Axel Wolf

Connecting the C166 architecture to CAN (I)

Controller area networks (CANs) are becoming increasingly popular, especially in automotive and industrial electronics. The C167Cx is the first derivative of the C166 16-bit microcontroller to have an integrated CAN module. But other members of the Siemens C166 family can also join the dialog on the CAN bus via the SAE 81C90/91 standalone full-CAN controller, which has proved particularly flexible when connected to the host controller or the physical layer of OSI.

Salient features of the CAN protocol are high transmission speed and short latency, a multimaster concept plus comprehensive error detection and elimination. Bus access control by the message identifier, high electromagnetic insusceptibility and multicast capability also account for the growing popularity of CANs in automotive and industrial electronics. A CAN license has been granted by Bosch, so that CAN modules from Siemens can now be used without restriction. The first part of this article presents the C167Cx and other members of the C166 family along with the SAE 81C90/91 CAN controller. Three specimen circuits will show how these modules give easy, reliable access to CAN.

Connecting an SAB 80C166-M to CAN with the SAE 81C90/91

The SAB 80C166, a powerful 16-bit microcontroller which has been on the market for about four years, is the basic building block of the C166 family. It contains a RISC-like, register-bank-oriented CPU with a four-stage pipeline which ensures that most of the 76 instructions can be executed in a single machine cycle of 100 ns. The user-programmable interrupt system contains 32 independent sources with 16 priority-setting levels and has response times of only 300 to 500 ns. The SAB 80C166 also contains autonomous peripherals of modular design, such as a 10-bit A/D converter with ten channels, a capture/compare unit, two serial interfaces and two complex timer blocks. The controller has 1K bytes of internal RAM and, depending on derivative, another 32K bytes of memory, either as on-chip ROM (in the SAB 83C166-5M) or flash EPROM (SAB 88C166-5M), plus a bootstrap loader. The entire architecture is designed for rapid processing of instructions and minimum response times for external events. CAN modules from the Semiconductor Group thus offer maximum real-time performance for a wide range of applications, especially in industrial automation and control, and in automotive electronics.

CAN controllers SAE 81C90 (P-LCC-44 package, two 8-bit I/O ports) and SAE 81C91 (P-LCC-28 package, no I/O ports) contain all elements required for autonomous transmission and reception of CAN protocol messages, and can be clocked at up to 20 MHz. They support CAN specification V2.0A (B passive), i.e. they can process messages provided with the 11-bit standard identifier. Messages with 29-bit extended identifiers are not stored, but tolerated. Various implementations of the physical layer (ISO/OSI layer 1) can be connected by means of a flexible, programmable interface. The connection to the host controller can be set up either in parallel via a multiplexed 8-bit address/data bus compatible with Siemens microcontrollers (SAB 80C5xx, SAB 80C166, SAx-C16x) or serially by means of a very fast synchronous interface (>1 Mbaud). All module functions are then controlled from the user CPU via the 8-bit control register. Software drivers from various CAN tool suppliers are already available for the SAE 81C90/91.

The SAE 81C90/91 can administer 16 CAN message objects. Each of these comprises eight data bytes and two descriptor bytes containing important information about the configuration of the relevant object. Objects 0 to 7 additionally possess two time-stamp bytes, from which the currency of the data in the data bytes can be inferred. Object 0 can be configured to receive all messages that are not covered by the other memory locations. This module, too, thus offers the basic CAN feature.

Another special feature of the SAE 81C90/91 is its transmit check unit. Via the normal receive path, this reads back from the bus interface a message which has just been sent and compares it with the received data. In this way, the module monitors on-chip conversion of data stored in parallel to the serial bitstream, a procedure which is not covered by the CAN protocol.

Fig. 1 depicts connection of an SAB 80C166-M ("M" stands for the P-MQFP package) with the SAE 81C90. Both controllers are connected via the multiplexed 8-bit bus (address/data lines AD0 to AD7, signals WR#, RD#, ALE). This parallel connection is selected by applying a low logic level to pin MS (a high level would activate the serial interface). With the aid of the remaining address lines AD8 to A17, the chip-select signal for the CAN controller (low/active) can be generated via decoding logic, depending on the external memory configuration. The SAB 80C166-M can use the multiplexed 8-bit bus for the corresponding memory range, and the faster non-multiplexed 16-bit bus, for example (with individual bus timing in each case), for the remaining addresses.

The SAE 81C90 obtains its defined reset via the RSTOUT# pin of the SAB 80C166-M. The INT# interrupt output of the CAN module is routed to a capture/compare input of the host controller (P2.0 in this case). Via this line, the CAN controller can report incoming messages. A 40 MHz quartz oscillator feeds the SAB 80C166M, whose CLKOUT pin in turn supplies the CAN controller, with 20 MHz clock information.

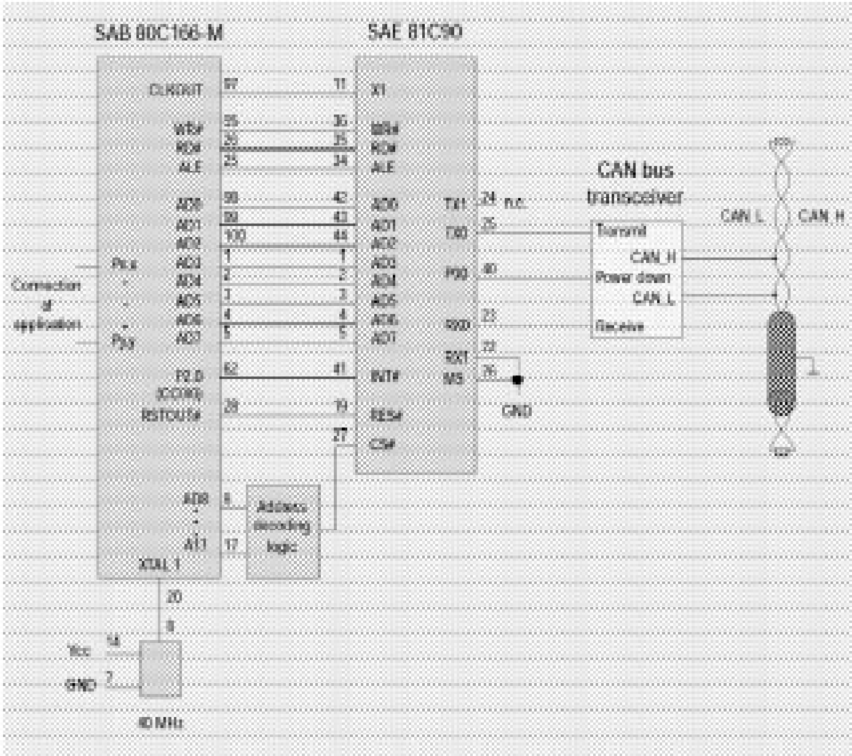


Fig. 1 Connection of an SAB 80C166-M to CAN via the SAE 81C90 (parallel)

The SAE 81C90 contains no implementation of the physical layer, as this was intentionally left undefined in the CAN protocol specification. A transceiver must therefore be used. This driver module is connected to the SAE 81C90 via pins TX0 (transmitter output 0, set by software as a push-pull output) and RX0 (comparator input 0, digital input). Neither the second transmit pin TX1 nor the analog input RX is required here (RX1 is at 0 V). Two of the transceiver pins are then directly connected to the CAN_H and CAN_L lines of the CAN bus, which is shown in the specimen circuit as a shielded, twisted wire pair with terminating resistors at the ends of the bus line. If the transceiver has a bus-off or power-down pin, this can be driven by a pin of the two 8-bit I/O ports of the SAE 81C90 (e.g. pin P00). The application driven by the SAB 80C166-M, e.g. a robot controller, thus allows data interchange with other subscribers in the same CAN network.

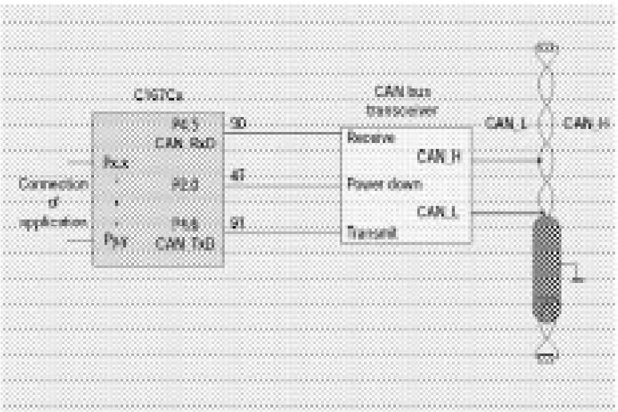
The C167Cx 16-bit controller and connection to CAN

The C167 also belongs to the C166 family and has been available since early 1994. It offers extensive peripherals with maximum packaging density and extends the functionality of the SAB 80C166 in several major points. The CPU can now administer up to 16M bytes of address space, several instructions have been added to the instruction set, and the A/D converter now has 16 channels. The C167 has 2K bytes of on-chip RAM, and the interrupt system has likewise been extended. Another capture/compare unit, three 8-bit ports and a PWM unit with four independent channels have also been implemented. Five bus-control registers and an equal number of chip-select signals allow the C167 to access various external components without additional address decoding logic. One of the two USARTs of the SAB 80C166 has been replaced by a synchronous interface with full-duplex capability and a data rate of 5 Mbaud. The on-chip XBUS recently introduced permits straightforward upgrading of the C167 module by simply adding peripheral functions, including application-specific ones.

The C167CW (without oscillator prescaler) represents the first derivative with an on-chip CAN module complying with CAN specification V2.0B (active). The C167CR is equipped with the same CAN module. This version additionally contains 4K bytes of RAM and a PLL. So the C167 with its various derivatives is well equipped for future high-end applications, especially in automotive and industrial electronics. Introduction of ROM and flash EPROM variants (flash samples are scheduled for the second quarter of 1995) will make it a perfect building block for single-chip applications designed for the most demanding requirements.

The CAN module on the C167Cx

The CAN module contains the XBUS interface and the actual CAN controller in the form of function blocks. The XBUS interface links the CAN module to the on-chip XBUS and thus sets up a very fast connection between CAN controller and CPU. The CAN controller itself comprises several function blocks operating in parallel. These can send and receive data, including error correction, without increasing the load on the CPU. The internal memory of the CAN module can



Wolf Bild 2

Fig. 2 Connection of the C167Cx to CAN

receive 15 message objects with a data length of up to 8 bytes each. Each of these objects has its own identifier plus its own control and bits, and can be defined as either a transmit or a receive object. All the control registers of the CAN controller are stored together with the message objects in a 256-byte address area specially reserved for the CAN module. The C167Cx likewise covers a wide range of basic CAN functions.

Fig. 2 shows the connection between the C167Cx and the CAN bus. The CAN module is connected to the outside world via two pins, P4.5 and P4.6. of port 4. P4.5 receives data from the physical layer of the CAN bus (CAN_RxD signal), while P.4.6 transfers data to the physical layer (CAN_TxD signal). The application (e.g. an engine management module or electronic fuel injection system) is linked to the CAN bus. As in the SAE 81C90/91, the physical layer is not implemented in the CAN module, so the C167Cx is likewise connected via an external transceiver to the CAN bus lines. If a power-down pin is present, it can be driven via a port pin of the C167Cx (P2.0 in this case).

(To be continued)

Check #5-94-8 (HL) on Reader Service Card

Axel Wolf
Dipl.-Ing. (BA),
studied telecommunications in Stuttgart. In April 1994, Mr. Wolf (25) joined the Semiconductor Group of Siemens AG, where he is involved in product marketing for 16-bit microcontrollers.
Tel. (+49 89) 4144-8066