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16-bit microcontroller C167R with full-CAN module:

Tuning up automotive networks with the CAN bus

Serial CAN buses in motor vehicles simplify monitoring of the engine management system as well as wiring. For networking of automotive electronic systems, Siemens has added the SAB C167CR-LM microcontroller with integrated full-CAN module to its 16-bit product family. Mercedes Benz, for example, is using this Siemens microcontroller for engine management in its new E class.

Serial communication systems in motor vehicles must be absolutely safe if they are to operate reliably in environments exposed to strong electromagnetic interference (from ignition coils or nearby radio transmitters, for example). A distinction must be made here between interference with components caused by radiation (e.g. from car radios, traffic information systems or airbags) propagated through the vehicle's electrical system and interference caused by spurious emission of radiation (such as sparks from electronic ignition systems). The higher the transmission rate of a serial network, the costlier electromagnetically compatible design becomes. The CAN* bus meets the demand for high insusceptibility to electromagnetic interference because it has been specially designed for automotive electrical systems, where networks are left partially unshielded on grounds of cost. So the security mechanisms implemented by the CAN protocol definition, such as bit stuffing errors, CRC check errors, bit, format or acknowledge errors, already yield distinct advantages. CAN buses used in motor vehicles can be divided into two classes which differ, according to requirements, in their data transmission rates, physical drivers and cable layouts.

* Licensed by Robert Bosch GmbH

CAN bus in body electronics

Body electronics includes systems such as central door locking, sun roof control, car radios, seat height adjustment, seat heat-

ing, airbags or multifunctional displays for satellite navigation. Networking with the CAN bus enhances convenience at moderate cost because the status of all these systems can be displayed on the dashboard and the cause of any fault can be directly indicated to the driver (or service staff in the dealership). Servicing is also simplified because the CAN network of the vehicle has a connector which interfaces with an external diagnostic system. Faults can thus be diagnosed without removing the component in question. In these applications, system costs for the physical driver and the microcontroller with its on-chip CAN module must be kept to a minimum. CAN's low data rates in the region of 40 kbit/s help keep design costs down.

Other benefits of the CAN bus are simplification of cabling, with resulting savings in weight, space and cost, as well as improved convenience and quality. In many applications, the cable harness, which is cluttered up by a growing number of electronic controllers, for example, must be significantly reduced in total length, girth and complexity. Serial networking with the CAN bus has the advantage that in an ideal configuration only four wires have to be run to each load, all loads being connected in series.

CAN products currently available

The SAE 81C90/91 standalone CAN module is a flexible interface between CAN and microcontroller. In industrial electronics in particular, several serial communication interfaces, some of them very different, must often be served concurrently. For this purpose, a control unit must be designed with a Profibus interface, a CAN interface or an interbus-S module. In such cases, a standalone CAN component can be used optimally by implementing a plug-in module with the appropriate component (SAE 81C91) on the actual control unit.

The C167CR is the current full-CAN implementation in the field of standard 16-bit controllers. Its CAN module supports CAN protocol version V.20 B (active) and is therefore suitable for both industrial control applications (converters, SPCs, 11-bit or 29-bit arbitration frames) and automotive electronics.

As control units become smaller, more numerous and more closely packed, and EMC regulations tighter, the resulting space and radiation problems preclude the use of an external CAN controller in many applications. The situation is similar with power converters linked to CAN, because the nature of the application (three-phase converter from a DC voltage link circuit with field-oriented control to drive an asynchronous machine) imposes a very high processing load on the CPU.

	SAE 81C90/91	SAB C167CR-LM
CAN classification	Standalone	16-bit microcontroller
Protocol version	V2.0 Part B passive	V2.0 Part B active
Basic CAN feature	X	X
Full-CAN feature	X	X
Number of communications objects for		
– Basic CAN	1	1
– Full CAN	15, 16	14

CAN bus in engine management

Engine control components include ABS, drive slip control, suspension control, electronic acceleration, gearbox control and engine management. Decisive factors in networking these components are application of only a low load to the CPU by the on-chip CAN interface and a communication system capable of real-time operation (faster than 100 kbit/s). The paramount goal of networking engine management components today is improved environmental performance at low cost, i.e. low emission levels and low fuel consumption, accompanied by optimum interoperation of all components in the engine management system.

In addition, tougher environmental legislation insists that service staff at dealerships be able to diagnose increasingly complex control equipment. This means that all relevant sensors and actuators as well as all controller functions throughout the vehicle must be monitored, and any deviations from specified values detected, recorded in an error memory and transferred via a defined interface to an appropriate vehicle diagnostic system as required.

OBD II (on-board diagnosis) legislation calls for monitoring of all functions of an engine management system relevant to exhaust emissions. Thus a second lambda probe, for example, must permanently monitor the conversion rate of the catalytic converter. Regulation of the secondary air quantity must likewise be monitored to maintain the optimum exhaust/air ratio, and any malfunctions must be either adaptively corrected or, failing that, logged as malfunctions. All this calls for significantly higher performance from automotive CAN controllers. OBD I and OBD II requirements can thus account for as much as 50% of the performance available from the microcontroller used in the engine management module.

C167CR:
Ideal controller for the CAN bus

The C167C*16-bit microcontroller (**Fig. 1**) has been specially designed for automotive applications in the range from –40 to +125 °C. Its peripheral functions, interrupt structure and short instruction processing time as well as a modular design with four internal bus structures ensure adequate reserves of processing power for the CPU. Even the stringent OBD II requirements for reduced fuel consumption and emission levels can easily be satisfied. At the same time, optimum networking of the various controllers via the extremely powerful full-CAN interface on the XBUS of the C167CR reduces CPU load significantly in comparison with an external standalone CAN module.

*PRO ELECTRON designation: SAK-C167CR-LM

Features of the C167CR

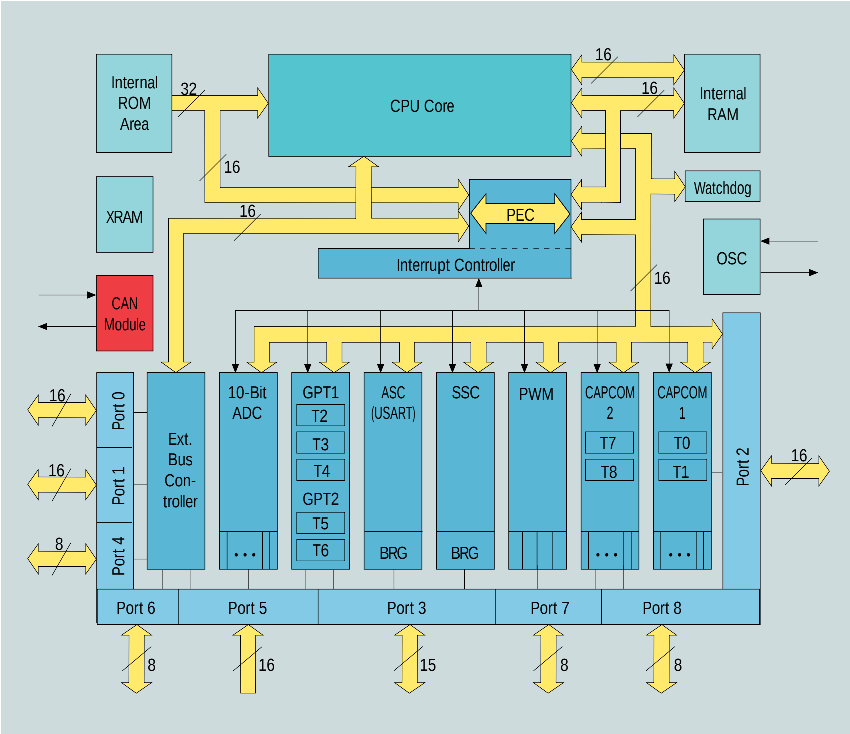

Fig. 1 The C167CR 16-bit microcontroller with full-CAN module satisfies the most stringent requirements in automotive engineering

- Two capture/compare units with 16 channels can be used either as a capture input with interrupt function (pulse width measurement) or as a compare output (PWM signal for D/A converters or injection time generation). Highly complex time-dependent signals can be generated and measured with a variety of interlinking facilities, including other timer units, and with the aid of five different and largely autonomous operating modes.
- A PWM unit with four independent, user-programmable channels, each channel possessing a 16-bit timer with 50 ns resolution. This unit can be used to generate asymmetrical and symmetrical PWM signals as well as burst and single-shot functions. The four timers can be started synchronously.
- A synchronous interface (SSC) with full-duplex capability can be used with its own baud-rate generator in master or slave mode at transmission rates up to 5 Mbit/s. The protocol is SPI-compatible and supports word lengths from 2 to 16 bits. The user can also select whether LSB or MSB is to be sent first.
- 16-channel A/D converter with a resolution of 10 bits and a conversion time of 9.6 µs. With effect from the current version, the A/D converter is self-calibrating. Various operating modes, and programmable conversion and sample times allow more flexible matching to highly resistive sensors, for example. The additional operating modes can be exploited to convert a channel (triggered by software, an interrupt or a compare signal) in burst mode, whereas another ten channels, for instance, can be simultaneously operated in continuous auto-scan mode.
- Five timers of GPT1 and GPT2 all have a count and a direction input, so that a maximum of five incremental emitters can be evaluated in parallel.
- A PLL oscillator ensures higher reliability should a crystal break (emergency operation features) and improved EMC. In addition, an interrupt is triggered if the crystal oscillator or external clock supply fails.
- 111 I/O port pins.
- An interrupt structure with separate vectors for almost all of the 56 sources.
- 4K bytes of internal RAM, permitting code access to 2K bytes in 100 ns (at 20 MHz).
- Address space with a code and data area of 5M bytes (if the CAN interface is used) or 16M bytes (if the CAN interface is not used), specially designed for control applications in which larger volumes of data must be processed.
- Access to various components without address decoding logic with five BUSCON registers and assigned chip-select signals. This can be done regardless of whether the addresses are 8-bit or 16-bit, whether the bus is multiplexed or non-multiplexed, or whether wait states, ALE lengthening or memory-tristate wait states have to be specified when the various components are addressed.
- Instructions based on brief blocking of all interrupts (for one to four instructions). The pipeline structure is then circumvented. Semaphore instructions needed in operating systems can thus be implemented very simply and efficiently. Memory access is optimized for larger programs as well.
- A PLL with a multiplication factor (0.5/1/1.5/2/2.5/3/4/5) configurable via port 0.
- Input switching thresholds switchable between TTL and CMOS levels at ports 2, 3, 7 and 8.
- An XBUS interface for extension of the C167 without compromising the C167 standard.

This extensive range of features plus an outstanding price/performance ratio makes the C167CR the ideal partner for the CAN bus in high-end automotive applications. ☐

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