PLC modulation: OFDM/OQAM or a flexible transceiver scheme?

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Abstract

Several modulation schemes have been proposed for the transmission over Power Line Communication (PLC) channels. The multipath characteristic of these channels gives an advantage to multicarrier modulation (MCM) schemes. In the IEEE P1901 standard, defining the PHY and MAC layers for PLC, two different MCM schemes (windowed OFDM and wavelet OFDM) have been retained. OFDM/OQAM constitutes another MCM alternative with many attractive features, while, in another hand, a flexible modulation scheme could avoid standardizing dual PHY systems and also provide an appropriate interoperable solution.

MCM: The alternatives

Windowed OFDM
- Based on OFDM with Cyclic Prefix (CP-OFDM)
- Requires a pulse shaping (window) to be usable for PLC

Wavelet OFDM
- Based on critically sampled cosine modulated filter banks (CMFB)
- No CP

Filtered Multitone
- Based on an oversampled DFT filter bank
- No CP (but a guard frequency interval)

OFDM/OQAM
- Based on a critically sampled DFT filter bank
- No CP

LP-OFDM
- OFDM with linear precoding (LP)
- LP can be envisioned with all the above MCM schemes

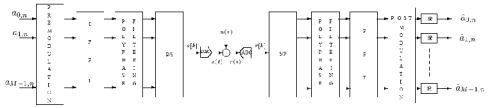
OFDM/OQAM: Basic features

Baseband discrete signal

$$s[k] = \sum_{m=0}^{M-1} \sum_{n \in \mathbf{Z}} a_{m,n} \underbrace{p[k-nN] e^{j\frac{2\pi}{M} m(k-\frac{L-1}{2})} e^{j\phi_{m,n}}}_{p_{m,n}[k]},$$

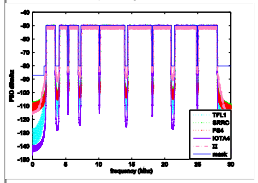
✓M is the number of subcarriers (M even), N=M/2
✓$a_{m,n}$: real and imaginary parts of symbols of a 2^{2K}-QAM
✓$\phi_{m,n}$ is an additive phase term
✓p is the prototype filter of length L
✓ Applying Hermitian symmetry conditions on $a_{m,n}$, we get a ral-valued signal (HS-OQAM)

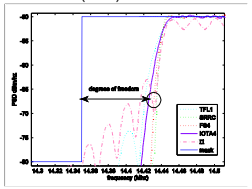
Implementation scheme



OFDM vs. CP-OFDM: Pros and Cons

Pros (w.r.t. the HPAV spec.)
No CP: Theoretical increase of the bitrate around 13%
Better frequency localization: extra subcarriers (~4%) are transmitted

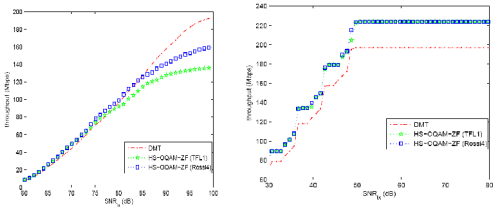




Cons
No CP also means intersymbol and intercarrier interference when transmitting through PLC channels

Throughput comparison

HS-OQAM vs. CP-OFDM: Results depends on the channel model, SNR and prototype filter and equalization technique being used for OFDM/OQAM

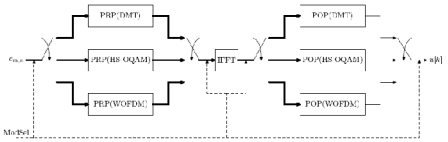


Bitcap=10, HPAV notching, target SER=10^{-3}, Class 2 (Left), Class 8 (Right)

Comparison in an extended bandwidth (up to 100 Mhz)
Due to EMC regulation, the maximum transmitted SNR will not exceed 60 dB, increasing the advantage for OFDM/OQAM, but, in any case, a flexible structure could be of interest

A Flexible Transceiver

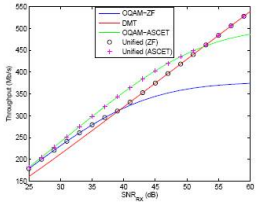
A Flexible scheme with 3 different MCMs



-PreProcessing (PRP) and Postprocessing (POP) blocks depend upon the modulation scheme being used
-The cost of PRP, POP blocks is less that the one of the IFFT kernel
- Either an IFFT or a FCT/FST kernel could be used
- ModSelec is a parameter controlling the switching operation
- A dual structure is implemented at the receiver side
- The principle can be extended to cover the FMT scheme

Example of switching

HPAV-like spec.: M=3072
Sampl. Freq.: 75 MHz
CP=417 samples
No notches, no bitcap, no, coding
Class 3 and AWGN
Rossi protoype filter (length =4x3072)



Conclusion

This poster illustrates some of the Orange Labs studies carried out on the modulation aspects within the WP3 of the Omega Project. Current works on an extended bandwidth, and taking into account some other type of distortions (impulsive noise) and elaborated channel coding strategies are expected for the Omega deliverable D3.2, completing the answer to our question.

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

Acknowledgement
The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013 under grant agreement n° 213311 also referred as OMEGA.

European Commission
Information Society and Media