Wireless and Power Line communication in vehicle

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Abstract

The aim of this project is to design an embedded video help system for car parking. Three cameras fitted to the rear of the car transmit a wireless video signal to the driver who can select the camera through power line transmission.

1. Introduction

Today the automotive manufacturers must meet a customer demand for more individualized vehicles introducing the need for tailoring the vehicles and the provisioning of new features. The electronic units (ECU) already use networks like CAN and Flexray. However, the network must be already in place and the ECU must integrate the specific protocol. In this paper, the proposed network uses the DC power line (PLC) and/or wireless systems to transmit the data between ECUs. The demonstration is based on three rear cameras that project images of the area behind the vehicle on a small colour monitor mounted on the dash or windscreen. The video signal is sent by wireless whereas the control of the cameras is sent over power line.

In the first section, we will present the PLC modulation technique used at the physical layer. Then, the wireless technology is introduced. The different ECUs are described, the receiver with the screen and camera selection, the transmitter with the video switching and transmission.

2. Intra vehicle transmission

Today’s vehicle networks are not just collections of discrete, point-to-point signal cables. The amount of cables has been drastically reduced by using fieldbus or specialized networks. To reduce the complexity, without reducing safety, it is desirable to commit to a limited set of networks. However, it is not in the near future that the number of networks can be reduced to only one or two as such technology would provide the properties supporting the most demanding automotive systems. Hence, it is more likely that a few network technologies will be used while providing timeliness and fault tolerance. Three most common vehicle networks, namely LIN, CAN and Flexray are used today [1]. These embedded networks have both increased the functionality and decreased the amount of bundles of cables. However, the usage of different wires for the different networks still has the disadvantage of being heavy, complex and expensive.

One solution to reduce the amount of wires would be to use the PLC technology that is currently being developed for domestic networks to transmit information or at least some of it, over the 12V power distribution system found in cars. The other solution is based on wireless solution, which does not need wire. We will introduce these two solutions.

Power Line solution (PLC):
For PLC domestic used, the HomePlug AV standard has been recently introduced [2]. The HomePlug AV’s objective is to distribute multi-media content as well as data within the house. The PHY layer still operates in the frequency range of [2 – 28] MHz and provides a 200 Mbps PHY channel rate. It is based on OFDM (orthogonal frequency division multiplex) with 917 narrow band carriers used in conjunction with a flexible guard interval. Modulation densities from BPSK to 1024 QAM are independently applied to each carrier based on the channel characteristics between the transmitter and the receiver. In [3] we have experimented this PLC technology inside a vehicle over DC lines. A network composed with 4 ECUs connected through modified PLC adapters has been built. According to the configuration, we have shown that it is possible to achieve up to 18 Mbits/s which is on average higher than the rate obtained with Flexray. These adapters are used in the demonstration.

Wireless communications:
To our knowledge, there are not a lot of wireless experiments in intra-car communications. Among the potential wireless solutions, we specifically focus on techniques working in the 2.4 GHz band and allowing data rate from 250 kbps up to 50 Mbps, namely Bluetooth, IEEE 802.11 b/g and ZigBee. Measurements in the 2.4GHz band have shown that the channel is nearly flat with very low attenuation. The main differences between the wireless technologies we have considered come from the different target applications they are designed for. Bluetooth can be suitable for voice and audio applications thus eliminating short distance cabling. IEEE 802.11 b/g can address multimedia applications as file transfer with much higher throughput than Bluetooth. However, if we consider power usage and real time constraints, both ZigBee and Bluetooth require much less power than IEEE 802.11 b/g whereas low power for cars manufacturers is a strong requirement. Furthermore, many existing products are interfaced with the TCP/IP protocol which incurs overhead for headers per frame.

3. Intra-vehicle video transmission
We will describe the two parts of the system: the transmitter and the receiver. Figure 1 illustrates the PLC/wireless embedded application.

The transmitter:
The driver is able to switch between the left video camera, the right one and the middle one. According to this choice, only one video signal is kept using a video multiplexer. The LMH6574 is an analogical multiplexer for professional grade video. It provides a 400 MHz bandwidth at 2 VPP output signal levels. The output amplifier selects any one of four buffered input signals. We have used a simplified wireless video modulator working in the 2.4 GHz band (AJV24 E modulator). This video transmitter has the following features: a PAL and NTSC input video format, a four channels selector, each channel has a 10 MHz bandwidth and a 10 dBm output. Using such solution, the ECU transmitter allows point to multi-point connections and does not need any MAC layer protocol and does not introduce overhead. It is possible to broadcast the video signal.

The receiver:
The receiver is based on the DE2 board of ALTERA [4]. The DE2 board has many features that allow the user to implement a wide range of designed circuits. An Altera Cyclone® II 2C35 FPGA device is provided connected to the hardware features. The DE2 board has two interesting features: the ADV7181B tv-decoder which generates an YCrCb 4:2:2 signal and an Ethernet RJ45 interface. These components are controlled by a NIOS II processor implemented in the Cyclone®. Figure 2 illustrates the receiver implemented in the FPGA and the interface with the other components. The tv-decoder is connected to the 2.4 GHz receiver which demodulates the signal. The signal is displayed on the TFT screen associated with the camera number. When the user selects a camera, an Ethernet frame is generated and transmitted through the Ethernet driver connected to the HomePlug AV adapter. This frame is caught by the video transmitter through another PLC adapter. The PLC adapters have been modified in order to be DC compliant and to fulfill automotive EMC (electromagnetic constraints) constraints. However, they are completely transparent in the data exchange between ECUs.

The Demonstration:
When the user changes the camera, we can observe that the video signal is modified with the camera number displayed on the screen. We can observe that there is no latency. The quality of the picture on the TFT screen was clear enough with a good accuracy. Further improvements are carried out to improve the antennas and the wireless transmission.

4. Conclusion
In this paper, PLC and 2.4 GHz wireless intra-car communications have been investigated in order to reduce and/or replace the amount of network wires in the car. The results show that it is possible to achieve over 10 Mbps with PLC and/or wireless solution. Additional studies are carried out in order to be able to switch between PLC and wireless for the data communication according to the network ECU configuration and signal to noise ratio.

5. References

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