

Energy Efficient Design – Guidance for Electronic Design Engineers

There are many reasons why engineers would want to design new energy efficient electrical products. One is concerns over global warming as this is resulting in legislation worldwide that requires more energy efficient designs. The European Union (EU) has adopted the Ecodesign of Energy using Products (EuP) directive but USA, Australia and many other countries also have legislation covering a variety of products.

Another reason for improved energy efficiency is demands from customers, mainly because of increasing energy prices and therefore energy efficiency is increasingly seen as a marketing tool.

Energy efficient design is not new. This can clearly be seen in portable battery-powered products that have been designed to last as long as possible between charges, with mobile phones being a good example. Customers require small size, light weight, greater functionality and longer battery life. Manufacturers have clearly achieved these aims but this has required huge technology changes in phone and battery design. These changes have included:

- Change from nickel / metal hydride to high capacity lithium-ion batteries
- Active power management to switch off functions not being used
- The use of lower voltage circuits. If voltage can be reduced from 3 to 1.5 volts, this reduces power consumption by half. This has been possible however only by developing components (ICs) that will operate with lower voltage supplies
- Low power consumption components have been developed with some designed to operate in either active and standby modes consuming less than 1 mA in active mode and even less in standby
- Combining functions on ICs. Modern mobile phones contain less ICs than 10 years ago but have many more functions

These types of design change can be used in any type of electrical product, not only portable items such as laptop PCs and PDAs. However, each type of product requires consideration of particular issues. The following examples are products that are or will soon be covered by EuP implementing measures:

Washing machines – Most energy is consumed in heating water and by electric motors. Machines that use less water therefore require less heat input although improved thermal insulation would also be beneficial. The energy efficiency of motors varies considerably and savings can be achieved by using the more efficient types.

Televisions – Most energy is consumed by the display in modern TVs. Liquid Crystal Displays (LCD) can be more efficient than plasma display panels (PDP) but the way that these operate influences energy consumption. If PDP pixels are switched off to show dark areas, then these use little power whereas the fluorescent backlights of LCDs continuously consume power as they are permanently on when the TV is in use. LCD lamp efficiency can

influence power consumption although there is a recent trend to use lower efficiency lamps that have improved colour quality. The most significant energy improvements will be achieved by adopting new energy efficient types of display. Several manufacturers have launched new TVs which have LED displays that consume less power than LCDs. These new displays are also increasingly used for laptop PCs as they give much longer battery life, mainly because there is no need to generate the high voltages needed to operate fluorescent backlights. Other novel display technology is being developed including OLEDs (organic LEDs). The TV EuP implementing measure requires that these switch to standby mode automatically if no user interaction occurs during a four hour period, which assumes that after four hours, no one is watching!

Refrigerators – The EuP implementing measure imposes maximum EEI (energy efficiency index) on refrigerators and freezers. To achieve this, insulation is clearly important. Most energy is consumed by the compressor motor and so its energy efficiency is important in achieving a low EEI.

Set top boxes – These have developed very rapidly with little consideration of energy efficiency. However, energy efficient design is being imposed by an EuP implementing measure that specifies maximum power consumption values for each function. Achieving reduced power consumption is not straightforward as set top boxes are complex electrical products. Minimising consumption of each function is required but this must not affect performance or compliance with other legislation such as the EMC directive.

Ovens – A study into ovens for cooking has begun recently. There are several types of oven on the market including microwave, gas, electric (with or without a fan) and oil powered. The quantity of global warming gas emissions for cooking a standard load is less with gas than with electricity in most EU States (Norway would be an exception as it generates electricity with almost no fossil fuel).

Microwave ovens are widely claimed to use less energy but research in the UK has shown that this is true only for some cooking processes such as heating pre-cooked meals. Defrosting and cooking vegetables is only slightly more efficient than with standard electric ovens. The most obvious energy saving design feature for ovens is the thermal insulation. Self-cleaning ovens need to have better insulation to prevent external surfaces becoming dangerously hot and, as a result, they are more energy efficient although these savings are offset by the energy consumed during self-cleaning.

Electric motors – These are one of the largest consumers of electricity as they are used in so many applications. Motors are used in central heating, refrigerators, industrial processes, machine tools and many other products. An EuP implementing measure has been adopted that imposes limits on the energy efficiency of motors that can be used. From 1 Jan 2015, all motors from 7.5 – 375 kW (from 0.75kW in 2017) must be IE3 unless they are used with variable speed drives then less efficient IE2 motors may be used. IE2 and IE3 are defined by EU regulation 640/2009. Electric motors coupled with variable speed drives (VSD) give much better energy efficiency overall but VSDs are not suitable for small low power motors or applications where space is very limited. Under these circumstances, more efficient motors are required.

There are also two “horizontal” EuP implementing measures that affect a very wide range of products and need to be considered by design engineers.

Standby and off mode power consumption:

This legislation includes household appliances, consumer products, toys and leisure equipment as well as IT and telecom products that are intended primarily for use in domestic environments. Products that are in scope will need to meet maximum energy consumption targets when in standby or off-mode and be able to switch to an off-mode or standby mode from September 2009 (maximum 1 watt or 2W if there is an information display). This will be required unless “inappropriate” for the product, such as for safety reasons, in which case, the reasons must be explained in the product’s technical file. From September 2013, the maximum energy consumption in standby and off-modes halves and it will be necessary to include a power management function that automatically switches the product into standby or off-mode. This should be after the shortest time that is reasonable for the product. The specific implementing measure for televisions sets this time to four hours. Some manufacturers have already adopted highly innovative designs and are able to easily meet the maximum standby mode power loss limit whereas others will need to make significant design changes in order to comply.

External power supplies:

Many millions of external power supplies are sold annually in the EU and will be covered by this legislation. There are several exclusions including battery chargers but if the power supply unit is used to power the product as well as charging its battery, then these will be in scope. In the EU, only power supplies intended for consumers are in scope but similar legislation in the USA and Australia include all power supplies. The regulation imposes a maximum power consumption limit when disconnected from the equipment (initially 0.5W) and minimum energy efficiency. This regulation will mean that switch-mode power supplies will need to be used as linear power supplies will not meet the requirements. Switch-mode power supply design and energy efficiency vary considerably with some products being far better than others. Energy efficiency is influenced by the circuit design, selection of components and the construction of the transformer.

The maximum power consumption and efficiency limits of most EuP implementing measures are based on “benchmark” products which are the best available on the market. Some manufacturers of electrical products adopted policies many years ago to develop equipment with energy efficiency as a high priority. This was originally seen as a marketing aid but also pre-empted future legislation. It has however enabled them to easily meet these new legal requirements and in the future it will be advisable for all manufacturers of electrical equipment to consider energy efficiency when designing new products.

With thanks to ERA Technology trading as Cobham Technical Services