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RESEARCH NEWS

04 | 2012 ||

1 Power without the cord

Cell phones and flashlights operate by battery without trouble. Yet because of the limited lifespan, battery power is not a feasible option for many applications in the fields of medicine or test engineering, such as implants or probes. Researchers have now developed a process that supplies these systems with power and without the power cord.

2 Shooting at ceramics

Producing thin ceramic components has until now been a laborious and expensive process, as parts often get distorted during manufacture and have to be discarded as waste. Researchers are now able to reshape the surfaces of malformed components by bombarding them with tiny pellets.

3 3D planning tool for the city of tomorrow

Noise levels, fine particulate matter, traffic volumes – these data are of interest to urban planners and residents alike. A three-dimensional presentation will soon make it easier to handle them: as the user virtually moves through his city, the corresponding data are displayed as green, yellow or red dots.

4 Detecting material defects in ship propellers

Ship propellers are as large as a single-family home – and manufacturing them is quite a challenge. During the casting process, pores and miniscule cracks can form that in the worst case may cause a blade to break. Now these massive components can be inspected for defects in a non-invasive manner, using a new kind of ultrasound process.

5 Comprehensive security of built structures

How safe are buildings and tunnels in the event of fire, or if there's an explosion or a plane crash? Are escape routes still accessible? Can people be rescued? Fraunhofer-Researchers and the Schüßler-Plan Group, an engineering consultancy, are together developing new concepts for the design and construction of bridges, tunnels and buildings.

6 Listening to the radio even with an electric drive

To enable radio reception in electric vehicles, manufacturers must install filters and insulate cables, since electrical signals will otherwise interfere with music and speech transmissions. Now, using new calculation methods, researchers are paving the way for pure listening pleasure while also helping to lower the associated costs.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 20,000, who work with an annual research budget totaling 1,8 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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1 Power without the cord

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For more than 50 years, pacemakers have set the rhythm for many hearts. The engineering of microelectronic implants has since advanced by leaps and bounds: they have become ever-smaller and more technologically sophisticated. The trend is moving toward miniaturized, intelligent systems that will take over therapeutic and diagnostic functions. For example, in the future implantable sensors will measure glucose levels, blood pressure or the oxygen saturation of tumorous tissue, transmitting patient data via telemetry. Meanwhile, medication dosing systems and infusion pumps will be able to deliver a targeted release of pharmaceutical substances in the body, alleviating side effects in the process.

Technology that can be worn on a belt

All these solutions are composed of probes, actuators, signal processing units and electronic controls – and therein lies the problem, too: they must have a power supply. Batteries are usually ruled out because of their limited durability – after all, implants stay inside the body for years. Currently, radio wave-based (HF) and inductive systems are most commonly in use. However, these exhibit differences in efficiency based on location, position and movement and are also often limited in range. Soon, a new power transfer system should circumvent the limitations of previous methods. Researchers at the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Hermsdorf succeeded in wirelessly transmitting power from a portable transmitter module to a mobile generator module – the receiver. "The cylindrical shaped transfer module is so small and compact that it can be attached to a belt," says Dr. Holger Lausch, scientist at IKTS. The transmitter provides an electric current of over 100 milliwatts and has a range of about 50 centimeters. As a result, the receiver can be placed almost anywhere in the body. "With our portable device, we can remotely supply power to implants, medication dosing systems and other medical applications without touching them – such as ingestible endoscopic capsules that migrate through the gastrointestinal tract and transmit images of the body's inside to the outside," says Lausch. The generator module can be traced any time – regardless of power transfer – with respect to its position and location. So if the generator is located inside a video endoscopy capsule, the images produced can be assigned to specific intestinal regions. If it is placed inside a dosing capsule, then the active ingredient in the medication can be released in a targeted manner.

Energy can pass through all non-magnetic materials

How does this new, already patented system work? In the transfer module, a rotating magnet driven by an EC motor generates a magnetic rotary field. A magnetic pellet in the receiver connects to the alternating exterior magnetic field and as a result, is set in rotation itself. The rotational movement is transformed into electricity, thus the power is produced right in the generator module. "With magnetic coupling, power can be transported through all non-magnetic materials, such as biological tissue, bones, organs, water, plastic or even a variety of metals. Moreover, the magnetic field produced has no harmful side effects on humans. It doesn't even heat up tissue," says Lausch, highlighting the advantages of the system.

Because the modules available as prototypes are scalable in terms of range, size and performance capacity, they can be used for more than medical technology applications. They can also supply power wirelessly to hermetically sealed sensors – such as those inside walls or bridges. This makes them suitable for use in mechanical engineering and plant construction and in the construction industry. Other conceivable applications include the charging of power storage units and activation of electronic components.

Using a hip implant as a demonstration tool, Lausch and his team will demonstrate how their wireless power transmission system functions at the Hannover Messe from April 23–27 (Hall 13, Booth C10). As used here, the technology electrically stimulates the ball-and-socket joint to stimulate the growth of cartilage and bone cells.

With the aid of magnetic coupling, power can be transmitted wirelessly from a transmitter to a receiver module. The prototype with the transmitter can be attached to the belt. (© Fraunhofer IKTS) | Picture in color and printing quality: www.fraunhofer.de/press

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2 Shooting at ceramics

In corrosive, high-temperature environments, metals quickly lose their elasticity. Beyond certain temperatures the material fails and its properties are compromised; metallic springs stop working if heated above 500 degrees Celsius, for example. But what to do if these are exactly the conditions a production process requires? One way of avoiding the problem has been to make components out of ceramic, a material that is lightweight, rigid, corrosion-resistant and able to withstand high temperatures. Yet this only offers a partial solution, as producing thin ceramics for parts such as leaf springs, lightweight mirrors for optical and extraterrestrial use, or membranes for sensors and fuel cells is both time-consuming and expensive. This is because ceramics can only be machined using costly diamond tools, and the process itself creates tensions within the surface of the material which cause the finished part to distort as soon as it is removed from the machine. Reshaping the components after manufacture has never been a viable option before as the material is too brittle, and so the large amounts of waste that are generated push the costs up.

Precisely calculated paths guide the way

Researchers at the Fraunhofer Institutes for Mechanics of Materials IWM in Freiburg and for Production Systems and Design Technology IPK in Berlin have now found a way to straighten out distorted ceramics using shot peening, a process by which small pellets, known as shot, are fired at the surface of a component with a blasting gun. The shot strikes the surface and alters the shape of the thin, outermost layer of material. By moving the gun over the ceramic part along a precisely calculated path, scientists are able to counteract any undesired warping or create lightly curved mirrors out of thin, even ceramic plates. "Shot peening is common practice for working metals," says Dr. Wulf Pfeiffer, who manages this business unit at the IWM, "but the technique has never been used on ceramics because they are so brittle – they could shatter, like a china plate being hit with a hammer. This meant that we had to adapt the method to the material with great precision." The researchers began by analyzing which size of shot would be suitable for use on ceramics, as the surface could be destroyed by pellets that were too big. Pellet speed is another critical factor: hitting the material too fast causes damage; too slow and the shape of the surface is not altered enough. They also discovered that it is important not to bombard the same spot too often with too much shot. Before producing a new component, the scientists first conduct experimental analysis to determine what can be expected of the particular ceramic involved. They fire a beam of shot at it and then measure the resultant stresses to see what sort of deformation is possible and how the beam should be directed.

The experts have already produced various prototypes, including a ceramic leaf spring and a concave mirror. For manufacturing simple components, the technique is now advanced enough to be used in series production. The IWM scientists have recently gone one step further and are developing a computer simulation that will allow components to be worked in multiple axes. Meanwhile their colleagues at the IPK are working on automating the process using a robot.

Shot is fired from a blasting gun at a ceramic leaf spring to correct its shape or cause specific warping as desired. (© Fraunhofer IWM, Felicitas Gemetz) | Picture in color and printing quality: www.fraunhofer.de/press

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3 3D planning tool for the city of tomorrow

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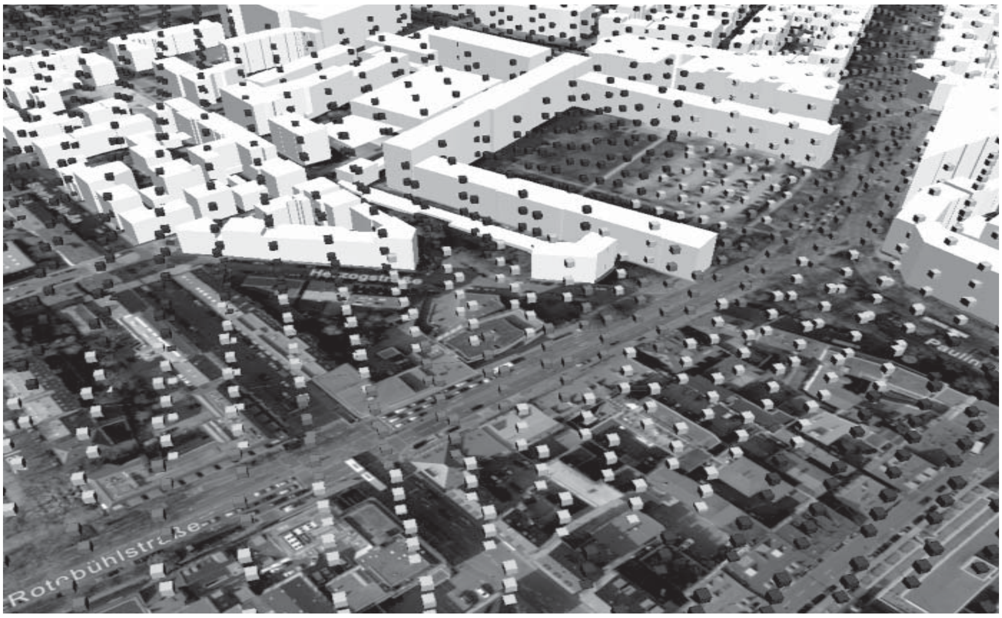
Fine dust, aircraft noise and the buzz of highways have a negative impact on a city's inhabitants. Urban planners have to take a lot of information into consideration when planning new highways or airport construction. What is the best way to execute a building project? To what extent can the ears – and nerves – of local residents be protected from noise? Previously, experts used simulation models to determine these data. The latest EU directives provide the basis for this. They obtain the data as 2D survey maps; however, these are often difficult to interpret, since the spatial information is missing.

That will get easier in the future: urban planners will be able to virtually move, with computer assistance, through a three-dimensional view of the city. In other words, they will "take a walk" through the streets. No 3D glasses required, though they would be a good idea for the perfect 3D impression. The corresponding values from the simulation "float" at the associated locations on the 3D map – where noise data might be displayed using red, yellow or green boxes. The distances between data points currently equal five meters, but this can be adjusted according to need. The user determines how the map is displayed – selecting a standpoint, zooming in to street level or selecting a bird's-eye perspective. This can provide quick help in locating problems such as regions with heavy noise pollution. The 3D map was developed by researchers at the Fraunhofer Institute for Industrial Engineering IAO and the Fraunhofer Institute for Building Physics IBP. "For the simulations, we used standard programs that are oriented around EU directives on noise-pollution control," says Roland Blach, department head at IAO. "The main challenge was to come up with a user-friendly way of displaying different simulation results."

Electric cars do not reduce noise levels

Another interesting consideration that the researchers were able to visualize with this tool: if electric vehicles alone were driven in the city, instead of cars with internal combustion engines, how would this change the volume level? What if both gas-driven and electric motor vehicles were on the roads? "Admittedly, you can barely hear electric cars when starting up. At about 30 kilometers per hour, however, you start to hear rolling noises that can get really loud at speeds of 50 kilometers per hour. Initial simulations found that the conventional simulation models stipulated by public agencies tend to average too sharply: we have yet to see any significant difference in the noise level in electric vehicles or gas-driven cars, since apparently it's the rolling noise that predominates," says Blach. Researchers are presenting these simulations, using Stuttgart as an example, at the Hannover Messe from April 23–27 (Hall 26, Booth C08).

The 3D map is only one of the tools developed by researchers in the "Virtual Cityscape" project. Another is parametric modeling. Here, a structure is designed such that any subsequent changes to dimensions can be made simply by entering the new measurements. If new buildings are to be planned, the scientists first analyze the logistical flows. How many people pass through which halls and corridors? What goods have to get through? “The program takes these usage parameters into account, and automatically incorporates them into the planning,” explains Blach. For example, if only standard windows are supposed to be used in a building, and the architect enlarges a space, then the program automatically places the windows at the appropriate distances or even inserts another one if space allows.



Red, blue and green cubes indicate noise pollution. (© Fraunhofer IAO) | Picture in color and printing quality: www.fraunhofer.de/press

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4 Detecting material defects in ship propellers

RESEARCH NEWS
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They can weigh up to 150 tons, and it's not uncommon for them to measure nine meters or more in diameter: the ship propellers on huge tankers, container ships and cruise liners are invisible giants. Damage to these massive propellers could render a ship unmaneuverable – with unpredictable consequences for people and the environment. Many defects do not come from external influences, but instead originate in the production or repair process. For example, when the molded parts are being cast, any turbulence could lead to sand inclusions and pores. Left undetected, critical imperfections could lead to breakage of a blade.

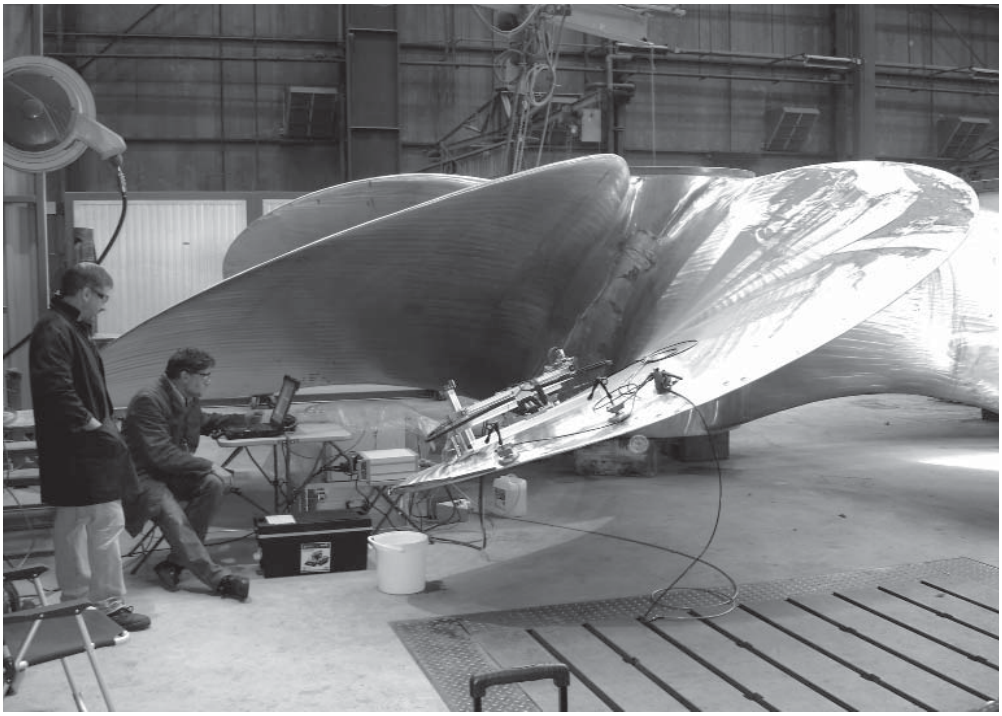
Until now, propellers have been inspected manually for inner defects when necessary. To make them visible, the inspector guides an ultrasound test probe over the component by hand – an error-prone procedure that fails to capture the entire volume of the component. This method cannot detect cracks inside the propeller in certain circumstances. To identify defects in a timely manner, researchers at the Fraunhofer Institute for Industrial Mathematics ITWM developed a mechanized ultrasound process that can be used for the non-destructive testing of complex components. The scientists received support from the GL Group (Germanischer Lloyd) and propeller manufacturer Wärtsilä Propulsion Netherlands.

Mobile scanner can be positioned freely

"With our mobile ultrasound test system, we can inspect copper-nickel-aluminum bronzes up to 450 millimeters thick and detect fissures down to a few millimeters in length. Because we emit the ultrasound at defined angles, we also find defects positioned at an angle to the surface," says Dr. Martin Spies of ITWM in Kaiserslautern. The system is capable of recording large volumes of digitized ultrasound test data, taking into account the many and variously intense curvatures of the propeller surface. The device currently scans test grids of 700 by 400 millimeters, achieving a rate of up to 100 millimeters per second. The mobile scanner can be positioned anywhere on the propeller, and, thanks to its suction feet, it can be attached in a horizontal as well as vertical test position. "We obtained the 3D data about the inside of the component by an imaging procedure known as SAFT. It provides a detailed display of inclusions and welding-seam defects. It basically works like computer tomography in medicine," explains Spies.

With the aid of special computational processes and algorithms, the experts have succeeded in reducing interference signals and intensifying error signals – a complicated task, since the various areas of the blade do not have a homogenously coarse grain. This can weaken the echo substantially. The specialists also use simulations to calculate in advance which ultrasound test probe they have to deploy.

The researchers use the mobile scan system for their on-site testing at foundries, at propeller manufacturers, on deck and in dry dock, and are currently improving scan times and 3D defect imaging. Only recently, they were able to put the efficiency of their procedure to the test at the world's largest shipbuilder in Korea. "The customer wanted to document the quality of its propellers, to gain an edge over the competition," says Spies. "With our procedure, we can test not only propellers but also other complex components made of materials that are difficult to test, like offshore components made of duplex steels," he stressed. ITWM researchers Alexander Dillhöfer, Hans Rieder and Dr. Martin Spies recently received the Innovation Award from the Deutsches Kupferinstitut for their outstanding accomplishments with copper and its alloys.



Suction feet are used to attach the mobile scanner to the propeller. Researchers record the ultrasound test data on-site. (© Fraunhofer ITWM) | Picture in color and printing quality: www.fraunhofer.de/press

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5 Comprehensive security of built structures

On October 24, 2001 a devastating fire broke out in the St. Gotthard Road Tunnel in Switzerland, costing eleven people their lives. The main traffic route through the Swiss Alps remained closed for more than two months following the disaster whilst extensive renovation works were carried out. Tunnels are not the only structures that can be destabilized by major incidents; buildings can be so damaged by explosives or fires that they collapse. How can multi-story buildings, bridges or nuclear power stations be made safe? Researchers at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institute, EMI are working alongside colleagues from the Schüßler-Plan Group, an engineering consultancy, to develop concepts for the comprehensive safety of buildings and structures. This means building contractors will in future be able to access the EMI researchers' expert knowledge at an early stage in the planning process. The guidelines are being realized by engineers from Schüßler-Plan as part of an interactive collaboration.

Risk analysis for building contractors

"Our collaboration supports building contractors from the initial planning stages right through to completion," says Dr. Alexander Stolz of the EMI in Freiburg. "We provide safety assurances during the planning phase by testing those loads that could potentially affect the structure, and we support contractors by furnishing them with a risk analysis report." Scientists at the institute benefit from having on-site facilities to investigate the effects an explosion has on built structures, either through trials involving real explosives or using their large shock tube, powerful enough to test storey-high test specimen. „We use the finite element method, which is a numerical technique, to check the validity of the trial, and can predict any event scenario we want. Schüßler-Plan then converts the results into engineering models. Building contractors can be certain that the dynamic and structural loads on buildings were calculated exactly. On top of this, we use the newest and most innovative protective and high-performance materials – materials that are both developed and qualified by us," he explains. The team also deals with retrofitting existing constructions such as airports, subway stations or underground parking lots. The experts do more than just help to make individual buildings safer, they also introduce safety-relevant aspects into urban planning. Simulation tools are used to calculate the incredibly complex way a pressure wave spreads through a built-up area. This enables different designs for urban structures to be judged on aspects concerning their relative safety – and improvements to be made accordingly – all whilst still in the planning stages.

Clear escape routes in the event of a plane crash

The collaboration between Schüßler-Plan und the EMI came about as part of the "Secure high-rise buildings" project. Markus Nöldgen, a former Schüßler-Plan employee and currently a professor at Cologne University of Applied Sciences, was prompted by the airplane attack on the World Trade Center in New York to consider the statics of high-rise buildings. The result was an ingenious framework construction built around an inner core of Ultra High Performance Concrete (UHPC), which ensures escape routes are kept clear and accessible in the event of an aircraft impact.

Dr. Ingo Müllers, head of department at Schüßler-Plan, welcomes the collaboration with colleagues from Fraunhofer. The engineering consultancy has more than 50 years of market experience. "We're delighted to now be able to offer our clients an additional service," he says. The purchase of a single contract buys the client the expertise of both scientists and engineers. In fact the cooperation extends so far that even the construction work itself is overseen by both partners. "We are a one-stop shop for customers, who only have to deal with a single contact – which is what the market demands – leaving all the necessary interactions to take place between experienced planners."

How safe are high-rise buildings in the event of a plane crash? Special methods allow the calculation of exactly what the dynamic and structural loads are on buildings. (© Fraunhofer EMI) | Picture in color and printing quality: www.fraunhofer.de/press

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6 Listening to the radio even with an electric drive

Listening to the radio is a favorite German pastime. Every day, more than 60 million people turn their radios on, especially while driving, and studies show that one in two of them are unwilling to give up enjoying radio programs behind the wheel. But in the vehicle of the future, the electric car, listening to the radio is in principle not possible, since electrical interference impedes the reception of radio waves. These disruptions are caused by the frequency converter, which changes electrical energy into mechanical energy so as to control the electric motor's speed and direction of rotation. These converters turn the current and the voltage on and off rapidly and frequently, and the way they chop electrical energy up in fractions of a second produces electromagnetic interference. If this becomes too loud, you can only hear the electric drive, not the car radio.

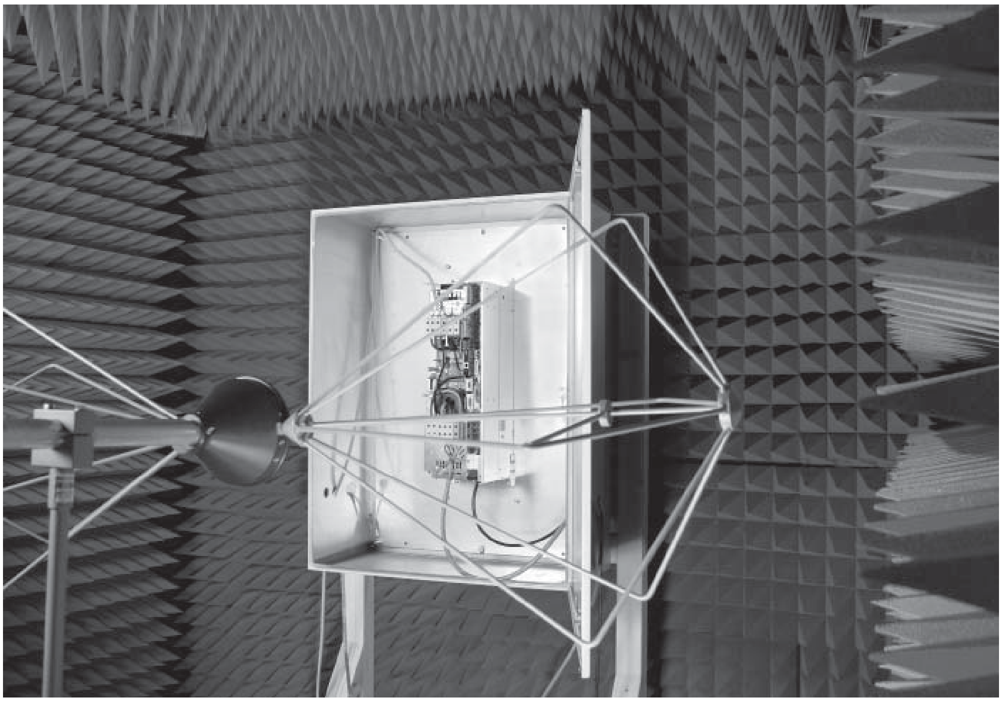
To get around this problem, not only must the engine's cabling be shielded, the motor itself must also be insulated – but this comes with a high price tag for automakers. Fortunately, researchers at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin have worked out how to significantly reduce these costs. Dr. Eckart Hoene, director of the Power Electronic Systems research group, and his team have developed a whole series of tools and methods for reducing interference. Using new simulations and calculation methods, the engineers can for instance now determine where in the vehicle components should be positioned to keep their electromagnetic interactions to a minimum.

Interference is affected by parts' position

"The size and position of individual components – including the electric motor, the battery, the air-conditioning compressor, the charging system, the DC/DC converter and the frequency converter itself – play a crucial role. How and in what direction cables are installed is just as important, as is the thickness of their insulation," explains Hoene. "With the help of simulations, we can also advise on the quality of the insulation and the plug connectors." The scientists have measurement techniques that allow them to pinpoint where exactly in the vehicle interference is coming from and to see how it spreads. What's more, they have developed a symmetrical power module which stops interference from being emitted. This is a component of the converter and already exists as a prototype.

All German automakers have benefited from the Fraunhofer experts' know-how. But as Hoene points out: "We advise not only German automotive manufacturers and suppliers, but increasingly Japanese and American companies, too." Tests and fault analyses can be carried out in the institute's own laboratory.

Electromagnetic interference is not just a problem in electric and hybrid drives. It can be a problem anywhere power electronics are installed: in avionics, or in wind and solar energy facilities, too. "Roofs with photovoltaic arrays will have a solar converter to change the direct current into alternating current, and this can impair radio reception inside of houses," Hoene adds. Thankfully, he and his colleagues can also provide expertise and advice in these situations to help keep interference to acceptable levels.



Measuring the electromagnetic compatibility of vehicle components in a laboratory chamber. (© Fraunhofer IZM) | Picture in color and printing quality: www.fraunhofer.de/press

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