Design Platform Combines Ready-To-Use Motor Control Algorithm With Application-Oriented Enhancements

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The last few years have seen a strong trend toward the use of variable speed drives (VSDs) instead of simple on-off motor controls. This trend favoring the efficient use of electrical energy will continue for years to come, driven by more stringent regulations worldwide as well as growing customer awareness (Fig. 1).

The significant growth of VSDs is not only happening in traditional application areas like the air conditioning compressor or the drum motor in a washing machine. More and more inverters are nowadays being applied to the motors in auxiliary drives like small fans or pumps, and increasingly, in small home appliances.

This significant widening of the application scope has driven Infineon to adopt a new approach in iMOTION, the company's family of integrated solutions for the control of variable speed drives. These products integrate a production-grade control algorithm for the motor, and an optional power-factor correction (PFC) control algorithm along with all required hardware functions.

The first generation of iMOTION motor controllers have been on the market for over ten years, driving motors in application areas like room air conditioning or major home appliances. In these applications, the motor controller is typically combined with an intelligent power module (IPM) to create the drive inverter. But in response to the growing set of applications, the newest generation of iMOTION products, iMOTION 2.0, contains a number of improvements in both hardware and software.

This article describes why and how the iMOTION hardware and software were changed to address the new application requirements, and how the new features and architectural changes in iMOTION 2.0 enable higher performance, reduce bills of materials and enhance design flexibility in the applications. The simplification of functional safety certification and enhancements to data security are also described. Finally, the case of a hair dryer design example illustrates how these new features are put to use in one of the newer applications for VSDs.

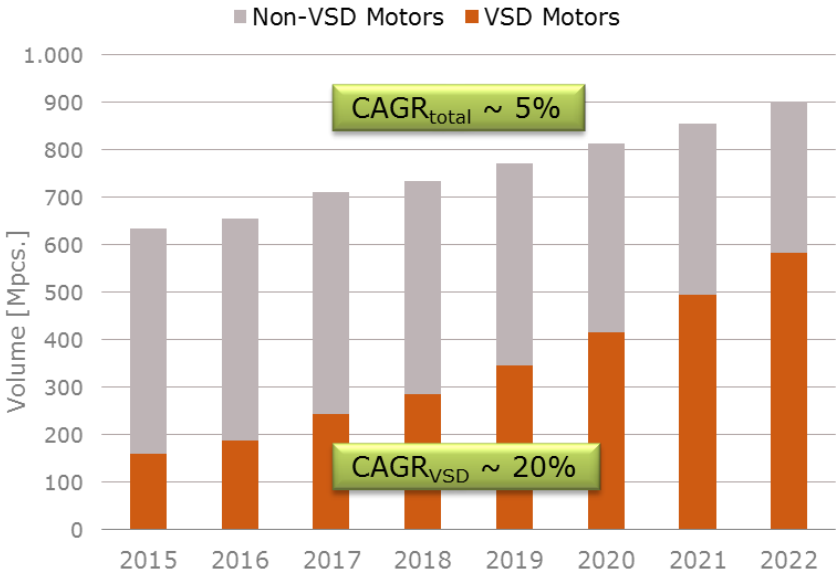

Fig. 1. Growth rate of variable speed drives. (Data coutesy of IHS Markit[1])

Hardware Improvements Address New Performance Needs

The new generation of motor controller ICs like the IMC100 or IMC300 series, which are part of iMOTION 2.0, is explicitly designed to meet the requirements coming from the aforementioned market trends. Targeting more and increasingly diverse motor controls required a change in implementation.

Consequently, the iMOTION team decided to base all coming products on a completely new hardware platform. This platform takes advantage of recent developments in the design of peripheral modules dedicated to motor control solutions. The analog portion of the chip brings a state-of-the art analog-to-digital converter (ADC) that has significantly better resolution, both in terms of effective number of bits (ENOB) as well as in terms of the timing resolution. The improved accuracy increases the accuracy of the control loop calculation, while the faster measurement cycles assist in reaching the higher and higher speed requirements for modern three-phase motors.

Furthermore, the ADC provides features like dedicated reference inputs for differential measurements and switchable gain amplifiers. These features make external operational amplifiers obsolete thereby reducing the customer bill of materials.

Integrated analog comparators are applied for fast overcurrent detection, and in combination with the ADC, they provide the necessary means to meet the functional safety levels of the UL60730-1 Class B. (More will be said on this topic below.)

The new analog side is also accompanied by a digital side, which implements special motor-control timers able to generate various PWM patterns with both high speed and high accuracy. In line with the widening of the application scope, the new platform supports not only sensorless operation of the motor but also operation employing Hall sensors.

For very low speed operation, and in those cases where accurate startup behavior is required, generation 2.0 products come with an internal module for connection to hall sensors. Taking into account the cost sensitivity in home appliances, the respective inputs work with digital hall switches as well as with low-cost analog hall elements.

A Modular Software Topology For The Motion Control Algorithm

Corresponding to the new hardware design, the further development of the integrated motor control software—the Motion Control Engine (MCE)—also has to meet the changing market requirements. Seeing three-phase motors (PMSM/BLDC) being applied in more and more VSDs from major to small home appliances demands a high degree of flexibility to account for differing customer desires.

The MCE still uses the field-proven, reliable and highly configurable algorithm that is already running millions of consumer appliances. However, the new implementation now uses a modular system of building blocks that are linked to each other via a base framework.

This modern software topology brings multiple advantages. The individual modules are easier to maintain, and new modules requested by customers can be added to the system without interfering with the existing ones. The agile software development methods employed make it much easier to implement specific customer requests and still run a release cycle of approximately two releases per year. Provisioning of the individual releases is done via the Infineon website giving customers easy access to all released versions with a clear documentation of newly introduced features (Fig. 2).

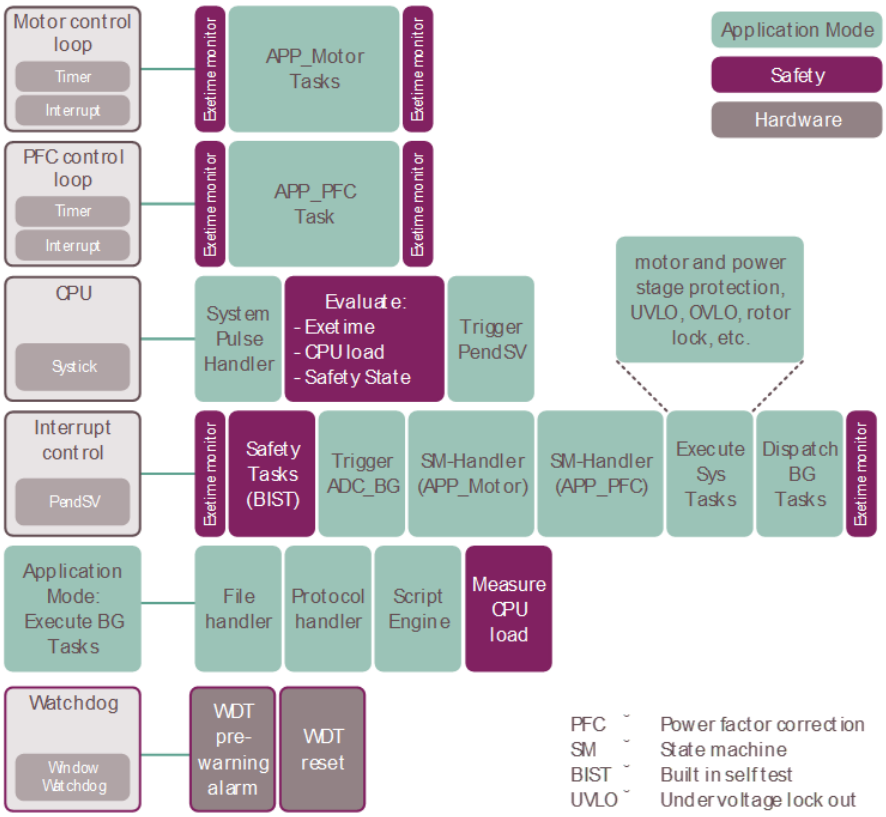

Fig. 2. iMotion 2.0's software building blocks.

Flexibility From Configuration Parameters To Multicore

The first generation of the MCE was already highly configurable for almost any PMSM motor and power stage. This configuration via parameter sets has been further improved, and now covers the optional power factor correction (PFC). As supported in the first generation, the controller can store multiple parameter sets for different drive profiles, and switch between them autonomously or in response to an external command.

The iMOTION motor controller ICs are offered both as single- and dual-core devices. The single-core IMC100 series can control a motor in parallel to a PFC, and offers the lowest-cost solution. On the other hand, the IMC300 series comes with an additional "customer microcontroller" which is completely independent from the motor controller and gives customers the maximum in flexibility on a minimum of board space. The additional MCU is based on the industry-standard Arm Cortex-M0 core with a flexible peripheral set and multiple communication interfaces (Fig. 3).

In competitive markets, all of the components applied in a high-volume product have to be put to optimum use so that the bill of materials is kept to a minimum. The generation 2.0 products offer an additional degree of flexibility with the introduction of a scripting engine. This script engine runs as a background task of the MCE similar to a small virtual machine (Fig. 4). Accordingly, additional flexibility is achieved without any additional hardware costs and without interfering with the motor and PFC control algorithm.

The script language uses an easy-to-understand "C" style syntax, and supports things like the reading of sensor inputs, switching outputs or the communication with a remote host. In addition, with access to the MCE parameters, a modification of the motor behavior during run time is possible, e.g. to implement a special startup procedure. The script engine can run two parallel tasks with one having a minimum cycle time of 1 ms and the other running every 10 ms.

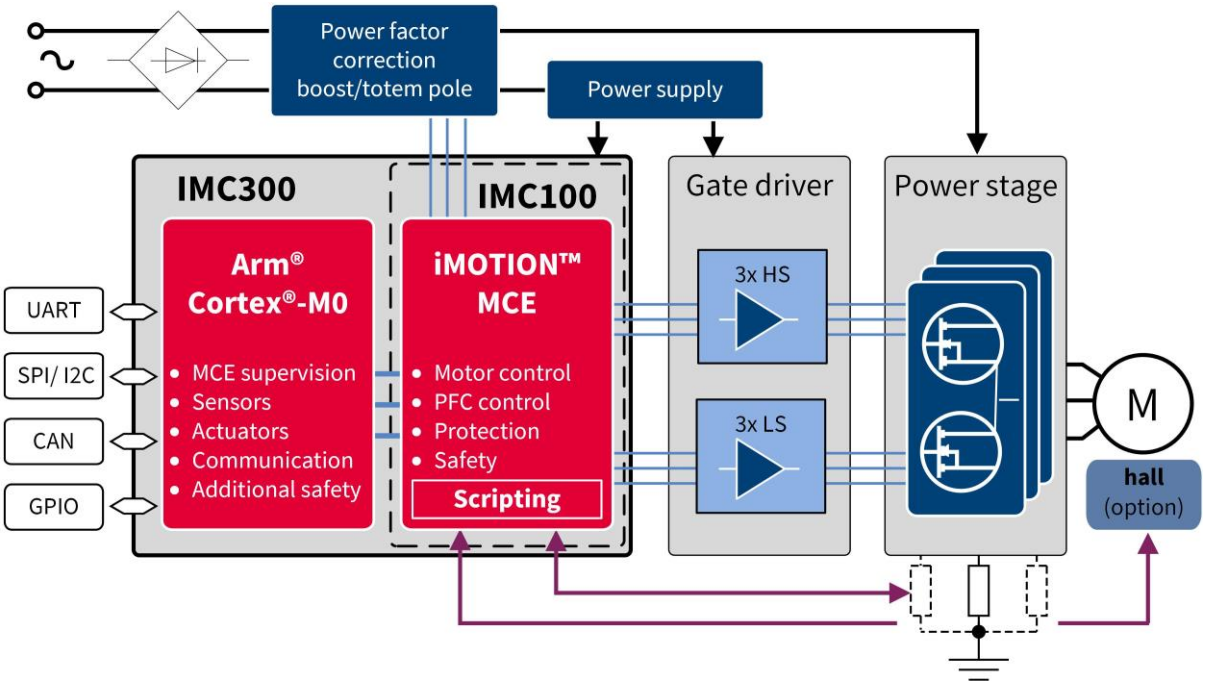

Fig. 3. iMOTION 2.0 motor controller with optional additional MCU.

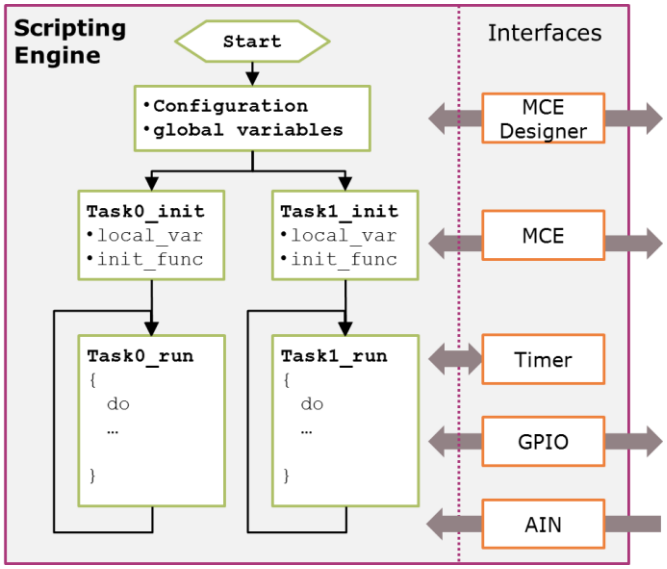

Fig. 4. Script engine implementation.

Functional Safety Included—Providing Savings In Certification

In today's global economy, an increasingly large number of companies are not only serving their local market but also exporting into other regions. Quite often, this corresponds with the request to meet regulations for functional safety. The most common standards are the UL/IEC60730-1 Class B for home appliances.

One of the main differences between iMOTION products and standard microcontrollers is that iMOTION motor controllers are used as a functional building block. This allows the "motor control building block" to be defined in such a way that it can be certified as a functionally safe component.

This is a clear advantage over standard microcontrollers where the MCU supplier offers a C library implementing the individual safety functions but the drive manufacturer has to integrate them into the actual drive application and then apply for the certification.

Achieving a safety certification for an already existing VSD requires significant changes in the control algorithm and might even require additional hardware components. In the definition of the iMOTION 2.0 generation the certification for functional safety was one of the design targets. In view of the cost sensitivity of typical applications like home appliances, the safety functionality has been implemented in a way that it does not require any external hardware like comparators or operational amplifiers.

With the IMC100 series, the first iMOTION product family has already been listed on the UL web page, with all other generation 2.0 products to follow.[2]

The safety certificate considerably reduces the effort for the certification of the full appliance. A customer using iMOTION products can rely on the fact that the hardware and software have been checked to meet the respective safety standards.

Fig. 5 gives a brief glimpse of the safety implementation of the MCE showing the measures to be considered for the UL/IEC 60730-1. The schedule framework uses a combination of hardware (watchdog, interrupts) and software methods to monitor the behavior of the drive during runtime. Not shown are the power-on-self tests (POST) which run once on powering up the VSD.

Use of the safety functions is configurable, i.e. if no safety is required; the respective functions can simply be disabled leaving more headroom for motor and PFC calculations or the integrated scripting engine.

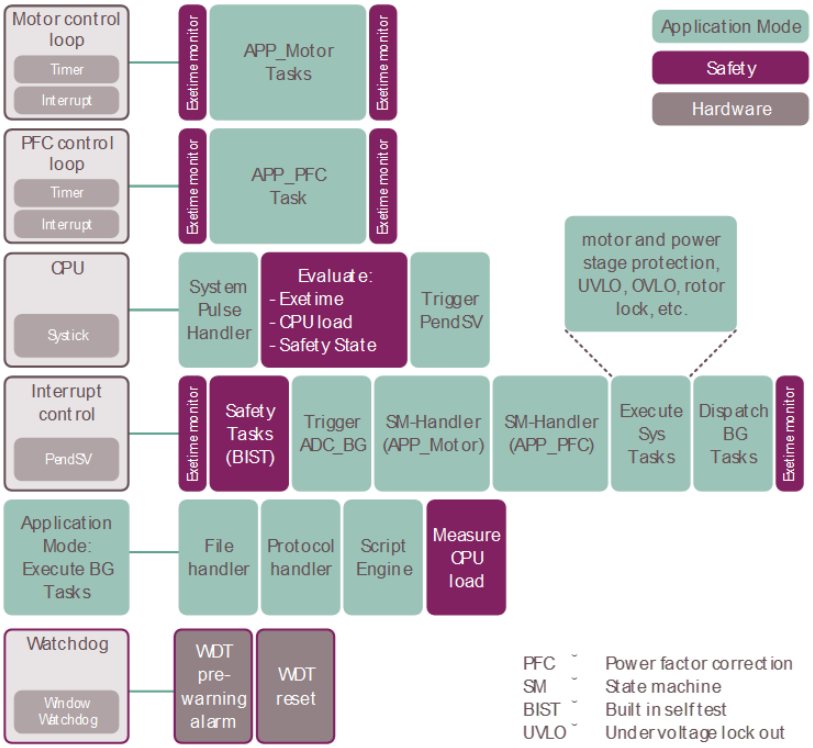

Fig. 5. Motion control task scheduler including safety tasks.

Integrated Security For Data Protection

Another important criterion in designing the new generation was data security. The data in the controller has to be protected from both modifications and from being read by an attacker. This refers to the motor control software (MCE) itself, the motor and PFC parameters and the scripts containing the adaptation to the customers' application.

Infineon provides the MCE itself on the website as an encrypted image. Upon installation, the motor controller itself is decrypting the image using an on-chip key. Customer scripts in turn are compiled in a compact byte code representation, and cannot be read from the chip once they are programmed. To protect the configuration parameter sets, a password protection scheme will be implemented in an upcoming release.

The integrity of the code, parameters and script is safeguarded via checksums, which are computed at every startup of the controller. In the previous generation of iMOTION, data security was left up to the customer.

Application Example—A Hair Dryer

An example of the increasing utilization of inverter-driven three-phase motors is show in Fig. 6.

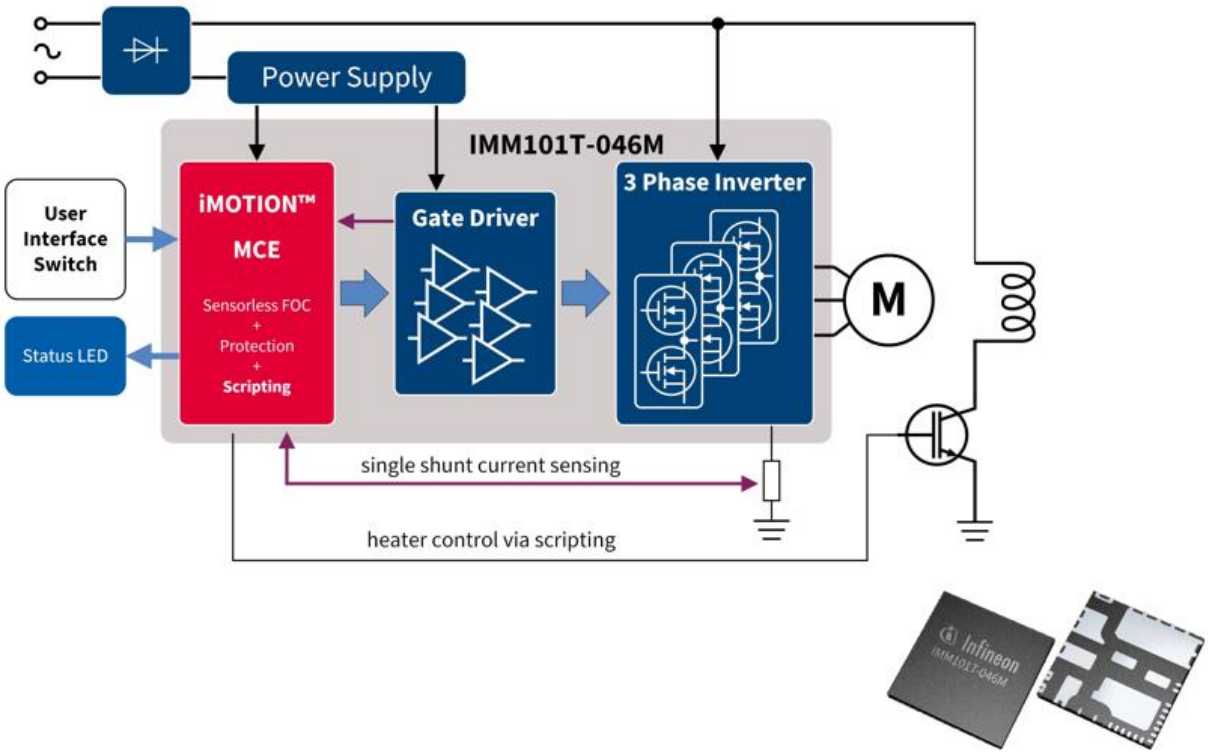

Fig. 6. BLDC-driven hair dryer. The functions shown in the gray box are contained in the 12-mm x 12-mm smart IPM pictured in the lower right hand corner.

With the exception of some high-end or professional models, almost all hair dryers have used simple brushed dc motors. But now several of the leading manufacturers have started to integrate three-phase motors.

Shown above is the design of a leading Asian manufacturer that uses an iMOTION SmartIPM. The SmartIPM integrates everything from the motor control software to the MOSFET power stage, resulting in a minimum bill-of-materials. On top of the ready-to-use motor control, the customer uses the iMOTION scripting language to implement all needed control functions like the heater switch or the user push buttons. Scripting also adapts the hair dryer to the different grid voltages of 230/110 V.

Summary

The new generation of iMOTION products builds on the success of more than ten years' experience and millions of appliances in the market. iMOTION motor control solutions can be used as a standard building block implementing a highly efficient variable speed drive. Even in cases where functional safety is required, the drive manufacturer does not have to dive into implementation details resulting in shorter design cycles and savings in R&D costs.

With a new hardware platform and a new software development procedure following modern agile design methodologies, these motor controllers are ready for the next generation of inverterized drives.

The ongoing development of motor-control building blocks has resulted in functionality improvements iMOTION 2.0 such as the closed loop start and enhanced catch spin control. New features like power factor correction, support for hall sensors, and initial angle sensing are now available. The scripting engine brings a significant amount of flexibility without any burden on hardware costs, and the safety certification reduces R&D efforts and time to market.

Future development efforts will bring further enhancements, and target the iMOTION ecosystem to improve the ease of use also for the non-experienced user.

References

1. IHS Markit Home Appliance Database All Devices and Associated Electronics, May 2018.

2. UL website.

About The Author

Ingo Skuras is the product marketing manager iMOTION at Infineon Technologies. In this role he focuses on motor control solutions for home appliances and small industrial applications. Ingo has more than 20 years' experience in the electronics industry. Prior to joining Infineon, Ingo held various positions in engineering, project management and marketing in companies like Siemens, Tyco and Vincotech. Ingo holds an engineering degree from the Technical University of Dresden.

For more on design of power converters for motion control, see How2Power's Design Guide, locate the Application category and select "Motion Control". Also, location the Power Supply Function category and select "Motor Drives".