# The very model of a modern transistor

21 May 2008

New models of how two types of power transistors perform will result in more efficient smart electrical circuits, making such technologies as cars and home appliances more reliable and environmentally friendly.

Power transistors are used to control large electrical loads and are at the heart of the modern smart circuits used in all kinds of equipment from motor steering units to stereo amplifiers. More efficient transistors would thus contribute to the move toward greener power supplies by using energy sources in a more economical manner.

A power transistor is a type of tiny semiconductor valve that works behind the scenes to ensure the correct electrical current flows to devices. Two important power transistors on the market are known as DMOS (double-diffused metal oxide semiconductor) and LIGBT (lateral-insulated gate bipolar transistor).

Due to the lack of accurate models of how DMOS and LIGBT behave under different conditions -- such as temperature, high voltage and fast switching -- semiconductor manufacturers have tended to over-compensate in their design. This over-dimensioning of the power circuit chips to ensue a margin of safety has resulted in a costly waste of the materials used to make them and the energy they consume.

**Better for the environment, reducing costs**

Now, European researchers working on the EU-funded Robuspic project say they have developed the necessary models for DMOS and LIGBT that will reduce such costs, and be better for the environment.

The team believes semiconductor and system manufacturers can use the models to design more efficient power transistors — and smart circuits— for the automotive, industrial and home appliance markets. The models will help manufacturers reduce their costs and could ultimately lead to the development of new applications, says Edgard Laes, coordinator of the Robuspic project team.

“Design and fabrication of highly reliable and efficient smart-power circuits is one of the most important strategic ways to reduce drastically energy losses in power systems by ensuring optimal energy conversion at all times,” says Laes. “This is in line with major European policies for use of clean energies, reducing pollution and generally building a friendly environment.”

The EU-funded project targeted DMOS and LIGBT as essential to the development of smart-power integrated circuits, which are being used more and more for reducing energy wastage in the consumer, industrial and automotive markets.

For example, modern mid-sized cars contain about 30 electric and electronic systems with up to 100 microprocessors and about 100 sensors. Such complex systems need a large number of semiconductors to connect the sensors and actuators with the microprocessors, often by using smart-power circuits.

The ‘smart’ in the circuit refers to its ability to adjust automatically the efficient switching of power from source to load as conditions change. In extreme cases, such devices are ready to stop the power in the case of a short circuit.

“Smart-power circuits and technologies contribute in a unique way to the realisation of the system-on-chip concept by combining digital logic with analogue signal processing and power and high-voltage switching,” Laes says.

The Robuspic team’s main objective was to model DMOS and LIGBT transistors accurately and enable the more efficient design of smart-power integrated circuits. To design the circuits, drive the electrical motors or make the power supplies, the manufacturer needs a model that accurately describes the behaviour of the DMOS or LIGBT throughout all variations of voltage, current, temperature and other factors.

**Better design efficiency**

While previous models of DMOS and LIGBT were valid at room temperature, these were not very useful at helping manufacturers predict how the transistors work when the temperature is raised – for example, near a car engine – or switching the load on and off very rapidly.

Now, the Robuspic models will allow manufacturers to better predict the tolerance of a transistor to a variety of temperature changes. So, they do not have to overcompensate in its design to ensure operational efficiency.

“This modelling allows the designer to make these motor drivers and power supplies very efficient and thus avoid waste of electrical energy,” says Laes. “An additional goal is to make these circuits very reliable with a long lifetime.”

The models also allow manufacturers to simulate how reliable the power transistors will be, helping to extend the working lifetime and reliability of smart-power circuits. As a result, European integrated circuit manufacturers will become more efficient and competitive, he suggests.

The technical benefits resulting from the Robuspic project will translate into an estimated cost savings for the participating manufacturers of a sum of around five times the EU funding of €2.6 million for the project, he says.

However, the biggest gain will be generated by additional business since the designed circuits are more competitive in cost, design time and reliability. The cost savings plus the added business add up to an estimated sum 18 times the EU funding over a four-year period. The project partners kicked in another €2.23 million in additional funds dedicated to the project.

**Results being implemented**

AMI Semiconductor, Germany-based Bosch, UK-based Cambridge Semiconductor and France-based Cadence Design System were involved in the project, along with a number of universities. Ecole Polytechnique Federale de Lausanne created the base for the DMOS model and the University of Cambridge formulated the LIGBT model in close co-operation with the industrial partners.

AMI supplies smart-power devices to automotive system companies around the world. Bosch is the largest automotive system company in the world. Cambridge Semiconductor is a small company fully dedicated to power switching and control. Cadence is a large EDA (electronic design automation) supplier.

Since the project finished last year, Bosch and AMI have started implementing the DMOS transistor model by testing it in manufacturing processes and will use it in the design of innovative automotive circuits. Cambridge Semiconductor has been working on designing power supply circuits using LIGBT.

“Moving up the actual application of such models requires a thorough industrialisation process,” says Laes. “It takes a lot of investment to switch over manufacturing processes, so we want to be sure to get it right.”

Robuspic received funding from the EU's Sixth Framework Programme for research.

Source: ICT Results