CAN powerline application for rolling stock

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Powerline Interfaces enhance the fields of application for CAN. Notably effects can be achieved in the area of automation of rolling stock. New ways of communication become possible. Flexible network configurations during the composition of a train demand rugged network connections. Powerline provides an effective solution for this problem. With simple means at low cost a reliable communication can be realized. Industrial applications prove already the capability of this new interface.

Preface

The aspect of a flexible system composition for rail-bound vehicles plays an important role. This affects especially the wire-bound communication of information and control systems. Every time a train is composed a new network has to be formed and set up.

From a technical point of view this flexibility means that a serial bus line has to be routed via a large number of contacts (e.g. UIC connection) from wagon to wagon. These connections need to be very reliable. In order to achieve this, the serial lines are operated in principle with a higher voltage (50-60V dc) in combination with a line fritting current. This provides a reduction of contact resistance and increases the contact reliability.

The communication of a Controller Area Network (CAN) via such a line is based on the principle of Powerline Communication. This means, that the bus nodes will communicate over a loaded DC line.

A conventional solution for a CAN communication between two wagons has been introduced in [2]. In order to overcome the contact resistance between the wagons and increase the contact reliability, the bit rate had to be decreased.

When the principles of Powerline are to be used, it is difficult to keep the usual CAN functionality. This is because of the access methods of CAN and its inherent properties.

In order to reach the goal of achieving a bit rate, that is comparable to a standard CAN and its usable length, a CAN Powerline transceiver was designed.

The high demanding requirements for equipment for rolling stock in respect to immunity and emissions according to EN50155 and the demand for high reliability are of primary importance. It was necessary that the new interface could be integrated into a PLC of the Train Bus Coupler series TBC 701-T [9].

2. Principles of CAN-Powerline

In several publications ([1], [3], [4], [5], [7]) the different principles of CAN Powerline implementations have already been discussed.

Restrictions always will be caused by the particularities of the Multi Master network CAN. This includes especially the limited signal propagation times and the resulting bus length.

In order to achieve a suitable solution both Powerline principles

-base band method and

-signal carrier method

had to be analyzed further and verified for their qualification for use in the targeted area of application [3][4][5].

The signal carrier method utilizes the high-frequent carrier frequencies for digital modulation. Modulation can be realized by using one of several carrier frequencies. Figure 1 and 2 demonstrate the basic principles of this form of modulation. For transmitting a dominant bit the carrier is modulated, for a recessive bit the carrier is not modulated (principle of ASK - Amplitude Shift Keying). This principle, as other broad band principles, is very demanding in regard of signal processing capabilities. Also, they cause different signal propagation delays.

This means a significant reduction of the maximum obtainable bit rate. Signal carrier principles, that have been examined so far (carrier frequencies of Cenelec band D), can achieve bit rates of max. 30kbps. By utilizing higher carrier frequencies (1 … 5 MHz should be considered) higher bit rates are possible in the future. Investigations of multiple carrier principles (see figure 2) are still in the experimental phase [11].

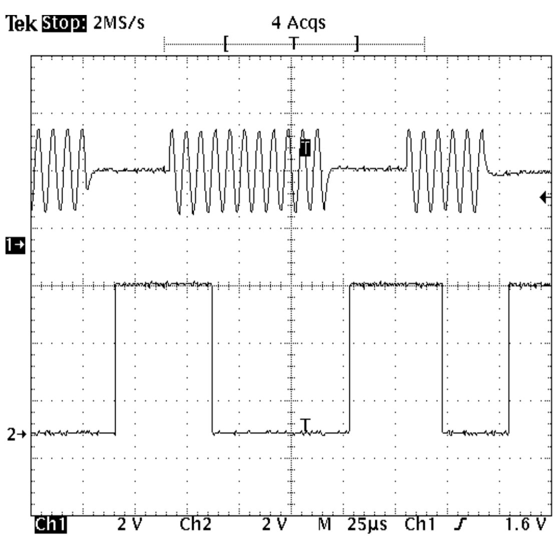

Fig. 1: Single Carrier Principle

In comparison to this, the use of the base band principle allows for much higher bit rates. Base band modulation means, that for every bit only a single impulse is modulated onto the voltage-carrying bus line.

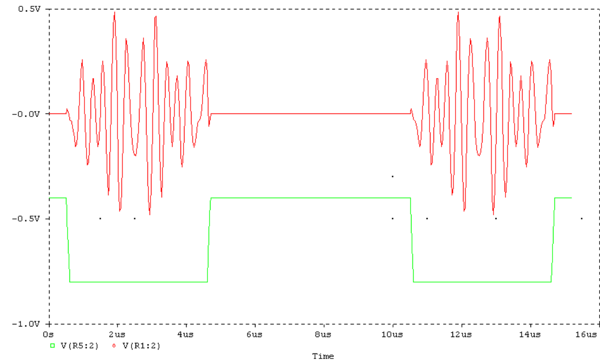

Fig. 2: Timing signal with 3 narrow carrier frequencies (2,3/2,7/3,3MHz) [11]

Figure 3 shows an example of a CAN frame on a bus line. The delays between the transceivers are considerable smaller when using the base band principle. Also, the effort for signal processing is much less. Therefore an optimal transceiver can easily be realized.

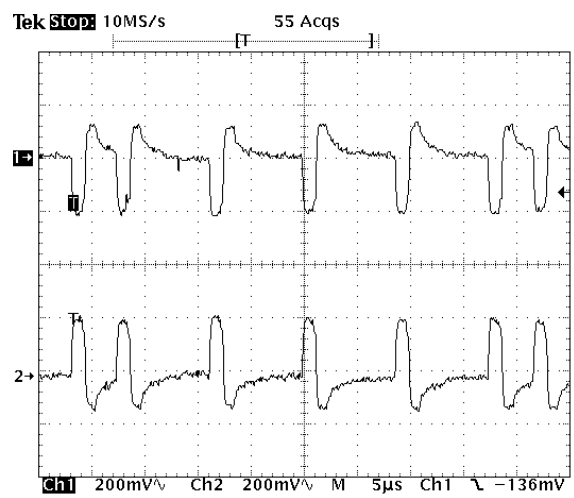

Fig. 3: Bus level on a base band Powerline

A transceiver according to the base band principle has been specified for the use in the area of inter vehicle communications for rolling stock [11].

3. Solutions for Rolling Stock

While designing a base band transceiver the specific demands of electronic equipment for rolling stock and the demands of CAN itself have to be considered.

For every wagon a Train Bus Coupler (TBC 710-T) is intended. These Train Bus Couplers will connect the internal CAN of every vehicle onto the CAN Powerline train bus. The principle is shown in figure 4.

Every node is equipped with a CAN Powerline transceiver.

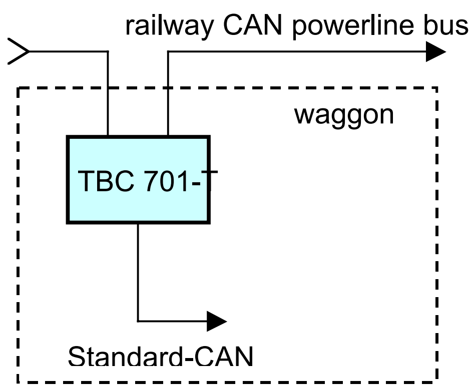

Fig. 4: Railway CAN Powerline bus: CAN Powerline through UIC-line

The base band principle has been implemented according to the structure shown in figure 5.
A Philips CAN-Controller SJA1000 has been used. Besides analog filters, drivers, triggers and limiters, the entire digital signal processing of Powerline impulses has been integrated into a programmable circuit (FPGA).

For the necessary potential separation an impulse transformer had to be utilized.

The limits for bit rate, propagation delay and cable length have been examined in a laboratory analysis. Cable simulation with loads and ESD-protection circuits have been utilized.

The main problem are the already known signal delays of the transceivers. Also heavy jitters where caused by the synchronization mechanism between the bus nodes.

Impulse delay and insertion loss of he transceivers, that are available so far, allowed a bit rate of max. 125 kbps at a maximum cable length of 330m.

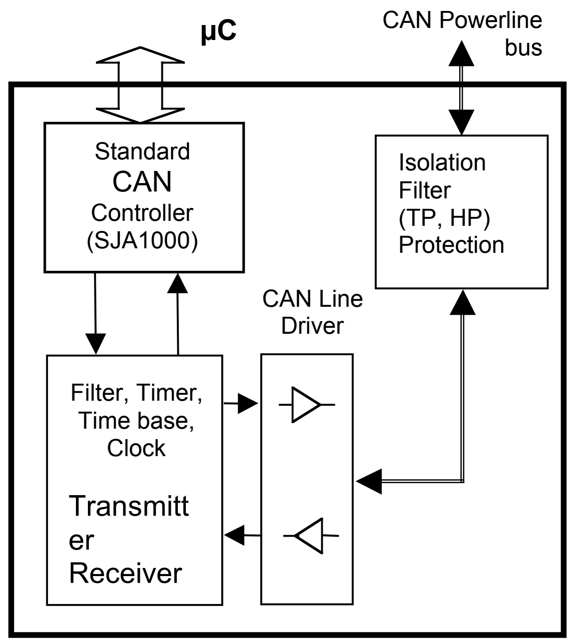

Fig. 5: Principle of Interface

Figure 6 shows the extreme case of maximum delay and attenuation, that the system can safely cope with. In a common diagram a data impulse is shown at the beginning and the end of a bus cable.

The analog impulses can be compared to the digital send and receive signals by using the same time base. The overall signal delay can be exactly determined (cursor difference 2,32 µs).

In field tests with industrial equipment the laboratory results could be proven. Attenuation and delay showed the calculated and expected results.

Figure 7 shows a data impulse (positive level) of a real network with 9 connected Powerline bus nodes.

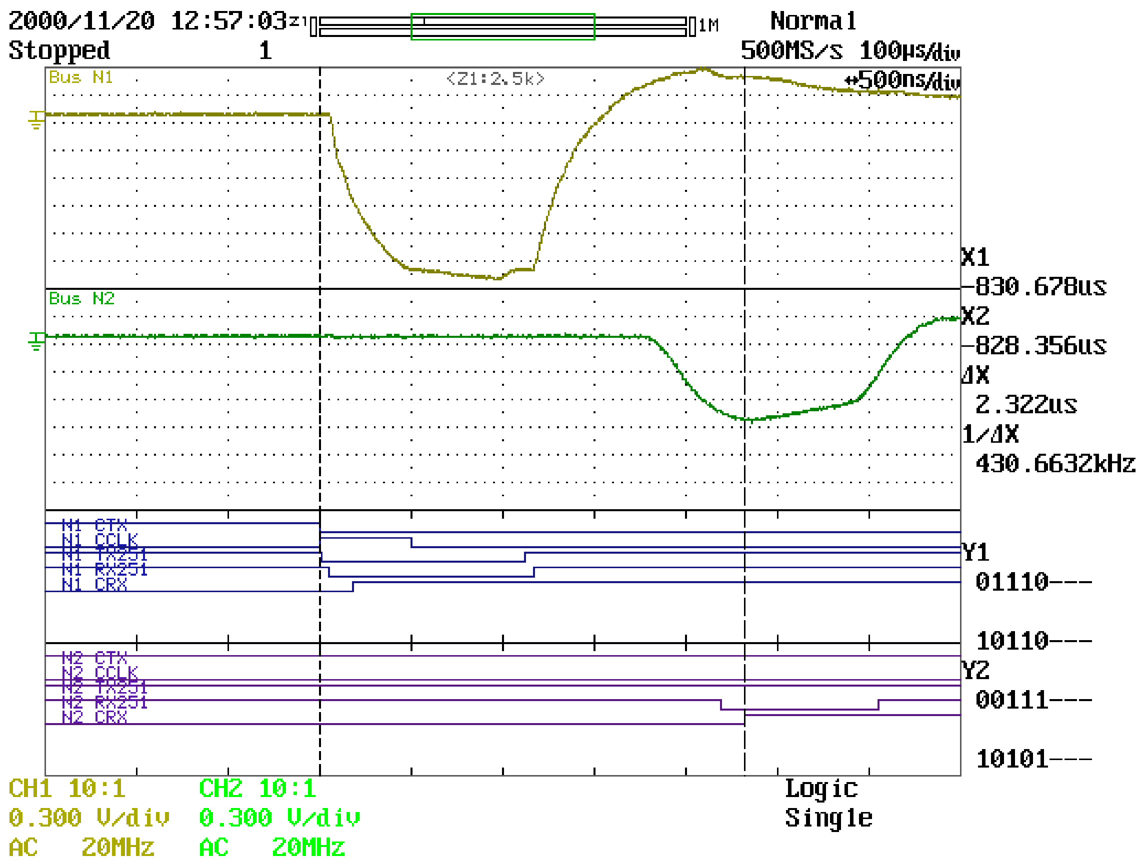

Fig. 6: Impulse Attenuation and Delay in laboratory tests (Δl=330m, 125kbps, 1µs pulse width)

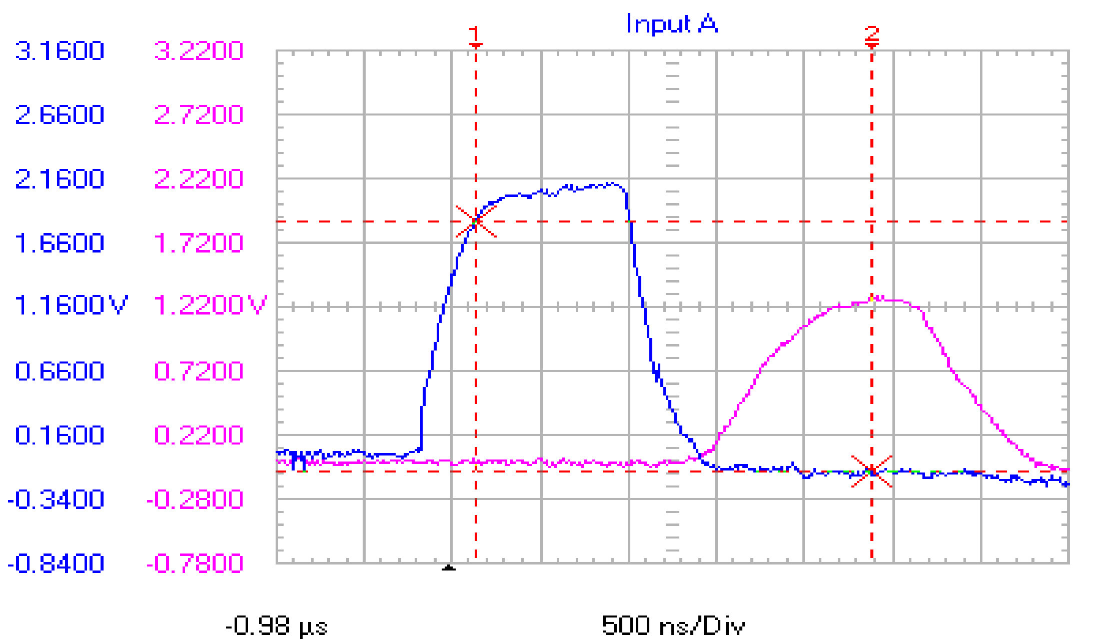

Fig. 7: Impulse Attenuation and Delay in industrial tests (Δl=310m, 125kbps, 1µs pulse width, real network with 9 nodes)

4. Future Trends

The available test results prove the successful function of a CAN Powerline system, that is based on the base band principle.

A further development of this principle primarily includes the integration of the whole transceiver (except potential separation) into a single chip. High volume production would allow a substantial cost reduction per node.

Plans for the introduction of this interface as a CAN standard benefit from the successful industrial practical tests. According activities will start soon.

Additional tests for specification of bit rates and bus cable length (possible combinations) are planned for the coming months. Also the transceiver circuitry will be further optimized, in order to achieve even higher bit rates.

A large number of new applications can be found for this new interface. Slip rings or safety related communications are some of them.

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