Flexible Design of ARM- CAN MCUs with Powered Gate Technology

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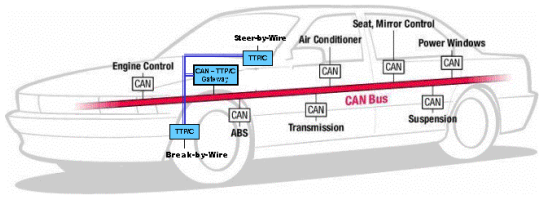
So far potential users of ARM 32-bit RISC-Controllers always had the choice between using predefined Standard MCUs with given features or to build up a custom specific solution around the ARM core.
Looking at the second solution, it offers the possibility to include exactly those IPs which are needed for a certain application, but on the other hand, this solution requires a high investment, since it is made using a full-custom approach.
OKI´s POWERED GATE Technology™ is an alternative solution to this problem. The POWERED GATE device is a preproduced ASIC which already includes the ARM7TDMI –Core and basic functions like Flash, SRAM, A/DC and clock generator. All other peripherals will be realized in a Sea-of-Gates area, that offers 100K usable gates on chip.
With an extensive library of existing IPs, including network functions like CAN, VAN, USB, timers, UART,.. it is now possible to design a custom ARM MCU at the cost and development time of a standard ASIC.

The actual status

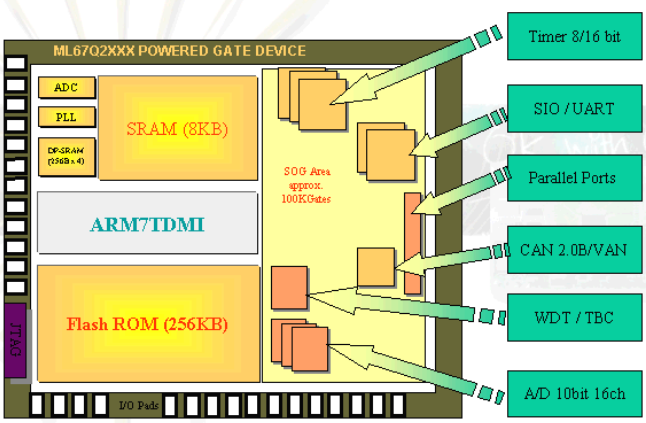
After their success in the area of handheld telecommunication equipment, 32-bit RISC cores from ARM are getting more and more popular also in automotive and industrial applications.
With their licensing program, ARM has now more than 34 semiconductor vendors, offering ARM based products.
The majority of these partners has fixed their portofolio to one certain type of implementation, either offering Standard MCUs with fixed functionality or ASIC and full custom solutions which are fully adapted to the required application, but have high engineering charges.
Fast changing requirements of the market and the increasing need for the support of different network options keep potential users away from custom solutions. In order to avoid high investments into new developments they stay with standard MCU and realize their required interfaces with external peripherals.
On the other hand it is becoming very difficult for the semiconductor vendors to supply the right standard devices for networking, especially in cars, since the number of different network types and their interconnection is increasing. New options for multimedia applications as well as highly fault tolerant drive-by-wire tasks are introducing new networks in a car, VAN, TTP, Firewire, the corresponding gateway devices for intercommunication.
Similar to the automotive area, there are also different network requirements being introduced to the industrial control field. Apart from CAN gateways between different CAN networks as well as gateways to Ethernet or USB will become more and more popular. However, quantities will not be so high, that a full custom approach can be justified.



Picture 1: Different network gateways in cars today

Powered Gate technology™ offers flexibility

Powered Gate offers an intermediate step between the Standard MCUs and Custom Solutions.
Powered Gate™ is offering a preproduced ARM MCU were the basic functions are already implemented on silicon. Each Powered Gate™ base chip already contains the ARM7TDMI as a processor core. In addition the chip includes a 256KB Flash ROM, 4 or 16 KB of SRAM and a flexible on-chip oscillator cell with PLL, which allows easy adaption of the controller to existing system clocks.
In adition to these core functions, the device has a Sea-of-Gates area on chip with approx. 100.000 usable gates.
This area can be used to customize the ARM Controller according to customer needs.
Several standard peripherals, which are used in most microcontroller designs will be supplied as templates and can easily be implemented as macros. Available templates are 8/16 bit programmable Timers, UART, SIO, GPIO, WDT, TBC and 10 Bit A/D Converter. The designer can decide, how many of these peripheral cells will be needed for his application.



Picture 2: Powered Gate Technology™ Base Chip

Table 1 gives an overview of all available peripheral IPs that are available for integration into the SOG area of Powered Gate™. Since all of these IPs are scalable it offers an easy and quick approach for customer MCUs.
Compared with a full custom or standard cell design, Powered Gate Technology™ can reduce the design cycle by more than half, since we only need to produce the 7 the-shelf. Another positive effect of this preprodcution is the reduction of NRE charges down to a range of compatible Gate Array designs.

Type	Specification
Timer: 8- or 16bit	Capture Auto-Reload Compare Output PWM
	Time Base Counter Watch Dog Timer
Serial Ports	Asynchronous, UART with BRG Clock Synchron 7/8 bit Full Duplex
Parallel Ports	8-bit, comfigurable on bit level as I/O
Analog/Digital Converter	Resolution 10bit Maximum 12 Channels Operating Mode : Scan or Select Mode
Interrupt Controller	32 Sources internal and external 8 Priority Levels Assignment of number to each interrupt to allow direct branching
External Memory Controller	Max 6 Banks Direct connection of ROM, SRAM and I/O Devices programmable Bus width and Wait cycle for each bank
Clock Generator	Quartz Oscillator PLL for adaption of clock frequency Clock Gear Funktion for adjustable power saving Low frequency watch clock

Table 1: Overview of available peripheral IP for Powered Gate™

High end peripherals for car networks

Apart from the standard peripherals that are needed for any kind of Microcontroller, Powered Gate Technology also includes a number of high end peripherals which can be integrated for embedded networking solutions

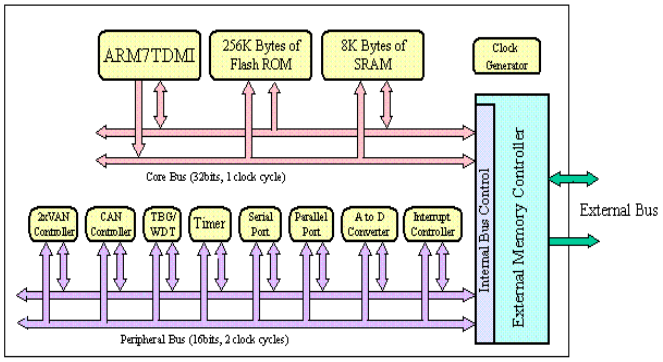
The Powered Gate library includes such controller block as CAN, TTP,VAN, MOST[1], GPS , USB, Ethernet MAC . Other network interfaces like Bluetooth will be available in the near future.

The **CAN** controller interface is complient with the Bosch standard Version 2.0b. It is based on the MSM9225B from OKI offering Full CAN functionality.

- **3 Transmission Systems: NRZ by Bit Staff Function / Multi-Master / Broadcast**
- **Real-time transmission control at maximum 1Mbps.**
- **Message buffer maximum 16 messages X 8bytes**
- **Message group function: up to.2 groups**

Table 2: CAN Interface features

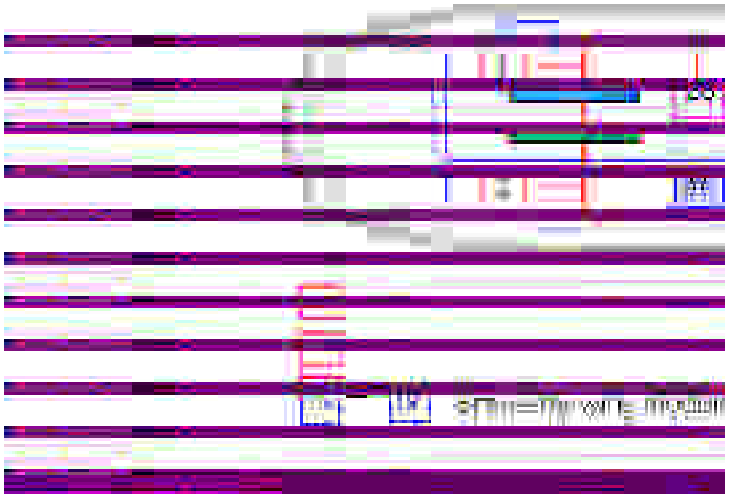
TTP/*C*[2] is a new network protocol for applications with high safety and redundancy requirements in cars and aircraft. X-by-wire is the keyword that brings up TTP. The trend to save weight in modern cars forces the manufacturers to look for new systems like Power Steering or break-by-wire, which will allow to get away from the heavy mechanics used in todays traditional steering and break systems. X-by-wire will also allow easy control of such safety relevant functions by embedded system control. Different to CAN , TTP is not event driven, but as the name says- a time triggered protocol. Using this approach it is possible to have a faster reaction on any changes in the parameters of a system. In addition the fixed timing for checking certain parameters will asure that failures in subsystems will be detected at the next timeslot. Nevertheless CAN and TTP will certainly coexist in future cars and Powered Gate will offer the possibility to implement both interfaces in one MCU building a gateway between both worlds.
Another LAN system used in todays cars is the **VAN**[3] Bus introduced by PSA Peugeot. Different from the CAN protocol, VAN allows word lenghts up 256 bit and offers a different error checking mechanism.
Similar to TTP the VAN protocol will not take over all tasks in a car network. Due to its special features, VAN will mainly be used in the body control and dashboard LAN, since the longer word length allows better transmission of text messages for car radio, navigation system or air conditioning.
On the other hand several ECUs will still remain on the CAN bus requiring data from sensors in the VAN environment.. Again Powered Gate Technology™ offers an easy means to build up Intelligent Switching Units that help to exchange data between VAN and CAN.



Picture 3: ML67Q2200 VAN-CAN Interface MCU

Not only security and information systems in the car need a LAN. Current developments are now integrating multimedia features like Video, Internet or game consoles into the new cars. All of these need high bandwidth communication which cannot be achieved with CAN or VAN. For such applications **MOST**[4] is the best candidate offering transmission rates of up to 24.8 Mbps over optical links and MOST V2 will deliver data with up to 100Mbps. MOST alsoneeds to communicate with subsystems on the CAN network (radio, Driver Information system) so again network intercommunication will be required.
On the other hand this multimedia network needs access points for external devices like the Laptop of a business traveller who wants to download some urgent data from the internet, while being somewhere on the road (hopefully not driving by himself). In this case a **USB**[5] interface or a **Bluetooth**[6] access point can help him to access to the car LAN and further to the internet.

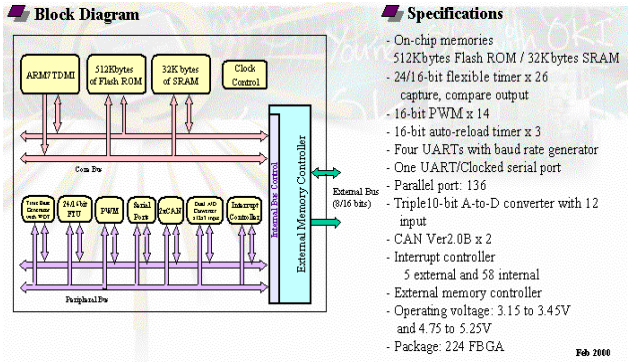
USB and Bluetooth are other optional peripherals that can also be implemented on a Powered Gate device.
In any case CAN will remain the backbone of the car LANs and the combination of the Powered Gate Technology™ with all these different peripherals will allow easy design of embedded solutions that integrate various network interfaces in one device.



Picture 5: Different LANs around the CAN backbone

Powered Gate not only for network switches

Instead of integrating several network interfaces on one chip , Powered Gate can also be used to design high performance ECUs for Power Train applications. Especially Controllers for engine management or automatic gear boxes will require lots of timers and interrupts in order to controll all different sensors and control subsystems that are needed to handle all parameters of a complex system like car engines today.
Also here Powered Gate gives the highest flexibility. Apart from one or two CAN interfaces the base chip offers enough space to integrate as many timers and IRCs as will be needed for a certain application and since the design cycles are short and the cost is low, it will be easy to develop derivatives of one device that will be optimized for different engines. The basic block of an ARM core with Flash memory, SRAM and a CAN controller can be maintained and the user can simply add or delete peripherals to this base chip,



Picture 6 : ARM – CAN ECU (ML67Q2001)

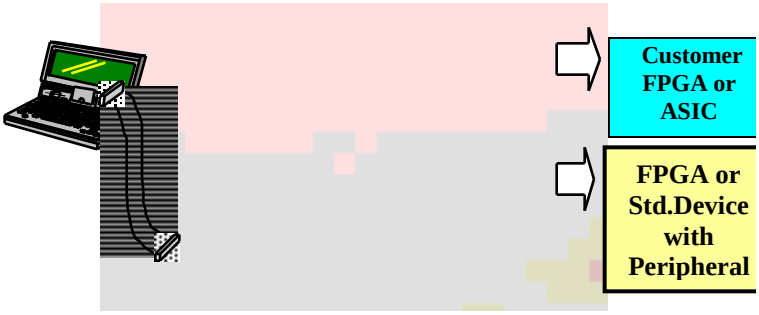
Another area of interest for ARM-CAN MCUs is the field of Telematic services or ETC[7].
Also here the ARM controller is getting strong due to its high performance and low power consumption. Since such systems need to exchange data with other car equipment, a CAN controller is required for such communication.
In order to build a telematic system, it is required to have the information on the exact location of a car. Only with this information is it possible to supply the driver with those traffic messages, which apply to him. The most exact positioning information today can be extracted from **GPS[8].** Calculating the exact position from the GPS data needs a powerful CPU like the ARM cor. The CAN interface will distribute this data to the corresponding systems which will then carry out further processing. Such GPS baseband can be implemented on the Powered Gate device and together with the CAN controller offer a highly embedded solution for any kind of position processing.
GPS is not only needed in Telematics and navigation system, but will also become a key function in new tolling systems for cars and trucks which will be required in the near future. The combination of GPS and **DSRC**[9] will allow exact location of vehicles and the calculation of the driven distance in order to charge the toll fee to the owner.
First implentations of such DSRC based systems have been released already in Japan, were the ETC service commenced this April. In this case also the computing power of an ARM MCU is needed, since all data will be RSA scrambled and the requirement for additional data from the car will make it necessary to

have a LAN interface, which is likely to be CAN integrated on the system.

The interfacing of different network systems with CAN networks is not only resticted to automotive applications.
There is a need in the industrial area, different bus systems will have to communicate with each other.
Interbus-S, Profibus, CAN and Ethernet are not restricted to special applications and it can happen at any time that data between these networks have to be exchanged using some kind of interface device. Since applications in the industrial controller field do not normally reach quantities that could be compatible with automative applications. It is always a problem to develop custom solutions, since so far the NRE charges have been too high.
With Powered Gate™ this barrier can be reduced drastically, since the SOG part of the device will allow quick and flexible designs with low engineering cost.
The user can choose between different existing interface blocks like CAN, 10/100MB Ethernet, USB, **Firewire**[10] or IrDA. On the other hand, there are many ASIC designs that have been made for industrial control systems and with Powered Gate™ it will be easy to integrate these ASIC blocks onto an ARM controller, thus going a step ahead to a system on chip solution, which is certainly also the goal for industrial control applications.

Design work easy made

The SOG part of a Powered Gate device is based on OKI´s standard ASIC technology. Therefore all available tools for making an ASIC design can also be used for the design of the SOG part.
This means that custom specific blocks, that are designed in VHDL or Verilog HDL can first be implemented in a FPGA in order to check the functionality before going into real silicon.
OKI is offering an evaluationboard for the Powered Gate™, which includes a base chip with an empty SOG area. The internal bus is accessable on external pins. This design environment together with the ARM software development Toolkit (SDT) will allow the designer to start evaluation of the final system at a very early stage. It can also be used to integrate existing standard devices, like the FPGA into such a system and to test it in the target application.
As an additional benefit , the software developers are able to start software development and debugging at a very early stage without having to wait for first silicon.



Picture 8: Powered Gate Technology™ Evaluation environment

Software support

Since ARM has approached not only the semiconductor vendors, but also the software and system manufacturers with their partner program, there is a wide variety of operating systems and developments tools available on the market.
The standard design environment for Powered Gate™ is based on various OKI ARM evaluation boards and the ARM SDT 2.5. For a first system simulation ARMULATOR models are available, allowing a simulation of the complete system process independently from having any silicon.
Some partners fo the ARM 3rd party club of RTOS manufacturers have already ported their OS to Powered Gate Technology™. The first available RTOS is the SSX 5 from Realogy offering the smallest footprint of all available ARM complient RTOSs on the market. This will enable designers to realize a RTOS on chip.
Especially for applications in the automotive area support for OSEK/VDX will become a mandatory requirement, since it offers high fault tolerance and portability.
Powered Gate devices are supported by the leading suppliers of OSEK RTOSs like Vector Informatik (osCAN) or Realogy´s SSX5, which are both OSEK V 2.1 complient. Other RTOS

By this it will be assured that MCUs based on Powered Gate Technology™ can be implemented in standard CAN networks without special efforts.

Type	Key Feature
CAN	**V 2.0B Complient** **Full CAN**
TTP	**Time triggered** **Fault tolerant time base** **Transmission speed up to 5 Mbps**
VAN	**Variable word length up to 256 bit** **Powerfull error correcction**
MOST	**Multimedia Network** **25 Mbps transmission rate optical link**
Ethernet	**10/100Mbps selectable industry standard** **MII support**
USB	**V 1.1 complient** **Full 12Mbps transmission speed** **Supports up to 6 endpoints** **V 2.0 (400Mbps) under development**
IEEE1394 Firewire	**Optical link** **High performance (400Mbps)**
Bluetooth	**Wireless protocol** **Low power consumption** **1Mbps transmission speed industry standard**
GPS	**GPS baseband** **Supports up to 12 channels** **High precission, quick acquisition time** **Support for all GPS systems (US, EU, Russia)**

Table 3: Available IP blocks for Powered Gate™

Summary

ARM-CAN MCUs based on Powered Gate Technology™ will offer the designer of complex systems a toolbox which allows a quick and flexible design of many kinds of LAN based MCUs.The preproduced basechip with the fixed kernel of an ARM Controller makes

In addition, most of todays network or system interfaces are available from a design library and can be mixed on the device together with any kind of standard peripheral, thus allowing the designer to get an optimized design at low cost and risk.

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