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Comparison of PLC G3 and PRIME

Martin Hoch
Institute for Information Transmission, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany
hoch@LNT.de

***Abstract*—For the emerging IEEE 1901.2 standard on Narrow–Band Power Line Communications there are two proposals regarding the Physical and Medium Access Control Layer—PLC G3 and PRIME. In this paper, the Physical Layers of both drafts are compared to each other, by theoretical analysis as well as simulation results.**

I. INTRODUCTION

Power Line Communications (PLC) have not been standardized for a long time, but only some regulations have been established like CENELEC norm EN 50065-1. In addition to the standardization efforts on Broad–Band PLC for in–home PLC–based Local Area Networks and internet access (IEEE P1901.1 [1]), standardization of Narrow–Band PLC for SmartGrid applications has been started, too.

The committee has to discuss two proposals regarding the Physical and Medium Access Control Layer: PLC G3, which has been launched by ERDF and Maxim, and PRIME, initialized by the PRIME Alliance (Iberdrola, Texas Instruments et. al.).

In this paper we will focus on the respective Physical Layers, only, which are specified in [2] and [3].

Both drafts intend to use CENELEC A band by Cyclic Prefix (CP) Orthogonal Frequency Division Multiplexing (OFDM) in combination with coded Differential Phase Shift Keying (DPSK), which is known to be a simple and robust technique for data transmission over frequency selective channels as OFDM can be implemented highly efficiently by the Fast Fourier Transform (FFT) and DPSK modulation allows for receivers without any channel estimation algorithms.

In the following short overviews of PLC G3 and PRIME will be given in Sections II and III, respectively. After that, Section IV discusses the differences of both proposals from a theoretical point of view while Section V presents simulation results for typical power line channels. Finally, conclusions are given in Section VI.

II. PLC G3

The PLC G3 system is operating at a sampling frequency of $f_s = 400\,\text{kHz}$ and uses an FFT size of $M = 256$, leading to a subcarrier spacing of $\Delta f = 1.65625\,\text{kHz}$. Thus by modulating carriers No. 23 to 58, only, G3 occupies the frequency range 35.9–90.6 kHz.

Fig. 1 shows the block diagram of a PLC G3 transmitter. For data transmission G3 offers three modes "Robust", "DBPSK", and "DQPSK" [1], facilitating packets of data of at maximum

[1] In [4] a "D8PSK" mode is announced, too.

Fig. 1. Block Diagram of PLC G3 (from [2]). FCH: Frame Control Header. FEC: Forward Error Correction. DBPSK: Differential Binary Phase Shift Keying. DQPSK: Differential Quaternary Phase Shift Keying. IFFT: Inverse Fast Fourier Transform. CP: Cyclic Prefix. AFE: Analog Front End.

133, 235, and again 235 bytes, at a data rate of 33.4 kbps maximum (in DQPSK mode).

In all modes data are protected by the rate–1/2 convolutional code with generator polynomials 171 and 155 and interleaved within the whole packet. Frame Control Header (FCH) data and data in Robust mode are additionally repeated six and four times, respectively, by the interleaver prior to DBPSK modulation (repetition coding). Non–FCH data are encoded with an appropriately shortened Reed Solomon (RS) Code, too, which is based on RS (255, 247) for Robust, and RS (255, 239) for DBPSK and DQPSK mode.

The PSK symbols are differentially encoded per subcarrier in time (t-DPSK), thus carriers that suffer from frequency selective attenuation or disturbance can be switched off. Thereto, the subcarriers are arranged in nine groups and a "Tone Map" field in the FCH indicates which of them are active.

Furthermore, each OFDM symbol is windowed by a raised–cosine slope of 8 samples at its beginning and end for spectral forming, thus the guard interval is reduced from $L_{CP} = 30$ samples to an effective length of 14.

The parameters of PLC G3 are summarized in Table I, 2^{nd} column. For further details regarding PLC G3, the reader is referred to [2].

III. PRIME

In PRIME the sampling frequency has been chosen to $f_s = 250\,\text{kHz}$, while the FFT size is $M = 512$, i.e. the subcarrier spacing accounts for $\Delta f = 488\,\text{Hz}$. As carriers 86–182 are used for transmission, the PRIME signal is located in the frequency range 42–89 kHz.

The signal processing in a PRIME sender is depicted in Fig. 2. By selecting the modulation scheme DBPSK, DQPSK, or D8PSK and switching on or off the convolutional coding

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