



Energy Efficiency

Driving Complete Solutions for the European Market

Our Number One Challenge

As a leader in embedded energy-efficient solutions, Freescale is enabling a new generation of electronics to help make the world a smarter and cleaner place. As global consumer demand for new electrical and electronic products increases, global energy demands also increase. Freescale is dedicated to designing solutions that improve the energy efficiency of products, from washing machines and set-top boxes to industrial robots, to help minimise their carbon footprint and reduce energy use.

Reducing energy consumption

Europe has embarked on an ambitious plan to cut its energy consumption by 20 percent by 2020 [1]. It is a bid to reduce its dependency on imported oil and gas and slash its energy bill by an estimated 100 billion euros per year, with total potential electricity saving in excess of 200 billion kilowatt hours (kWh) in 2015. This savings is equivalent to the output of 30 nuclear power plants [2]. If it delivers, the plan would also reduce the amount of CO₂ emitted into the atmosphere by 780 million tonnes per year, which is twice the amount the European Union (EU) agreed to under the Kyoto Protocol [3].

Due to the critical importance of this effort, Europe is planning to make several proposals in 2008 to further reduce its energy consumption.

To reach these aggressive energy efficiency goals, a primary focus is domestic appliances. Well-known programs targeted at energy use by appliances include ENERGY STAR® in the United States and the EU's new energy labeling and classification for appliances. For more than 10 years, Freescale has been working with the world leaders in the appliance market to develop more energy-efficient and environmentally friendly products. Our digital signal controllers (DSCs) are engineered to allow more efficient electric motor control and variable speed control in appliances, such as washing machine, refrigerator or air conditioning systems. Our pressure sensors help provide more accurate water level measurement, and our microcontrollers offer more sophisticated control algorithms—all contributing to energy savings.

Residential electricity consumption represents almost 30 percent of the overall electricity consumption in the EU 15, with almost 50 percent of that attributable to home appliances [4]. Approximately 7 percent of that energy consumption is due to unloaded standby equipment, such as TVs, DVD players/recorders and set-top boxes, that are permanently connected to a power source and consuming electricity, even when they're not in use. This issue is so important that the EU has implemented a Code of Conduct, and Germany has initiated The Blue Angel program that require equipment manufacturers to specify the maximum standby current consumption for such devices. Freescale is already helping develop innovative solutions, based on our microcontrollers (MCUs) and advanced power management products, to help meet these new requirements.

An additional area of focus is within the industrial market—65 percent of industrial electricity consumption comes from electrical motors [5]. Freescale has more than 12 years of motor control experience, and our global center of expertise in the Czech Republic is helping our customers optimise their applications for better energy efficiency.

New technologies are also being developed to optimise electricity distribution and consumption through connected, intelligent electricity meters. In the near future, meters will manage home electrical usage, and consumers may have real-time access to electricity consumption data via the Internet. For instance, a washing machine may be connected to an electricity meter using wireless connectivity, such as ZigBee® technology, or power line communication to automatically detect the best time to start a washing cycle. Similarly, the intelligent meter could lower the air conditioner's electricity consumption during peak hours.



Bruno Baylac
Director of Marketing
Consumer & Industrial

- [1] Presidency Conclusion of the Brussels European Council (8/9 March 2007)
- [2] "Electricity Consumption and Efficiency Trends in the Enlarged European Union," European Commission report (2006)
- [3] "Action Plan for Energy Efficiency: Realising the Potential," Commission of the European Communities (19 October 2006)
- [4] "Electricity Consumption and Efficiency Trends in the Enlarged European Union," European Commission report (2006)
- [5] "Energy Efficient Motor Driven Systems," European Copper Institute, Fraunhofer-ISI, KU Leuven and University of Coimbra (April 2004)

Target Applications for Energy Efficiency

Freescale is dedicated to expanding our technologies for energy efficiency, developing new techniques for next-generation products that are even more energy-efficient. We work closely with our customers to clearly define the performance and energy parameters they require. Through close cooperation, we can optimise our solutions to help make energy-efficient designs that are easy to develop, speed time to market and are more attractive to end consumers.

We deliver products designed to improve energy efficiency, while helping you meet your performance goals for applications such as:

Industrial motor control

- Enabled by our high-performance DSCs and ColdFire® and Power Architecture™ embedded controllers

Domestic large appliances

- Enabled by our high-performance DSCs, MCUs & Sensors

Building automation

- Enabled by our high performance ColdFire Ethernet embedded controllers, wireless ZigBee/802.15.4 compliant solutions, low-power MCUs and sensors

Digital power supplies

- Enabled by our high-performance DSCs, MCUs and sensors

Remote power management and metering

- Enabled by our high-performance Flexis™ series of HCS08 and ColdFire V1 MCUs and ZigBee compatible solutions

Audio and video consumer products

- Enabled by our SMARTMOS™ analog power management chip sets, i.MX processors and sensors

Factory automation

- Enabled by our ColdFire, Power Architecture and wireless IEEE(R) 802.15.4 compliant solutions

Automotive braking energy regeneration

Automotive hybrid engine control

Automotive alternator and starter technology

Petrol and diesel engine control.

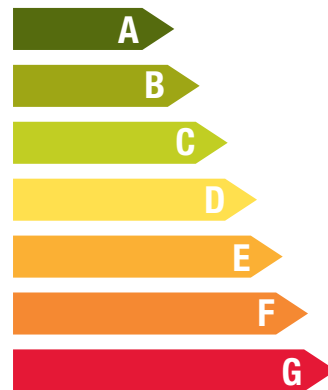
- All enabled by our high-performance microprocessors (MPUs) and MCUs built on Power Architecture technology

Energy

Manufacturer Model

Fridge-Freezer

More efficient



Less efficient

Energy consumption 2Wh/year
(Based on standard test results for 24h)

325

Actual consumption will depend on how the appliance is used and where it is located

Fresh food volume 1

190
126

Frozen food volume 1



Noise

(dB(A) re 1 pW)

Further information is contained in product brochures

Norm EN 153 May 1990
Refrigerator Label Directive 942/EC





Industrial **Motor Control** and Domestic Large **Appliances**

Take a quick look around and you will see you are surrounded by electric motors – air conditioners, computers, washing machines, power tools, blenders, ceiling fans, digital cameras ... and the list goes on. All of these products contain electric motors. Two of the key market segments, industrial motor control and domestic large appliances, can greatly benefit from efficient motor control solutions that help significantly reduce energy consumption.

Industrial motor control

Industrial electric energy statistics are overwhelming. In the EU, industry consumed 951 billion kWh of electricity in 2000 – 65 percent of that, or 614 billion kWh, for motor-driven systems. It is estimated that energy-efficient motor-driven systems can save Europe 200 billion kWh of electricity [1].

In real-world terms, 200 billion kWh of savings avoids construction of 45 gigawatts (GW) of power generating capacity. This equals 130 fossil fuel power units, at 350 megawatts (MW) each, or 30 nuclear power plants. The savings also reduces greenhouse gas emissions by 100 million tonnes per year [2].

Introducing advanced technology

Improving the energy efficiency of motor-driven systems can be achieved by replacing less efficient motors or by introducing advanced-technology variable speed drives. Existing, less efficient drives often use a universal motor or single-phase AC induction motor

with simple triac control. This can be quite inexpensive; however the low precision speed and torque control cannot facilitate today's advanced control algorithms that can help improve performance and energy efficiency. In addition, universal motors typically operate at a low 60-70 percent efficiency range, whereas brushless DC or 3-phase AC motors, with more advanced electronic control, can achieve an operating efficiency of 85-95 percent.

Introducing variable speed drives across the industrial segment can also achieve significant improvements in operating efficiencies and energy consumption. A conventional pumping system, for example, has an efficiency level of a mere 31 percent because considerable energy is wasted through the mechanical valve. Replacing the valve with a variable-speed drive can dramatically improve liquid flow control as pump speeds are adjusted. The operating efficiency of a pumping system with variable-speed drive can help you reach up to 72 percent efficiency.

[1] "Energy Efficient Motor Driven Systems," European Copper Institute, Fraunhofer-ISI, KU Leuven and University of Coimbra (April 2004)

[2] *Ibid.*

Motor control in large appliances

In the home, large appliances, such as the washing machine and refrigerator, can benefit from the energy-saving characteristics of advanced motor control technology. Consumers are not only interested in saving energy costs but also in reducing the environmental impact of electricity-generating facilities ([visit freescale.com/appliance](http://www.freescale.com/appliance)).

Since a refrigerator is always on, it can consume up to 50 percent of a home's energy budget, with virtually all of that is used to run the compressor motor. Most refrigerators still use a constant-speed on/off compressor. However, variable-speed compressors are gaining traction in the market. They are designed to enable more efficient cooling with precise temperature control, thus reducing overall energy use. In addition, manufacturers are increasingly employing more efficient brushless motors, which can also help reduce the amount of energy consumed.

In washing machines, replacing low-end solutions, such as universal triac driven motors, with newer 3-phase AC or permanent magnet motors, greatly increases performance and drive efficiency. The advanced control techniques are engineered to enable shorter washing cycles, not only saving electric energy but also reducing water consumption ([visit freescale.com/motorcontrol](http://www.freescale.com/motorcontrol)).

Delivering solutions for energy-efficient motor control

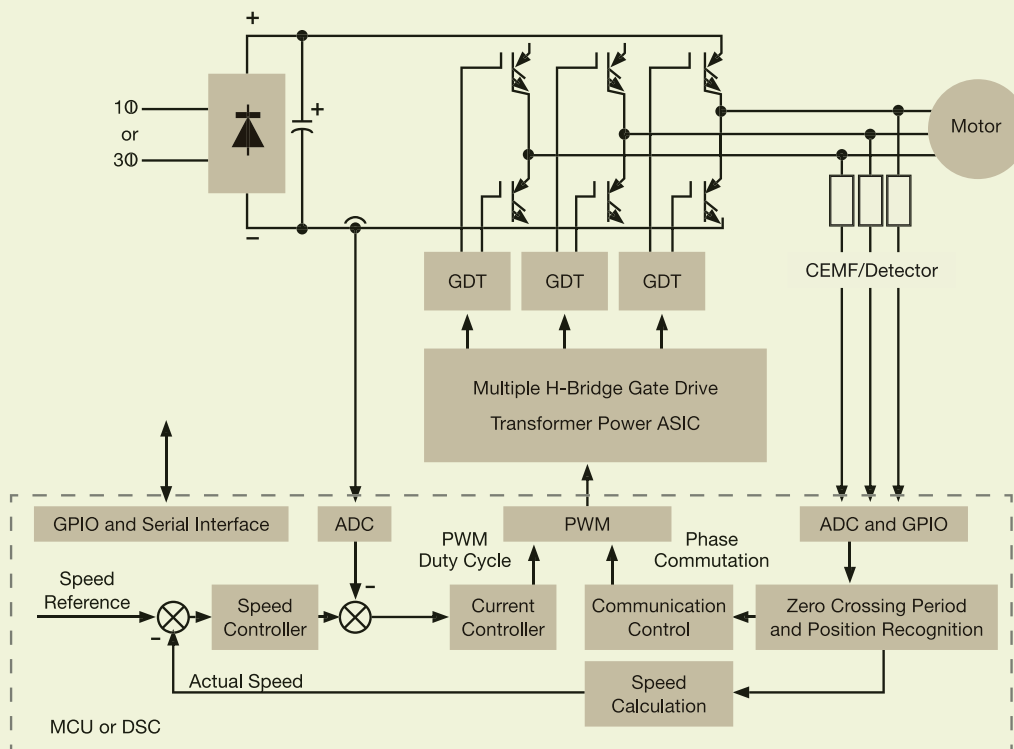
Freescale offers a broad portfolio of MCUs ([freescale.com/mcu](http://www.freescale.com/mcu)) and DSCs ([freescale.com/dsc](http://www.freescale.com/dsc)) that are designed to deliver energy-efficient advanced motor control solutions. The portfolio starts with 8-bit MCUs for low-cost fans, compressors and pumps. The next level includes a family of high-performance 16-bit DSCs with dedicated motor control peripherals for advanced appliance and industrial applications. The portfolio also includes 32-bit devices, which are often preferred for high-end industrial drives.

Freescale delivers solutions that feature time processing units (TPUs) and enhanced time processing units (eTPUs) that can be considered motor control coprocessors. These perform most, and sometimes all, of the motor control functions, freeing the CPU to perform other tasks critical to the application.

Freescale also offers a comprehensive set of software development resources to assist product development and further reduce time to market. These include algorithm-specific libraries, peripheral drivers and code examples that accelerate the learning curve, as well as a large number of reference designs, demos and application notes.

Freescale is dedicated to providing comprehensive system solutions designed to improve energy efficiency across the whole spectrum of motor control applications ([visit freescale.com/analog](http://www.freescale.com/analog)).

Motor Control System



EU Standby Initiative

Today, appliances in standby mode are gaining attention as major energy users and contributors to unnecessary greenhouse gas emissions. This has generated increasing consumer interest in household appliance energy consumption, even in the lowest power modes. TVs, DVD players and set-top boxes are now in the spotlight for their energy use. As energy efficiency becomes a larger factor in consumer purchasing decisions, manufacturers are reacting to satisfy consumer demand.

Standby power accounts for approximately 10 percent of home and office electricity use in EU member states. The fast penetration of new digital technology is likely to mean that this figure will increase, further prompting the need to introduce intelligent power saving technology into these appliances.

Recognising the potential for energy conservation in this area, the European Commission has implemented a series of agreements with the individual consumer electronics manufacturers and the EU trade association to reduce the standby electric current losses in TVs, VCRs, audio equipment and DVDs.

Many products are good candidates for the EU Standby Initiative because they contain microcontrollers that can control the application power use, enabling power-hungry modes only when required. Combined with high-efficiency power management products, they are ideal solutions for meeting the energy saving standards.

Freescale has developed reference designs to illustrate improvements in standby power management where systems can provide power efficient functionality suitable for consumer products (visit freescale.com/analog and freescale.com/mcu).



Building Automation

Building automation systems (BAS) present significant opportunities for energy conservation in the home and in the workplace, where poor scheduling and manual control can result in inefficient or even round-the-clock operation of lights, HVAC and other environmental control systems. It's estimated that a fully optimised BAS can return energy savings of between 10 and 30 percent. The number can be greater if BAS is employed in older or poorly maintained structures, and will typically repay its initial investment within two to four years [1]. At the heart of a BAS is a programmed, computerized, intelligent network of electronic devices that monitor and control the mechanical and lighting systems, usually from a central control panel. As well as enabling more effective resource management, such systems help to reduce maintenance costs and provide increased levels of comfort, safety and security.

The concept of building automation may also be extended to domestic appliance management. Many modern appliances have digital controls that employ MCUs with integrated interfaces to simple, low speed serial communications via wired or wireless mediums. This enables the appliances to be interconnected relatively easily, and, with the addition of a single-chip Ethernet gateway, integrated into home automation networks. Where traditional mechanical-based timer systems were once found, Ethernet-based systems can now be employed, giving users increased flexibility and control over appliance operation and in turn optimising their energy consumption.

Enabling BAS implementation

In commercial properties, a typical BAS comprises three major components: workstations, supervisory controllers (typically a programmable logic controller) and application controllers. The workstations provide the user interface for monitoring and adjusting the facility operations. Supervisory controllers communicate to the application controllers, perform scheduling and trending tasks

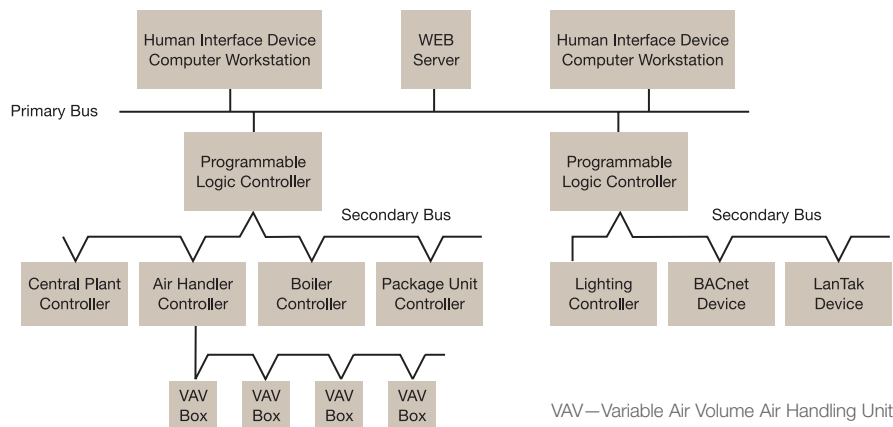
and obtain data on energy use throughout the building. Application controllers control the various systems functions throughout the building.

Freescale offers a range of embedded processor and sensor products that fit the requirements of the modern BAS. Communications protocols, such as CAN, Ethernet and USB, in combination with other sophisticated MCU peripherals such as floating point units (FPUs) and on-chip flash memory, enable BAS to have almost any given point/device within a system communicate with any remote location. Freescale's ColdFire portfolio (visit freescale.com/coldfire) includes MCU families with CAN, Ethernet and USB communication peripherals that deliver such connectivity. These include the MCF5223x, with integrated Ethernet MAC and physical interface (PHY) and the MCF5222x with USB On-The-Go functionality. Each family features highly reliable flash memory, enabling engineers to minimise user disruption by performing cost-effective field upgrades to meters, fans or elevators, for example.

Most building automation networks consist of primary and secondary buses that connect all the distributed controllers and I/O devices to the user interface. These buses can be implemented using a variety of protocols, including Ethernet, BACnet, LONTalk, serial or wireless. Where proprietary LONTalk networks are employed, the MCF523x with an integrated eTPU timing co-processor can be used.

Wireless protocols present an obvious benefit for BAS in terms of flexibility and ease of installation. Here the cost-effective, low-power characteristics of ZigBee technology make it a natural fit. Freescale offers an extensive range of ZigBee-compatible solutions that include RF chip sets, low-power MCUs, sensors, reference designs, protocol stacks and development tools (visit freescale.com/zigbee).

Building Automation System



[1] "Maximizing Green Design through Building Automation," Rob Moulit and Dave Matasek, Environmental Design + Construction, October 2001

Digital Power Supplies

In today's technology-driven society, the demand for power-driven equipment is pushing energy consumption to new levels, increasing costs to consumers and the environment. Companies are feeling the financial burden, and governments are pressured to introduce environmental legislation to limit consumption. These issues are elevating energy efficiency to a top priority in consumer purchasing decisions.

Along with consumer demand for lower power consumption is the ever-increasing demand for improved system performance. Manufacturers are increasing system integration, driving the need for greater performance. However, greater performance generally means higher power consumption. The demand for better performance and lower power requires better power supply designs.

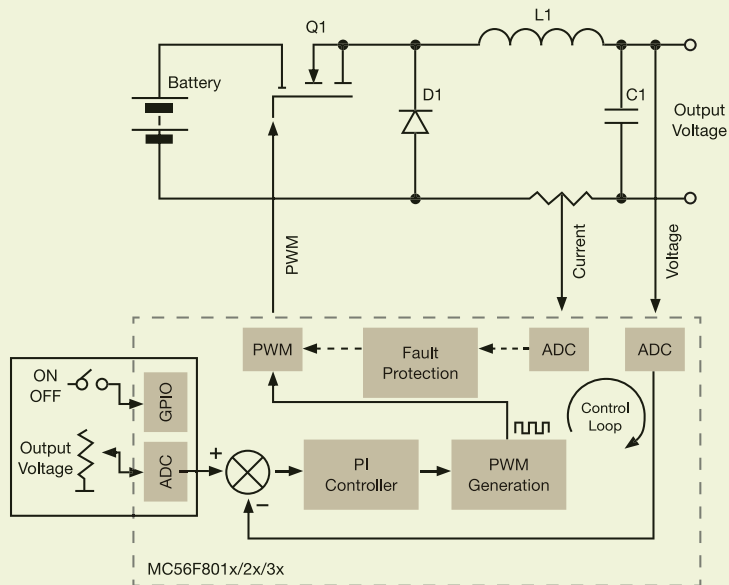
The digital solution

The existing solution to the power supply design problem, an analog system, limits the power supply flexibility. Analog systems cannot provide the dynamic control that enables the much-needed power savings. A digital solution provides power-saving control and flexibility within the system. The digital solution responds to dynamically changing factors, such as a sudden increase or decrease in load, therefore reducing the need for "always on" designs.

Through the implementation of advanced algorithms, digital architectures continuously record, monitor and respond to critical system parameters, such as input/output voltage, current, power and temperature. The architecture's enhanced processing capability is used to provide additional awareness to the rest of the system, and through this dynamic control, huge power savings can be realized.

Freescale's digital signal controllers, such as the MC56F802x/3x family, are able to provide large efficiency gains because they are designed to meet digital system requirements by combining the best of the MCU and DSP worlds. DSCs provide key features, such as a high-performance core for processing the advanced algorithms, high speed/ performance analog-to-digital converters (ADCs) for fast dynamic responses to signal capture requests, high-speed sophisticated pulse width modulators (PWMs) and timer modules for accurate signal construction. Finally, DSCs provide the all important safety features to help achieve reliable system operation (visit [freescale.com/dsc](http://www.freescale.com/dsc)).

Fully Integrated Digital Control Loop



Learn More: For current information about Freescale products and documentation, please visit www.freescale.com/energyefficiency

