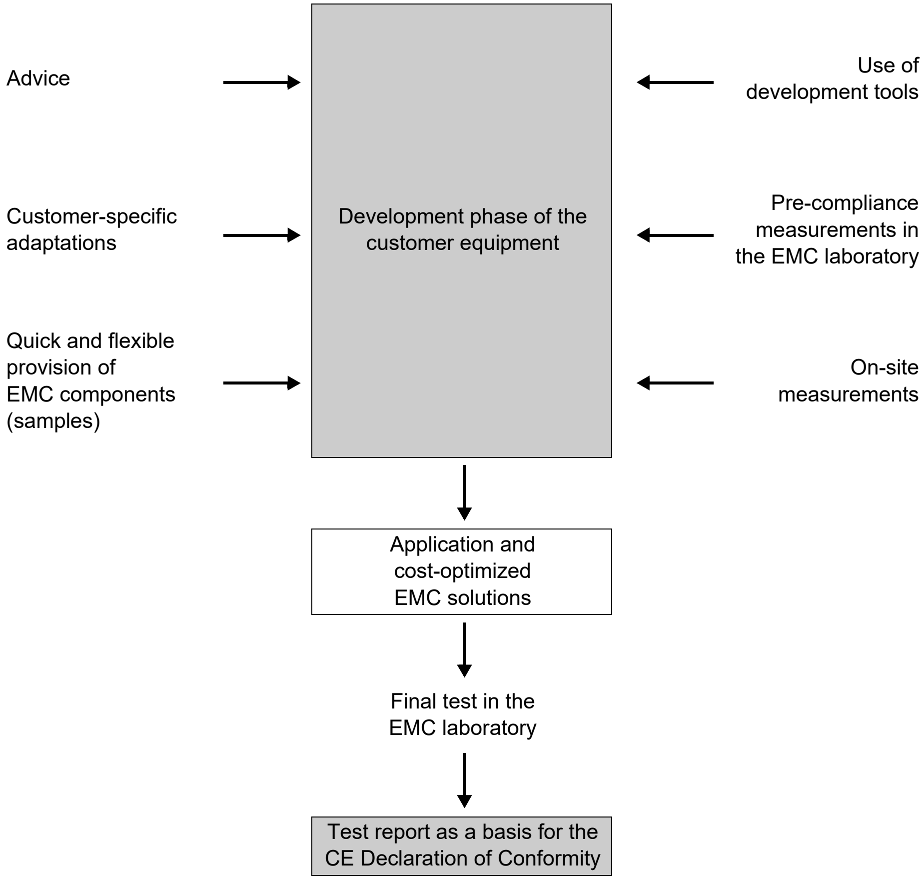
EMC filters

EMC services and EMC laboratory

Date: August 2022


Advice
Customer-specific adaptations
Quick and flexible provision of EMC components (samples)
Development phase of the customer equipment
Use of development tools
Pre-compliance measurements in the EMC laboratory
On-site measurements
Application and cost-optimized EMC solutions
Final test in the EMC laboratory
Test report as a basis for the CE Declaration of Conformity

1 Expert advice by EPCOS engineers

Experienced engineers with comprehensive know-how about numerous electrical and electronic equipment and installations and their specific EMC behaviour are available to offer their advice from the beginning of a project. Our specialists would be pleased to help you develop an individual cost-effective EMC solution, either by telephone or on site in the event of more complex problems.

2 Development-stage tests in the EMC laboratory

To support our customers with their EMC problems and for basic examinations in the application of EMC components, we run an extensively equipped EMC laboratory in Regensburg (see section 7 "EMC laboratory"). It is used to determine cost-effective EMC solutions for equipment, installations and machines so that the applicable limits are observed.

3 Customer-specific product adaptations

TDK offers a wide range of standard filters and chokes which cover most of our customers' application. In some cases, however, it may be necessary for technical or cost reasons to develop products tailor-made for the customer's requirements. In selecting suitable solutions, the customer may call upon an experienced team of engineers. The decision to go for a specific adaptation or a standard series must be taken on a case-by-case basis.

Figure 1 shows the relationship between relative price and number of items. At low item numbers, the use of standard filters and chokes is recommended in most cases. These are quickly available, have been tried and tested in many applications and are usually less expensive than specific solutions. At very high item numbers, a solution adapted precisely to the customer's requirements can be a better option, and can also be incorporated cost-effectively.

The inclusion of our EMC experts at an early stage can reduce total system costs thanks to the optimum matching of the frequency converter/filter system. In addition, development times can be shortened, so that the end product can reach the market more quickly and the customer gains a decisive competitive advantage.

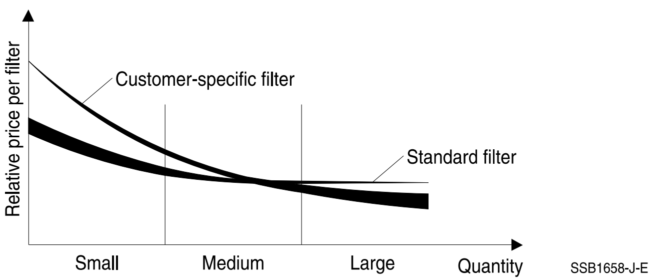


Figure 1 Relationship between relative price and number of items

4 Solving problems by on-site measurements

In addition to the facilities of the EMC laboratory, TDK also offers direct collaboration with equipment manufacturers. Our engineers have extensive expertise in the entire field of EMC as well as many years of experience in the application of EMC components. Thanks to the close cooperation between the equipment manufacturers and TDK, optimal and cost-effective results are quickly obtained.

- Helping in localizing interference sources
- Appropriate prototypes are provided for interference suppression tests, components and mechanical materials are available
- Fast creation of optimal, cost-effective solutions by experienced personnel
- Customer-specific components can be developed more quickly
- Recommendations for EMC measures such as shielding, grounding, EMC components, chokes and EMC filters
- Close cooperation between the customer and EMC engineers
- Shorter development times by task simulation

A large selection of transportable equipment is available to carry out the measurements and services listed above

directly at the customer's premises

if required.

5 Rapid provision of sample filters or chokes and standard components

Irrespective of whether you go for standard or customer-specific filters or chokes: TDK can always provide you quickly with the corresponding product.

Advice by TDK

Customer-specific product → **Development**

- Construction of electrical and mechanical prototypes
- Mechanical workshop
- Housing manufacture
- Heating, attenuation, shock and vibration tests on the premises
- Experienced personnel
- Components and materials in stock

→ Fast delivery of prototypes and pilot series

Standard product → **Products from stock**

- Stocks from the EMC laboratory Regensburg; fast “overnight” availability
- Distributors
- High availability
- Cost-effective

→ Standard filters and chokes available immediately from various sources

6 Simulation as a tool for filter selection and optimization

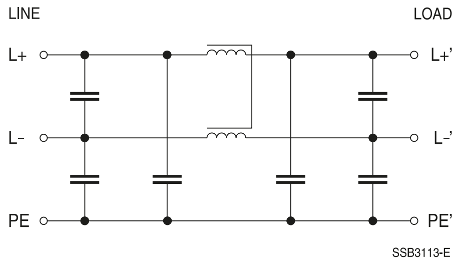
Simulations emulate real functions and properties with the aid of models calculated by means of appropriate software on a computer. This software may be a network simulator (SPICE[1]), a two or three dimensional finite-element simulator or a mathematical description in a computer algebra system.

1) SPICE = Simulation Program with Integrated Circuit Emphasis

6.1 Simulation applications

The following tasks are increasingly solved at TDK with the aid of simulation:

- **Virtual prototyping**[2]:
  - Results-oriented development
  - Fewer tests required
  - Faster development
  - Reduced costs
  - Optimization with respect to volume and weight
- **Modeling**:
  - Producing suitable models of components and filters
  - Support for our customers
  - Analysis of physical characteristics
  - Derivation of improvement approaches
- **Simulating filters in their operating environment**:
  - Analysis of filter topologies
  - Selection aid for new customer developments
  - Reducing the number of prototype filters
  - Support for system optimization
  - Securing quality and operating life
- **Analyzing and eliminating undesired side effects**:
  - Analyzing secondary effects before building prototypes
  - Fewer complex test configurations
  - Analysis of hard-to-handle exceptions
- **Tolerance and product quality analysis**:
  - Considering tolerances as early as the development stage
  - Cost optimization vis-à-vis the production process and customer
  - Satisfying APQP[3] requirements and monitoring quality



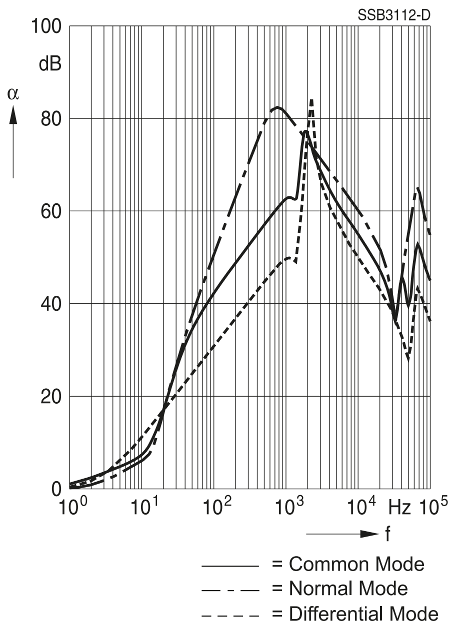


Figure 2

Filter model of an automotive HV filter, wiring diagram and attenuation curve[4]

2) A digital development process based on 3D and calculation models
3) APQP = Advanced Product Quality Planning
4) Source: "System simulations with EMI filter in an automotive high-volt environment", PCIM Europe, Nuremberg, 2017

6.2 Simulations tools

TDK uses a wide range of simulation methods for the product development stage in order to offer our customers optimum products with short development times.

Mathematical descriptions are used to calculate basic dimensioning parameters, to estimate the parasitic properties of the components to be developed and to analyze fundamental physical principles.

The finite element method (FEM4) is used to dimension inductive components and to optimise geometries with respect to various requirements. Simulations of electric or magnetic fields and mechanical or thermal simulations are used.

Various network simulators are used to estimate or simulate the electrical properties of complete filters and their behaviour in their operating environment in order to optimize the behaviour of the component or filter in the application. This can be done by TDK or by the customer using models of our filters.

Filter modeling is based on real simulations of the filter components by means of corresponding models of resistors, chokes or capacitors, which are in their turn based on physical models. This approach allows inferences to be made about the physical causes of various effects and behaviours with a view to developing optimisations. In the event of insufficient accuracy, parasitic effects are adapted and integrated by extending the simulation models to the measured reality.

Major time and cost expenditures are required to make the models available to our customers in the desired high quality. We can currently produce reliable models in the sector of small-signal analysis for chokes and filters. Simulations of the entire application in the time domain necessitate a knowledge of the relevant system parameters and the use of simplified models.

In order to further extend our expertise and experience in the sector of simulation and modeling, we are highly interested in working together not only with our customers but also with other partners.

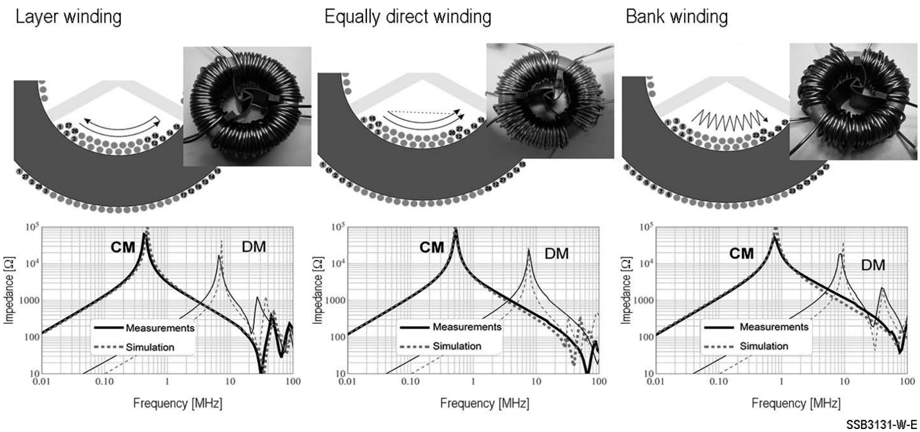


Figure 3 Simulation of parasitic properties for various winding types
CM = Common Mode
DM = Differential Mode

7 EMC laboratory

The EMC laboratory in Regensburg has been accredited as a test laboratory since October 1994, and is approved to the latest quality standard for laboratories, namely DIN EN ISO/IEC 17025. These standards ensure the consistent independence, unbiased character and integrity of the measurement and test results. The many years of experience in the entire field of EMC (Europe's first anechoic chamber 1963) and active collaboration in national and international EMC standardisation bodies represent an outstanding basis for meeting all customer requirements in this sector.

The distinction must be stressed here between the terms test laboratory and certification body. The EMC laboratory in Regensburg is an accredited test laboratory which tests products and issues test reports on the basis of which the manufacturers can issue their conformity declarations. Development-stage measurements with notes on product improvement, which can be performed with the same procedures and apparatus, can generally not be completed with a test report of an accredited laboratory. Development support and testing within the scope of the laboratory accreditation are processed separately at TDK.

A certification of products is not provided according to the EMC legislation.

Figure 4 Accreditation certificate for the EMC laboratory Regensburg

7.1 Facilities

An anechoic chamber for 10 m test section with a turntable of 4.8 m diameter (can take up to 4 t) as well as five test stations for conducted interference in shielded cabinets.

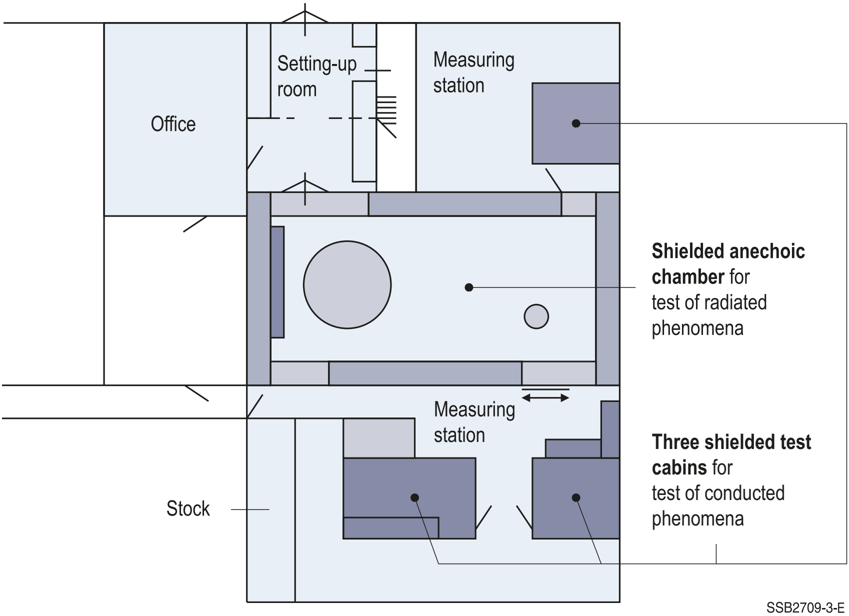


Figure 5 EMC Laboratory Regensburg, site plan

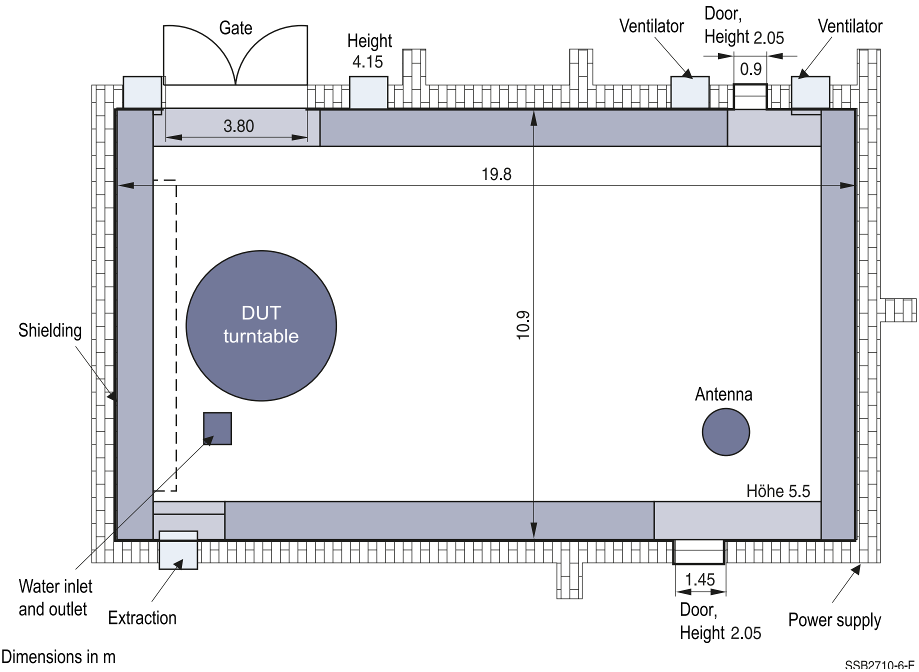


Figure 6 EMC Laboratory Regensburg, anechoic chamber (all dimensions in m)

7.2 Equipment

Measurement and test equipment for conducted electromagnetic interference:

Emissions		**Noise immunity**	
Test receivers	9 kHz to depending on the standard	Signal generators	9 kHz to 230 MHz
FFT test receivers for real-time analysis	to depending on the standard	Power amplifiers	Up to 400 W
LISN[1]	to 350 A, 690 V	Pulse generators	ESD EN 61000-4-2 Burst EN 61000-4-4 Surge EN 61000-4-5 Automotive ISO 7637-2, -3
Oscilloscopes			
Probes			
Current clamps		Coupling networks	
Harmonics test station	3 × 16 A	Capacitive coupling clamps	
Flicker test station	3 × 16 A	Inductive coupling clamps BCI clamps	
Network analysis			
Leakage current analysis	to 100 kHz		

1) LISN = Line impedance stabilization network

Measurement and test equipment for conducted electromagnetic interference:

Emissions		**Susceptibility**	
Test receivers	9 kHz to 26 GHz	Signal generators	9 kHz to 6 GHz
FFT test receivers for real-time analysis	to 7 GHz	Power amplifiers	to 400 W
Antennas	10 kHz to 18 GHz	Antennas	
Absorber clamps	30 MHz to 1 GHz	Directional couplers	
		Additional absorbers	

7.3 Test scope of the EMC Laboratory

The extensive apparatus of the laboratory enables testing to be performed according to various national and international EMC standards (see chapter "Technical information", section 19.3 "EMC standards").

The following list shows a selection of the tests offered by us. In addition to this, tests can also be performed according to other applicable EMC specifications. We would be more than happy to discuss your individual requirements for EMC testing with you.

Selection of tests conducted in the EMC laboratory

- Conducted interference, industrial and automotive
- Field strength measurements with 10 m measurement distance
- Field strength measurements according to CISPR 25 (Automotive)
- Immunity test to 20 V/m
- Coupling on lines: induced RF fields and BCI
- Harmonics of equipment to 16 A, analyses also for higher current consumption
- Flicker
- Test for voltage dips, short interruptions and voltage variations
- Pulses industrial/residential area: Burst, Surge, ESD
- Automotive pulse

8 Interference suppression of equipment

All equipment that contains electrical or electronic components is subject to EMC requirements on the basis of the EMC directive and national laws on electromagnetic compatibility of equipment. The EMC Directive stipulates the observance of protection requirements, which can be derived from harmonised standards.

Where no specific EMC product standard exists for an item of equipment, the respective product family standard applies: it describes the applicable limits as well as test configurations and procedures. Equipment which cannot be assigned to any product or product family standard is subject to the basic technical standards (see the "Standards overview" section in the document *Technical information*.

Equipment in the sense of the EMC Directive 2014/30/EU covers apparatus and fixed installations. The former are intended for use by end users according to this directive and can cause electromagnetic interference or be perturbed by it [Article 3, Section (1) 2.]. They include sub-assemblies, i.e. functional units intended to be incorporated by end users into equipment, as well as mobile installations consisting of a combination of equipment and possibly other installations designed for operation at various locations [Article 3, Section (2) 2.].

Fixed installations consist of several types of apparatus and, where applicable, other devices, which are connected together or installed and intended to be used permanently at a predefined location [Article 3, Section (1) 3.].