Wiring Reduction by Battery Power Line Communication

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Abstract

Innovative technology for high-speed communication over noisy DC power lines is described. The DC-BUS™ power line multiplex technology transfers digital information (i.e. Car Audio, Navigation) inside a car, over a single cable that conducts both power (14V / 42V) and communication. The technology simplifies the installation, reduces harness weight and enables multiple communication channels for Mechatronics @10Kbps, Telematics @250Kbps and Multimedia @1.7Mbps. Each of the channels serves up to 16 nodes (devices).

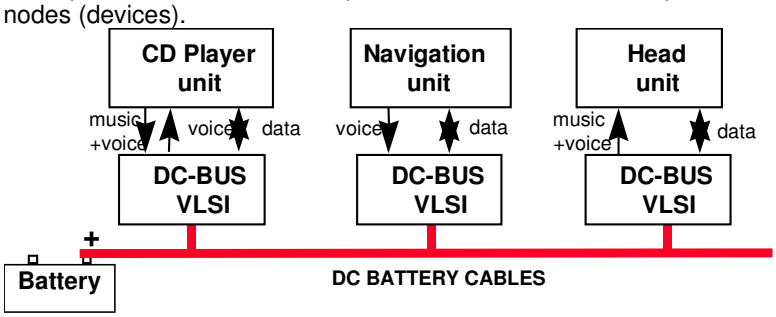

Figure 1 - DC Communication in a car

Introduction

Electronics is finally getting its important roll inside cars. Currently electronics is 18% of vehicle's content and its share is expected to increase up to 50%. The harness is already the second heaviest component after the engine. What will be the size and complexity of such harness when half of the car content will be electronics?

The multiplex network, in which multiple nodes are connected by relatively few wires (bus) is the solution which the industry has adopted. The dream of a single bus that will connect every single node in the car has vanished. Already several buses are implemented in a car for Power train, Body electronics, Entertainment and more. The use of the vehicle battery power lines for communication (PLC) will further reduce the amount of cables and will simplify the installation of after-market modules. Battery PLC is a technological challenge, because the battery lines are noisy and have very low impedance, which changes whenever a load is switched (lamp, air-condition). Only recently, with the progress of semiconductor technology, it became possible to implement Digital communication technology in a small semiconductor device to overcome the hostile conditions and provide economical solution for the automotive industry.

PLC Benefits

Saving the Cost and Weight of Ordinary Wiring - The DC-BUS does away with the multiple and bulky wiring presently required between the various units of a vehicle's electronic system. The electrical wires and their connectors are expensive in material and labor. Such wiring adds significantly to a vehicle's weight (1-3Km of wires). The technology replaces the cost and weight of copper wires and connectors with a small silicon.
Flexible Modifications - A vehicle's harness is difficult to modify for new installations. The PLC based components need only a single battery line, therefore are flexible for installation in every part of the vehicle.

Simplicity of Installation - Installation of a security system consisting of 4 units requires 3-4 working hours, while by using the PLC it can be reduced to less than 1 hour.

PLC Applications

Automotive multiplex communication (bus) is divided into three categories. Power line communication is applicable to all these categories.
1) Hi-speed Multimedia bus for PC and Entertainment systems (1-100Mbps)
2) Medium-speed Data bus for Telematics Data exchange (10K-1Mbps)
3) Low-speed Data bus for activation of actuators and reading sensors (1K-10Kbps).
Mechatronics - The number of sensors and actuators in cars is growing rapidly. Most of these devices require low rate communication. Examples of such applications are: Smart Battery State Of Health readout (developed by iQ Power Technology), Climate Control, Door Module Control, Security Immobilizer, Rear Obstacle Detector). A low cost solution for such applications operating at 10Kbps, implementing several interfaces to protocols commonly in use by automotive manufacturers such as CAN and J1850 was tested for several automotive applications. It enables the use of existing software for PLC.
Telematics - Medium speed PLC of 250Kbps enables use of digitized voice and Data communication (e.g. Internet, Navigation, Truck-Trailer). This solution will proliferate with the deployment of the emerging data bus standard (SAE ITS Data Bus J2366). Yamar's evaluation boards are under tests by leading automotive companies.
Multimedia - The most challenging development was 1.7Mbps PLC prototype that demonstrated two way CD quality music channels on noisy vehicular DC power line. Application example: link between CD Changer in the trunk and a Head Unit on the dashboard.

Figure 1 presents concept of such system. In this example, a Head Unit, installed in the dashboard, communicates with a CD Player Unit and a Navigation Unit installed in the trunk; a single DC Power cable to the battery connects all these units.

Technical Solution

The concept of PLC over AC lines is well known and used in many applications requiring relatively low bit rates. The use of battery lines (e.g. car) for communication became feasible when microelectronics and digital communications enabled economical realization of complex communication algorithms in a single VLSI device.
Yamar developed algorithms based on combination of data coding and modulation techniques. The solutions were simulated in vehicular car environment for efficient and reliable operation. Measurements performed in actual car environments proved the communication capabilities.

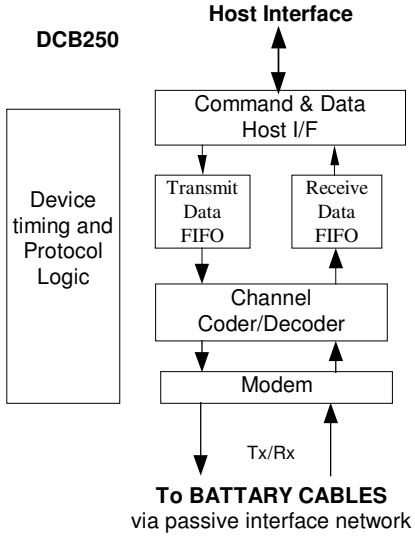

Figure 2 – Device Building Blocks

Data entered from a sensor or any data entry source such as CAN Controller is buffered in a Transmit FIFO, translated into packet message and coded by Error Correction Codes. When battery line channel is not busy by other devices transmission, the coded message is modulated and transmitted to all other devices on the battery line. Built-in collision resolution mechanism disables two devices from transmitting simultaneously. All devices receive and decode the message, correct errors(if they exist) and transfer the message to its connected host controller. Figure 2 describes the internal logical building blocks of the device.

Network operation - The DC-BUS was designed for network operation of up to 16 different users. The high-speed digital communication requirements in a car dictates a topology similar to cables, where several sources of data may send only one bit stream to a destination in a given channel. Power Amplifier will get its input either from Tuner, or from MD or CD Player, but not from all of them simultaneously. Therefore, the DC-BUS was designed with the channels structure in mind. Each device may be controlled by a Host Controller. Multiple channels for Mechatronics, Telematics and Multimedia can use the same power line.

Channels allocation

The DC-BUS system is based on Carrier Sense Multiple Access with Collision Resolution (CSMA/CR) protocol. It controls all the devices in the system and data transfers between devices on the DC lines. Figure 3 is an example of channels allocation for verity of uses such as Mechatronics (F0), Telematics (F1, F2) and Multimedia (F3, F4).

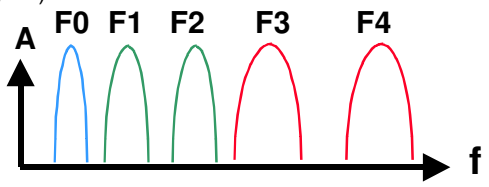

Figure 3 - Channels allocation

Device implementation

The devices for Mechatronics and Telematics are implemented using CMOS technology. The silicon is designed using VERILOG tools, each block was compared to its Matlab model for verification.

The Future

Standardization will drive many new applications into vehicles as happened to the PC market. The PLC can become an additional physical layer to the emerging automotive standards, keeping compatibility with the existing standardized upper communication layers such as CAN, J1850, LIN and others. Power line communication will get its greatest boost when the 42V will become the dominant power source in cars. **End**