CANopen truck gateway

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Current problems with the interface between the truck and the superstructure will be explained and the requirements for an “ideal interface” will be defined. The requirements with respect to flexibility and real-time capability recommend the use of a field bus system. Reasons for choosing CANopen protocol will be explained. This will be followed by information about the structuring of the CANopen Truck Gateway standard, explaining also default communication and safety concept. In addition, the integration of the interface into the entire system of truck and trailer will be highlighted as well as special objects and mechanisms for superstructure manufacturers. Finally current activities with application specific associations are mentioned. Their focus is to ensure an application specific interface setup in an plug & play manner offering significant rationalisation.

1. Introduction and History

In addition to the classical use of a truck about one-third is adjusted to special customer-specific requirements, and this is an increasing trend. In general, these customer-specific adjustments are made by the superstructure manufacturers. These are mostly small to mid-sized companies, which have focused on special applications. All, however, have one thing in common: they need an interface to the truck. The type and the extent of the required information from the vehicle and access onto the vehicle vary considerably and are highly dependent on the specific application. This is nothing new and that is the way it is, the way it was and it will continue to be the case. However, trucks have undergone fundamental changes in the last 10 to 20 years. Meanwhile Trucks are complex systems reacting extremely sensitive to any changes by 3rd parties. Therefore well defined interfaces between trucks and superstructures are getting more and more important.

2. Requirements for an "Ideal Interface"

An ideal interface should universally cover all the various requirements from the low-end to the high-end applications. Of course, it should be based on a digital interface. But before analysing the various bus systems an ideal interface shall satisfy following functional requirements:

- Considerable number of information and controls
- Flexible selection of information and control needed

- Flexible Communication setup to match specific application needs
- Clearly defined safety aspects
- Expandable and future prove
- Cost efficient

Physical aspects, such as the definition of standard connectors, its pin assignments and the connector locations are assumed self-evident and will not be discussed further.

Beside these functional requirements an ideal interface shall provide a bus system allowing connection of various in- and output devices. Surely it shall base on a known and wide spread protocol. For the use of programmable devices, the Master / Slave communication should be supported. The increasing trend to shift intelligence into peripheral devices and the increased process splitting to several programmable devices make a Multimaster bus access necessary. The bus system should encompass devices with high complexity such as supervising control units as as the simplest and very low-priced devices like binary sensors and actors. Beside the availability of low-cost components, predefined devices and application profiles are extremely important for economic system integration. Such application profiles are the prerequisite for the use of standard devices allowing rationalisation. Further, the bus system must satisfy high requirements for communication security in an environment, which is influenced by electromagnetic interference's. The bus system usage is expected mainly in process related communication. Short telegrams would be sufficient for this purpose. For special requirements, such as the transmission of configuration files, diagnosis data or things similar, the transmission of longer telegrams should also be supported. As a summary, the bus system should satisfy the following requirements:

- Real-time capability High
- Transmission speed High
- Reliability & failure tolerance High
- Electromagnetic capability High
- Flexibility / configuration High
- Installation / assembly Low
- Cost effectiveness High

These requirements are fulfilled by field buses.

3. Overview of Field bus Systems

What field bus systems are available on the market? Investigating the most conventional field bus systems

- PROFIBUS
- InterBus
- Bitbus
- CAN
-

indicates benefits of the CAN bus system, in particular in the area of electromagnetic capability. The additional requirements according to section 2 as regards real-time capability, transmission speed, flexibility and cost effectiveness are fulfilled by the CAN bus system. CAN was originally developed by BOSCH especially for vehicles requirements. In the meantime, CAN is being used in a high number of non-automotive applications with great success. The sale of more than 100 million CAN transceivers impressively shows the success story of the CAN bus system.

4. CAN Standardisation

4.1. available CAN protocols

The standardisation of CAN in accordance with ISO 11898 only includes the ISO/OSI[1] layers 1 and 2. The implementation of the application layer is left to the user. He must define:

- values to be transmitted including value resolution
- value mapping into messages
- assignment of priority and transmission parameters of messages.

This does not present any problems for closed systems. However, if CAN devices and components from various manufacturers are to be integrated into one CAN bus system, then all of the above points must be individually defined and agreed on for each implementation. This would be associated with a very high expenditure and would not be economically feasible. As already mentioned, an "ideal interface" between the truck and the superstructure must, on the one hand, allow a free communication set-up and, on the other hand, be highly standardised by means of device or application profiles. Various approaches have already been developed with the goal of standardising CAN communication. The conventional CAN protocols are:

- SDS (Smart Distributed Systems)
- Device Net
- CANopen
- SAE [2] J1939

The CAN protocols SDS and Device Net were developed for the automation technology. SAE J1939 was specially developed for automotive applications and CANopen focus on distributed automation

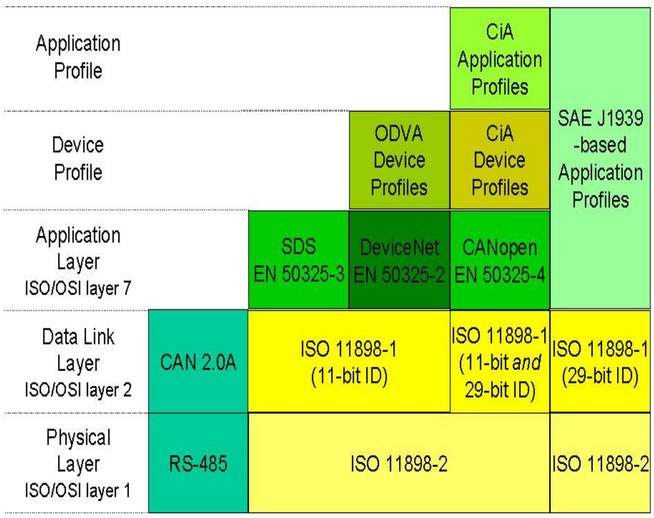

illustration 1: CAN Standardisation

technology. Nevertheless only SAE and CANopen protocol support application profiles (see illustration 1). The SAE J1939

[1] ISO/OSI – International Standards Organisation / Open Systems Interconnection

[2] SAE - Society of Automotive Engineers

describes in detail the communication of various devices within an automotive application. Thus it assures the easy exchangeability of various well defined automotive subsystems but however provides low flexibility only.

4.2. CANopen Field Bus System

Thus only CANopen fulfils the requirements on both high flexibility and application profile support. As already pointed out the CANopen field bus approach is the standardisation for distributed automation technology based on CAN. CANopen is standardised in EN 50325-4. Just shortly after its introduction, it became widely used and can be seen as the definitive standard in Europe for industrial CAN-based system solutions. The CANopen product family is based on "communication profiles". Further highlights from the user point of view are a well defined conformance test and the electronic data sheets (EDS), which are a detailed and standardised electronic device description. All of these standardisation's are a significant advantage compared to other bus systems. The user doesn't have to worry about settings and compatibility problems but allows him to individually adjust all parameters. These technical prerequisites and the non manufacturer dependence of the protocol have lead to a rapid widespread use of the CANopen protocol in the various applications. This is also shown in the numerous components, development and application tools, and CANopen source code etc., which have been available from various manufacturers on the market for years.

5. CANopen Device Profile - Truck Gateway DSP 413

The founding of the CANopen Special Interest Group (SIG) Truck Gateway was in 1998. Participants in the definition included CAN-in-Automation (CiA), all German truck manufacturers, various software and ECU manufacturers and superstructure manufacturers, which were represented by the 'Verband für Arbeitsgeräte und Kommunaltechnik' (VAK). Meanwhile also the other European truck and superstructure manufacturers are participating.

5.1. Structuring

The CANopen Truck Gateway device profile is structured as follows:

- Part 1: General definitions and "default" communications
- Part 2: image of ISO 11992-2 "brake and running gear"
- Part 3: image of ISO 11992-3 "other than brake and running gear"
- Part 4: image of ISO 11992-4 "diagnosis"
- Part 5: Objects for superstructure manufacturers
- Part 6: Generic SAE J1939 – CANopen Gateway

CANopen 413 parts 1, 2, 3, 5 and 6 have been approved within 2003. Thus, well over 200 CANopen objects have already been standardised. One reason for this structuring was the already existing ISO 11992 standard, focusing on the data exchange between the truck and the trailer(s). This structuring provides advantages to both the truck and superstructure manufacturers. The truck manufacturer profits during implementation since ISO 11992 and CANopen signals are identical. The superstructure manufacturer will profit since the very same CANopen objects are available in both the truck and in the trailer.

5.2. "Default" Communication

In addition to the above general statements, CANopen 413 part 1 defines "default" communication, which provide a basic functionality in the delivery condition. This was aligned to ISO 11992 part 3 communication

5.3. Safety Concept

Particular attention is drawn to an integrated safety concept for accesses to the vehicle. For the various access CANopen provides an additional information, whether or not a certain access is allowed. Thus, the superstructure manufacturer is always informed in a uniform manner about the authorisation of the various access. Thus, this clear separation increases the safety level for the entire combination of vehicle and superstructure.

5.4. Integration into the Entire Vehicle Truck and Trailer

A further goal is the complete integration of the CANopen interface into the entire vehicle. To achieve this, mechanisms were defined, which use existing network structures without additional wiring. This "tunnelling" mechanism is based on the reservation of special parameter group numbers (PGN) within SAE J1939 and ISO 11992 networks. This really encompasses nothing more than empty messages. The contents of the data, that is all 64-bit user data within the telegram, can be freely defined by the CANopen user. The mechanism is shown in illustration 2. /1/

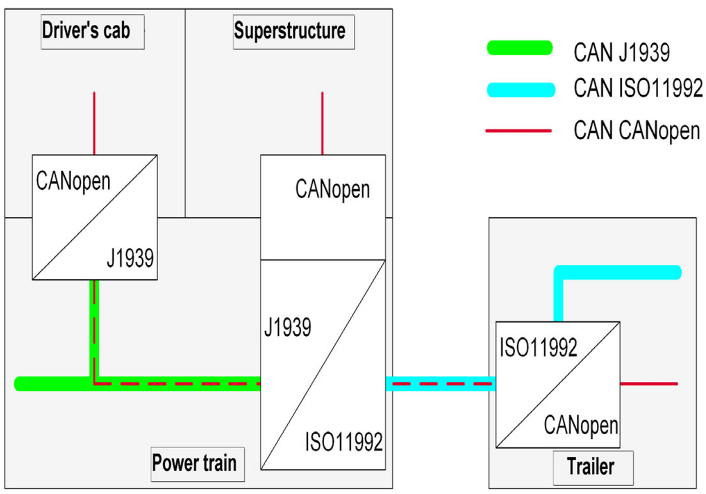

illustration 2: CANopen Tunnelling

5.5. Part 5 – Superstructure Manufacturer

After decisions were made about the basics, co-operation with the superstructure manufacturers of various branches was systematically sought. Their overall requirements were partially covered in CANopen 413 parts 2 and 3. The remaining requirements are standardised in CANopen 413 part 5. These objects can be classified into three groups:

- General Status Information:

Signals mostly simple but highly useful in practice such as:

- Selected language,
- Parking lights,
- low and high Beams
- etc.

- Additional Status Information:

Two of the most important accesses for the superstructure manufacturer are the engagement of various power take-offs and the control of the engine. CANopen 413 part 5 provide for each PTO individually "PTO control allowed".

- For engine following "control allowed" stati are defined:
- Control engine rpm upper limit
- Control engine rpm lower limit
- Control direct engine rpm
- Control engine torque limit

- Superstructure Status Information:

Future developments for commercial vehicles may consider certain superstructure internal status. Certainly, only standardised information can be considered on vehicle developments. Knowing well, that the presently defined objects only represent the very beginning, the following information is already standardised:

- Current consumption superstruc-ture [A]
- power consumption (net torque) superstructure[kW]

5.6. current activities

The variety of objects offers both complete new functionalities as well as rationalisation. On the market the available objects will significantly depend on both Truck OEM and vehicle configuration. For instance only an vehicle with electronic display may provide the object “selected language” or requesting “stopping brake device” requires that vehicle option being present.

To overcome such practical limitations the CANopen Truck Gateway setup for the various applications will be agreed with the responsible associations resp. user groups. There the mandatory objects will be commonly agreed to ensure base functionality in an plug & play manner. This will be extended for the optional features.

6. Conclusions

First branches have noticed the benefits of an uniform and the manufacturer-independent CANopen Truck Gateway. Simply by aligning the communication setup allows easily the definition defined base and optional functionality in an plug

& play manner. And all that being available independent on both Truck OEM and superstructure manufacturer. That offer significant rationalisation for all affected parties. Such co-ordination will soon be finished for refuse collection vehicles, other applications will follow soon.

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7. Literature List

/1/ Peter Fellmeth, Vector Informatik GmbH
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/2/ With the kind approval of CAN User Organisation, CAN-in-Automation (CiA), Erlangen