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A Data Acquisition Node Using CAN with Integrated Power Transmission

Abstract

The integrated transmission of information and power is a very important point of interest and a demand of many industrial bus system users. First results of such bus systems especially for simple binary sensors are known. The main task of our research activities is the integrated power transmission (IPT) in CAN systems even for analogue sensors with features of signal conditioning and data pre-processing.

The paper presents a solution of such a bus node. Beside the conventional data processing a power management is necessary. In relation with the abilities of the node two methods of integrated transmission of information and power will be explained. The advantages and disadvantages for several application fields will be shown. Finally the results of the investigation of dynamic behaviour, error behaviour, and power capacity will be summarized.

Structure of the Data Acquisition Node

Bus systems with integrated transmission of information and power are known especially for simple binary Inputs/Outputs. Additional such systems with bus participants with higher functionality but low power consumption are required.

In figure 1 a structure of a bus participant for data acquisition and data processing is shown. This bus participant is designed for interfacing with bus systems having integrated power transmission. It contains all components for the data acquisition (Data Acquisition Subsystem), for the data processing (Host Controller) and for the data communication (Communication Controller). Also there is a new functional block which provides the power supply to the bus participant by using the power that is transmitted by the bus. Because of its very low power requirements such a bus participant is also called Zero Power Node in this paper.

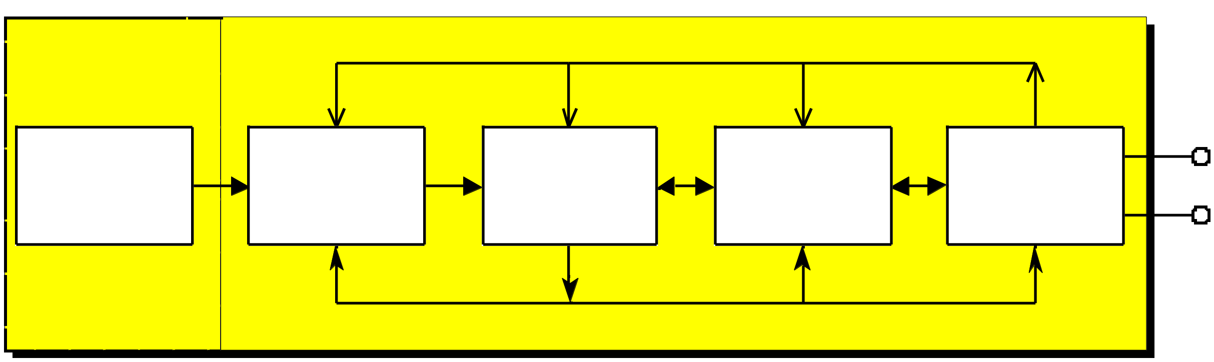


Figure 1: Structure of a Zero Power Data Acquisition Node

In addition to the data processing tasks the Host Controller is responsible for the local power management. For an optimal usage of the power available in the bus system it is necessary to reduce the power consumption of the bus participant during its idle phases. Idle phases are times without necessary activities for maintaining the scheduled operating sequences.

Data Acquisition Subsystem

For a proper signal conditioning a signal conditioning ADC AD7714 is used. Therefore power intensive external components for a signal conditioning are not needed. The major advantage of this solution is that all components involved in signal conditioning fitting optimal to each other. This includes the possibilities of controlling and configuring by the host controller, the self calibration and the option for the power management. This way the interfacing of praxis related sensors, as for instance thermo couples, is very easy.

This ADC employs a sigma-delta technology. In dependence of the programmed output refresh rate conversion results with an effective resolution of 10-22 bit are provided. For simple applications, where an effective resolution of 11 bit is sufficient, a new data word from the ADC is available at every millisecond. For more demanding applications like the correction of the direct part of a signal of a Pt100 (RTD) by software an effective resolution of 22 bit is recommended. In this case a new data word is available every 200 ms, what is quit enough for most temperature related applications.

The applied ADC has capabilities for power down mode, selfcalibration and it has an easy to use 3 wire serial interface for interfacing to the host controller.

Host Controller

The host controller has to perform mainly the following tasks:

- initialization of the bus participant and its diagnosis during operation mode,
- acquisition, processing and transmitting of the sensor data,
- realization of a power optimized operation of the bus participant.

The host controller communicates by an on-board serial bus with its sub components like ADC and communication controller. Those and the host controller itself are equipped with a power down option. Therefore the total control over the power consumption of the whole electronic circuit is given. In addition to that the host controller also controls the peripheral components necessary for sensor interfacing (see also [4]).

A PIC 16C54/56 is used as the host controller. This type of microcontroller qualifies itself because of its very low power consumption. It offers a performance of 5 MIPS, which is enough to implement demanding applications in the signal processing area. The PIC’s have 25 data bytes and 512 (PIC 16C54) respectively 1024 (PIC 16C56) program words of memory resources.

Communication Controller

The applied communication controller, a SAE81C90, is able to handle the CAN bus protocol fully independent. For this reason the host controller is released from this task and it can - depending from the implemented operation sequence - set itself into sleep mode. Meanwhile the bus node can still participate in bus activities. Is this also not necessary the Communication Controller can set into sleep mode, too.

Transceiver for Integrated Power Transmission

An interview of potential users of bus systems with integrated power supply lead to following main demands:

- transmission of a 24 V direct voltage;
- overall supply current of about 2 A respectively a supply current of 50 to 100 mA per participant;
- a transmission distance of about 100 m;
- no considerable influence of the power transmission to the information transmission and vice versa.

The integrated power transmission in CAN systems is associated with two main difficulties. Firstly CAN is a multi master system. That means it is possible that at the same time more than one participant may cause the transmission of a bit. The bit levels can be of the same or of inverse bit levels. Even by using RTR-frames there is, however, the acknowledge bit which can lead to complications. The new physical layer for integrated power transmission has to handle these cases. Secondly the delay time between two participants is influenced by the transceiver of the integrated power transmission and is generally greater voltage. The inductances of the participants power supply have got the same function. Because of the capacitance suddenly occurred power requirements do not influence the information transmission. The consumer may be connected directly to the 24 V or via a DC-DC-converter [**Fehler! Textmarke nicht definiert.**].

The next question to be answered was, how to combine the transmission of information with the power transmission. Basically there are two possible methods, which will be discussed below, the base band transmission and the modulation.

Base Band Transmission

The first idea is a 100% keying of the 24 V. In this case the power transmission is interrupted during dominant bits [1]. That's why long idle times are necessary to supply the participants, what means that it is only possible for very slow systems. Another method is to add the CAN voltage signal to the 24 V (NRZ-coded). But it would be very difficult to realize an electronic design for such a solution. Especially the selection of signals and load changes and the detection of longer series of dominant bits is difficult.

Further reflections related to manchester-coded signals as well as to the transmission of impulses at the beginning of every bit (symmetric, asymmetric) or the transmission of impulses at the beginning and at the end of a dominant bit [3]. All these examinations did not lead to a satisfying result. In most cases the arbitration can not be realized.

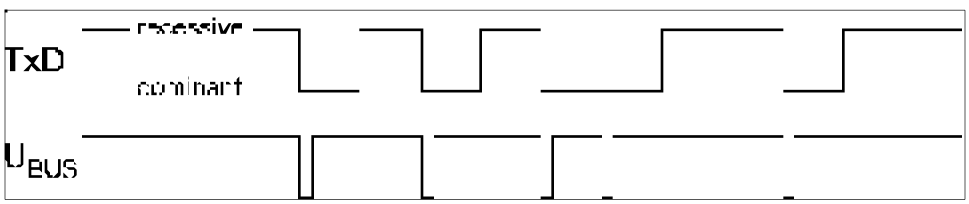
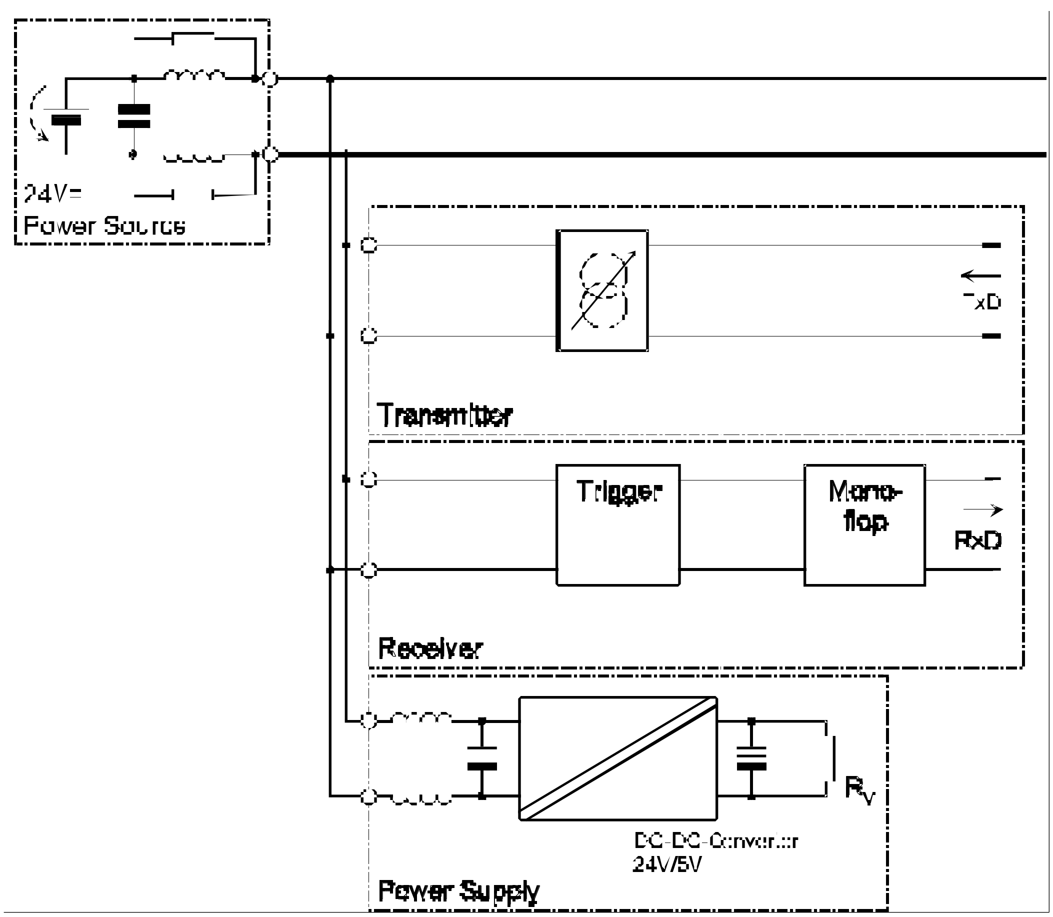


Figure 2: CAN related Bus Signal with Base Band Transmission



A possibility to solve this problem is the transmission of an impulse at the beginning of every dominant bit (figure 2). This impulse duration time is about a fifth of a full bit duration time. Figure 3 shows the principle diagram to realize this method. The transmitting participant generates a current impulse with a controlled current source at the beginning of a dominant bit. This impulse is formed by a central bus power source in an voltage impulse because the participants can not detect current impulses. But the formed voltage impulse can be detected also by long distance remote participants. The receiver contains a trigger with a dynamic threshold, detecting the voltage impulse. The following retriggerable monoflop regenerates the full bit for the CAN Controller.

Presently several electronic design solutions are investigated.

Modulation

The second kind of simultaneous transmission of information and power is to modulate a sinusoidal signal added to a 24 V direct voltage. In such a way the power transmission is continual, the addition and selection of information and power is very easy as well as a galvanic isolation. Several methods of modulation were analysed. Since more than one participant may transmit a bit at the same time methods like the Frequency Shift Keying (FSK), the Amplitude Shift Keying (ASK) ore the Phase Shift Keying (PSK) can not be used. The only method to fulfil all demands is the so called On Off Keying (OOK). The form of the signals are shown in figure 4.

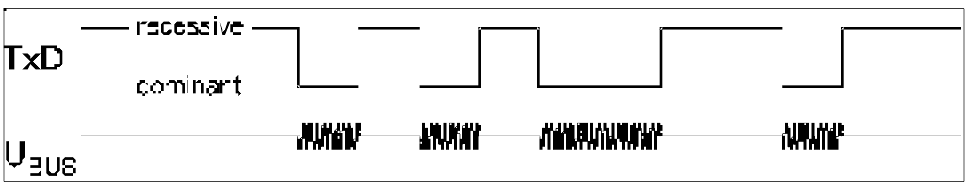


Figure 4: CAN related Bus Signal with Modulation

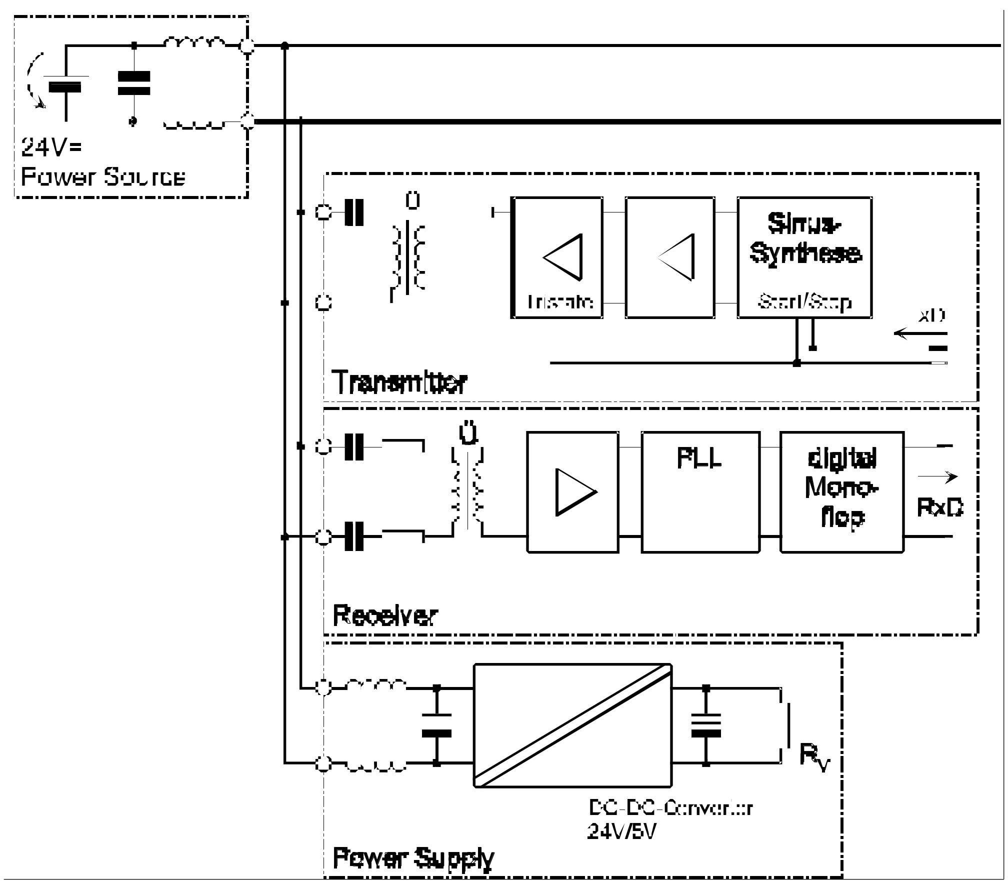


Figure 5: Principle Diagram of an Transceiver for Modulation

time an amplifier is activated to add the signal to the bus voltage. If a recessive bit occurs the sine-wave is lead to its zero value and stopped then. The amplifier is switched into tristate. The receiver contains a Phase-Locked-Loop (PLL) to detect the dominant bits. In opposite to its normal use the PLL disengages after every dominant bit. This occurs a time delay of detecting a dominant bit as well as a jitter of the the recessive dominant edge. A filter and a monoflop suppress the chatter of the PLL. To prevent a bus voltage short cut by the transmitter as well as by the receiver capacitors have to used to connect the transmitter and the receiver to the bus line.

In the present case baudrates up to 10 kbit/s are possible. The communication between two participants may be faster, but if several participants are sending a dominant bit (Acknowledge bit) it often happens that this dominant bit is detected to late by one of the participants. The reason is the signal amplitude, resulting by superposition of several sinusoidal waves and especially the occurring phase shifts. So one or more PLL detect the dominant bit to late and the CAN Controller send an error frame. That means such an error is detected by every participant in every case, so that semantic errors never happened. With a faster PLL also better results are expected.

Current Consumption of the Zero Power Node

In order to investigate the influence of the power management to the current consumption of the bus participant a test program was implemented. This program performs a cyclic data acquisition, a conversion of the ADC data word into the IEEE754 floating point format and the transmission by the CAN. After this the PIC and the ADC are set into sleep mode. The dependence of current[1] consumption vs. time during such a cycle is shown in figure 6.

It can be seen

- that the total current consumption can be reduced to one third and
- that the total current consumption is dominated by the PIC.

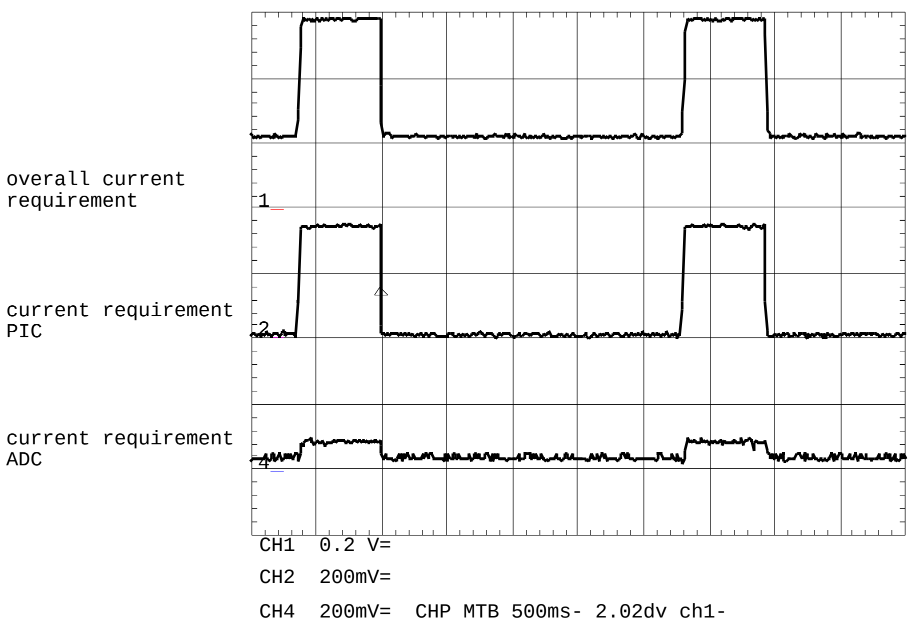


Figure 6: Current Consumtion of the Zero Power Data Acquisition Node

The dependence of the average current consumption vs. the time the bus participant is in power down mode is shown in figure **Fehler! Textmarke nicht definiert.**. The average current consumption can be reduced roughly by 50% by the power down mode of the Zero Power Node.

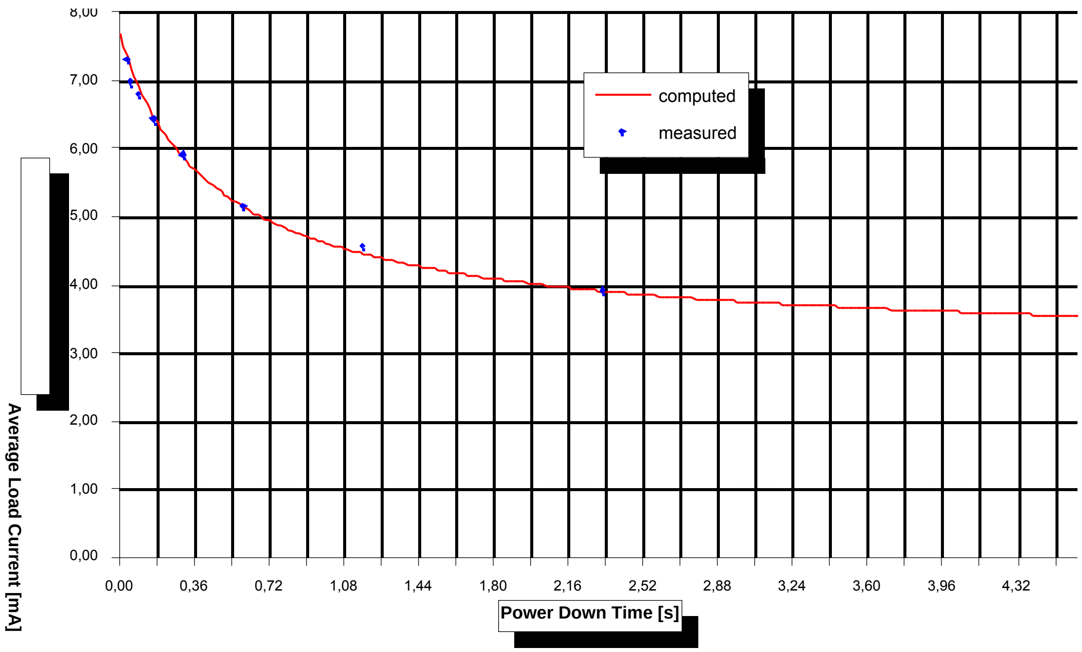


Figure 7: Average Current Consumtion of the Zero Power Data Acquisition Node

Conclusions

The paper shows, that it is possible to realise a decentralised system with processing bus nodes using CAN with integrated transmission of information and power. Firstly the participants can be designed in such a way that they have a small power consumption. Secondly the quantity of the power, which can be transmitted especially by the modulation method, depends practically only on the dimensions of the bus line or the electronic design of the couple circuits of the transceiver. Load changes (e. g. switching of lamps), even of greater power value, have practically no influence to the transmission of the information using modulation.

Due to the fact, that the carrier frequency of a modulated signal has to be at least 10 times higher than the baudrate, higher baudrates are possible with base band transmission.

To assess the requirement of integrated transmission of information and power not only the number of bus lines are important but also a simple connection of bus nodes and in future the possibility to use devices in environments with a danger of explosion.

Because of the excellent fault detection and fault reaction CAN is very qualified for a system with integrated transmission of information and power.

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