# Embedded electronics make White Goods more reliable and efficient

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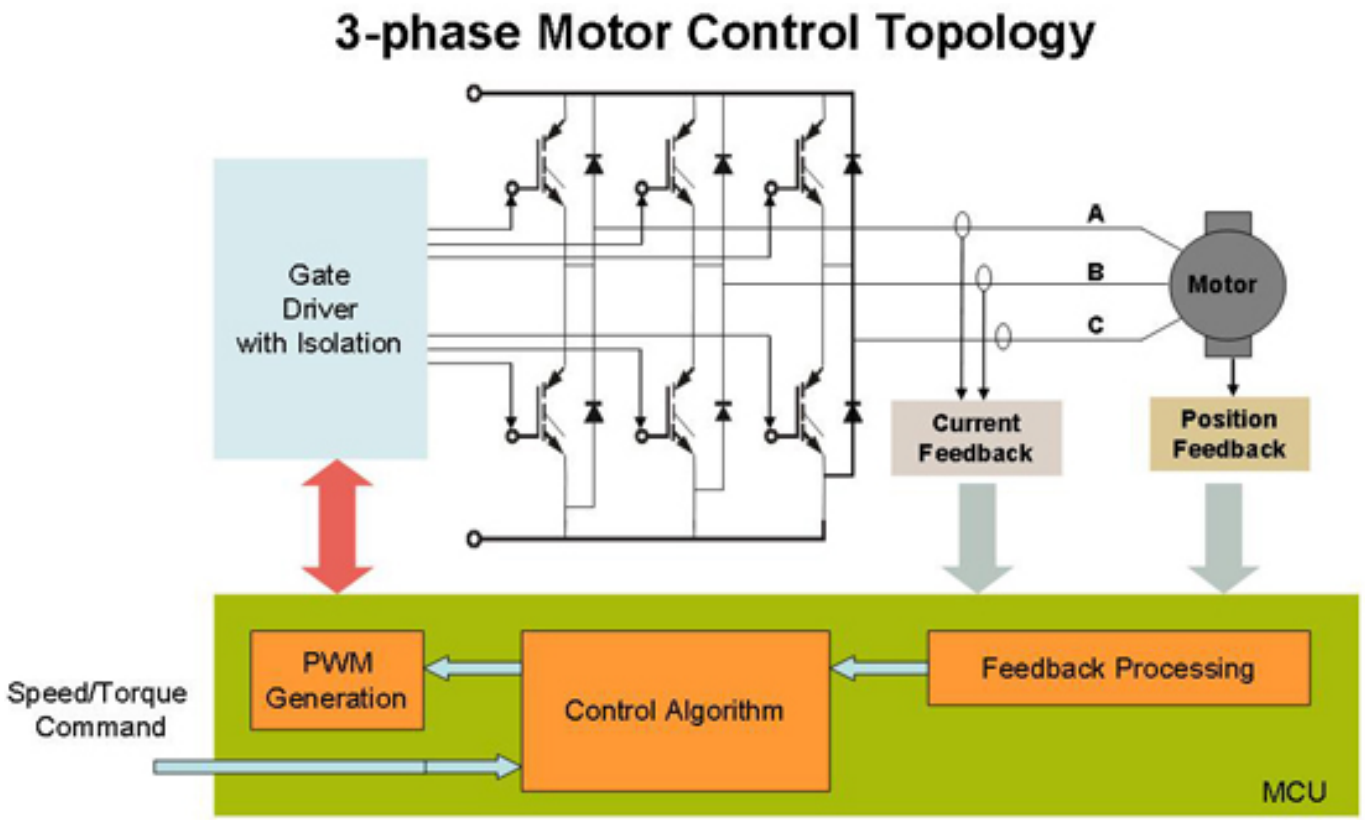
The U.S. Department of Energy (D.O.E) is pushing to encourage conservation by getting consumers to replace old, wasteful appliances with new, more efficient Energy Star certified machines. A program that kicked in last year will offer consumers cash to help buy new home appliances. The federal government has set aside $300 million for the program as part of the economic stimulus plan. Trading in old home appliances will soon earn consumers up to $200 towards the purchase of high-efficiency upgrades. The program will apply to household appliances like refrigerators, washing machines, and dishwashers, as well as furnaces and air-conditioning systems.

The key challenge for appliance manufacturers is to increase the efficiency of their products without increasing the cost. Although consumers are considering more the longer term running costs, they are still requiring government aided discounts before making purchases.

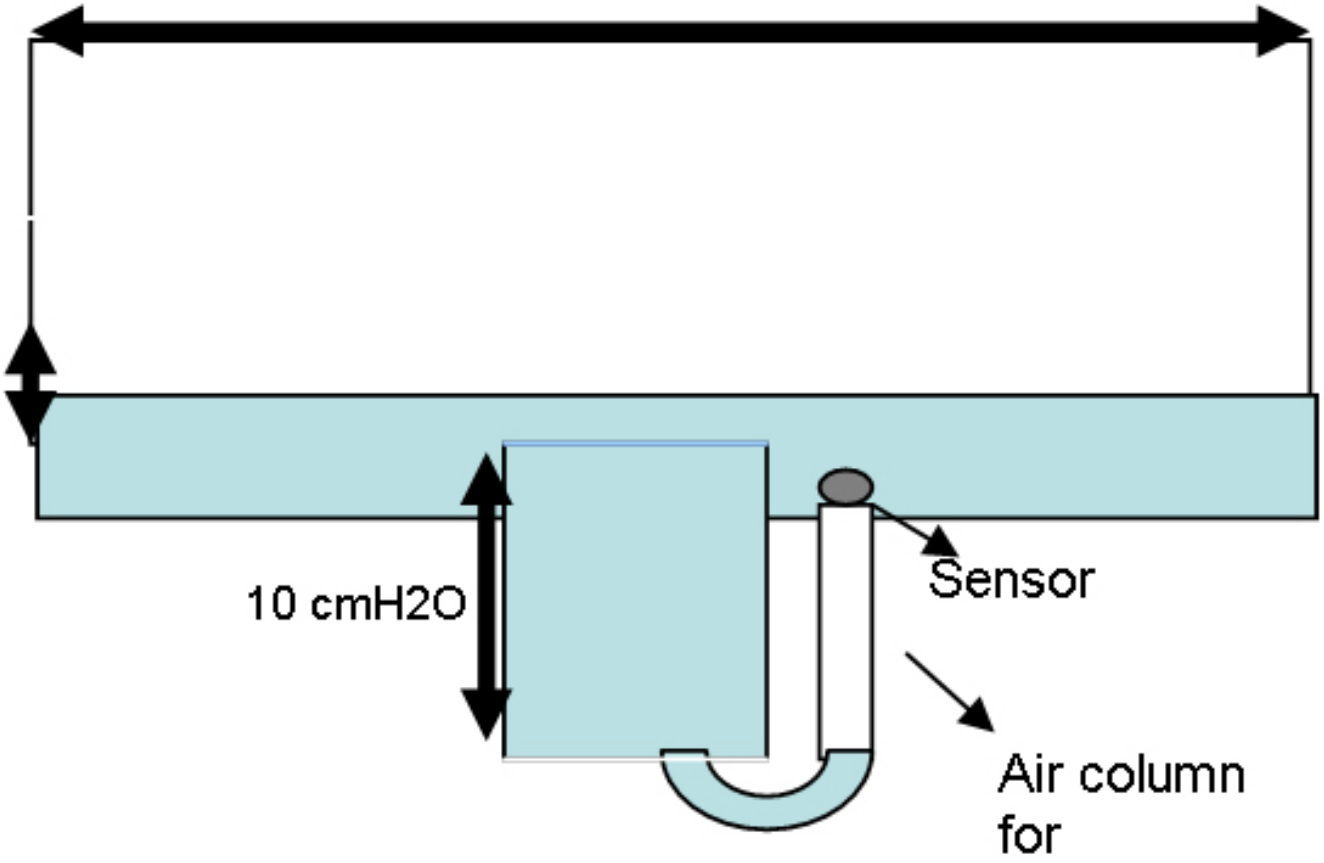
To achieve electrical energy efficiency, appliance manufacturers are focusing on motor control for functions such as washer drum, water drain pump, in washing machine and dishwashers, and variable speed compressors for fridge/freezers and room air conditioning. Traditionally, appliance manufacturers have deployed single phase AC motors (such as AC induction) where speed control for these high voltage motors is performed using a voltage/hertz speed algorithm. The electronic drive for these types of motors is fairly easy to implement with an embedded single chip microcontroller with a timer function and software to drive a high voltage triac which drives the AC motor. These single phase motors work well enough, but deploying three-phase AC motors  can achieve significant savings in energy efficiency.

Typical three-phase AC motors being deployed are permanent magnet synchronous motors (PMSM) and brushless direct current (BLDC). Both are brushless ( so no wear out), and the overall mechanical construction is simplified compared to existing universal induction motors. In high volume, this will drive the cost of these mechanical motors downwards, but the downside is that the electronic drive is more complex which requires significant CPU power and sophisticated digital drive electronics, but as these are continually being deployed in smaller geometries in silicon this will help alleviate some of that extra cost. Overall, consumers will benefit as these three-phase motor control solutions will provide higher energy efficiency, more reliability, longer lifetime, and decreased acoustic noise.




The three-phase motor control drive will generally consist of three pairs of complementary PWMs (pulse width modulation) channels which drive a pair of high voltage MOSFETs or IGBT transistors configured in a push-pull arrangement, to drive each of the three-phase windings of the motor. Additionally, the current/voltage of each of the phases is measured using either analog comparators or analog to digital converters. This is known as sensor-less control since there is no speed position sensor to provide a closed control loop. When a phase is not being driven, due to the magnetic field produced by the spinning motor, a back EMF voltage is presented on the unused phase and thus, a comparison of this signal in time, speed and position can be made. In parallel to maximize energy efficiency, appliance manufacturers are executing advanced algorithms such as “field vector control” which are mathematical models of the motor’s expected phase voltage and currents. The modeled performance is compared with the actual measurement and the resultant error is used to modify the PWM drive. This type of motor control requires high performance CPUs with MAC instructions sets of >30 MIPS. Freescale Semiconductor’s Digital Signal Controllers like the MC56F8002/6 family have dedicated six-channel PWM modules that synchronize automatically with high speed comparators and analog to digital converters without CPU intervention. Advanced motor control algorithms such a “field vector control” are easily performed on the 16-bit CPU with its MAC instruction set, providing leading edge motor control.

Where advanced motor control helps improve electrical energy efficiency, appliance manufacturers are also being driven by consumer and legislation to increase the efficiency of water use. In legacy wet appliance designs, it was acceptable to switch on a pump and measure the actual time the pump was ON, to calculate the water used.

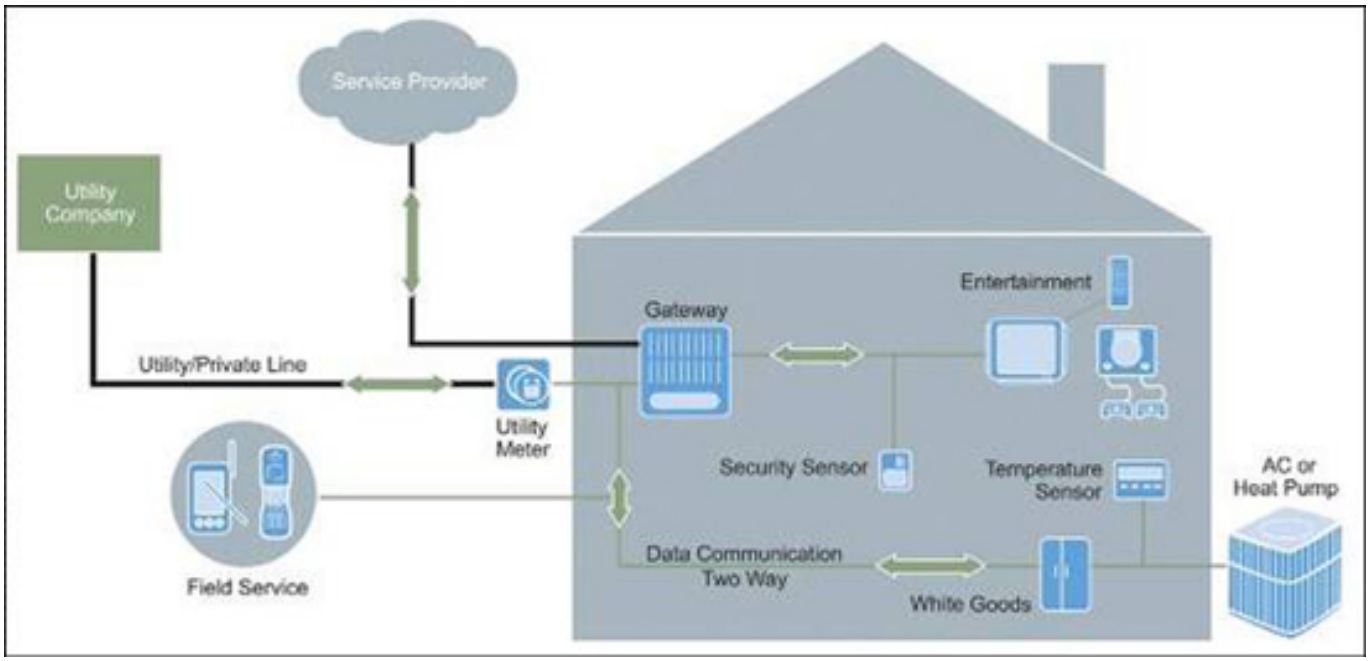



Due to differing cold water pressure in homes, this is not particularly accurate. Wet appliances are being designed to accurately measure the amount of water consumption being used to an accuracy of +/-1 mm. Two methods are being investigated, one being a reed flow sensor which calculates the flow of water. Reed water flow sensors can be very accurate but are currently expensive. An alternative method is to use an air column assembly, connected to the washer drum, by using compensated differential air pressure sensors. Here the difference in air pressure is proportional to the change in water level. Using another pressure sensor to measure load weight, an intelligent controller will reduce the amount of water for smaller loads, thus increasing the efficiency of water usage over time automatically.

Additionally, appliance manufacturers are designing larger capacity machines to help increase energy efficiency where, for instance, the same compressor can be used to cool a larger cabinet. Or, a larger wash drum load that is driven by the same motor control module will help to meet legislative levels which are based on load/wash cycle basis. Although increasing the drum size of a washing machine is not difficult, there are limitations owing to a standard size of cabinet, to fit with the standard kitchen installations. So, the drum is now very close to the external cabinet wall, and thus any significant wobble from the drum will initially touch with the cabinet and cause unwanted noise and vibration – enough to make the machine move, which amounts to wasted energy. Appliance manufacturers are now implementing complex algorithms along with intelligent sensors such as accelerometers, that measure the start of wobble, to compensate the motor drive to ensure the drum runs true. Freescale has various low G two-axis and three-axis accelerometers which can help sense motor unbalance.

Longer term, home appliance manufacturers are looking at more intelligent control of the appliance to help increase energy efficiency by connecting the appliance and the electricity meter. In the short term, this provides consumers the ability to select suitable operation times to use lower tariff electricity, and it will allow the energy providers to automatically pause the appliance when the grid is meeting with a short but high demand. The key challenge in connectivity for appliance manufacturers is what medium to use: wireless (ZigBee, or <1 GHz, WiFi) or wired power line modem (PLM). The key benefit of wired PLM is that the wired infrastructure already exists, and modulation on top of the AC mains wires is used. In the past, getting a reliable communication with PLM was not high enough. Now we are seeing new protocols with enhanced filtering of noise, and integrated data protocols that have error detection and correction are making this a more reliable and a feasible medium.

Also being investigated is wireless, which again uses the existing air as its medium. WiFi is an existing protocol and has a high penetration in homes in the developed countries, but energy providers are concerned about the security of being connected directly to the internet and are driving an independent home network that can be isolated more securely. Since the data being communicated is expected to be the form of control commands and status updates lower bandwidth alternatives are being examined due to their lower power consumption. IEEE 802.15.4 and ZigBee currently seemed to be favored due to the 2.4 GHz Mesh protocol, which allows optimal re-routing of communications within the home, and inherent security in the protocol using smartcard type encryption AES-128. In the next few years, expect to see a “energy gateway” in the home which will likely support WiFi, ZigBee and PLM to give consumers a greater choice and ensure that the control of appliances is secure.




The connectivity medium for the Smart Grid inside the home is expected to be a mixture of wireless and wired.

One dominant medium is 802.15.4 where Freescale has RF transceivers, such as the

MC13202 which can be connected to any embedded microcontroller, as well as fully compliant ZigBee platforms such as the MC13224V, a single chip solution with RF transceiver, 32-bit TDMI ARM core, 128K Flash and certified ZigBee-PRO stack with Smart Energy profile. This extremely small footprint platform with low discrete components required, provides appliance manufacturers the capability to situate the antenna node anywhere on the appliance and also remotely.

Although features such as three-phase motor control and Smart Grid connectivity help increase energy efficiency, the next challenge for the appliance manufacturer is to make it easy to use for the consumer. Communication of the different optional electricity tariffs must be easily presented, and selection of the various wash programs and how they compare with respect to saving energy must be visually easily understood and easy to select. Appliance manufacturers are looking at implementing and enhancing the user interface to the appliance using technologies driven by current consumer trends. Displays are moving from simple LED indicators to segment and graphic LCD where manufacturers can provide motional graphics representations on the appliance program and set-up to help consumers easily understand how to get the best performance from their appliance. Freescale provides solutions for mid-range segment display, MC9S08LG16/32 MCUs with configurable segment display module ( 8x37 or 4x41) to high-end graphical solutions using i.MX233 MPU with video capability and integrated touch sense control. User control keypads are moving to flat panel touch-less solutions utilizing products such as touch panel drop in analog ICs providing capacitive touch sensing in standalone device.

In summary embedded electronics are aiding Home Appliance manufacturers make their appliance products, more energy efficient and environmentally friendlier, easier to use, more reliable and safer, and cheaper to run for the consumer.