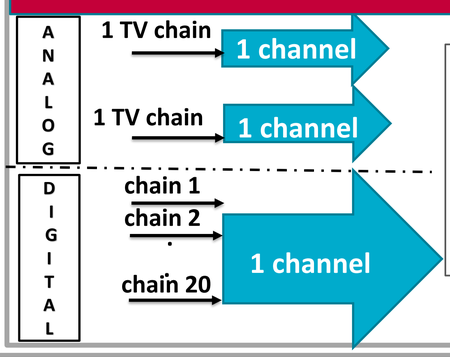
OPTIMIZATION OF CHANNEL CODING AND MODULATION FUNCTIONS USED IN DVB-T2

A-C. HONFOGA, V. MOEYAERT, M. DOSSOU

University of Mons, Faculty of Engineering, Electromagnetism and Telecommunication Department, Mons, Belgium

INTRODUCTION

CONTEXT



AVAILABLE FREQUENCIES = DIGITAL DIVIDEND

Mobile Telephony

Spectrum sensing

DVB-T2 (Digital Video Broadcasting-Terrestrial _second generation) is the second generation of digital terrestrial Television standard published by ETSI (European Telecommunications Standards Institute) in 2009.

Improvements
- *Strong FEC (Forword Error Correction) method*
- *Increase of capacity (50 Mbit/s) instead of 31 Mbit/s in DVB-T*

AIMS OF THE THESIS

The aims is to improve DVB-T2 performances
- *By optimizing some of techniques used in its system*
- *By substituting them by others techniques used in wireless communication systems like 5G*

Rotated constellation used in DVB-T2

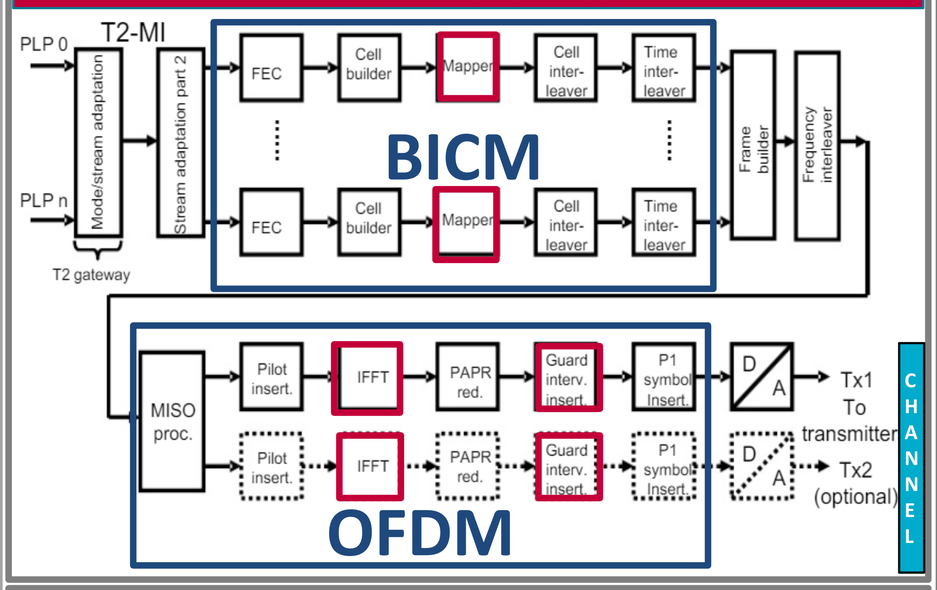
Hierarchical modulation insertion

FBMC insertion in DVB-T2 systems

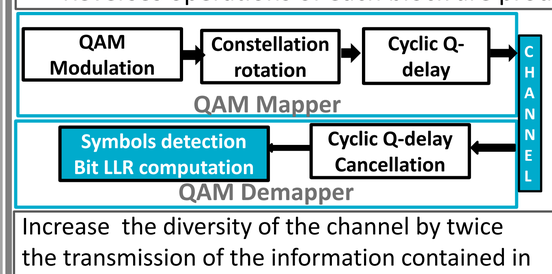
Study of the DVB-T2 system

THEORICAL BACKGROUND

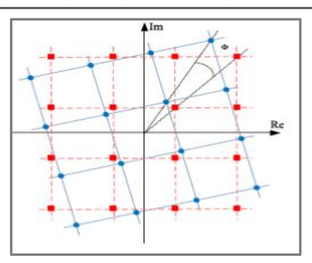
DVB-T2 Transmitter



- BICM: Bit-Interleaved Coded Modulation
- OFDM: Orthogonal Frequency Division Multiplexing
- PLP: Physical Layer Pipe
- FBMC: Filter Bank Multicarrier
- AWGN: Additive White Gaussian Noise
- LDPC: Low Density Parity Check
- Reverses operations of each block are produced at the DVB-T2 receiver



Increase the diversity of the channel by twice the transmission of the information contained in each symbol.



16-QAM rotated constellation

Need for a low-complexity QAM-Demapper

Rotated constellation effect → Creates **correlation** between In-phase (real) and Quadrature (imaginary) components

Cyclic Q-delay effect → Makes fading channel coefficients independents

- Each complex symbol or cell S becomes Z after rotation

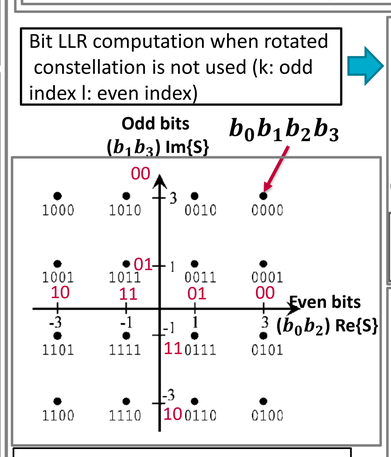
$$S = S_I + jS_Q \longrightarrow Z = S * \exp(j\theta) = Z_I + jZ_Q$$

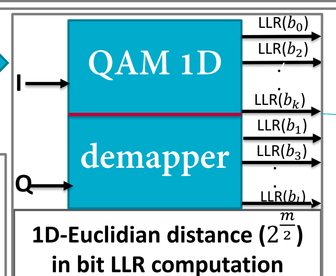
- Each transmitted cell x includes its own I component and Q component of the previous cell.
- If Z, Z' and Z'' are the cells to transmit, after cyclic Q-delay, Z, Z', and Z'' become respectivement

$$X = real(Z) + JImag(Z'')$$
$$X' = real(Z') + JImag(Z)$$
$$X'' = real(Z'') + JImag(Z')$$

AFTER CHANNEL: Channel coefficient for real(Z) ≠ Channel coefficient for imag(Z)

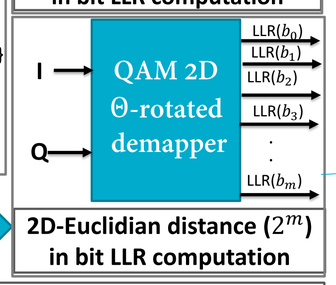
Bit LLR computation when rotated constellation is not used (k: odd index l: even index)





1D-Euclidian distance ($2^{\frac{m}{2}}$) in bit LLR computation

Bit LLR computation when rotated constellation is used (m bit number)

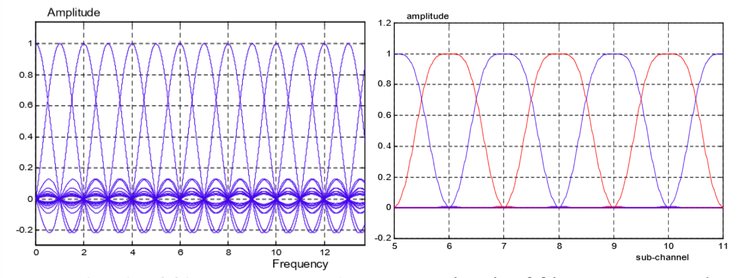


2D-Euclidian distance (2^m) in bit LLR computation

THE USE OF 2D DEMAPPER LEADS TO AN INCREASE OF COMPLEXITY OF RECEIVER.

FBMC insertion in DVB-T2 System

Difference between frequency responses of FBMC and OFDM



A bank of filters generated With rectangular filter (OFDM)

A bank of filters generated With PHYDYAS filter (FBMC)

OFDM	FBMC
• Need for CP (Cyclic Prefix) inserted to mitigate ISI (Inter Symbol Interference) • Allows overlapping of the sub-channels with all others sub-channels • Allows out-of-band (OOB) power leakage • Is quite sensible to Frequency offset	• Avoids the use of CP • Allows overlapping of the subchannels with their immediate neighbors • Allows out-of-band (OOB) power leakage reduction • Is less sensitive to Frequency offset

The purpose of substitution of OFDM by FBMC in the DVB-T2 system
- *deal with long CFO (Carrier Frequency Offsets) in the case of mobile reception*
- *Increase spectral efficiency by cyclic prefix deletion*

SIMULATION TOOLS, METHOD AND PARAMETERS

Tools

CSP (Common Simulation Platform) DVB-T2 simulator → MATLAB model of an end-to-end chain compliant to the DVB-T2 standard

Matlab (matrix laboratory) environnement → Ligth version implementation of DVB-T2 system

Hierarchical modulation

Rotated constellation demapper

FBMC

DVB-T2 parameters

FEC Encodeur (BCH+LDPC)(Code Rate)	1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 5/6
Trame FEC (LDPC)	64800 bits, 16200 bits
M-QAM modulation	M=4, 16, 64, 256
OFDM (mode FFT)	1K, 2K, 4K, 8K, 16K, 32K K=1024 sub-carriers
Cyclic Prefix (CP)	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
Bandwidth	1.7, 5, 6, 7, 8, 10 MHz

Fading channel models

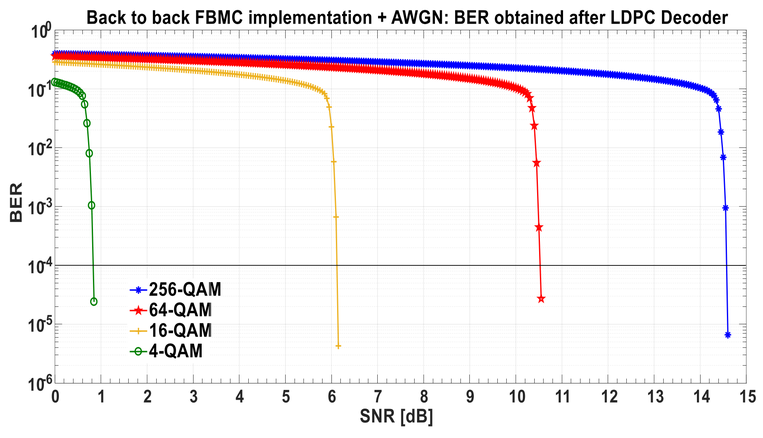
Ricean channel
Rayleigh channel
Rayleigh with erasure
0dB echo channel
TU (Typical Urban) 6 channel

- **AWGN channel which is not a fadind channel is used to simulate a noise added to signal by the receiver**

RESULTS AND DISCUSSIONS

FBMC Back to Back Implementation +AWGN

Simulations parameters	
LDPC Code Rate (64800 bits)	1/2
QAM modulation	4, 16, 64, 256
Mode FFT	M=8K (8192)
Filter bank	PHYDYAS filter
Overlapping factor	L=4
Length of the filter	Lp=L*M



Discussions

QAM modulation	FBMC: SNR obtained for BER=10^{-4}	OFDM: SNR of DVB-T2 standard for BER=10^{-7}
4-QAM	0.8dB	1dB
16-QAM	6.15dB	6.2dB
64-QAM	10.5dB	10.5dB
256-QAM	14.6 dB	14.4dB

Comparables performances

Penality of 0.2dB

CONCLUSIONS

Our work is based on FBMC insertion in DVB-T2 system, the implementation of a low complexity demapper and the joint use of rotated constellation and hierarchical modulation. To overcome these challenges, we implement FBMC with the ligth version of DVB-T2 system including LDPC decoder and only AWGN channel. We will continue this work by inserting fading channels and channel equalization methods in order to get better results. In parallel, the implementation of low-complexity demapper will be investigated.

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Université de Mons

Anne-Carole HONFOGA (anne-carole.honfoga@umons.ac.be)