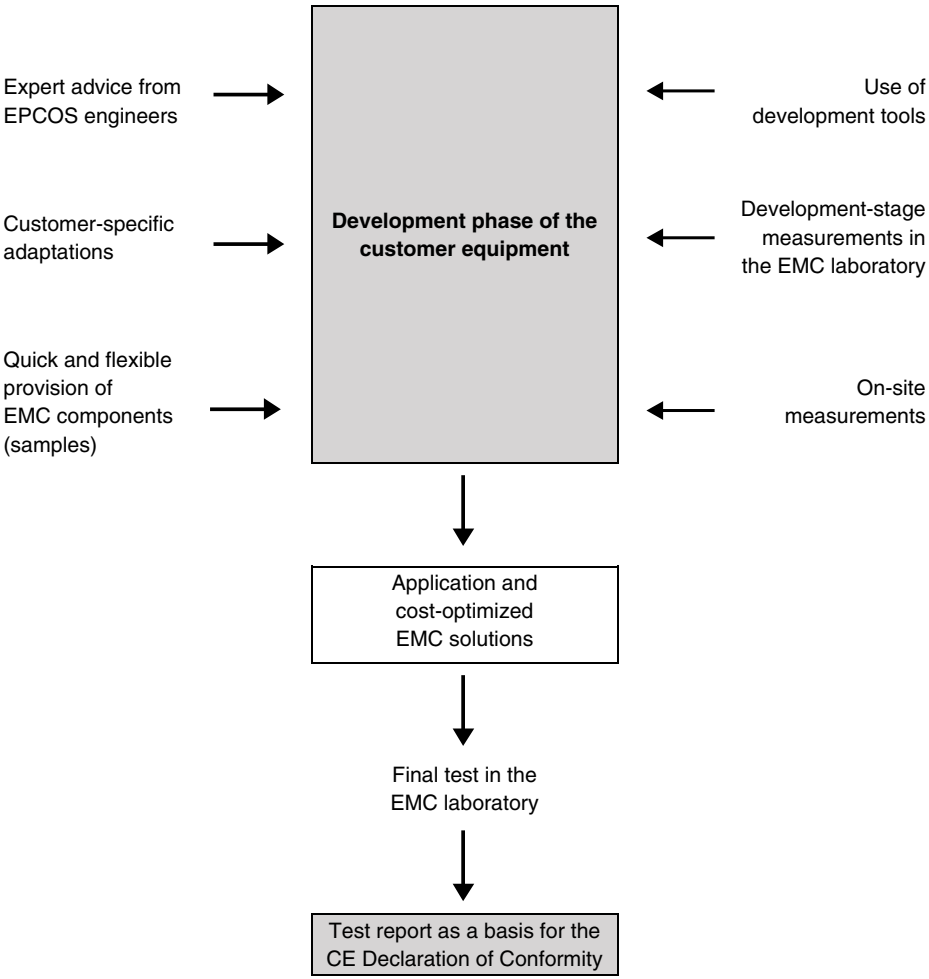

Expert advice from EPCOS engineers
Customer-specific adaptations
Quick and flexible provision of EMC components (samples)
Development phase of the customer equipment
Use of development tools
Development-stage measurements in the EMC laboratory
On-site measurements
Application and cost-optimized EMC solutions
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 behavior 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 filters and chokes

EPCOS offers a wide range of standard filters and chokes which cover most of our customers' applications. In some cases, however, it may be necessary for technical or cost reasons to develop products matched to 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 into the equipment.

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.

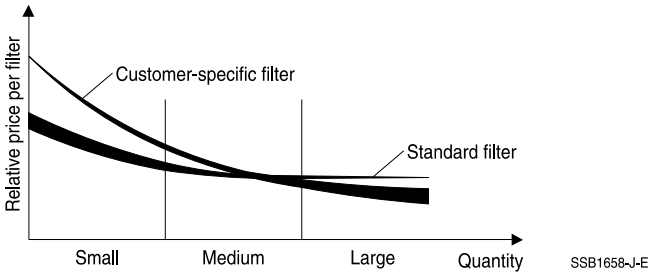


Figure 1 Relationship between relative price and number of items

4 Solving problems in on-site tests

In addition to the facilities of the EMC laboratory, EPCOS 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 EPCOS, optimal and cost-effective results are quickly obtained.

- **Helping in localizing interference sources**
- **Appropriate prototypes are provided for interference suppression tests, with a range of sample components**
- **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**

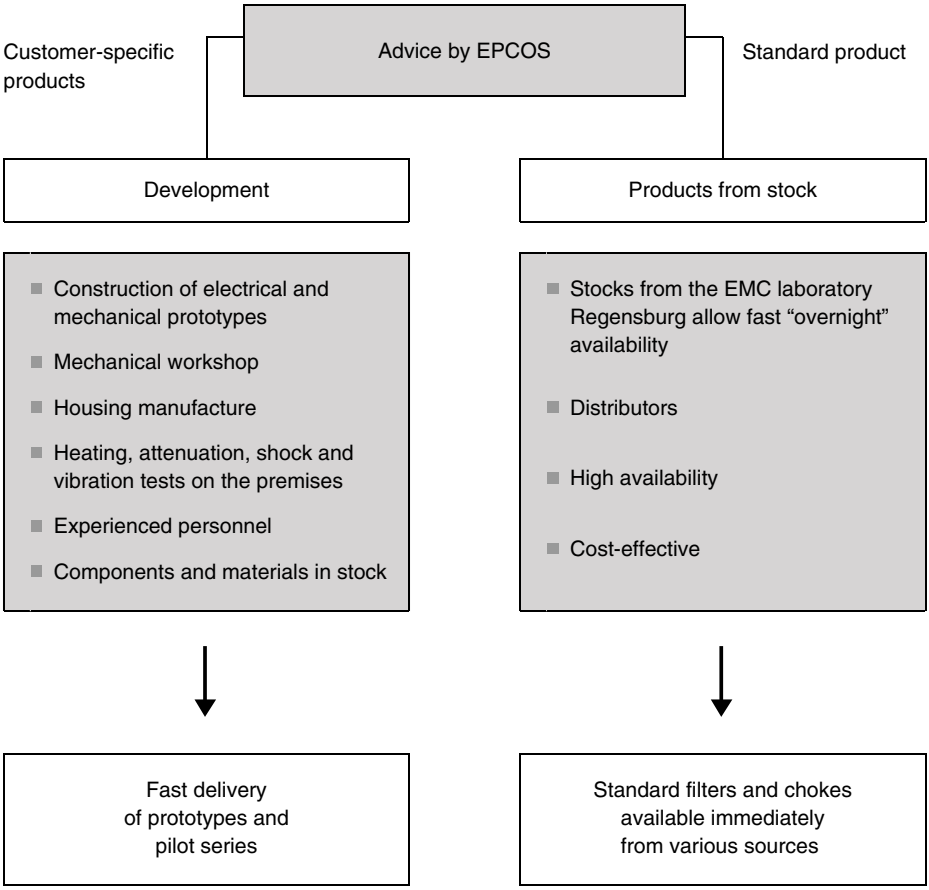
A large selection of transportable equipment is available to carry out the measurements and services listed above

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, EPCOS can always provide you quickly with the corresponding product.



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 may be a network simulator (SPICE[1]), a two or three-dimensional finite-element simulator or a mathematical description in a computer algebra system.

6.1 Simulation applications

The following tasks are increasingly solved at EPCOS 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

1) SPICE = Simulation Program with Integrated Circuit Emphasis
2) A digital development process based on 3D and calculation models
3) APQP = Advanced Product Quality Planning

6.2 Simulations at EPCOS AG

EPCOS 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 (FEM[4]) is used to dimension inductive components and to optimize 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 behavior in their operating environment in order to optimize the behavior of the component or filter in the application. This can be done at EPCOS or at the customer's premises with 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 behaviors with a view to developing optimizations. 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.

4) A numerical procedure for solving partial differential equations

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 absorber hall 1963) and active collaboration in national and international EMC standardization 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/Germany is an accredited test laboratory which tests products and issues test reports on the basis of which the manufacturers can issue their conformity declarations. These do not comprise development-accompanying measurements, although the latter are naturally also carried out. A cerification of products is not provided according to the EMC legislation.

7.1 Facilities

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

7.2 Equipment

Measurement and test equipment for conducted electromagnetic interference:

Emissions		**Noise immunity**	
Test receivers	9 kHz to 30 MHz	Signal generators	9 kHz to 230 MHz
FFT test receivers for real-time analysis	to 30 MHz (1 GHz)	Power amplifiers	25 W to 250 W
LISN[5)]	to 350 A, 690 V	Pulse generators	ESD EN 61000-4-2
Oscilloscopes			Burst EN 61000-4-4
Probes			Surge EN 61000-4-5
Current clamps		Coupling networks	
Harmonics test station	3 × 16 A	Capacitive coupling clamps	
Flicker test station	3 × 16 A	Inductive coupling clamps	
Network analysis			
Leakage current analysis	to 100 kHz		

5) LISN = Line impedance stabilization network

Measurement and test equipment for radiated electromagnetic interference:

Emissions		**Noise immunity**	
Test receivers	9 kHz to 26 GHz	Signal generators	9 kHz to 4 GHz
FFT test receivers for real-time analysis	to 1 GHz	Power amplifiers	25 W to 250 W
Aerials	10 kHz to 18 GHz	Aerials	
Absorber clamps	30 MHz to 1 GHz	Directional couplers	
		Additional absorbers	

The comprehensive range of equipment of the laboratory allows tests to be carried out on the basis of many applicable national and international EMC standards (see Chapter "General technical information", Section 1.8).

Figure 2 shows a selection of the tests that we offer. Tests on the basis of other relevant EMC specifications can naturally also be carried out. We would be happy to discuss your individual requirements at any time.

Selection of tests conducted in the EMC laboratory

- **Conducted interference, also under rated load**
- **Field strength measurements with 10 m measurement section**
- **Immunity test to 20 V/m**
- **Low-frequency system perturbations to 16 A**
- **Flicker test; tests for voltage dips, fluctuations and short-term interruptions**
- **Burst test**
- **Surge test**
- **ESD test**

Figure 2 Selection of tests in the EMC Laboratory Regensburg/Germany

In order to design the tests as simply as possible for our customers while still carrying them out under realistic conditions, many auxiliary installations are already in place on site. They include

- Loading stands for converter tests up to 90 kW
- Power supplies to 100 A (400 V)
- Various DC sources
- Waste gas extractor
- Transformers for measurements at various nominal voltages (to 690 V)
- Water connections for DUTs

The laboratory is located on the ground floor. Doors allow ground-level access for large-volume and very heavy equipment.

We place great value on maintaining a high quality standard, whether for development tests or final EMC tests. Regular calibration and internal checking of our test equipment is a matter of course, but we place equal value on the experience and training of our staff. The test documentation can be made available in either English or German.

All equipment and information entrusted to us by our customers are naturally treated with absolute discretion. We are happy to conclude a *non-disclosure agreement* with you at your request.

7.3 Accreditation document and site plans

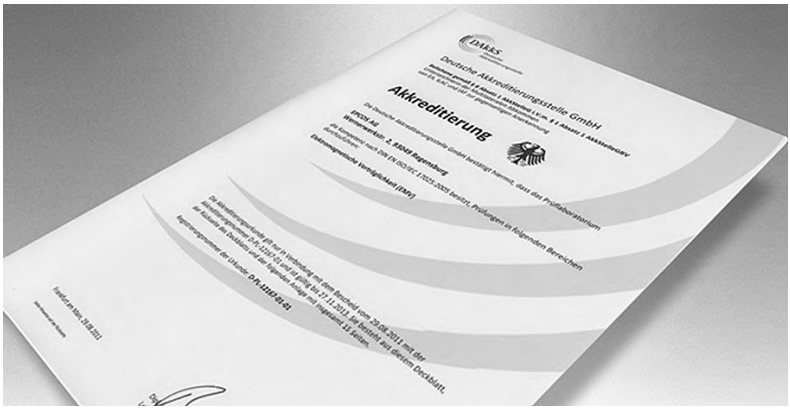


Figure 5 Accreditation document for the EMC laboratory Regensburg

EMC Laboratory, site plan

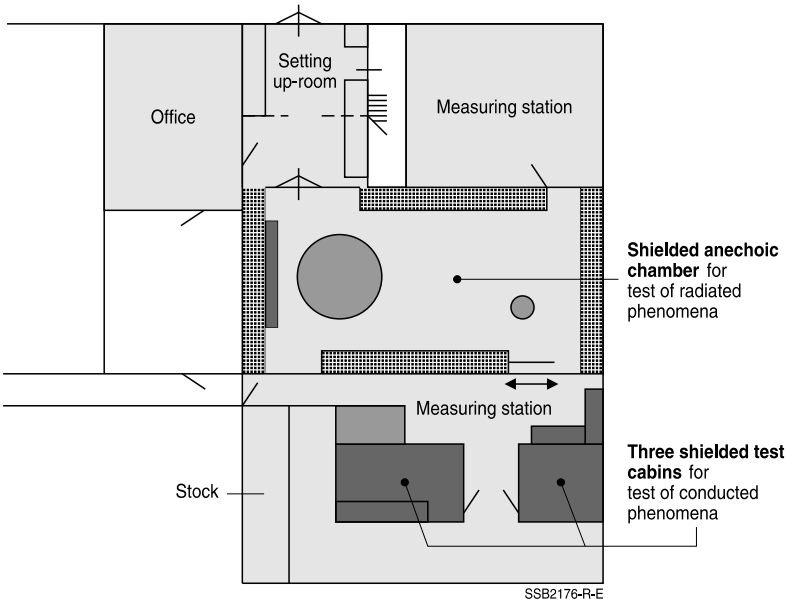


Figure 6 EMC Laboratory Regensburg, site plan

EMC Laboratory, anechoic chamber

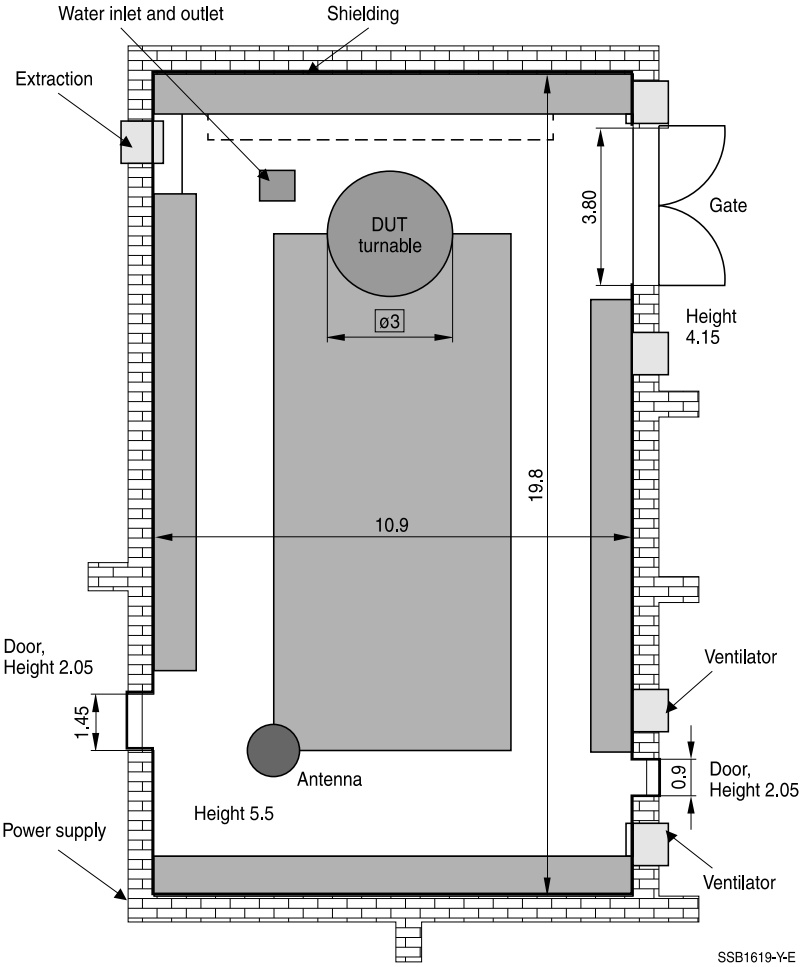


Figure 7 EMC Laboratory Regensburg, anechoic chamber (all dimensions in m)