEC governing the radio interference suppression (electromagnetic compatibility) of motor vehicles to technical progress and for amending Council Directive 70/156/EEC on aligning the legal provisions of the member states governing the operating license of motor vehicles and motor vehicle trailers. Link: [http://www.europa.eu.int/eur-lex/lex/LexUriServ/site/de/oj/2004/l\\_337/l\\_33720041113de00130058.pdf](http://www.europa.eu.int/eur-lex/lex/LexUriServ/site/de/oj/2004/l_337/l_33720041113de00130058.pdf)
- [4] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on Radio Equipment and Telecommunications Terminal Equipment and the Mutual Recognition of their Conformity. Link: <http://www.newapproach.org/directives/directive-list.asp>
- [5] Normann, N.: Reifendruck-Kontrollsysteme für alle Fahrzeugklassen. In: ATZ 102 (2000), Nr. 11, p 157
- [6] Schneider, S.; Kienzle, T.: Das Reifendruck-Kontrollsystem TSS. In: System Partners, Sonderausgabe ATZ und MTZ, Mai 2003, p 10
- [7] Bochmann, H.; Kessler, R.; Schulze, G.: Stand und aktuelle Entwicklungen bei Reifendruck-Kontrollsystemen. In: ATZ 107 (2005), Nr. 2, p 110



Figure 7: Control stand in the Beru EMC Center



Figure 8: Testing area in the Beru EMC Center



BERU Aktiengesellschaft  
Mörkestrasse 155  
D-71636 Ludwigsburg  
Postfach 229  
D-71602 Ludwigsburg  
Phone: ++49/7141/132-693  
Fax: ++49/7141/132-220  
E-mail: [info@beru.de](mailto:info@beru.de)  
[www.beru.com](http://www.beru.com)