Very High Data Rate for Power Line Communications in Home Networks

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SEVENTH FRAMEWORK PROGRAMME

Abstract

OMEGA work package 3 (WP3) for PLC aims to investigate and develop very high speed systems in the home environment. To achieve this goal, the main targets are:

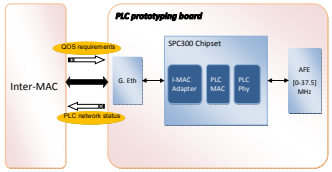
- Optimisation of PLC performances in the [0-100] MHz band by improving spectral efficiency with advanced Multi-Carrier Modulation (MCM) schemes, defining adapted MAC layer protocols, and keeping Homeplug AV and ETSI requirements as reference standards for OMEGA PLC systems.
- Development of prototyping boards to demonstrate high-rate feasibility and Inter-MAC capabilities for PLC systems.

OMEGA Power Line Communications

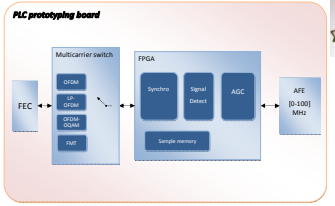
- Work Package 3 of FP7 IP OMEGA
- Runtime: January 2008 – December 2010
- Total resources: 228 PMs
- 5 European partners from academy and industry

OMEGA PLC Demonstrators

Two prototyping boards will be developed in order to demonstrate Inter-MAC capabilities and physical layer enhancement



- Uses SPC300 chipset flexibility to integrate real-time Inter-MAC functionalities (guaranteed bandwidth, path selection,…)
- I-MAC QOS requirements: Min/Max/Average data rate, delay/Jitter bound, packet size,…
- PLC network status: PLC network topology, data rate, latency statistics, failure,…



- Powerline communications using [0-100] MHz band with EMC constraints
- Ability to switch to each multicarrier modulation scheme: OFDM, FMT, OFDM-OQAM, LP-OFDM
- Validate Gigabit feasibility on real PCL channels and physical layer enhancement capabilities

OMEGA MAC Layer Studies

The aim of this task is to define MAC mechanisms adapted to the high-rate requirements

- Homeplug AV MAC protocol compatibility adapted to higher data rate
- *Cross layer resource allocation schemes in multi user context:* two multi user scenarios using FMT-FDMA and LP-OFDMA are studied. New resource allocation algorithms based on linear precoding (LP) technique for multicast OFDM systems are also studied. These algorithms aim to increase the bit rate for all the multi user scenarios.

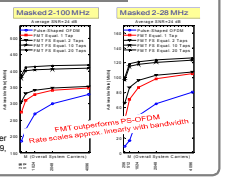
OMEGA WP3 Physical Layer

To optimize PLC performances in [0-100] MHz frequency band, several alternatives are studied

Filtered Multi Tone Modulation (FMT)

FMT is a multicarrier filter bank modulation which uses filters that privilege the frequency confinement

- FMT achieves higher rate than raised cosine Pulse-Shaped OFDM
- The lower the SNR the higher is the advantage of FMT w.r.t. PS-OFDM
- FMT has a better notching capability w.r.t. PS-OFDM
- FMT achieves the maximum rate with a smaller number of tones



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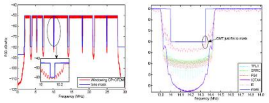
OFDM-OQAM Modulation

OFDM/OQAM *is a MCM that can satisfy* ***real orthogonality*** *conditions together with a pulse shape being well localized in time and frequency and a a maximum theoretical spectral efficiency (no CP)*

Therefore its advantages vs. CP-OFDM (w.r.t. the HPAV spec.) are:

- No CP: Theoretical increase of the bitrate around 13%
- Better frequency localization: extra subcarriers (~4%) are transmitted



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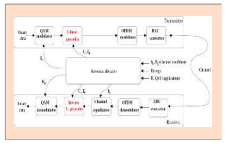
Linear Precoded OFDM

LP-OFDM is a combination of OFDM and spread spectrum using Tx/Rx Hadamard matrices

- Best global throughput
  - Increase virtual constellation granularity
  - Increase number of loaded subcarriers
- Best use of power under PSD constraint
  - Power mask constraint converted to sum power constraint
- Compliant with existing standards (e.g. HPAV)
- Low additional complexity (precoding matrices of {+1,-1} at Tx and Rx)



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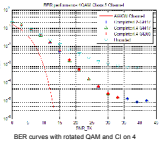
Algebraic Rotation and Windowed Cosine OFDM

The system concepts for improving the BER performance of Broadband PLC modems that was investigated are: 1) Algebraic Rotation of m-ary QAM constellation (for diversity gain), 2) Windowed Cosine (WC) OFDM waveform shaping with Guard Interval for increasing throughput, BER performance and Peak to Average Ratio (PAR) 3) the implementation impacts

The **Algebraic Rotations** is a coded modulation with high Hamming distance and product distance among codewords in order to improve diversity and coding gain. **Sphere decoder** algorithm shows its strength for fixed point implementation and it perfectly feasible for hardware realisation. The advantages of **WC-OFDM**:

- Notching between the carriers is not needed PSD since of side-lobs are -90 dB,
- Higher Guard Interval (GI), or CP, can be adjusted for worst class of channels, e.g., 2 to 5, to mitigate efficiently channel impairments.
- S/N loos in BER performance for higher GI (e.g., 25-50 % of Ts) is compensated



BER curves with rotated QAM and CI on 4 subcarrier for two class of channels 5 and 9.

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OMEGA PLC Future Work

The future work on physical layer and MAC layer will define Omega PLC devices functionalities that will be demonstrated at the end of the project (December 2010), showing very high data rate feasibility and Inter-MAC capabilities.

OMEGA project website http://www.ict-omega.eu *Contact OMEGA* info@ict-omega.eu

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