

by Willie Fitzgerald and Greg Robinson

# NAVIGATING AUTOMOTIVE BODY-CONTROL DESIGN CHALLENGES

As electronics growth continues to outpace mechanics, pneumatics and hydraulics, OEMs are facing increasing challenges in manufacturing vehicles that are safer, smarter and more energy efficient. Electronic control modules are helping to address these issues.

The continued advancements of electronics within the vehicle are being driven by the challenges that automotive OEMs face in making their vehicles safer, smarter and more energy efficient. Electronics continues to be the fastest growing sector of automotive content, over mechanical, pneumatics and hydraulics. Embedded systems designers continue to develop new electronic control modules (ECMs), to enable targeted vehicle features that address the desires of the driver. Most of the growth in automotive electronics can be attributed to the growing demand for more safety, comfort, security and driver-information applications. This growth is being stimulated by both consumer preferences and governmental actions, in an environment where the OEMs are cost conscious due to the competitive global market.

Flash-based, highly integrated, power-managed microcontrollers (MCUs) are not only the cornerstone of the ECM, but are the key enablers that support embedded system designers in overcoming the significant challenges that are encountered in implementing new features. Challenges range from power

consumption and space constraints to ECM connectivity for diagnostics capability, while remaining cost sensitive. The subsystems suppliers are continuously working with their own suppliers to develop innovative solutions that are reliable and cost effective. Addressing challenges with competitive solutions is the prevailing environment of today's automotive embedded system designer.

### CHALLENGE: STAYING WITHIN THE POWER BUDGET

With increased electronics penetration across the spectrum of applications within the vehicle, the number of ECMs continues to expand—taxing the vehicle power budget. Some higher-end vehicles can have more

than 80 ECMs, which means that current loads are increasing. An increase in battery size to support the growing power requirements is an alternative to overcoming this challenge. However, larger batteries do not always provide a good trade off in an environment where space is limited and weight is critical, due to the negative impact on fuel consumption.

A better alternative is to address the power-consumption requirements of those ECMs that consume power when the ignition is off. With more power loads present when the ignition is off, such as keyless entry and infotainment systems, automotive OEMs are moving toward tightening their ignition-off power budget to less than 1 mA per ECM. A family of power-man-

Multiple Enhanced Power-Managed Modes	<ul style="list-style-type: none"> <li>• Alternate Run Modes</li> <li>• Multiple Idle Modes</li> <li>• On-the-Fly Mode Switching</li> <li>• Low-Current Timer 1 and Watchdog Timer</li> </ul>
Flexible Clock Switching	<ul style="list-style-type: none"> <li>• Multiple selectable oscillator options</li> <li>• Wide range of hardware choices</li> </ul>
Dual-Speed Startup	<ul style="list-style-type: none"> <li>• Immediate startup via internal oscillator</li> <li>• Code execution during clock startup interval</li> </ul>
Fail-Safe Clock Monitor	<ul style="list-style-type: none"> <li>• Main clock source monitoring against a reference signal</li> <li>• Internal oscillator block implementation on failure</li> </ul>

Table 1. Ideal power-managed features in a microcontroller family.



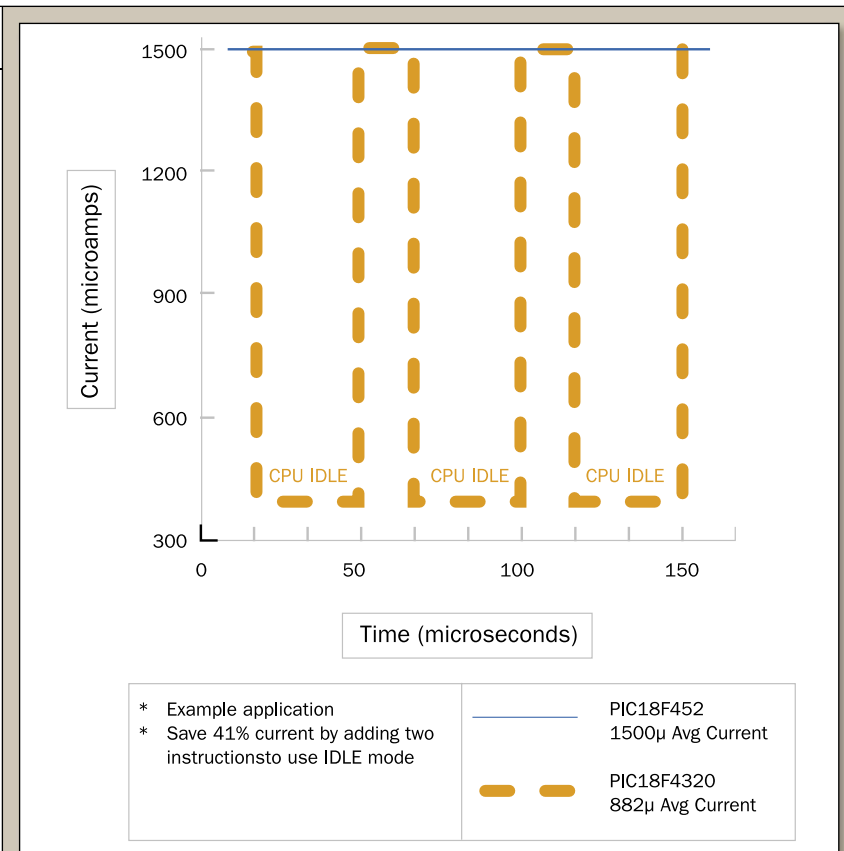


Figure 1. Power-saving application example. (Source: Microchip Technology)

aged microcontrollers is a key enabler for embedded system designers, in this environment where a high value is placed on energy-efficient operations without sacrificing performance.

Power-managed microcontrollers offer the designer on-chip flash memory, maximized system efficiency, increased system robustness and minimized costs and board space by eliminating external components. Multiple power-managed modes offer designers the flexibility of switching between modes, and incorporating power-saving routines in the application software. The innovative solutions developed to enable microcontrollers to be more efficient in performing power-management duties are welcome tools for the automotive embedded system designer. It's desir-

able for the microcontrollers to provide flexible power-managed technology over their operating-frequency range. The power-managed microcontrollers must be versatile and give designers technically feasible, cost-effective options to address the complex challenges associated with reliable low-power operation in the advanced automotive body-control systems.

Table 1 summarizes some of the power-management features to consider in selecting a microcontroller family for your body-control electronic modules.

The ideal microcontroller family will provide the designer with a platform to innovate creative power-saving routines. This platform should include a comprehensive array of on-chip peripherals with selectable oscillator options and multiple crystal

modes, external clock modes, external RC oscillator modes, plus an internal oscillator block that generates multiple clock frequencies under software control. Figure 1 shows a power-saving example, based on a power-managed microcontroller.

Low power and dependable operation are key considerations in the development of body-control ECMs. Figure 2 shows the range of functions that are needed in a power-managed microcontroller to enable flexible control and optimum low-power operations, which minimizes overall current draw and reduces power consumption.

Key on-chip building blocks for reliable low-power operation include an internal oscillator, sleep modes, power on reset (POR) function, brown out reset (BOR), device reset timer (DRT) and power up reset timer (PWRT). The internal oscillator is critical for enabling the necessary performance requirements of a power-managed microcontroller. Adjustable performance of the internal oscillator, while maintaining stability over the voltage and temperature ranges, enables an array of options.

With a number of oscillator options available on the microcontroller, the designers are able to gain tighter control of their ECM's power consumption, adapt to changes on the fly and reduce external components, delivering enhanced performance with reduced system cost.

Sleep modes minimize average power consumption by putting the microcontroller to sleep during inactive periods and waking up only when necessary to perform a designated task. DRT or PWRT are based on an internal timer that keeps the microcontroller in reset and allows sufficient time for the supply voltage and the internal oscillator to stabilize. POR is based on internal circuitry, which ensures that the supply voltage of the microcontroller has achieved a minimum good voltage level before releasing the DRT. The BOR ensures reliable operation of the microcontroller by resetting the microcontroller when the supply voltage spikes below the normal operating voltage. Power-managed microcontrollers provide designers with the flexibility to create the appropriate embedded solutions for

their project, with minimized current draw and reduced power consumption.

### CHALLENGE: ADDRESSING INCREASING PERFORMANCE REQUIREMENTS IN A SPACE-CONSTRAINED ENVIRONMENT

The growth of body-control ECMs can be attributed to the desire of car-makers to address the functional requirements of targeted automotive buyers. As a result of this ECM growth, available space is limited. The microcontrollers being used are expected to have a high level of on-chip peripherals, both digital and analog, to support the overall goal of conserving space. Figure 3 shows the wide range of on-chip peripherals available with most microcontroller families in today's market.

Though microcontrollers can be viewed as building blocks for ECMs, it's important to note that one size does not cover all requirements. It's critical that a broad range of compatible microcontrollers is available to designers, which allows the selection of the appropriate microcontroller for the specific application being designed.

The compatible-family concept is most powerful when both software and pin-out compatibility are sustained.

The microcontroller architecture is critical to supporting software migration. The more popular microcontroller architectures in the industry support a broad migration path, where their upward compatibility is tailored to optimize processing efficiency and performance. For

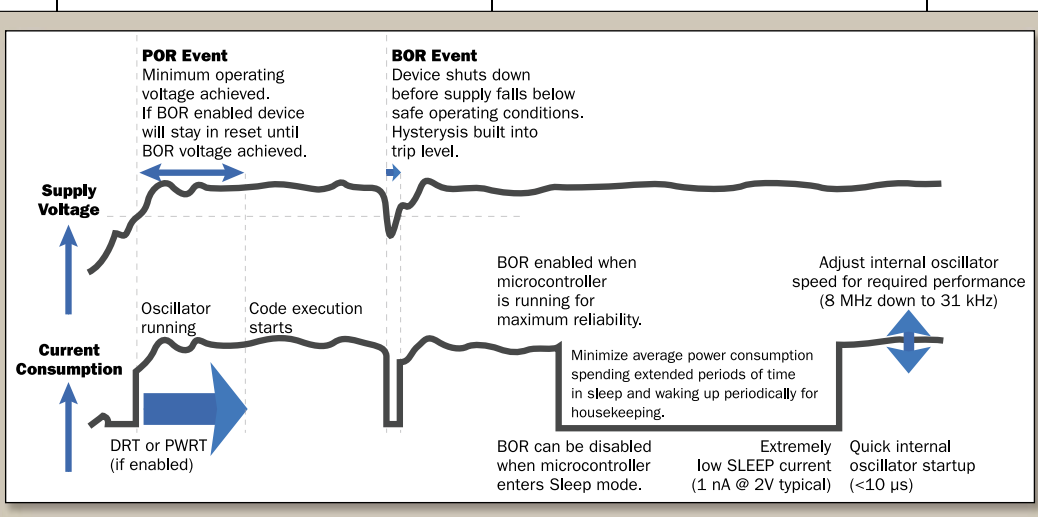


Figure 2. Microcontrollers can employ multiple modes and methods to reduce power consumption.

example, the PIC microcontroller architecture combines RISC features with a modified-Harvard, dual-bus architecture, where instructions and data are transferred on separate buses. As a result, processing bottlenecks are avoided and the overall system performance is improved.

Strong migration compatibility facilitates reusable engineering blocks that are instrumental in saving valuable development time and overall costs.

Compatibility is the key to re-using microcontroller designs. The standardized pin-out schemes of microcontroller families are desirable, since they support the development of a code library that is usable across a broad range of applications. A microcontroller architecture that provides socket, software and peripheral compatibility will deliver superior flexibility to the designers. For example, when each pin is capable of accommodating several peripheral functions, designers can add or swap functionality without changing the printed circuit board. The end result is minimized or eliminated re-design costs.

Reuse of proven engineering blocks not only saves time and costs, but it can also directly improve the overall system quality—since the engineer has access to performance from earlier designs and is able to apply the appropriate lessons learned to the current design. Ultimately, overall product development efficiency is gained from compatibility and reusability, which is critical in the current industry environment where experienced embedded designers are limited.

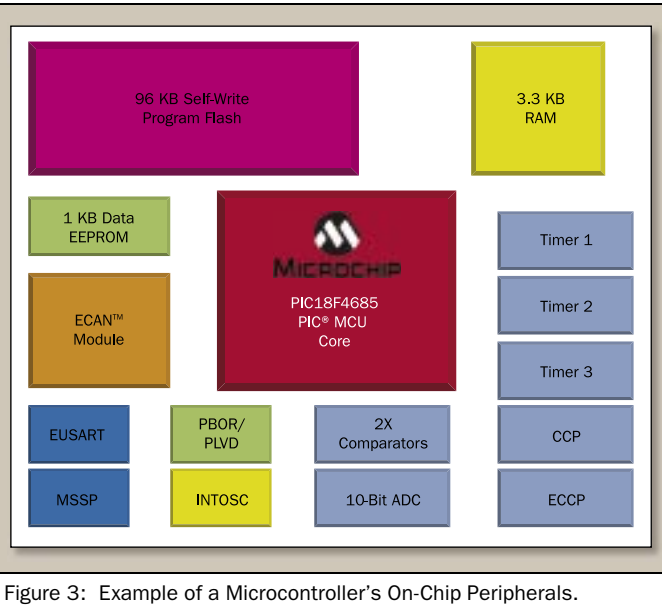


Figure 3: Example of a Microcontroller's On-Chip Peripherals.

### CHALLENGE: ENABLING COST-EFFECTIVE CONNECTIVITY OF THE DIVERSE SET OF ECMS IN THE VEHICLE

The growing number of ECMS within the vehicle creates an environment for the “networked” vehicle. Body-control electronics improve the comfort and safety of vehicle occupants. Advancing body-control electronics are essential in order for car manufacturers to produce smarter vehicles that are pleasing to drive, reliable and safer. Body-control electronics improve the vehicle’s safety factor by simplifying its operation and releasing the driver from distracting secondary activities. Networks are a key element of the vehicle’s electrical architecture. A single network protocol cannot satisfy the broad range of applications throughout the car. The architects of the car’s electrical systems are challenged to define the appropriate network protocol to achieve the desired performance within the targeted budget. So, the selected network protocol must be matched with the appropriate application where the price/performance requirements are aligned.

Once defined by the car’s architect, the challenge to stay within the cost budgets are requirements that embedded system designers must satisfy. Figure 4 shows the various communication networks used within the vehicle, along with the relative cost to implement a node for each. Two of the most popular automotive networks are the controller area network (CAN) and local interconnect

network (LIN).

CAN offers a multimaster hierarchy, which supports the development of intelligent, redundant systems. In this type of network, if a network node is defective, the network remains functional. Messages are still broadcast across the network. All nodes receive the messages, and are able to read the message and determine whether it is relevant to them and requires any action. In this environment, data integrity is ensured—as all nodes of the system use the same information. Data integrity is supported via error-detecting mechanisms and retransmission of faulty messages.

The LIN protocol is a holistic communication concept for smaller vehicle networks. The specification covers the definition of the protocol and the physical layer, as well as the definition of interfaces for development tools and application software. LIN enables a cost-effective communication network for vehicle switches, smart sensor and actuator applications where the bandwidth and versatility of CAN is not required. This communication protocol is based on the SCI (UART) data

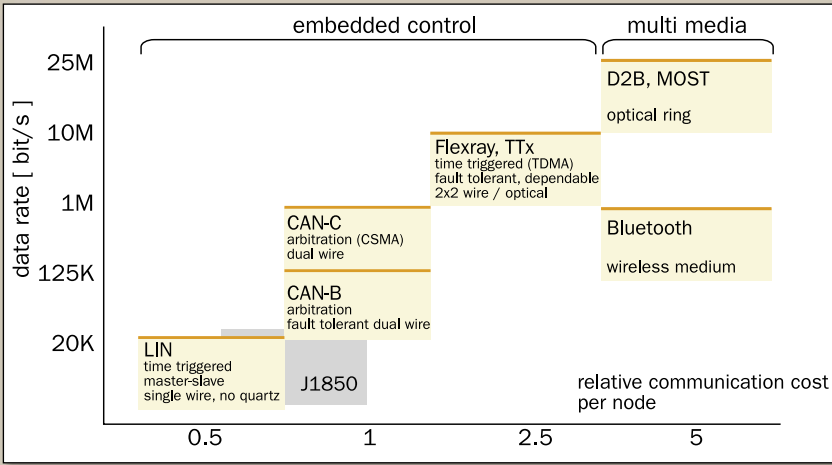


Figure 4. Automotive networking protocols.

format, with a single-master/multiple-slave concept, with a single-wire 12 V bus and clock synchronization for nodes without a stabilized time base.

With LIN residing in low-end applications, two factors are critical: first, the communication cost per node must be significantly lower, compared with CAN; second, the performance, bandwidth and versatility of CAN are not required. The main cost savings of LIN versus CAN are derived from: 1) the single-wire transmission, 2) the low cost of implementation as hardware or software in silicon, and 3) the avoidance of crystals or ceramic resonators in slave nodes. The main features of the LIN and CAN protocols are shown in

Table 2.

Microcontrollers with on-chip peripherals to support the CAN and LIN communication protocols are available to embedded system designers. Gateway microcontrollers are used to provide the transition between the high-speed and low-speed CAN buses, as well as between the low-speed CAN bus and other networks—such as the multimedia, fiber-optic point-to-point network and the media-oriented systems transport (MOST) protocol. LIN is a sub-bus network that can directly connect to the CAN network. The integrated microcontroller support of these communication protocols facilitates the trend to reduce component count and system costs for

	LIN	CAN
Medium Access Control	Single Master	Multiple Master
Typical buss Speed	2.4 to 19.6 kbd	62.5 to 500 kbd
Multicast Message Routing	6-bit Identifier	11 / 29-bit Identifier
Typical Number of Nodes	2 to 10 Nodes	4 to 20 Nodes
Encoding	NRZ 8N1 (USART)	NRZ with Bit Stuffing
Data Byte per Frame	2, 4, 8 Byte	0 to 8 Byte
Transmission Time for 4 Data Bytes	3.5 ms at 20 kbd	0.8 ms at 125 kbd
Error Detection	8-bit Checksum	15-bit CRC
Physical Layer	Single Wire, Vbat	Twisted Pair, 5V
Clock Generation	Master: Crystal, Slaves: RC/Resonator	Crystal
Relative Cost per Node	0.5	1

Table 2. Overview of LIN and CAN protocols.

the increasing number of ECMs within the vehicle.

### SUMMARY

In the quest for increased comfort and safety in the modern car, the car is becoming increasingly more intelligent. Microcontrollers are a vital tool for the embedded system designers of automotive electronic modules to address the challenges associated with:

- Implementing cost-effective networks of ECMs within the vehicle.
- Delivering targeted functionality within the allocated space parameters.
- Adhering to the allocated power budgets.

Power-managed microcontroller families with a broad range of integrated peripherals provide the designer with flexibility and options to create innovative, compact, cost-effective advanced solutions that meet the expectations of the automotive consumer. Uncompromising flexibility is a significant factor in reducing the time to market for the ECM being developed. ■

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### ABOUT THE AUTHORS

*Willie Fitzgerald is director, product marketing, Automotive Products Group, Microchip Technology Inc. Greg Robinson is manager, applications engineering, Automotive Products Group, Microchip Technology Inc.*

