Partial and Pretended Networking Reduces CAN Power Consumption

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Minimizing energy consumption has become a major need for any new product design, including industrial and automotive systems that use the CAN bus. One way to reduce system energy consumption is to shut down elements not currently being used. To use this approach in CAN systems, however, requires re-imagining CAN controller architectures.

In recent years, significant efforts have been made within the industry towards reducing the energy footprints of many systems. For instance, in the automotive environment, efficient engine management and weight minimization of the vehicle bear the most significant potential for savings. But apart from factors including engine efficiency, vehicle weight, and aerodynamic drag, the power efficiency of the electronic control units has great potential as a field of activity for engineers designing to save energy. As a result, developers are also focusing on electronic functions in order to exploit every opportunity to reduce consumption.

The use of low-power electronic control units has in the past been particularly important for parked vehicles, in order to achieve maximum standby times with existing battery capacities. But current drain has now become important for driving vehicles, as well, because the electrical energy must be delivered by the combustion engine and thus has a direct influence on fuel consumption. And not only is the automotive industry facing the challenge of reducing its energy footprint: Global warming and the need of reducing emissions ask for better energy efficiency across many application domains.

Analyzing the electronics landscape in modern electronics quickly raises several questions. Are the functions offered by the different electronic control units (ECU) really required all the time and in every operating situation? Is the continuous current consumption of these modules really justified? Often, the answer is no! Not, for instance, for convenience functions in the car such as seat electronics, trailer control units, or tailgate control units that are seldom operated or only required at specific times. Additional examples include door control units, auxiliary heating, sunroofs, and rear-view cameras.

On the other hand, it must be possible to activate these control units at any time in order to avoid any functional or convenience impairment. Networking, i.e. communication between different ECUs, can facilitate the job of selectively turning on only those modules needing to be activated at any given time. With networking to provide selective (partial) activation of the ECUs belonging to a complex system, there is considerable potential for energy savings.

Assume, for instance, that an automotive ECU has an average current drain of 100 - 200mA and a car battery voltage of 14V. The potential savings amount to 1.4W to 2.8W for each idling control unit. Total energy savings for 10 nodes capable of partial networking therefore amount to an
average of 15W without any negative impact on functions or convenience features. According to the established conversion formula, 40W of electrical power represent 1.0g of CO2 emissions per kilometer. Thus, the introduction of partial networking leads to potential emission reductions of 0.375 grams of CO2 per km.

But there are even more reasons why a partial network is an interesting approach. Consider, for instance, the charging of electric vehicles. Although charging requires a communication link to the supervising control unit, most of the control units connected to the bus are not required for this task and can thus be selectively powered down. The same is true for future application scenarios entailing data transmissions between a parked vehicle and mobile end devices.

These future use cases also result in increased requirements regarding the operating life of the components. This can be compensated to a certain extent by partial networking, resulting in reduced costs.

High speed CAN is the networking technology usually used in automotive and industrial applications where the bus runs from one end of an environment to another one. But there is a problem with selective activation when using the CAN bus. Although current CAN nodes already provide low-power modes (e.g. standby, sleep), they immediately wake up if any communication occurs on the bus. These low-power modes can thus only be used if all nodes connected to the bus are disabled simultaneously (so-called 'bus idle').

Simultaneous disabling of nodes is possible in the case for a parked vehicle (see Fig. 1). When a CAN message is transmitted on the bus, all connected controllers are awakened by the respective transceiver. But in the case of a moving vehicle these sleep modes are not helpful because at least some of the nodes on the bus must be continually active.

One possible approach for leveraging CAN sleep modes in such situations is based on dividing the networks into sub-networks and disconnecting specific controllers from the supply voltage. Apart from the restrictions regarding the network layout, though, using multiple power supplies leads to additional overhead. Nonetheless, solutions of this kind are already in use today.

A more flexible approach is to have the ability to wake up specific controllers using dedicated, pre-defined wake-up messages. This ability allows partial networking, in which not all nodes need to be
The only way to avoid activating the microcontroller (with the resulting increased current drain) is to have the wake-up detection occur in the transceiver.

**Partial networking to the rescue**
The strength of conventional CAN transceivers (Figure 4) is their bus-level translation capability with full signal fidelity and immunity against external noise signals and bus interferences. Having only very basic logic functions for detecting simple bus errors, conventional transceivers are activated by every bus level transition. This, in turn, precludes capturing and evaluating any incoming messages. Message interpretation is the task of the MCU’s on-board CAN controller, which has the precise reference clock (crystal oscillator) required for evaluating the message.

Fig. 4 Partitioning of a conventional control unit
CAN transceivers capable of partial networking (Figure 5) therefore need a highly precise internal reference clock in order to reliably capture and decode the incoming bitstream. In addition, this reference clock must be stable in the relevant temperature range. Considering the maximum tolerance of the transmitting node and common disturbances on the bus (including blurred edges, reflections, and EMV effects), the oscillator must provide a precision of <1% over the entire temperature range (40 to +105°C) and the operating life of the component.

The oscillator concept used in partial-networking CAN transceivers therefore plays a primary role and represents the main challenge during the development of these devices.

The CAN transceivers will need to do more than capture the bitstream, however. The information payload must be extracted from the captured bitstream according to the CAN protocol before the retrieved data can be compared to the wake-up messages. And the transceiver needs to be configurable to define its individual wake-up message. The transceiver must thus provide an interface for configuring the partial networking mode and the dedicated wake-up message. The basic configuration of such a partial-networking CAN transceiver is illustrated in Fig. 6.
This selective wake-up and sleep concept should be most interesting for automotive equipment powered by re-chargeable batteries because the reduced consumption results in longer cruising / operating range. But the concept has numerous possibilities beyond the automotive arena. Among the manifold application ranges for the CAN bus as communication- and diagnosis-interface could be cleaning equipment like scrubber-driers or sweepers, logistic vehicles, or mobile service- and assembly-robots, as well as industrial manufacturing equipment.

With a partial networking concept as described above, a very low standby current mode can be achieved in a large system because individual ECUs or clusters of ECUs may be sent to sleep mode when their function is not required. At the same time, the ECUs or clusters can be woken up selectively when particular tasks are needed. Among various options, this concept allows the highest level of energy savings.

At the same time, partial networking in CAN also requires significant effort. The dedicated transceivers need to comprise a high precision oscillator, bit time logic, and a frame decoder in order to identify specific wake-up frames in the incoming bitstream. The wake-up frames are configurable by SPI, which adds even more logic inside the transceiver. In addition, the entire network management needs to be adapted to facilitate the selective sleep and wake-up mechanism.

Still, such intelligent CAN transceivers are emerging. The High Speed CAN with partial networking is currently being specified in a new release of ISO 11898-2. The standard also allows the use of extended identifiers that are frequently used in industrial applications, enabling usage of the concept in this field as well. And there are also devices entering the market. The STMicroelectronics’ L99PM72GXP Power Management System IC (see Fig. 7) is such a System Basis Chip supporting the partial networking concept. It is based on the L99PM62GXP and is hardware and software compatible with this device.
There is also an alternative to partial networking that allows moderate savings at lower efforts: pretend networking. In this concept, each ECU may selectively decide when to enter or exit a low power mode. Once this decision has been made, and the ECU places itself in a lower power state, the relevant microcontroller (MCU) is also set in standby mode. But the ECU pretends to be available on the network so that no modification to the network management is necessary.

To save energy in this lower power state, the ECU can reduce the number of tasks executed, limit or hand-over communication to other hardware, and make use of so called ECU degradation. This means that overall ECU performances, through microcontroller operations, can be reduced (degraded). Some functionality can be switched-off, some others can be lowered/reduced (i.e. clock frequency), and cores and peripherals can be de-activated in order to provide tailored performance only when asked (and avoid providing full power capability when it is not really needed).

As soon the microcontroller identifies a CAN message that requires full availability of the ECU, however, the ECU goes back to full operational mode. In this way, it is possible to use existing transceivers, reduce the overall consumption, and the implementation of the network is easier.
STMicroelectronics’ new generation of door zone ICs supports both concepts, partial and pretended networking, by means of dedicated SPI configurations. Devices like the L99PM72GXP also support pretended networking by providing a dedicated standby mode where the voltage regulator is still active to supply the microcontroller. However, current consumption is reduced by means of a dedicated low-current mode at lower accuracy (degradation). The transceiver just passes the CAN messages to the microcontroller for frame decoding.

Next generation devices will also include automatic voltage biasing, which was first described in ISO 11898-6. This feature turns off the biasing of CAN bus lines in case of no communication on the bus. The biasing is turned on automatically as soon as a wake-up pattern is seen on the bus. A dedicated interrupt signal informs the microcontroller about incoming CAN messages.

Both partial and pretend networking in CAN bus systems have the potential to reduce system power consumption. A pretended network doesn’t bring the same level of low consumption offered by partial network, but it is also easier to implement both in terms of transceiver design and system control. Ultimately, the tradeoff is that the higher the power saving, the higher the cost for external hardware and topology implementation.

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