Microcontrollers for Industrial Ways of Interconnectivity

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During recent years, not only CAN and UART communication have been important for microcontrollers, also Ethernet was gaining importance. Therefore, microcontrollers for industrial application do not only need an intelligent CAN module, they also need smart ways of connecting to other protocol engines. This article shows one solution to do so.

Introduction

During recent years, the Industrial world has been developing in the direction of Ethernet. Ethernet as well as CAN are the protocols for interconnectivity of different ECUs. Also inside the automotive world, there is a strong trend in the direction of Ethernet. Therefore, microcontrollers especially industrial microcontrollers of certain performance classes do need an Ethernet module in addition to an intelligent CAN module.

CAN module

Since 2003, Infineon has been using the MultiCAN module. As a reminder, what does MultiCAN mean?
MultiCAN is a CAN v2.0B active module, supporting the following features:

- Supporting up to 8 independent CAN nodes
- supporting up to 256 freely assignable message objects (organized in double-chained lists)
- can run up to 1MBit/s
- FIFO functionality (FIFOs of arbitrary size)
- Gateway functionality
- Mask registers for all message objects.
- Time stamping register entry available for all message objects
- Powerful counters for example usable for baudrate detection

The module is highly flexible in its configuration, therefore it can be found on 8, 16, and 32bit devices. The smallest configuration today is for example on the XC800 family has 2 nodes and 32 message objects. On the XE16x, the MultiCAN module goes up to 6 nodes and 256 message objects.

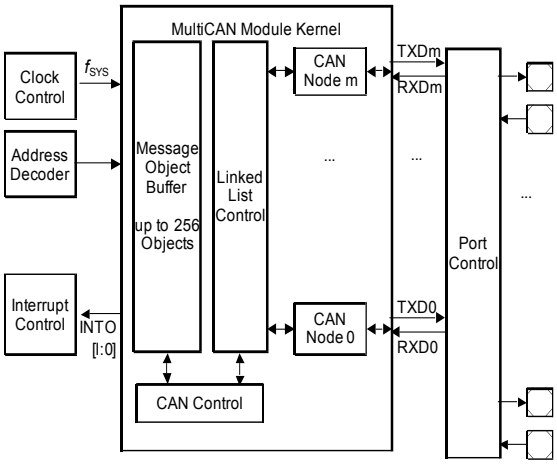

Figure 1: Block diagram of MultiCAN

The block diagram in Figure 1 shows the split among the block of the module. The node logic includes the message handling as well as the error handling.

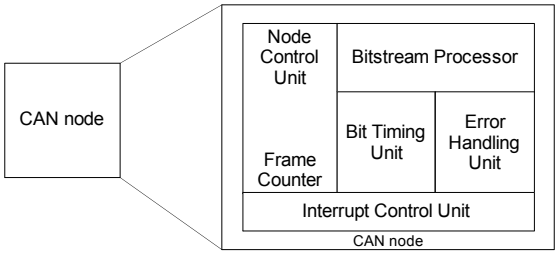

Figure 2: Block diagram CAN node

The linked list control (see Figure 1) is responsible for the management of the message object buffers. It enables the module to get message objects assigned to a certain node and to guarantee the high flexibility of the module. The organization is done in double chained

lists, which enables the software to move in both directions among the message buffers.
With the high flexibility of the module, also a FIFO structure, a Gateway structure, as well as combination of both, can be easily programmed and is fully supported in hardware.

FIFO

A FIFO for a node can be collected among free message objects. For example, the message objects 5, 16 and 3 are still free and a FIFO is needed, via the double-chained list approach, the message objects are linked to each other. In this example the FIFO gets its starting point at list element number 5, which is linking as predecessor to itself, the next element is 16, and therefore the successor of 5 is 16. 16 as middle element of the list, has as predecessor 5 and as successor number 3. The end of the list is programmed in a similar way as the start of the list, the predecessor is defined with number 16, the end has no successor, and therefore this element is having itself as successor meaning number 3. This principle is also shown in Figure 3.

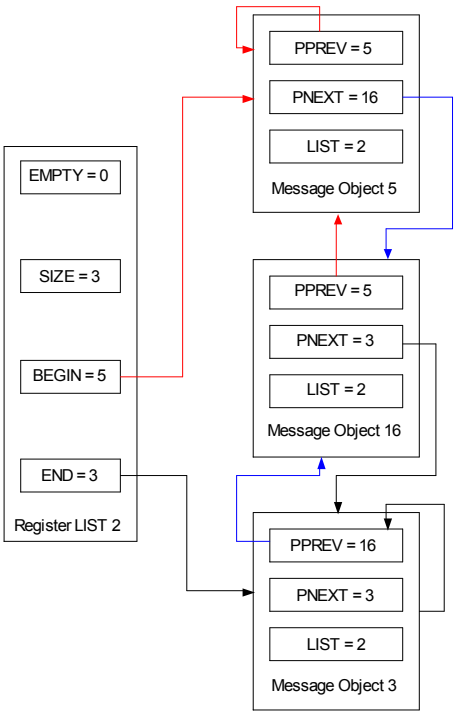

Figure 3: FIFO structure with MultiCAN

Gateway

The linked list approach also enables a flexible Gateway structure. A single reception message objects configured in Gateway mode, links to a transmission message object or FIFO on the side. Connecting a Gateway with a FIFO enables having two busses connected, running at different speed. The Gateway feature is configurable, it is possible to copy the Data, the Identifier, the Data Length Code and to set the transmit request automatically.

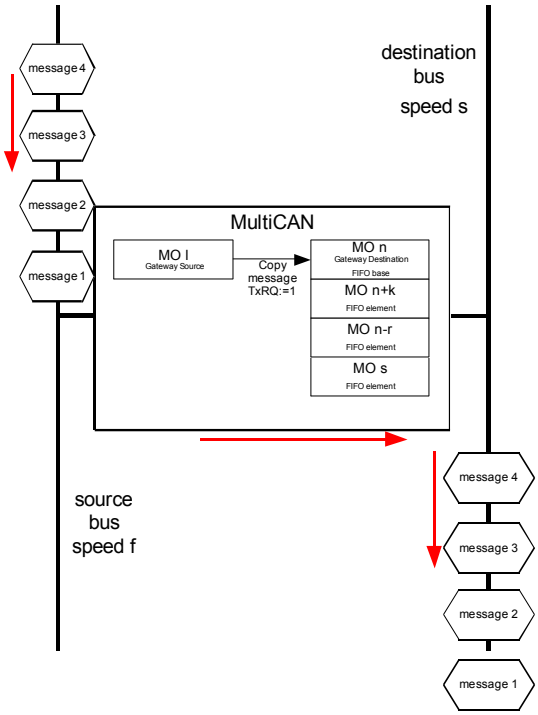

Figure 4: Automatic Gateway

The MultiCAN module incorporates also an interrupt router, which enables the application to map any of interrupt sources to one of the interrupt nodes. For example a transmission interrupt generated by message object 27 shall generate an interrupt on interrupt node number 5 of the MultiCAN module. The transmit interrupt enable bit in the message object needs to be set and in the MOIPR the TXINP gets set to 5. The interrupt output number 5 will be activated as soon as the transmission took place.
In case a DMA shall be used, a single message object or a single FIFO has to be

used for accessing the data or preparing for transmission. (Otherwise the advantages of a DMA cannot be used, as a source checking has to take place afterwards. In case of several interrupt sources to one interrupt node, an interrupt routine is the better solution)
The CAN module enables the application to have software with little CPU load. Gateways can be realized with 0% CPU load, as the Gateway hardware feature runs without any interaction of the CPU.

Ethernet module

The Ethernet module is a standard IP, from a well known supplier. It supports the following features:

- Supporting IEEE802.3
- Supporting IEEE1588
- Supports 10/100-MBit/s data transfer
- Supporting RMII/MII interface
- Supports both full-duplex and half-duplex operation
- Supports CSMA/CD Protocol
- Supports IEEE 802.3x flow control
- Support of Pause framing
- Preamble and start-of-frame data (SFD) insertion and deletion
- Automatic CRC and pad generation and stripping
- Support Standard or Jumbo Ethernet frames up to 16 KB
- Programmable InterFrameGap
- MDIO Master interface
- Detection of LAN wake-up frames and AMD Magic Packet frames
- Enhanced Receive module for checking IPv4 header checksum and TCP, UDP, or ICMP checksum encapsulated in IPv4 or IPv6 datagrams.
- Sixty-four-bit time stamps are given in each frame's transmit or receive status.
- 2kByte internal buffers, with DMA move engine.

With IEEE 1588 applications microcontrollers are enabled to have a real-time communication. IEEE 1588 in the version 2008 has not only the Grand Master Clock it also enables Transparent Clocks, which means that the precision can be even higher precisions than in the version of 2002 can be reached.
The Ethernet module has an internal DMA, allowing to control the transfer from the Ethernet module to a RAM area, closely linked to the module. This can be seen in the block diagram in **Figure 5: Basic Block diagram**

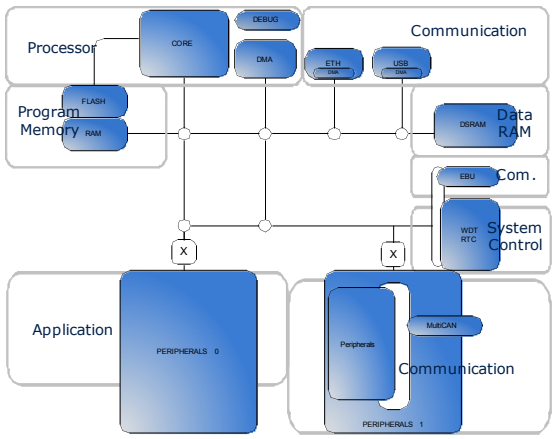

Figure 5: Basic Block diagram

The descriptor structures of the Ethernet module show the exact address of the data. Therefore, it is possible to have certain address areas, to access the information from the Ethernet module. Keeping in mind, that the CAN bus has a maximum data rate of 1 MBit/s against the 100MBit/s, the buffers have to be well adjusted to the data amount coming from the Ethernet system.
The industrial microcontroller family has a scatter/gather DMA, which helps the application to setup the data from the Ethernet or CAN module accordingly. Especially in the case of streaming data, where often a counter as well as an additional CRC is part of the CAN data, information has to be either added or has to be cut off the data. Here the scatter/gather DMA supports the CPU by taking care of some of the operations.
In case other real-time Ethernet protocols beside a hardware driven IEEE1588 is needed, an EBU (external bus interface unit) is available, enabling to have for example ASICs with other Ethernet protocols, like for example EtherCAT or Profinet attached to the device.

For customers using the Automotive microcontroller family controllers, the upcoming devices will have compatible modules for CAN and Ethernet operations.

Summary

With having a powerful MultiCAN and an Ethernet module including IEEE1588 as well hardware CRCs, in combination with strong DMAs the industrial microcontrollers are well prepared for the high connectivity which is needed for the future.

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