Future High Speed In-Vehicle PLC Networks

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Abstract

This paper deals with power line communication in vehicle (PLC). PLC is a very promising communication solution in order to offer future in-vehicle applications without increasing wiring harnesses. We join recent additional measurements which have been carried out using modified indoor PLC modems. These PLC modems are based on the two main technologies, HomePLUG AV and HDPLC.

Index Terms

HomePLUG AV, HDPLC, in-vehicle, EMC.

I. INTRODUCTION

THE in-vehicle PLC solution has numerous advantages, notably in terms of reliability, because it would reduce the amount of splicing that is necessary, as well as simplify and lighten the cable bundles. Today, indoor PLC is a common way of communication in local area networks and a lot of modems based on HomePlug are on the market. A theoretical bit rate of about 200 Mbps can be achieved. This is the reason why for automotive applications, a PLC solution may be studied by car manufacturers. Indeed, the ever growing development of safety and comfort equipments needs high bit rate and this also leads to an increase of the communication wires with a negative impact on reliability. The possible applications of automotive PLC are very wide, extending from high-speed multimedia buses for entertainment systems to low-speed data buses for activating. actuators. Mock-ups are being developed in the automobile industry to demonstrate the feasibility of the PLC approach. The studies carry out in [1] have lead to a demonstrator based on a video transmission between a camera at the back of the car and a screen placed on the dashboard. However, to our knowledge, there are no cars that are currently available in the market that use PLC data exchanges instead of dedicated buses. Many studies are carried out today as presented during the conference ISPLC 2009 [2]. Previous work [3] has demonstrated the feasibility of PLC in vehicle. The recent workshop held in Italy [4] is aimed at presenting the state of the art in communication systems in a modern car, in order to optimize and reduce the cabling on board. Some useful results expected from the workshop are: a general layout of a useful benchmark; the specifications expected from a PLC based protocol to meet the automotive requirements; a list of significant experiments aimed at defining the viability of a PLC solution. In this paper, we focus on the comparison between two PLC technologies, namely HomePlug AV (HPAV) and HDPLC;

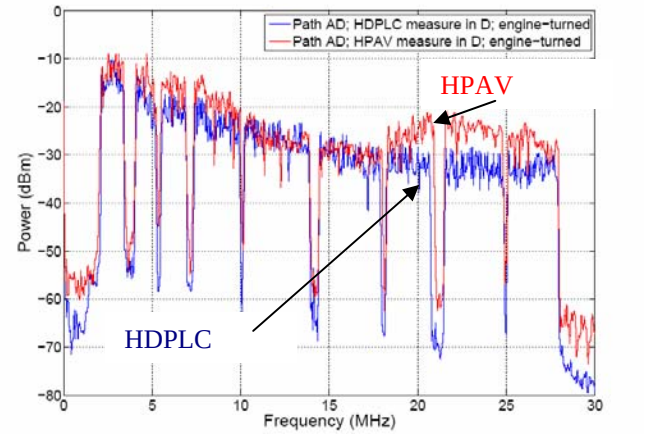
I. EXISITING POWER COMMUNICATION SYSTEMS: IN-VEHICLE COMPATIBILITY?

The enhanced HomePlug V1.0 is the HomePlug AV (HPAV) standard with an OFDM modulation realized thanks to a 3072 points IFFT/FFT with a frequency sampling of 75 MHz. In this case the OFDM symbol duration is 40.96 µs and the space between each carrier is 24.414 kHz. The HPAV uses higher modulation order from BPSK (Binary phase-shift keying) up to 1024 QAM than HomePlug V1.0. Moreover, several guard interval (GI) can be used depending on the channel and so the data rates can be improved. Previous results [5] obtained show that the median values of coherence bandwidth (Bc) are 1.3 MHz and 700 kHz for in-vehicle direct and indirect connections. If we consider the delay spread (DS) and the GI, the authors report that the Ds remains under 380 µs for all the cases. This delay is longer than the [2-5]µs Ds obtained in indoor (it can also be on the order of some microseconds as in the cars). Generally, the GI duration should be about two to four times the DS. If we compare the HPAV parameters with the Bc and Ds constraints, we can observe that they fulfil them

The HD-PLC alliance [6] (HDPLCA) is an additional group which promotes the PLC networks based on its HDPLC technology. It is based on a specific OFDM modulation called Wavelet-OFDM which exploits the Wavelet transform. It appears with this modulation that the notches are deeper than OFDM realized with IFFT/FFT. Moreover, Wavelet-OFDM does not use guard interval and so it has a better spectral efficiency than OFDM modulation. Pulse-Amplitude Modulation (PAM) with an order from 2 to 32 is used for modulation. The MAC layer uses the hybrid TDMA and CSMA/CA protocols synchronized with the AC line cycle. These two standards have been tested in vehicle according to many configurations and discussed in the next section.

II. RESULTS :HPAV VERSUS HDPLC

We have measured the two spectrums over the DC channels according to the configuration presented in [3]: ignition OFF, ignition ON, ignition ON and equipments, paths Rear-Rear, Front-Rear, Front-Front. Other configurations have been considered and will be presented in the final paper. Fig. 1 illustrates these two spectrums.



The input impedance has not been yet modified and the transmitted OFDM waveform is not EMC compliant. We can observe that HD-PLC presents deeper notches than HPAV with a less emission power. We can notice that it is not possible to use the two protocols at the same time as they have non-interoperable PHY layers.

The throughput has been measured using UDP traffic. For Front-Rear paths, we obtain about 15 Mbps/s for both HPAV and HDPLC. For Front-Front paths, the mean data rate is about 15 up to 25 Mbps. The highest one is 40 Mbps using the shortest Fron-Front path. However, we have noticed a little throughput decrease on the long paths when the electronic units are in active use and the engine is driven with HDPLC, not observed with HPAV. This decrease can be explained by the lack of GI in HDPLC. However, these results are better than the previous ones obtained in our previous study on HomePlug V1.0 and Spidcom modems.

III. CONCLUSION

The adaptation of PLC to vehicles holds great promises. It is possible to achieve high throughput as well as existing vehicle networks (FLEXRAY) suited for different applications (multi-media, safety). Different adaptations of indoor PLC will be proposed in order to fulfil vehicle constraints (EMC, synchronization). They cope both with the MAC and PHY layers.

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