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INTEGRATED POWER SUPPLY TRANSMISSION (IPT) FOR CAN

ABSTRACT

To simplify the structure of decentralized automation systems it is necessary in the future to transmit the information and the power supply for the bus nodes over one and the same line.

The paper gives a summery of existing serial bus systems with integrated power supply. The possibilities to use such systems in the sensor/actuator area is discussed and the physical and technical limits are shown. The conclusion is, that it is advantageous to adapt existing bus system of the sensor/actuator area by changing their physical layer. This can be done by several kinds of modulation as known in communication engineering.

INTRODUCTION

With the present change of conventional interfaces for process measuring techniques and sensor technologies to serial busses one can recordnize a shift of the functions for digitization and data processingof sensor signals in to the vicinty of the sensor. Major effects are obtained by more reliability and gauging accuracy as well as the implementation of decentralized automation functions.

The serial networking concern with the conceptional realization of the lower layer of the automation hierarchie close to the process,is called sensor actuator bus layer.

The system components bus line, bus participitor, sensor actuator moduls, sensor arrays excel in a clear material and cost reduction and therefore differ from process busses.

The rationalization effects of draft, project and installation of those systems are not to under estimate, especially by small system structures (less than 20 bus nodes). Figure 1 shows a generic structure. Additionally to the serial transmission line (in the best case a two-wire line) the bus nodes must be supplied with power. At least a third and a fourth line must be carried along. Electronic circuit technology and networking have to deal with problems like galvanic isolation and noise suppression (EMC).

Today many users are very interested in a „real two-wire bus“. The information exchange in this serial sensor actuator bus system is realized at the same time when the power supply is transmitted and on the same two-wire circuit.

This principle is called „Integrated Power supply Transmission“ - IPT. The following figure 2 shows the principle of a sensor actuator bus with IPT.

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Figure 1: Prinzip of sensor actuator bus system

REQUIREMENTS AND LIMITS

The system structure of serial sensor actuator busses with IPT are large variety. Systems requirements for data transmission of speed as high as possible and a non-expensive transmission medium (twisted pair) with an efficient way of installation (routing, cabling, connectors) are contradictional.

In every case solutions can be found only with well-suited compromisses. Those solutions are mostly depending on the aimed field of application.

In a specification of single requirements of system and components layout some limits have to be recognized, for example physical laws.

System parameters containin requirements and performances are for instance:

- topology (line, ring),
- line length, line sort, line cross sectional area,
- shielding of bus line, wave form of information signal,
- number of bus nodes in a system,
- cost per bus node,

- quantity of power supply transmission (0,5 ... 2 A; 10 ... 50 VA),
- galvanic isolation.

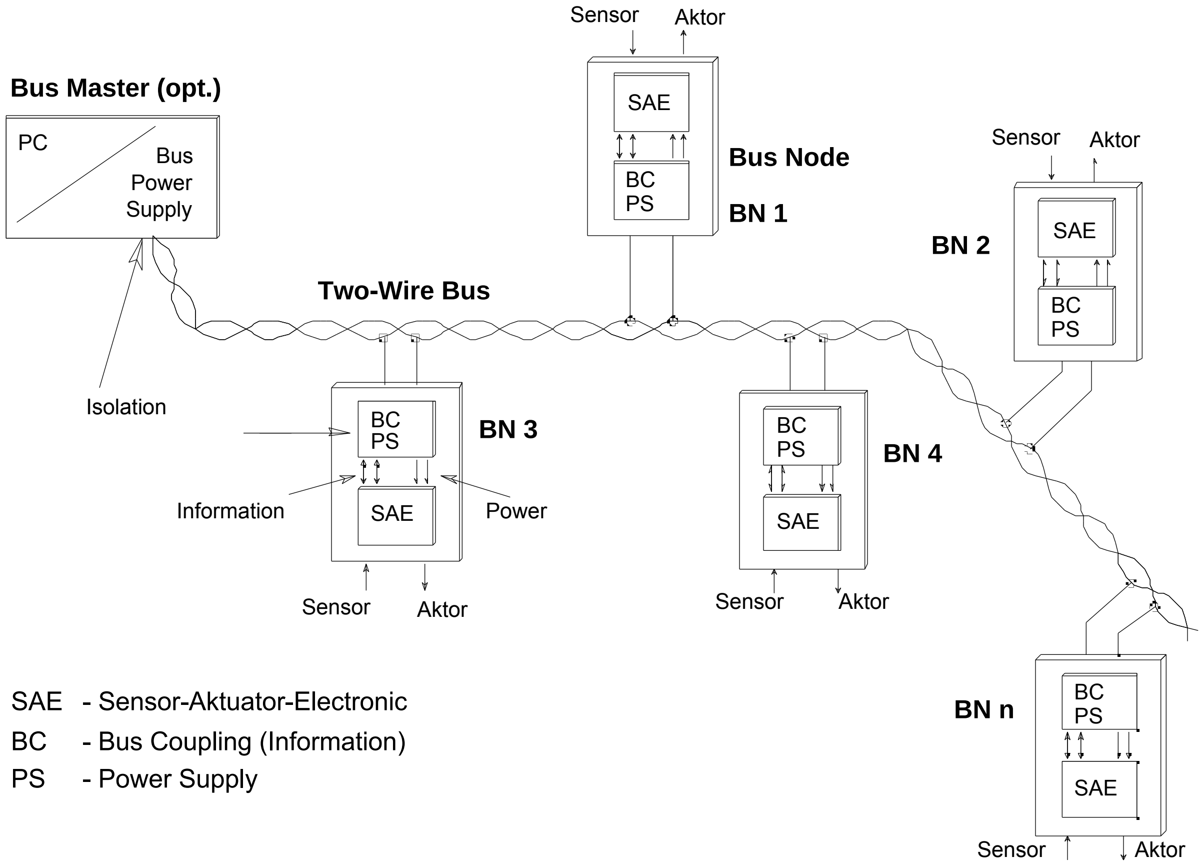

Figure 2: Bus system with IPT

These parameters are not independent. The relations can be estimated after numerical assignment. For instance, the maximal length of the bus line depends from the power load (current), the wire cross sectional area (resistance), the data communication speed and the number of bus nodes.

The point is a clear reduction of cost and material per sensor actuator connection. That aim is rechable by:

- a consistent integration of all electronic components (sensor + signal processing unit + bus interface circuit + ASIC ♉ micro system technology),
- reduction of the costs for connection and installation,
- integrated power supply transmission (IPT),
- a simple full automatic system management (parameter setting, operation, maintaince, diagnostics).

At the present time exist some realization limits caused by technical problems, for instance the implementation of all components into an ASIC (standard cell array). Problems of noise radiation from data transmission with unshilded two-wire lines have been mastered only with lower data transmission speeds yet (see ASI [2]).

With an increasing number of applications the signal and power supply transmission to the bus nodes has to be done with galvanic isolation in vicinity of the sensor or actuator..

By now sufficient results are reached only with transformer couplings. Those solutions are very difficult to integrate.

PRINCIPLES OF OPERATION

In order to get power transfer as large as possible using a „real two-wire bus" the bus should be connected to a high direct voltage (typically 24 V DC).

If the information carrier is also a voltage the power and information can be transmitted by the time division multi-plexing (figure 3). If the information carrier is a frequency the trans-mission can be done parallel (figure 4).

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Figure 3: System structure (information carrier voltage)

Power transmission

Independent on the carrier of information the maximum of power is limited at first by the resistance of the line. For this reason supply voltage should be as high as possible. In diagram 1 the voltage level on the bus node is shown for a supply voltage of 24 V versus the length of the line dependend on the line cross sectional area.

A constant power consumption of every bus node (transverter behaviour) was presu-med.

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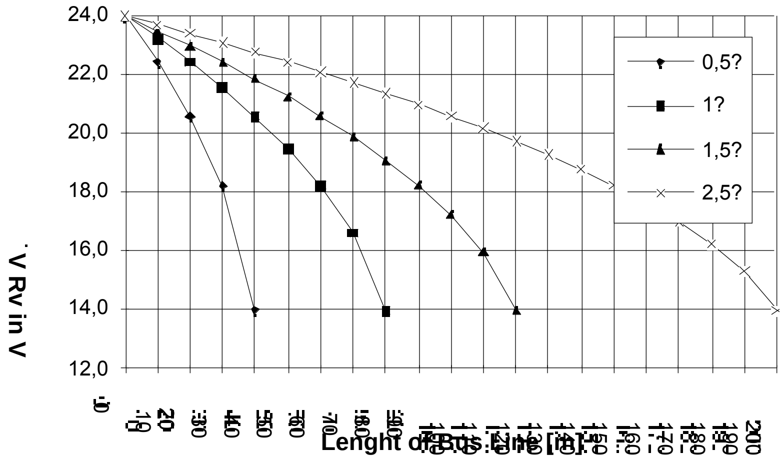
Figure 4: System structure (information carrier frequency)

Under all circustances a drop of the bus voltage to the half of the supply voltage (power fitting) must be prevented, otherwise the bus voltage will break down.

The actual rate of power that can be transmitted depends on the kind of information transmission. With other words, for given power needet and a given line cross sectional



$$V_{R_v} = \frac{V_S}{2} + \sqrt{\left(\frac{V_S}{2}\right)^2 - 2 \cdot R_L \cdot z \cdot P_{BT}}$$

mit $R_L = \frac{\sigma \cdot l}{A^2}$

V_S = voltage supply

P_{BT} = power supply (bus node)

z = nodes

R_L = wire resistor

Diagram 1: Supply voltage by the last bus node (25 nodes a. 2 W power supply)

Base band data transmission (information carrier voltage)

This kind of transformation uses the idle mode for voltage supply on the bus. The power supply of all bus nodes is guarenteed with 100 %. To transmit the information the bus node has to realize a short circuit of the bus (100 % throw, figure 3 and 5) or the defined decrease of the bus voltage (10 % throw, figure 6).

There power transmission is not possible during low-bit with 100 % throw. The power transmission during high-bits is also restricted. During the rising uptime no power can be transmitted. The use of the Manchester code for a guaranteed unity mark to space ratio is not recommended for this reason.

Much better are large breaks between single data telegrams, but the effective data transmission speed is decreased.

The large voltage throw (24 V) allows no high data transmission speed (< 9,6 kb). The nois radiation is high. In spite of these disadvantages such a system is easy to realize and qualified for relative time uncritical applications. Compared with this diagram 1 the

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Figure 5: Bus voltage by 100% throw

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Figure 6: Bus voltage by 10 % throw

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Figure 7: Bus voltage by FSK-Modulation

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Figure 8: Bus voltage by carrier keying

maximum length of line is reduced about 50 %.

From the transmission technological and energetical point of view it is much better to create voltage throws of a few percent of the supply voltage for the information transmission. A higher data transmission speed are possible, the nois radiation decreases and the power can be transmitted continously.

The receiving of data is very problematically. Whereas for a 100 % voltage throw only a comparator with constant voltage threshold is needed, higher expense have to be done for a few percent voltage throw.

Due to the fact that load changes may be interpreted as a signal, the load change speed must be limited by a special power coupling circuit.

Base band data transmission (information carrier current)

There are essential advantages, if a modulation of current is used for the information carrier. Beside a higher noise immunity it is possible to use longer line length for the transport of information. Information impulses are generated (sended) by a current keying with different impulse waveforms (rectangle, trapeze, sine) for systems with a line structure. This is the case for the most sensor actuator systems.

A corresponding industrial solution based on this principle was realized by the Actuator Sensor Interface (ASI) and is spreading out rapidly in its use. Arbitrating systems, for example CAN, have to be structured in a different way.

A solution attempt qualified in principle for multi master mode is the Meter-Bus system (Texas Instruments). Unfortunately only small amounts of power supply can be transmitted. The data communication speed is very slow (max. 9,6 kb). Figure 9 shows the generic system structure and the principle of operation.

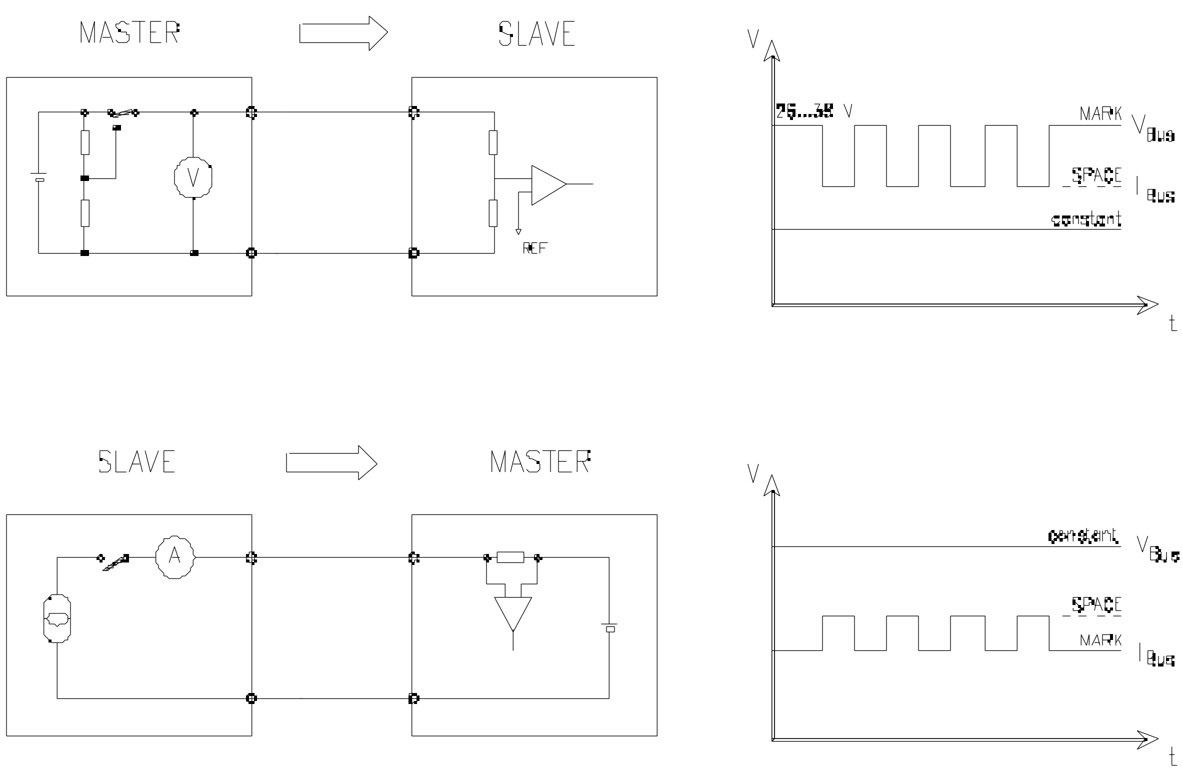

Figure 9: System structure of the Meter-Bus

The slaves send with a modulation current. This results in a voltage drop at the master side. It can be detected by all bus nodes with their built-in „read-in function“. Important advantages fot this system are gained by the availability of a bus interface circuit (CMOS-IC TSS 721).

The system with data transmission in the base band with modulation of current based on the princip of operation shown in figure 10 is usuable in general. Major point is the design of the differentiator at the central bus power supply. Recently interesting studies are presented in [9].

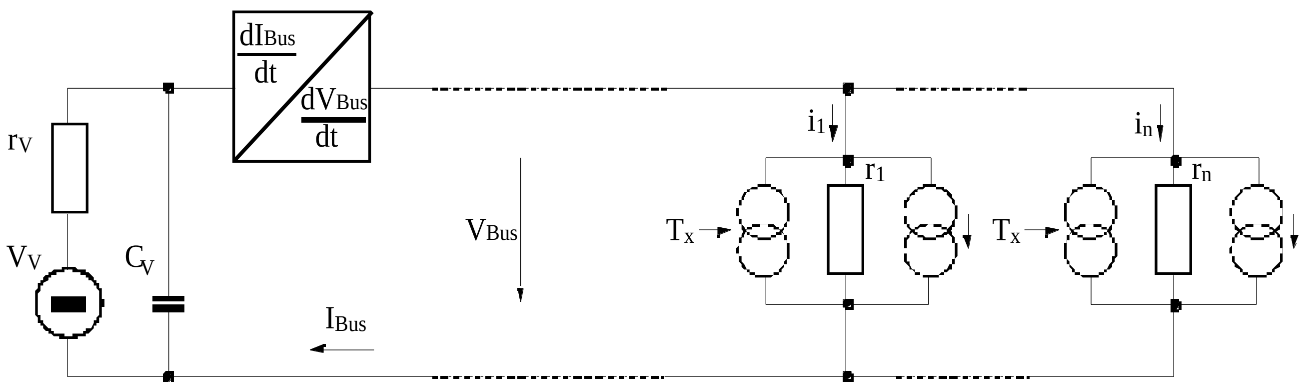

Figure 10: Current modulation

Modulation management (information carrier frequency)

The use of modulation management has the aim to separate information and energy easier and to enable a continously power transmission. The principle is shown in figure 4. It is comparable with the supply of a satellite receiver or an antenna power amplifier by the antenna cable.

Ideal conditions hold for the power transmission (see diagram 1). The information transmission can be realized by classical principles of FSK-Modulation (figure 7) or by carrier keying (morse principle, figure 8). The general problem is, that for a simple demodulation the carrier frequency has to be greater than the signal frequency by factor of 100 (VHF broadcast transmit about 1300) and there for the maximum data transmission speed is relative slow. Nowadays we are working on optimized demodulator circuits, which are supposed to reach a factor around 10.

The procedure of carrier keying could be suitable for the CAN, too. The above problem is becoming more difficult. The double signal delay time through modulator, line and demodulator has to be less than the maximum allowed skew between two CAN data telegramms.

SOLUTION FOR CAN

Right now the autors work on a system according to figure 4, that should be suitable for

At present scientific research at the University of Magdeburg pursues two major ways for the realization of a integrated power supply transmission for CAN.

The first way of solution bases on a modified FSK-prinziple (see figure 4). For now the realizable and principle caused data transmission speed is relative slow (10...20 kb). The advantages lie here especially in the synthesis with different forms of power supply (direct or alternating voltage), that promise economical automation solutions even for reconstruction projects and unpretentions wire based media.

The second way of solution based on the modulation of current impulses on a direct voltage level (base band, see figure 10). Large problems were caused by the structuring of the voltage impulse former cicuit with the function $\frac{dI_{bus}}{dt} \blacklozenge \frac{dV_{bus}}{dt}$. The generation of usuable impulses in an arbitrating system with power supply up to 2 A with passive electronic devices is very critical and not usuable for practical applications. First drafts of active electronic circuits are available. They contain some solutions, that meet the requierements at the first level.

Another direction of research based on the investigation of an effective galvanic isolation of the single bus node with IPT. As the most usuable solution at present time a pure inductive coupling device is further researched and tested. Partial solutions are present in [10].

CONCLUSIONS AND FUTURE VIEWS

Technical solutions of serial sensor actuator busses with integrated power supply transmission will increase the performance of the lower automation layers for a wide field of applications in future.

This results can only be reached with complex ASIC structures wich enable the design of single chip bus nodes, a non-expensive production and high performance application.

That means for CAN, that a new layer 1 with integrated power supply has to be designed for industrial use. New fields of applications can be found and existing systems enlarged with bus controller IC’s available now.

This development touches the field of microsystems technology. Single chip structures, that contain sensors/actuators and signal processing electronics and a serial bus interface will dominate in future.

REFERENCES

[1] ***Güttler, F.; u. a.:*** Sensorbusse. Forschungsbericht DFAM-Vorhaben Nr. 610011, TU-Magdeburg / IAM-Braunschweig, Dez. 1993

[2] ASI: Alternative zum Kabelbaum. Vorträge des 1. ASI-Statusseminars, Frankfurt, 26. Jan. 1993

[3] ***Schindler, Th.:*** Systemstrukturen und leistungsarme Schaltungsanordnungen in der sensornahen Meßdatenerfassung. Dissertation, TU-Magdeburg, 1987

[4] ***Seifart, M.; Rauchhaupt. L.; Beikirch, H***.: Leistungsvergleich von Bussystemen der Sensor-/Aktorebene. MessComp `92, Wiesbaden, Sept. 1992

[5] ***Schindler, T.; Beikirch, H.; Rauchhaupt, L.:*** Integrierte Hilfsenergieübertragung bei Sensor-/Aktorbussystemen. iNet '94, Hamburg, 14.-16. Juni 1994

[6] ***Meusling A.***: ASIC-Strukturen für dezentrale Funktionseinheiten der Meßwerterfassung. Dissertation A, TU Magdeburg, 1991

[7] ***Stollberg, A.***: Industrieerprobungsbericht zum Einsatz des IC "U5201 FC529" Meßwerterfassungsschaltkreis mit Feldbusanschluß. Energieversorgung Nordthüringen AG, Mühlhausen, Febr. 1991

[8] SMAR FB1050 Fieldbus Communikation Controller. Smar Research Corp. USA, 1992

[9] ***Pietsch, Ingolf***: Schaltungstechnische Untersuchungen zur gleichzeitigen Signal- und Hilfsenergieübertragung bei seriellen Sensor-/Aktorbussystemen. Universität Magdeburg, Fakultät Elektrotechnik, IPE, Diplomarbeit 1994

[10] ***Stert, Axel***: Potentialgetrennte Signal- und Hilfsenergieübertragung mit seriellen Sensor-/Aktorbussen. Universität Magdeburg, Fakultät Elektrotechnik, IPE, Diplomarbeit 1994