Potentials of DVB-C2 in Hybrid Fibre Coax (HFC) Networks

DVB World 2010, Lisbon, 9 March 2010
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Introduction

• Since approval of DVB-C2 by DVB-SB, DVB TM-C2 and ReDeSign have jointly pressed ahead with
  - Investigations on implementation issues based on computer simulations
    - DVB-C2 system layer simulations
    - Network requirements and performance evaluation
  - Dissemination of research results worldwide, e.g. at
    - ReDeSign – DVB Implementers Workshop (at IFA) in Berlin
    - IEEE-ICCE in Las Vegas
    - CableLabs Winter Conference 2010 in Denver
    - IEEE-BMSC in Shanghai
    - DVB World 2010 in Lisbon
• Hot topic emerging from the work: integration of DVB-C2 in DOCSIS
DVB-C2 Encoder Block Diagram

- **TS 1 Input Sync**
- **FEC**
- **PLP Header**
- **QAM Mapper**
- **Data Slice 1**
- **2D Interl.: Time + Frequency**
- **Frame Builder**
- **OFDM Genera.**

- **TS 2 Input Sync**
- **FEC**
- **PLP Header**
- **QAM Mapper**

- **TS n Input Sync**
- **FEC**
- **PLP Header**
- **QAM Mapper**

- **Common PLP Sync**
- **FEC**
- **PLP Header**
- **QAM Mapper**

- **Processing of Data Slice m**
- **Pilots**
- **L1 Coding**
- **FEC**

**Technical Details**

- \( n_{\text{max}} = m_{\text{max}} = 256 \)
- PLP – Physical Layer Pipe
- L1 – top layer
New Principle of Data Slicing and OFDM

- Efficiency
- Flexibility

![Diagram showing traditional and future channel utilization using DVB-C and DVB-C2](image.png)

- 8 MHz receiver bandwidth
- 24 MHz receiver bandwidth
- Selective blanking
- Unused frequencies
- Narrow band interference

Spectral locations of data slices
ReDeSign Channel Model for Performance Simulation

- Model of IEEE 802.14 used as basis
- Improvements to consider latest evolutions of HFC architectures
- Lab test with 96 256-QAM signals for intermodulation measurements, partly replaced by analogue signals
  - Investigations of intermodulation among digital signals
  - Investigations of intermodulation between digital and analogue signals
- Field measurements for evaluation of network performance
- Consideration of CENELEC/IEC standards requirements
configuration of channel parameters in dependence of actual network load!
Simulated Results for Narrow-band Interference

- Impact reduced by frequency interleaving
  - Erroneous information dispersed over all PLPs of a Data Slice
  - LDPC applied per PLP provides sufficient correction power
- Simulations result in SNR degradation of 0.2 dB
- Notching used as alternative method to completely eliminate narrow-band interference
Simulated Results for Burst Noise

- Interference caused by GSM used as model for investigations
  - Burst lengths of 550 µs close to OFDM symbol lengths (597 µs plus GI)
  - Bandwidth larger than bandwidth of Data Slice
- On-off channel model implemented
  - Single burst destroys entire OFDM symbol
  - Subsequent symbols not affected

<table>
<thead>
<tr>
<th>Time Interleaver Setting</th>
<th>FEC Modes for quasi error free reception</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 OFDM Symbol</td>
<td>-</td>
</tr>
<tr>
<td>2 OFDM Symbols</td>
<td>-</td>
</tr>
<tr>
<td>4 OFDM Symbols</td>
<td>2/3</td>
</tr>
<tr>
<td>8 OFDM Symbols</td>
<td>2/3, 3/4, 4/5, 5/6</td>
</tr>
<tr>
<td>16 OFDM Symbols</td>
<td>All</td>
</tr>
</tbody>
</table>
Simulated Performance Figures in AWGN Channels

- Increased robustness: 7 dB
- Increase of spectral efficiency: 35 %
- Gain of spectral efficiency in modern HFC networks: 60 %
- Simulation parameters:
  - 4 channels combined
  - GI = 1/128
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ReDeSign Network Topology Simulations Based on TNO’s UTOPICT Simulation Tool

- Input data received from cable vendors and MSOs
  - Network data: number of amplifiers per cascade, implementation margins, cable types etc.
  - Components specific data: amplifiers, ON etc.
  - Network load: frequencies, levels of signals (aTV, QAM, DOCSIS etc.)
- Output data generated by UTOPICT
  - System performance in terms of SNR, MER, CINRs, BER etc.
- Consideration of
  - AWGN,
  - CTB, CSO,
  - Intermodulation product generated by digital signals (broadband noise with impulse character) including 2nd, 3rd, and higher orders
Examples of Conclusions for N+4 and N+15 Cascades

- Network load in this example:
  - 20 aTV
  - 30 QAM/DOCSIS
  - 43 DVB-C2
  - 8 MHz grid
- Requirements:
  - 7 dB implementation margin
  - aTV must not exceed CENELEC quality requirements for noise and intermodulation
- Conclusion:
  - DVB-C2 transmission of constellations up to 4096-QAM supported by cable networks with a margin of some 5 to 6 dB in N+15 scenarios
  - All digital based on DVB-C2 (4096-QAM) may be critical in some networks
System Aspects: Opportunities for Utilization of RF Spectrum

Various opportunities for use of frequency
1. Transmission in traditional frequency raster

2. Combination of more than 1 traditional channel, e.g. 2 channels

3. Optimized Frequency Utilization, channel grid gets largely obsolete
Principle of Optimized Frequency Utilization

Synchronization in time and frequency domain required!
Flexible & Dynamic Bandwidths Allocation – DVB-C2 EdgeQAM Integration in DOCSIS

1 Gbps in 100 MHz = 12.5 Channels

Advanced solution for IPTV
Flexible & Dynamic Bandwidths Allocation – High Digital TV Bandwidth During Evening
Flexible & Dynamic Bandwidths Allocation – High Digital TV Bandwidth During Evening

Universal eQAM supporting DVB-C2

DOCSIS Core CMTS

Edge Resource Manager

Digital TV services

HSI services
Summary & Conclusions

• Networks are prepared to carry DVB-C2 signals using 4096-QAM
  - Results received by simulations based on realistic network data
  - Network fully loaded with 4096-QAMs may be critical
• Increase of spectral efficiency of 35 – 60 % per channel
  - High immunity against channel impairments
  - Utilization of 1024-QAM and 4096-QAM instead of 256-QAM
  - Channel lineup without gaps (Optimized Frequency Utilization)
• Integration in DOCSIS provides a high efficient and flexible communication system
  - Support of connections providing 1 Gbps with 12.5 connected channels
  - Support of low-end IPTV IRDs featuring tuners with traditional tuner bandwidth of 6 and 8 MHz, respectively
Thank You!

ReDesign

thanks to the European Commission for support and funding of the project

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