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A lightweight Method for Interconnecting Sensors via Power Line Communication

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Summary:
As a wireless connection of sensor systems is not always possible, a modem for powerline communication (PLC) was developed for the wired connection of sensor systems. Especially for retrofitting components in vehicles, for example, a data connection via the existing cable network is advantageous and no additional new cables need to be installed. For this purpose, a small and cost-effective PLC modem was developed that can be operated with the modulation formats BPSK and DSSS-BPSK in order to transmit sensor data at 19.2kBit/s via cable harnesses. The performance of the PLC modem in terms of channel noise and single tone interference was examined and discussed.

Keywords: Sensor interconnection, Power line communication, Automotive, Sensor retrofit, Data communication.

Introduction

Nowadays a large number of sensors are used to measure a wide range of parameters for different purposes. In order to be able to process the sensor data, the sensors are connected to a data processing unit by cable or wirelessly. A wireless connection is usually very easy to establish, whereas a wired connection of sensors is often associated with considerable effort. However, if there are already cables between the planned location of the sensor and the data processing unit (e.g. power cables), these can be used for data transmission with Power Line Communication (PLC). PLC describes a method in which the data to be transmitted is modulated onto one or more high-frequency carriers and the connecting cable is used as the transmission medium. However, the connecting cables are usually only optimized for energy transmission and not for data transmission. For example, the cables are not shielded against electromagnetic interferences and the available transmission bandwidth is only a few MHz. The modulation methods for PLC must therefore have a very limited bandwidth and a high resistance to electromagnetic interference. In addition, the PLC modem must be highly cost-efficient for use with simple sensor systems.

Methods

Two PLC modems with different data transmission methods were investigated [1]-[3]. The transmission methods investigated were Binary Phase Shift Keying (BPSK) and BPSK combined with Direct Sequence Spread Spectrum (DSSS). The data was modulated onto a carrier at 8 MHz with a data rate of 19.2kbit/s. The DSSS method uses a 7-bit Barker code for spreading. The PLC modems were implemented on the basis of a low-cost microcontroller from RENESAS R5F10 (R5F10: multi-chip package solutions with a RL78 16-bit microcontroller and a LIN system basic chip), whereby the number of additional electronic components was optimized and minimized. The PCB board of the realized PLC modem is shown in Fig. 1. The modem was optimized for networking sensors in the automotive sector and therefore designed for a supply voltage of 12V.

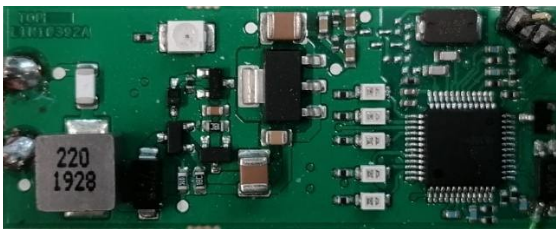

Fig. 1. Full functional board of the PLC-modem for BPSK or DSSS-BPSK (on the left edge: pads for connecting the power lines).

Results

The properties of a PLC modem with the modulation formats BPSK and DSSS-BPSK with data rate of 19.2kBit/s were investigated using

MATLAB simulations. A channel model representative of automotive cable harnesses with a typical delay spread of 0.8µs was used for the simulation [4]. A direct path and two reflections after 0.25µs (-10dB) and 0.5µs (-20dB) were used for the channel model of the cable harness. The carrier was selected at f_c=8.064MHz (420*19.2kHz) and the sampling frequency at 64.512MSample/s (3,360*19.2kHz). White noise limited by the sampling frequency and a sinusoidal interference signal with f_0=f_c+5kHz were used as interference signals. The bit error rates (BER) measured at the receiver as a function of the power of the interference signals on the transmission channel (SNR - Signal to Noise Ratio and SIR - Signal to Interference Ratio) were evaluated and compared for the modulation formats BPSK (Fig. 2) and DSSS-BPSK (Fig. 3), whereby the theoretical spreading gain of DSSS-BPSK compared to BPSK is $10*\log_{10}(N_{Barker})$=8.4dB. This spreading gain could also be demonstrated for single tone interference in the simulation (Fig. 4).

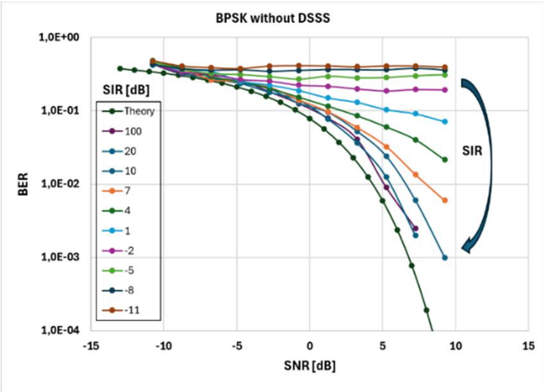

Fig. 2. Bit error rate (BER) in dependency of white noise (SNR) and a single tone interferer (SIR) of a PLC-modem with BPSK and without DSSS.

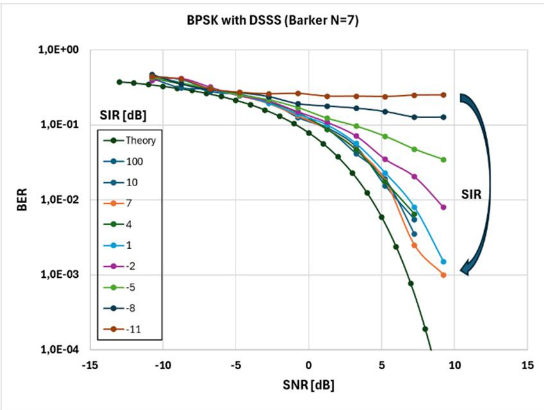

Fig. 3. Bit error rate (BER) in dependency of white noise (SNR) and a single tone interferer (SIR) of a PLC-modem with BPSK and with DSSS (N_{Barker}=7).

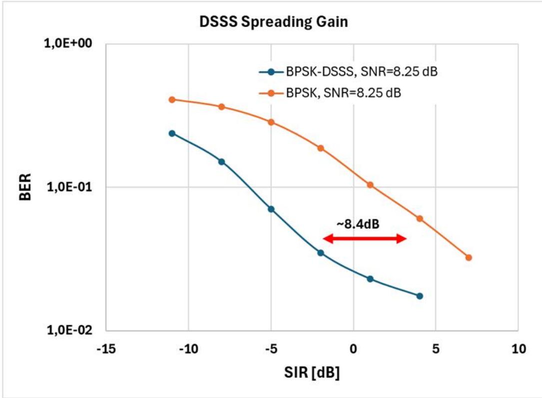

Fig. 4. Achieved compression gain of about 8.4dB by use of DSSS in case of a single tone interferer. The data rate was 19.2kBit/s and the channel SNR=8.25dB.

Conclusions

An integrated modem for powerline communication was developed to network sensors via an existing wired connection. The properties of the BPSK and DSSS-BPSK modulation formats used were investigated with regard to their immunity to white noise and single tone interference. It was shown that the use of DSSS with a 7-bit Barker code can achieve the theoretical compression gain of 8.4 dB to reduce single tone interference. Another advantage of using DSSS is that the transmission power can be higher by the spreading factor than with BPSK if the maximum transmission power (EMC limits) is specified. The PLC system shown uses a very cost-effective µC with few additional components and has been optimized for networking sensors in automotive applications.

References

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