Using Power Line Communication for Harness Reduction in Automotive

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Figure 1 – InnoTruck presented in Hannover Messe

The Truck-Trailer harness consists of many wires for activating simple On/Off front and back functions such as lighting. These wires are bulky, heavy and expensive. In the EU SPARC program conducted by Daimler, a new concept of using the powerline for controlling the backlights of both Truck and its Trailer saved significant amount of wires(1).
Adding LED lights, reduced further more the power consumption from the Truck's generator, saving 200W which were much needed for other electronic modules.

The technical challenges in communicating over powerline

Communicating over battery power lines is a challenging task. The DC-carrying copper cables were not designed for communication. Their attenuation depends on the quality of the cable's dielectric, shielding and the frequency of the signal.
The battery itself has very small impedance in the range of 1 Ohm. The loads connected to the battery such as ECU's, although consuming low power, exhibit low AC impedance due to using internal filtering capacitors aimed at mitigating electro-magnetic interference (EMI).
Moreover, the loads are switched on and off, changing the powerline impedance. Inverters commonly used in new electric vehicles generate high frequency impulsive interferences that are mixed with the powerline communication signal. This is demonstrated in Figure 1.
EMI regulations limit the maximum level of powerline communication carrier signal. The higher the carrier frequency, the greater the signal loss. As the frequency increases more of the energy is radiated rather than conducted through the cable.

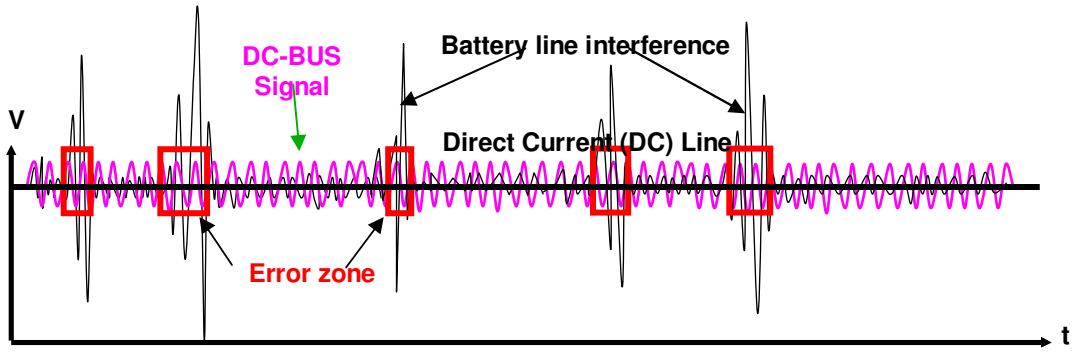

Figure 2 – Signal and noise over the powerline

Advantages and limitations of using PLC in vehicle

Advantages

- Simple installation, only power line required;
- Less wires, higher reliability;
- Simple maintenance;
- silicon replaces costly wires. (Copper price increase, Silicon price decrease);
- Operates on wide range of battery lines (6V, 12V, 24V…300V);
- Supporting variety of automotive protocols (CAN, LIN, UART, SPI);
- Allowing longer communication distances compared to CAN and LIN;
- Promotes new design concepts;

Limitations

- Limited number of nodes connected to the powerline due to wires attenuation;
- Possible data Latency

Case study – Light Control System in InnoTruck

The InnoTruck project is conducted by Prof. Dr.-Ing. Gernot Spiegelberg of the Technical University of Munich (TUM-IAS) with the brilliant design of Prof. Colani, with the objective of demonstrating a next generation, all electric, modular and flexible vehicles. As depicted in Figure 1, the innovative vehicle is constructed from a Truck containing the power train, a Semi-Trailer housing the driver cockpit and a trailer. The vehicle demonstrates aspects of electrical mobility, Drive by Wire, Aerodynamics and Communications. Yamar contributed to this project the Powerline Light Control System that will be described herein.

The InnoTruck Powerline Light Control System consists of front light module and six backlight modules: two modules in the left and right rear side of the truck, the Semi-Trailer and the Trailer. Since the basic requirement was to tow the Trailer and Semi-Trailer by an ordinary truck, two gateways were developed by Yamar, whose task was to translate the backlight status of the existing ISO-1185 connector into powerline commands activating the InnoTruck backlights. Figure 3 depicts the lights system tailored for the InnoTruck.

Figure 3- Light control network of a truck and trailer

Figure 4 shows the system building modules and its testers.

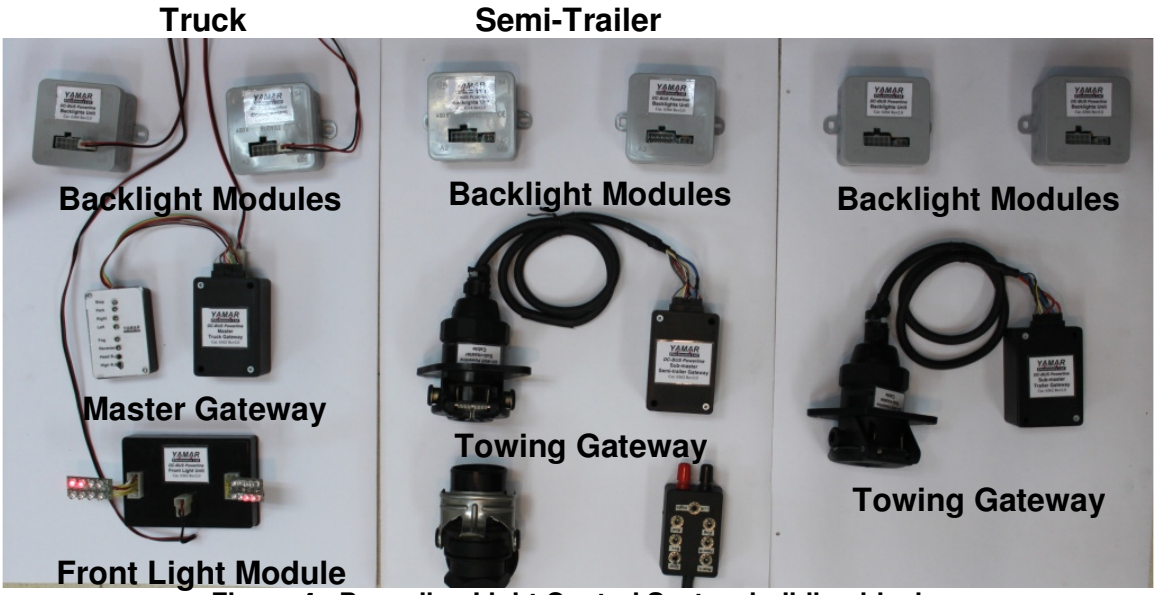

Figure 4 - Powerline Light Control System building blocks

This PLC Light Control System enables simple installation, saves harness complexity and weight by employing a single powerline wire for providing both power and control. The DC-BUS powerline communication technology is implemented by the SIG60 and SIG61 devices.

The DC-BUS network is controlled by the Master Gateway placed in the Truck. Two Towing gateways located at the Semi-Trailer and Trailer serve as sub masters when the towing truck is connected to the Semi-Trailer or the Trailer. The Master Gateway senses its input pins; when one of the inputs is turned "On", the gateway generates a message over the powerline to the Front light and Backlight modules using a SIG60 device. Each of the Trailer/Semi-Trailer PLC Backlight modules employs a SIG61 device that receives the PLC message and converts it into a signal activating the corresponding Park lamp, Stop lamp, etc.

The Towing Gateways have two modes of operation:

I. when a towing truck is NOT connected, the Towing Gateway operates as a master;
II. When the Trailer and Semi-Trailer are connected to the truck (normal operation) the gateways operate as repeaters – simply duplicating the command messages from the truck. This mode ensures proper operation even if the trailer's powerline attenuation is high.

Detailed description of the protocol used to operate the lights over the powerline may be found in the SIG61 data sheet.
Sleep mechanism keeps the power down when the system is not used. This mode is initiated by a command from the Truck Master ECU.

Master features:

- Remotely turn On/Off each of the light control lamps/LEDs.
- Set the Light units into Sleep and wake them up when needed.
- Provisions for future upgrade to multiple trailers network.

Benefits of Powerline in InnoTruck

- Cost reduction combined with 4Kg cable weight reduction (from 5Kg to 1Kg)

- Saved the cost of two Truck-Trailer ISO-1185 spiral cables and connectors and its 3Kg weight. See Table 1and accompanying figure.
- Reduced cables volume by factor of 4.
- Simpler installation and maintenance.

Source: Lapp group.

Figure 5 –Saved spiral cable

Structure	Core			Core			Cable	
No. of cores x nominal cross-section		Diameter of core max.	Color code		Diameter of core max.	Color code	O.D. max.	Weight approx.
mm²	mm²	mm		mm²	mm		mm	kg/km
FLRYY (GGVS)								
2 x 1	1	Ø 2.1					5.7	19.5
3 x 1.5 + 2 x 6	1.5	Ø 2.0		6	Ø 4.3		12.3	150
4 x 1.5 + 3 x 2.5	1.5	Ø 2.4		2.5	Ø 3.0		10.5	130
7 x 1.5	1.5	Ø 2.4					10.6	101
10 x 1.5 + 3 x 2.5 + (2 x 1.5) PP data pair	1.5	Ø 2.4		2.5 1.5	Ø 3.0 Ø 2.4		14.7	245

Table 1 – Automotive cables weights

Source: Leoni cables

DC-BUS Typical automotive applications

Besides the Front and Back lights application, the DC-BUS is used in variety of vehicle applications such as:

- **EV Batteries management** - The DC-BUS allows communication between the battery packs, providing the cells status to the battery management unit.
- **Doors control** – Replacing bulky harness that controls the doors and its mirror.
- **Truck-Trailer** – Redundant CAN communication over the powerline for mission critical data
- **Back-view cameras** – Allowing transfer of video stream from trailer to the truck using existing spiral cable.
- **Climate control** – transferring control and temperature data to and from the A/V unit.

References:

1) Using LIN Over Powerline Communication to Control Truck and Trailer Backlights – Yair Maryanka, Yuval Koren and Yaniv Seri
2) SPARC *Secure Propulsion using Advanced Redundant Control – EU6FP web*
3) www.yamar.com
4) Ein Beitrag zur Erhoehung der Verkehrssicherheit durch das Drive by Wire Antriebstrangmodul eXAct. Diss an der TU Karlsruhe, 2001. - Prof. Dr. Gernot Spiegelberg
5) Powerline Communication in Drive-by-Wire Vehicles with Redundant Data Networks using DC-BUS Components - Dr. Guenther Bauer
6) SIG60 Data sheet – Yamar electronics Ltd.