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THREE LEVELS OF THE ELECTROMAGNETIC COMPATIBILITY (EMC) IN AUTOMOTIVE ENGINEERING

An important quality factor for vehicles is the compliance of the Electromagnetic Compatibility (EMC). This compliance is given both through legal requirements and by voluntary defaults of the automotive manufacturers and suppliers.

In this paper, some selected EMC measuring methods will be presented, whereas two of these were recently developed at the EMC research laboratory at the University of Applied Sciences Zwickau in close cooperation with Volkswagen and Audi.

1. Introduction

With an increasing number of vehicles, interfering and disturbing systems as well as the increasing protection regulations against electromagnetic fields, the compliance of EMC get more and more important.

In a functional manner the EMC of vehicles can be divided into vehicle level, component level and semiconductor level. The present paper describes a series of test methods in these three levels (Figures 1 to 3). These methods and the appropriate measuring results will be presented in respect of the EMC main research at the Westsächsische Hochschule Zwickau (FH).

Fig. 1. Vehicle level

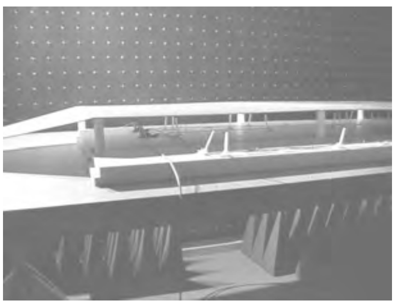


Fig. 2. Component level

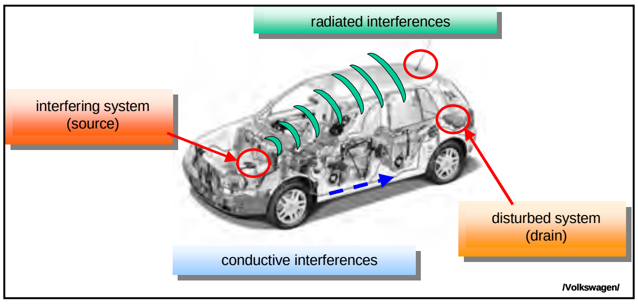
Fig. 3. Semiconductor level

2. Compliance of EMC at vehicle -, component - and semiconductor level

2.1. Vehicle EMC

While the outer EMC includes the interaction of vehicle and environment all kind of interferences inside the vehicle are part of the inner EMC.

Interference emission and interference immunity of vehicles are checked with extraordinary charges by the car producers to reach EMC compliance under worst case conditions.



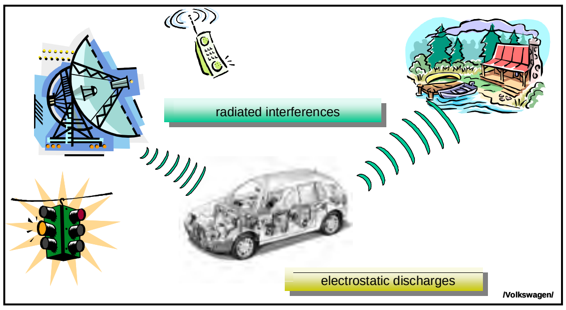


Fig. 4. Inner EMC

Fig. 5. Outer EMC

2.2. EMC at component level

At component level, a distinction is drawn between conducted and radiated interferences with the special case of ESD (electrostatic discharge). There are special measurement methods according to these different kinds of interferences.

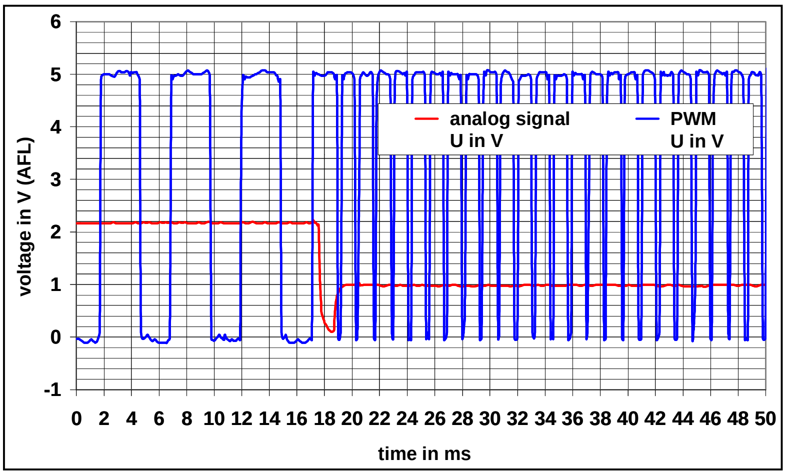
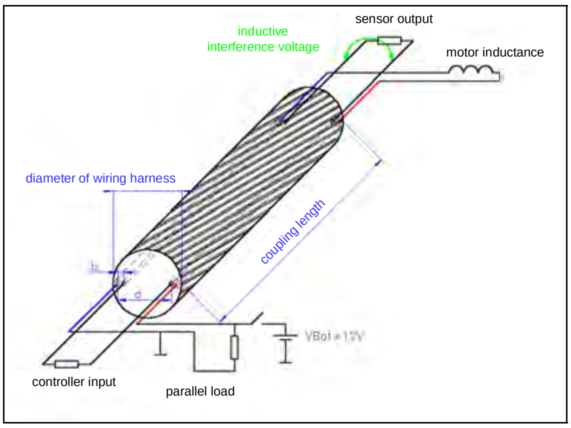


Fig. 6. Interference influence of a windscreen wiper motor



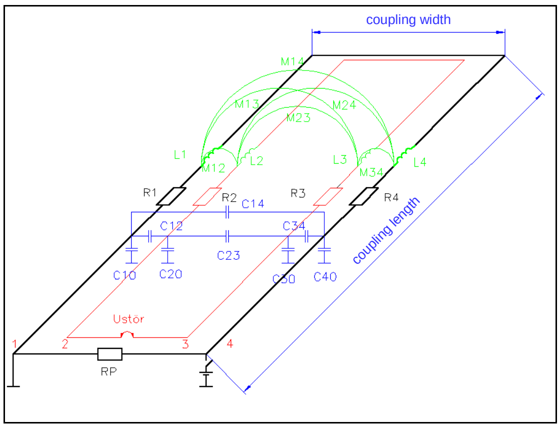


Fig. 7. Physical representation of the inductive coupling

Fig. 8. Equivalent circuit – a coupled electrical multiconductor system

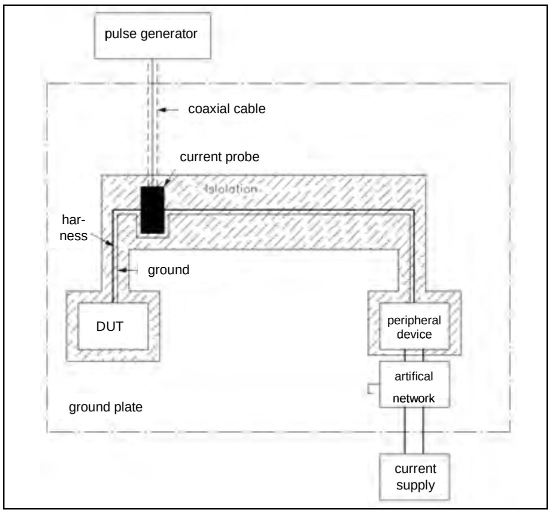


Fig. 9. Inductive coupling method Measurement set-up

Research results:

- introduction of a practicable laboratory measuring method for inductive interferences
- facility to reproduce the observed interferences in vehicles
- measuring method is a part of EMC company standards
- implementation of the measuring method into the international standardization (ISO) presently in progress

The increasing application of mobile telecommunications demands a test frequency range for radiated interferences up to 3 GHz, while standardized measuring methods only cover the range up to 1 GHz.

Field measurements play an important role in vehicles (Fig. 11–13). The high frequencies of the electromagnetic field lead to special „Interference Modes“.

digital radio service	frequency [MHz]	access method TDMA with repetition frequency [Hz] / time slot length [µs]	modulation method	$P_{transmit}$ of mobile sets [W]
TETRA	380- 440	17,6 / 14267	π/4DQPSK	10
TETRAPOL	80 / 450	FDMA/ 20	GMSK	10
GSM 900	876- 960	217 / 577	GMSK	2
GSM 1800	1710- 1880	217 / 577	GMSK	1
GSM 1900	1850- 1990	217 / 577	GMSK	1
UMTS	1900- 2170	10 / 625	GMSK	1
Bluetooth	2400- 2483	Frequency hopping: 1600/ 0,625-3,125	GFSK	0,1

Fig. 10. List of present and future vehicle relevant digital radio services

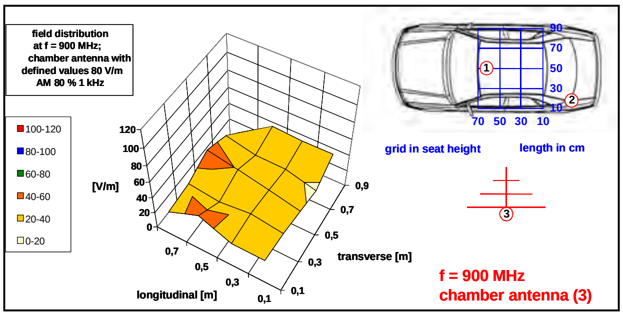


Fig. 11. Distribution of electric field strength chamber antenna

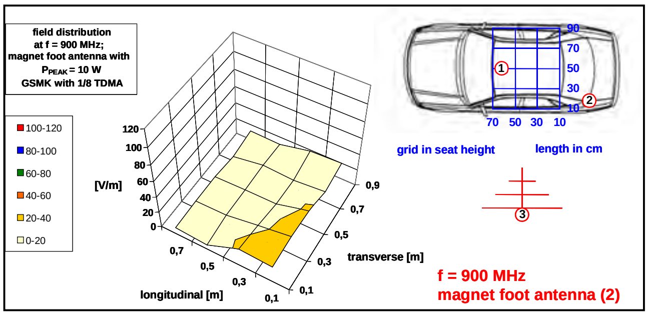


Fig. 12. Distribution of electric field strength magnet foot antenna

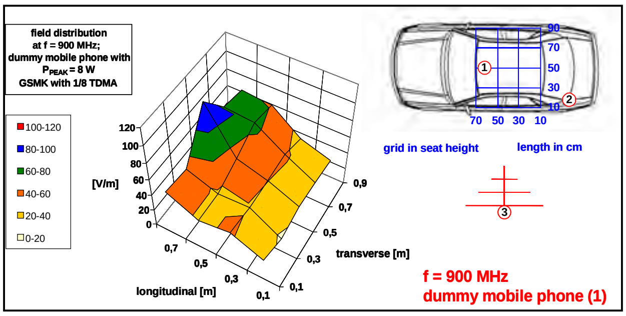


Fig. 13. Distribution of electric field strength dummy mobile phone

As a result of the electric field strength measurements, the engineers at the EMC laboratory at the Westsächsische Hochschule Zwickau (FH) developed an adequate measuring method for interference immunity for the frequency range from 1 to 3 GHz.

Compared with other methods as there are horn antenna, GTEM cell and dummy mobile phone, this new measuring method, the Tubular Wave Coupler, has some important preferences. These remains to a lower power consumption, a better wideband coupling function, a better reproducibility and a low insertion loss.

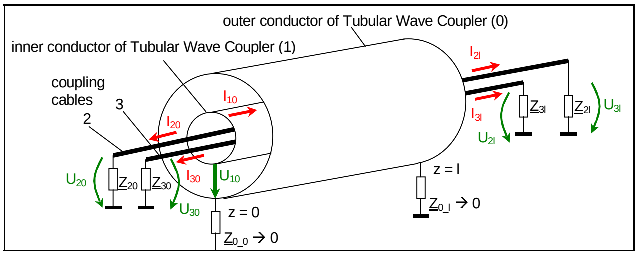


Fig. 14. Triaxial system: Tubular Wave Coupler with coupling cables

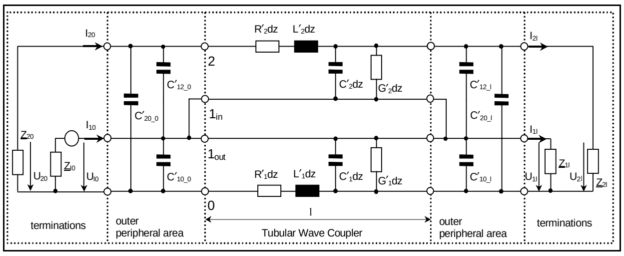


Fig. 15. Equivalent Circuit diagram of the Tubular Wave Coupler with a coupling cable

The wave coupler represents a short 50 • coaxial system with open ends. The injected RF-power excite an TEM wave inside the inner conductor with matched terminations. The wave coupler and the wiring harness represent a triaxial system with two coupling regions at the ends of the open wave coupler.

This system has a wideband coupling function from 200 MHz to 3 GHz. The measuring results show a very good comparability to the antenna test method (Fig. 17).

The Tubular Wave Coupler method both was developed to test the interference immunity of small shielded components with connected cables and the radiation of the DUT can be measured (Fig. 14–16).

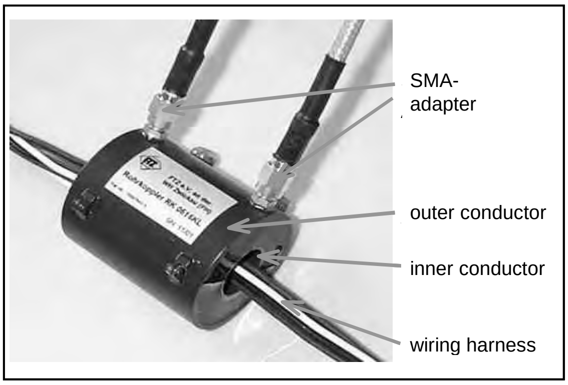


Fig. 16. Tubular Wave Coupler, new patented measuring method

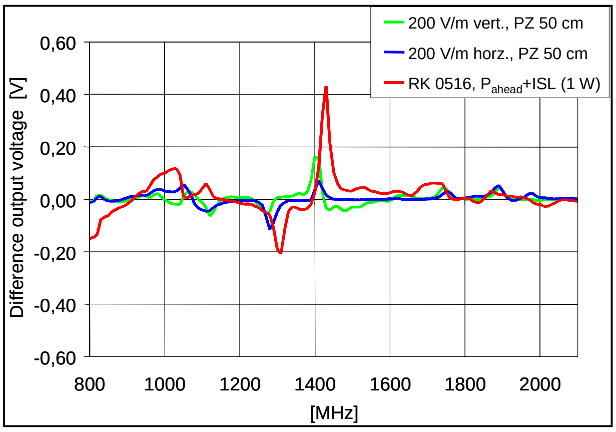


Fig. 17. Measuring results (Antenna / Tubular Wave Coupler)

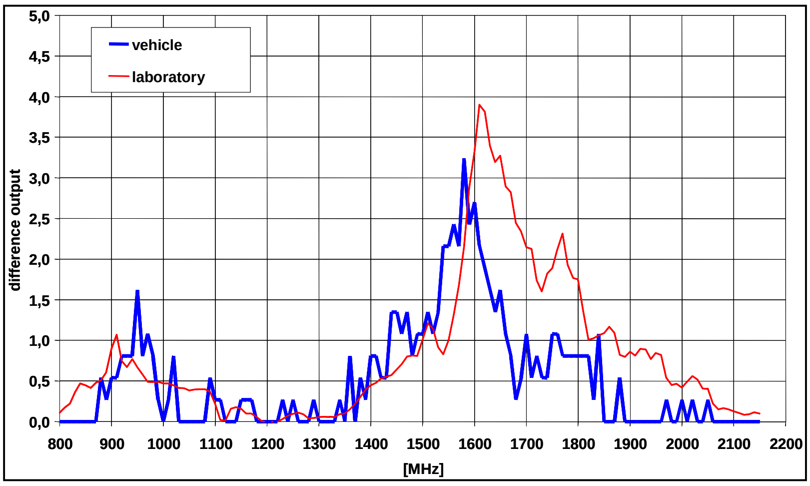


Fig. 18. Comparison of laboratory and vehicle tests

Comparison measurements between laboratory tests and measuring in a vehicle show a good correlation between these both tests.

The results of the comparison are shown in Figure 18.

Because of his special construction, the Tubular Wave Coupler can easily be used for electric / electronic components, which are already installed in vehicles (Figure 19).

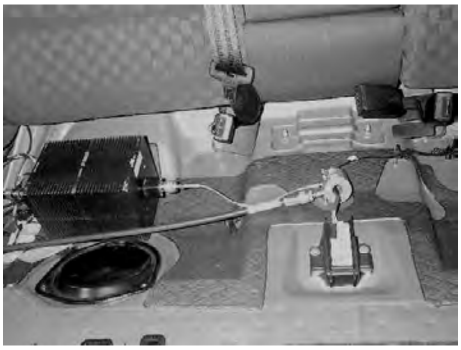


Fig. 19. Measurement of electronical components in a vehicle

Research results:

- development and patent of a practicable laboratory measuring method for interference coupling in the gigahertz range
- possibility to reconstruct observed interferences in vehicles
- realization of development accompanying measurements on electronical devices by order of research partners
- aim: implementation of this new measuring method into the company standards and international standardization

2.3 EMC at semiconductor level

The function of electrical / electronical components, and therefore of the whole vehicle, can also be influenced by the EMC-properties of semiconductors.

A special signification has the application of semiconductors as transceivers in vehicle data bus systems.

Automotive manufacturers and suppliers and manufacturers of semiconductors use a special program during the EMC-development of electronical components (Figure 19).

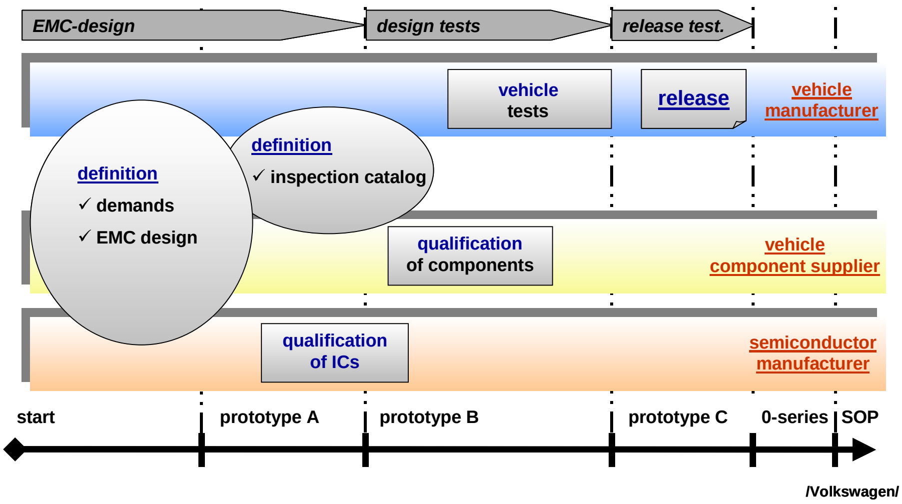


Fig. 20. EMC design process (Volkswagen)

There are several methods to simulate the indirect field coupling, via the connected wiring harness or PCB traces, or direct field coupling into the ICs. A preferred procedure for radio frequency coupling into semiconductors is the Direct Power Injection method - (DPI) [1].

By using this method the RF power is directly injected into the PINs of an active IC. The correct mode of operation of the DUT, i.e. an Transceiver, is checked within a specified tolerance of a window function.

This method guarantees a high degree of reproducibility and correlation of immunity measurements (Fig. 22–25).

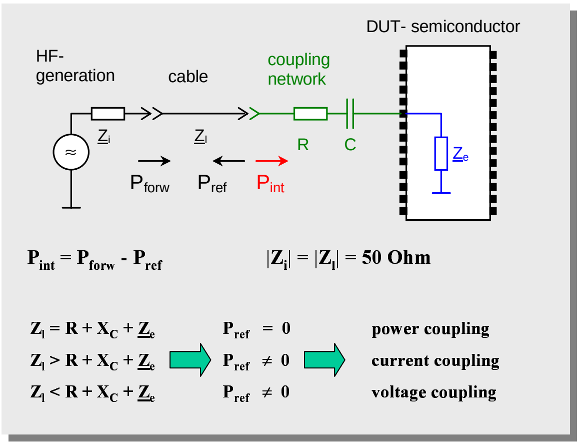


Fig. 21. Coupling into semiconductor

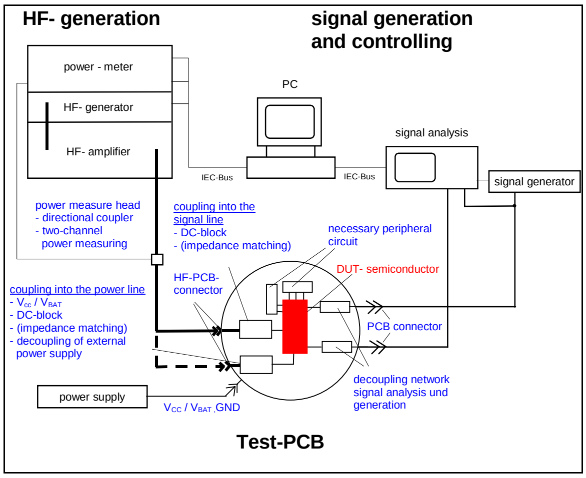


Fig. 22. diagram of set-up for DPI-measuring method

Fig. 23. Test set-up for DPI-measuring method

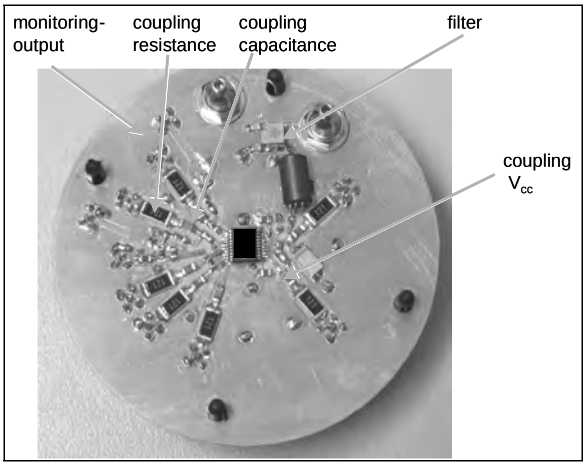


Fig. 24. example of a DPI test PCB

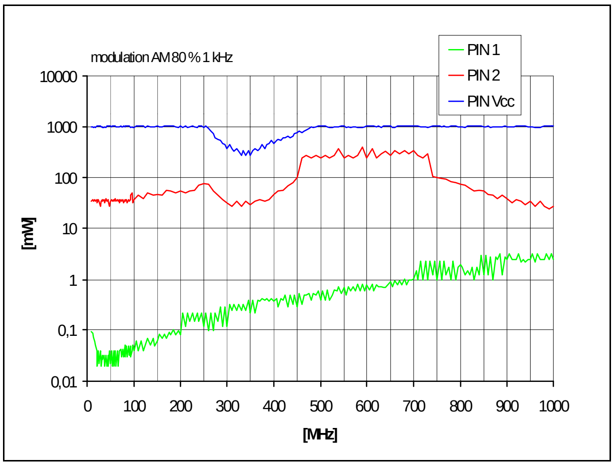


Fig. 25. Results of DPI-measurements

Conclusion

This paper has shown some important EMC test methods for the compliance of electromagnetic compatibility at vehicle level, component level and semiconductor level. These test methods were developed or proposed by the EMC research of the Westsächsische Hochschule Zwickau (FH) - University of Applied Sciences.

Especially the new measuring method of inductive coupling for conductive interferences and the Tubular Wave Coupler as a laboratory measuring method for interferences by mobile radio services should be accentuated.

The DPI measuring method, which is used for transceiver tests at data bus systems, was described specifically at the semiconductor level.

The results were reached in close cooperation with the automotive manufacturers Volkswagen and Audi as well as leading manufacturers of semiconductors.

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THE NEW DEVELOPMENTS IN ASSEMBLY TECHNOLOGY FOR THE SENSORS BASED ON SILICON STRUCTURES

Sensor manufacturing process uses various technologies and various materials, but the sensors based on silicon structure became a dominant group of these devices.

In the paper are given the last developments in assembly technique for silicon sensors. The results of our research concerning assembly technology for silicon humidity sensors and silicon gas sensors will be presented.

Applied assembly processes are based on flip chip technology which plays the most important role in sensor packaging technology.

1. Introduction

Over the last years a great progress has been made in sensors packaging technology. New silicon sensor designs have been appeared which created new challenges for sensors assembly processes.