Class B certification of inverterized motor control systems

Benefits of iMOTION™ 2.0 in meeting IEC/UL 60730-1 safety requirements

Abstract

Manufacturers of inverterized motor control systems used in home appliances need to design in measures to prevent their systems from becoming unsafe. The implementation and certification of these measures, called Class B control functions, represent a significant amount of development time and cost in the concept-to-production cycle of the motor control system.

Class B control functions at both the component-level and the system-level need to be implemented, documented and certified per the well adopted standard IEC / UL 60730-1. An engineering team developing a motor control system has traditionally been able to obtain component-level certification by using Class B libraries from the microcontroller supplier. System-level certification however represents majority of the certification effort, and the engineering team is left to design the software, carefully and extensively document the design, and then apply for certification proving conformity all on their own.

The iMOTION™ 2.0 turnkey solution represents a paradigm shift in the development of inverterized motor control systems. iMOTION™ 2.0 drastically lowers the barrier for inverterization by eliminating the need for engineers to develop motor and PFC control software. Furthermore, the motor and PFC control software included with iMOTION™ 2.0 is already Class B certified, covering component-level and system-level functions. Using iMOTION™ 2.0 thus simplifies the process for attaining IEC 60730-1 certification of a motor control system. Finally, iMOTION™ 2.0 allows for easier re-certification of derivative or upgraded motor control systems.

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1 Introduction

Household and commercial appliances need to be designed and built to prevent injury to their users or damage to the surroundings. Organizations like the IEC, International Electrotechnical Commission, develop standards governing the safety of appliances; other organizations like UL and VDE assess and certify the conformity of appliances to the standards. IEC 60730-1[1] is of particular relevance as it provides standards governing the safe operation of embedded hardware and software used in appliances.

Modern appliances like refrigerators, air conditioners, ventilation units and hydronic circulators utilize complex motor control systems to achieve high energy efficiency. These motor control systems are typically built with microcontrollers conducting the motor control algorithms as well as the system logic. Microcontrollers, on their own, are thus important components in the safety design of appliances. And as part of the overall system, which includes sensing inputs and the motor output processed via the embedded software, microcontrollers also become an important part of the system-level safety design of appliances. Safety standards consider both component-level and system-level safety features known as control functions. Appliances generally require Class B-level control functions.

iMOTION™ 2.0 is a complete solution for inverterized motor control systems used in domestic and commercial appliances. iMOTION™ 2.0 integrates motor, PFC and system control software in three hardware forms, hence providing a high performance motor control solution out of the box. By including both component and system-level Class B certification, iMOTION™ 2.0 drastically reduces the time and cost for developing an inverterized motor control system. This paper focuses on how iMOTION™ 2.0 simplifies the process of attaining UL 60730-1 certification for a motor control system.

Figure 1 **Embedded software and hardware in appliances like the refrigerator need to be designed to maintain a safe state in the event of failures or faults.**

2 Class B certification effort with iMOTION™ 2.0

Let's consider two independent engineering teams developing their first inverterized blower fan control system for an HVAC (heating, ventilation and air conditioning) unit. Team A takes the traditional route and uses a typical microcontroller platform. Team B uses iMOTION™ 2.0.

Team A must clear several technical and logistical hurdles in the design of their system before seeking an assessment of the conformity of their design from a certifying body such as UL. As described in Table 1, the team must design and implement component-level control functions that test the integrity of various microcontroller blocks periodically. The microcontroller supplier may provide Class B software libraries that the team could use when writing the software to perform component-level integrity checks. Should faults occur, they must write software procedures to put the system in a controlled state. Since documentation is key component of Class B certification, Team A must make and maintain ample documentation around the implementation of their component-level control functions.

Team B need not expend development or documentation effort to obtain component-level certification for their system. iMOTION™ 2.0 has built-in motor control software with component-level Class B certification.

Table 1 Component-level control functions

	Team A (MCU platform)	**Team B (iMOTION™ 2.0)**
Availability	Provided as a software library by MCU supplier	Built-in
Implementation effort	Software development and debugging using library	None

Team A now needs to dedicate development effort and time on the system-level integrity checks for the blower fan system. Table 2 describes the availability and implementation effort for system-level control functions. Unlike the component-level, the microcontroller supplier does not typically provide any aides for system-level integrity checks. How will the software and system-level hardware handle a loss of a motor phase? What about a motor winding short? What if the communication to the blower fan controller fails? Control functions are categorized as Class B if they prevent the system from entering an unsafe state. Team A needs to document the details around the implementation of their control functions and do a detailed failure mode and effects analysis (FMEA) on the system. The team will make appointments with the certifying agency and during one of possibly several meetings, review with the certifying agency their FMEA and documentation around the implementation of control functions. Finally, Team A will need to demonstrate in front of the certifying agency the performance of their control functions under simulated failures. The entire Class B design and certification effort can easily take 9-12 engineer-months. Figure 2 describes this effort with a typical flow chart.

Team B does not need as much time to achieve system-level Class B certification. iMOTION™ 2.0 comes with Class B certification of system-level control functions including motor phase loss protection, overcurrent protection, UART link break protection etc. Infineon has completed the Class B certification process so that Team B does not have to do so. The typical concept to production cycle of a motor control system with iMOTION™ 2.0 is depicted in Figure 3.

Table 2 System-level control functions

	Team A (MCU platform)	**Team B (iMOTION™ 2.0)**
Availability	Not provided by MCU supplier	Built-in for PFC, motor & communication
Implementation effort	Significant: Requires hardware & software implementation, documentation and certification process	Low

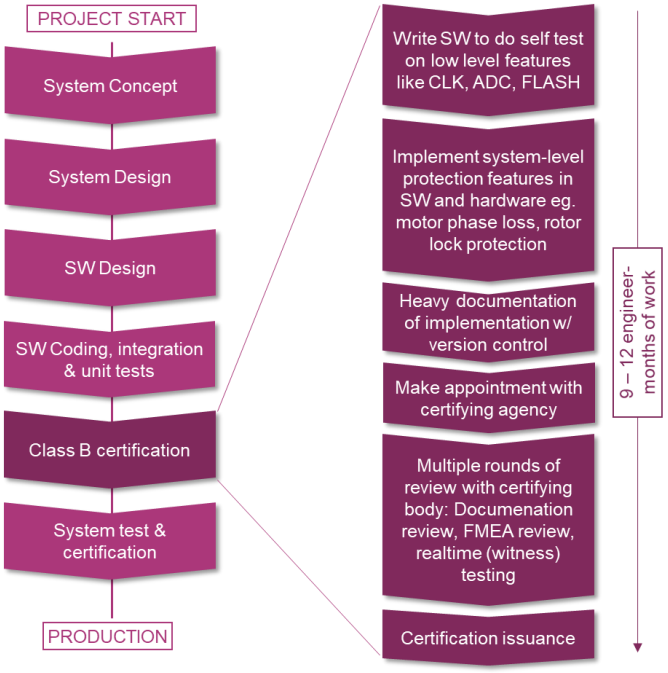

Figure 2 **Class B certification process (right) portion of the concept to production cycle of a microcontroller-based motor control system**

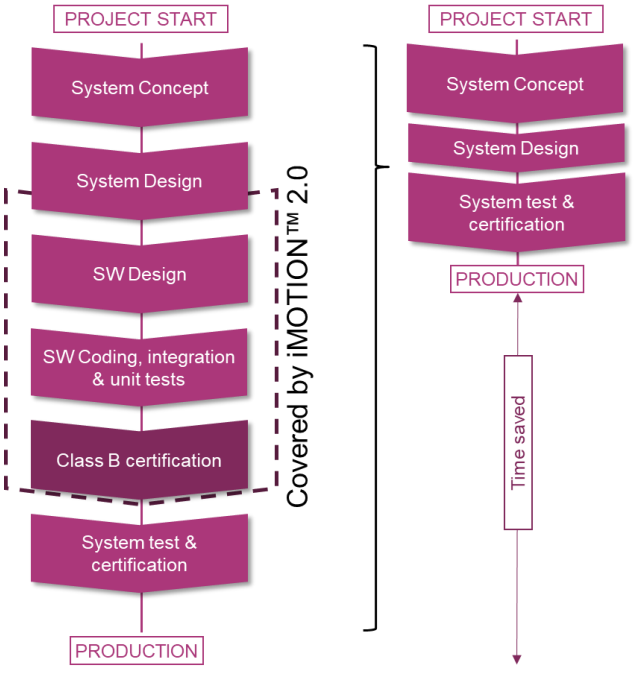

Figure 3 **Typical concept to product cycle of an iMOTION™ 2.0-based motor control system**

Refer to the Application Note AN2018-22 for details about the Class B safety implementation in iMOTION™ 2.0. The AN also covers hardware configurations that provide Class B certified system protection including from Overcurrent events [2].

3 Upgrading a motor control system

It is not surprising that engineers of Team A will feel a sense of relief to receive a certificate of Class B conformity because of the heavy effort they dedicated to prepare for the assessment of their motor control system. Unfortunately for them, the certification is strongly tied to the design of their system. A change to or upgrade of the design may require recertification effort.

Examples of design changes that would trigger a recertification include:

1. Hardware change - change in shunt resistor type, comparator, motor etc.
2. Addition of new hardware blocks – temperature sensing circuit, PFC etc.
3. Motor control software change – addition of new protection functions, improved algorithms, bug fixes etc.

The development effort required to support the Class B recertification of a motor control system can range from weeks to months of engineer time. It is not surprising therefore that motor control system makers tend to be resistant to changing core aspects of their designs.

Let's consider an example that requires a recertification. Team A wants to release a second model of the blower fan control system featuring a new premium thermal overload protection feature. Team A will add this new feature to the original certified design. A typical software implementation for the thermal overload protection feature would follow these steps:

1. Apply an integral function over the excess measured motor current (i^2t function).
2. Compare the measured value to a predetermined threshold for that motor.
3. If exceeded, issue a motor STOP command and transition to a fault state.

Team A would need to provide the following items to the certifying agency for a re-certification of the motor control system:

1. Version control documentation around the addition of the new software.
2. An inspection of the new software's dependency to existing current sensing software functions.
   - If the existing current sensing functions need to be modified, the recertification effort includes not only adding part of thermal overload function but also a re-review of the current sensing functions. This process takes almost as much effort as the original certification effort.
   - To make recertification easier, Team A should use a separate and redundant current sensing hardware component. However this approach will add to the hardware cost and require a hardware revision.
3. An FMEA considering the new software addition.
4. Test proof or a demonstration of the test in the presence of the certifying agency.

Team A faces an arduous and lengthy process to recertify the motor control system.

Using iMOTION™ 2.0, Team B faces a simpler and easier process rolling out the new premium thermal overload protection feature. Team B would add the new feature into iMOTION™ 2.0 using the Script language. Team B need not worry about dependencies to the existing current sensing software functions as these functions are locked in iMOTION™ 2.0 and cannot be modified. New, redundant current sensing hardware is not needed. For test proof, only the Script language based implementation results need to be provided. Note that application code written in iMOTION™ Script is not Class B certified.

Engineering teams using iMOTION™ 2.0 need not worry about the recertification effort for many types of design changes. Infineon recertifies each upgrade of the iMOTION™ 2.0 motor control software. iMOTION™ 2.0 thus allows customers to use the latest motor control features their motor control systems without worrying about the time and cost to re-certify their products.

4 Summary

Engineers of motor control systems used in domestic and commercial appliances need to design their systems with consideration of the safety of the end user and their surroundings. The effort involves careful system design work, software development, FMEA studies, version control maintenance and heavy documentation. The development cost and time associated with certification can be significant, on the order of 9-12 engineer-months. System engineers using iMOTION™ 2.0 can save a lot of this development effort and cost thanks to the advanced software implantation that comes out of the box and the already certified Class B component-level and system-level functions

References

[1] IEC: "IEC 60730-1: Automatic electrical controls – Part 1: General requirements (Edition 5.2)," 2020-04 (www.iec.ch)

[2] Infineon: "Application Note AN2018-22 (V1.2): Safety Class B with iMOTION™," 2020-08-25

Revision History

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1.1	Aug 20, 2020	Minor revisions

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