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Adding Value to Embedded Controls; Appliance Microcontrollers for a Better User Experience

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The ARM Cortex™-M3 processor has played a key role enabling embedded applications to deliver more sophisticated user experiences. The latest microcontrollers for domestic and industrial appliances make best use of the extra processing capability on offer by also implementing powerful application-optimised peripherals

New generations of embedded processors such as the 32-bit ARM® Cortex™-M3 provide dramatically higher performance than popular 8-bit architectures such as the 8051, at a competitive price, to support advanced features and functions in equipment such as domestic appliances and industrial controls. Processor performance alone, however, cannot solve every challenge; developers must also rely on application-focused microcontroller integration to help minimise development costs and deliver new products to market ahead of their competitors.

Markets for products such as washers, dryers, chillers and heaters for domestic and industrial use are today characterised by demands for advanced features such as graphical colour displays and touchscreen controls, as well as sophisticated motor or heater controls that provide flexible operating modes and ensure high energy efficiency. In addition, developers need cost-effective solutions that will speed up and simplify the design of mandatory features meeting standards such as IEC 60730 class B, which is a safety requirement for domestic appliances.

Enhancing the Core's Value

To help meet the diverse demands of appliance developers, microcontrollers such as the Toshiba TMPM370/380 families provide solutions to specific needs of industrial and home appliances. For example, Toshiba offers Cortex-M3 devices suitable for direct operation from a single 5V supply. This significantly simplifies integration with the power architecture of most domestic appliances, which are usually not designed to supply low-voltage devices requiring 3.3V or lower.

Among integrated peripherals conceived specifically to meet the demands of advanced appliances, the TMPM370/380's hardware Oscillation Frequency Detector (OFD) greatly simplifies designs that must achieve system-level approval to IEC60730 class B.

This is an important safety standard for domestic appliances, and requires the system to verify correct operation of the microcontroller.

The OFD monitors the clock to detect abnormal activity, and generates a reset signal for the MCU if the detected clock oscillation frequency exceeds the specified range. This is a useful technique for verifying correct processor operation and hence enabling the system to manage fault conditions safely in accordance with IEC 60730. Implementing such a function in software is time consuming and also demands considerable CPU resource. Figure 1 illustrates how OFD is implemented in hardware in the TMPM370/380.

The TMPM370/380 microcontrollers implement other features that simplify design and reduce development time for appliance designers, such as real-time clock with calendar and sensor inputs for capabilities such as temperature sensing. In addition, system-safety features such as a watchdog timer (WDT), Power-On Reset (POR) and Voltage Detector (VLTD) help to boost reliability and minimise warranty returns for manufacturers.

Efficient Motor Control

Many types of industrial and home appliances, such as washers, dryers, chillers/refrigerators and HVAC systems, require responsive and energy efficient motion controls capable of driving fans, pumps or compressors. Field-Oriented Control (FOC) is often used in preference to traditional trapezoidal or sinusoidal motor-control techniques; it achieves smooth and accurate torque control across a wide speed range, avoiding the low-speed inaccuracy of trapezoidal control and the high-speed inefficiency of sinusoidal control.

The FOC algorithm may be implemented in software either brought up in-house or sourced as third-party IP. Performing the FOC in dedicated hardware integrated on the host microcontroller, on the other hand, can offer several advantages. A hardware engine typically is able to perform a complete FOC loop in a few microseconds, resulting in a faster response to changes in speed and torque demand; this relieves demands on CPU performance and operating frequency. Also, offloading the FOC algorithm allows the host processor to be used for value-added functions at the application level.

Application-Focused Peripherals

In the TMPM374, Toshiba has integrated a combination of hardware resources dedicated to motor control. Together these resources save hardware and software development, as well as minimising CPU overhead. The on-chip circuitry includes a dedicated Vector Engine (VE), a Programmable Motor Drive block (PMD), and an Analogue to Digital Converter (ADC), as shown in figure 2.

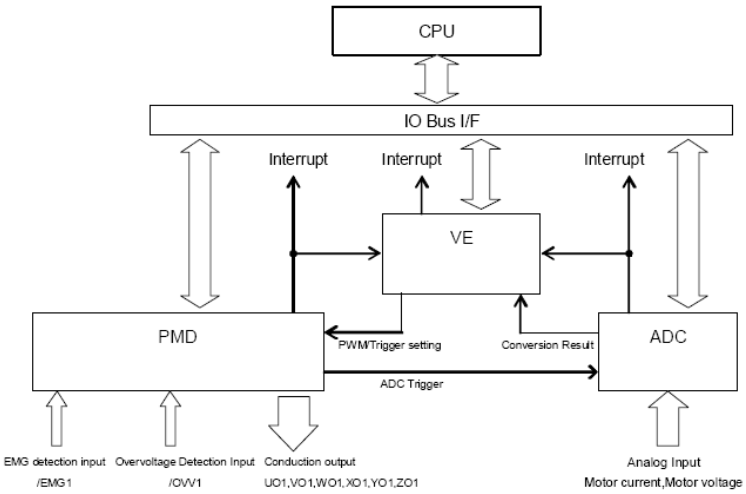

Figure 2. Dedicated motor-control hardware in TMPM374 microcontroller.

The VE performs the basic tasks and calculations needed for FOC and generates PWM output and control signals. Figure 3 illustrates the FOC functional blocks implemented in the TMPM374 VE.

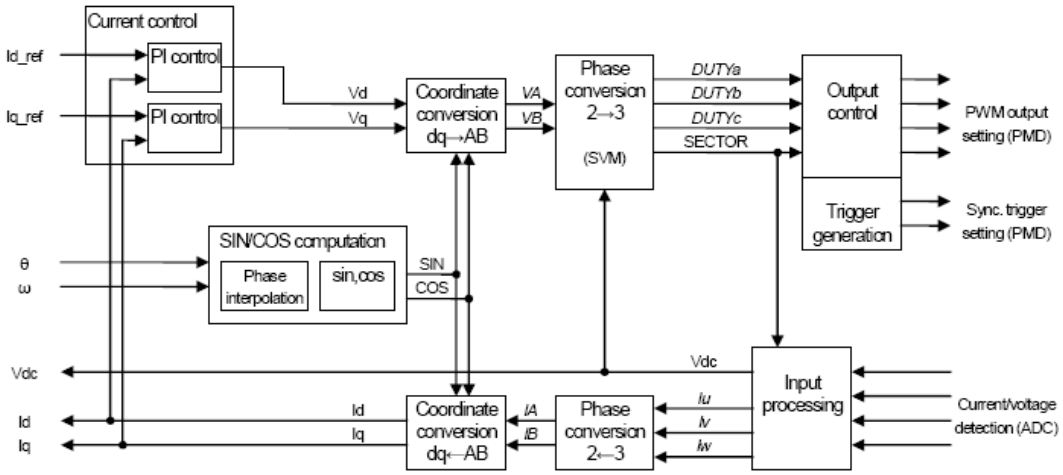

Figure 3. Block diagram of Field Oriented Control.

The VE receives digital current and voltage data from the ADC, handles the translation of the ADC values into a format suitable for the PMD, generates timing and trigger signals for coordinating the ADC and PMD, and performs the proportional-integral, phase interpolation, and axis and phase conversion functions that constitute the FOC algorithm. The VE uses fixed-point format data, which eliminates any need for software to manage decimal point alignment. A total processing time of just 9µs (at a core frequency of 80MHz) means that the hardware VE block offers significant performance improvements when compared with a software-based vector control algorithm running on a host microcontroller.

The PWM signals output from the VE are fed to the PMD, which generates six gate-drive signals for upper and lower phases of a 3-phase motor-control bridge. This block is implemented using Toshiba's third-generation PMD technology, PMD3+, and includes register-controlled dead-time circuitry as well as circuitry for generating trigger signals to synchronise ADC sampling and PWM generation. The ADC-timing network includes op-amp and comparator functions, so allowing precise measurement over the full positive and negative current range of the motor without requiring an external op-amp to perform level shifting.

The PMD block also implements over-voltage and emergency protection circuits, which are programmable via control registers. The emergency protection can be configured to generate an emergency stop when the microcontroller's EMG pin is asserted, by immediately disabling all output ports, or to set the external ports to a high impedance. The over-voltage protection circuit allows either upper, lower or both sets of phases to be disabled if an over-voltage condition is signalled at the microcontroller's OVV pin.

The ADC block samples analogue motor current and motor voltage, and provides fast current sensing and shutdown capability. Toshiba's TMPM374 also provides an incremental encoder interface featuring built-in digital noise filters, which can determine the direction and the absolute position of a motor, based on input signals from an incremental encoder or hall sensors.

Conclusion

The latest embedded 32-bit processors such as the ARM Cortex-M3 provide the performance boost that today's appliance designers need to satisfy market demands for increasingly sophisticated functionality and greater energy efficiency. However, the processor is only a part of the solution; developers also need enhanced peripherals that add value to key functions such as motor control, induction-heater control and safety features, to satisfy all applicable market and legislative demands and deliver reliable, innovative new products within the shortest possible time to market.

For more information visit Toshiba Electronics Europe's web site at www.toshiba-components.com

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