ATI REDEFINES INNOVATION AND CHALLENGES
THE BOUNDARIES OF WHAT’S POSSIBLE
IN THE CONNECTED VISUAL WORLD

CONNECTED
visual world

Digital Television Architecture
and Front-end considerations

Brian D. Mathews
Marketing Manager DTV ICs
US DTV Industry

- ATSC standard was catalyst
- FCC Mandate defined the timeline
- ‘til now DTV’s mostly high-end
  - Projection, Plasma, LCD large screens
  - All traditional major brands participating
- New co’s/brands entering, e.g. HP & Dell
- Next:
  - Mid-range and low-end DTV’s
  - Integration of DTV w/ home networking/PC’s
FCC Digital Tuner Mandate /Cable “Plug and Play”

FCC Digital Tuner Mandate

- TV manufacturers to include digital terrestrial tuners inside TVs according to this schedule:
  - 36” +
    - 50% by mid-2004
    - 100% by mid-2005
  - 25” to 35”
    - 50% by mid-2005
    - 100% by mid-2006
  - 13” to 24”
    - 100% by mid-2007
  - VCR DVD
    - 100% by mid-2007

Digital Cable-Ready

- TV manufacturers and cable companies have agreed to integrate digital cable functionality directly inside TVs
- No need for an external STB
- Takes effect in mid-2004
- 70 percent of US households receive primary transmission through cable
- All major consumer electronics companies are now planning to build Cable “Plug and Play” TVs

The USA DTV market continues to be driven by mandates and the P&P agreement

The USA DTV market continues to be driven by mandates and the P&P agreement
High growth drivers in ’05 are FCC Mandate, dropping prices, and HD content.

US TVs. ~35 Million TVs Sold Annually.

Source: Stanford Resources & ATI
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## Market Segmentation

<table>
<thead>
<tr>
<th></th>
<th>LCD</th>
<th>Plasma</th>
<th>DLP, LCOS, Proj</th>
<th>CRT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-end</strong></td>
<td><img src="image1" alt="High-end LCD" /></td>
<td><img src="image2" alt="High-end Plasma" /></td>
<td><img src="image3" alt="High-end DLP, LCOS, Proj" /></td>
<td><img src="image4" alt="High-end CRT" /></td>
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<tr>
<td>Primary TV Attributes:</td>
<td>&gt; Dual HD MPEG Decode</td>
<td>&gt; Up to 1920x1080P Display</td>
<td></td>
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<tr>
<td></td>
<td><img src="image5" alt="Low-end LCD" /></td>
<td><img src="image6" alt="Low-end Plasma" /></td>
<td><img src="image7" alt="Low-end DLP, LCOS, Proj" /></td>
<td><img src="image8" alt="Low-end CRT" /></td>
</tr>
<tr>
<td><strong>Mid-range</strong></td>
<td>&gt; Combo of features &amp; cost</td>
<td>&gt; Dual Analog Decode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary TV Attributes:</td>
<td>&gt; Single HD MPEG Decode</td>
<td>&gt; Single/Dual Analog Decode</td>
<td></td>
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<tr>
<td></td>
<td><img src="image9" alt="Low-end LCD" /></td>
<td><img src="image10" alt="Low-end Plasma" /></td>
<td><img src="image11" alt="Low-end DLP, LCOS, Proj" /></td>
<td><img src="image12" alt="Low-end CRT" /></td>
</tr>
<tr>
<td><strong>Low-end</strong></td>
<td>&gt; Pure Price focus</td>
<td>&gt; Single HD MPEG Decode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary TV Attributes:</td>
<td>&gt; Single Analog Decode</td>
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</table>
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DTV Architecture
DTV Architecture

> Inputs:
  > Antenna/Cable,
  > Component/Composite Video
  > Digital (HDMI, DVI)

> Major blocks:
  > Front-end (Tuner, IF, Demod, POD)
  > Back-end (MPEG Decode, Audio/Video Processing, System control, Display signal generation)
  > Display (Projection, Plasma, LCD)
High level DTV architecture

- DTV Tuner
- Peripheral Controller
- 8VSB / QAM Demod.
- Stereo Audio Decoder
- NTSC Analog Video Decoder
- Microprocessor
- Transport Demux
- MPEG Decoder & Graphics
- AC-3 Audio Decoder
- Image Processing
- Audio Encoder
- Flash
- DRAM
- 3D Comb
- NTSC Analog Video Decoder
- 8VSB/QAM Demod.
> HD MPEG video decoder (x 2)
> Video scalers & deinterlacers
> Picture-in-picture
> True color graphics menus
> HDTV & VCR outputs

> JPEG decode (cameras)
> Dolby AC-3 audio decode
> Hard drive interface (PVR)
> 300 MHz CPU
> Descrambling (cable)
> Peripheral interfaces
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Front-end Considerations
DTV Front-end considerations

> Tuner

> Sometimes includes Demod (aka NIM or ITD)

> Tunes a channel between 54MHz and 860MHz

> LNA, RF AGC, Mixer, Filtering, IF AGC, VCO, LO Synthesizer, Serial control interface (I²C)

> Traditionally a module enclosed in sheet metal ("tuner can") w/ threaded F connector and thru-hole pins

> Some integrated IC tuners finally starting to meet TV performance demands
Front-end - Demodulator

> IF

> Typical IF is 44MHz w/ SAW filtering and AGC preceding the demod

> Demod

> Extracts MPEG data stream from the terrestrial or cable signal

> 8-VSB Terrestrial and 64/256 QAM for cable

> Complex digital filtering and big equalizers
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Front-end – Demodulator

> 8-VSB demodulation (terrestrial)
> 64/256 QAM demodulation (cable)
> QPSK demodulation (OpenCable)

> Error Correction
> RF/IF AGC Control
> A/D converters

Demodulator

- Tuner Can
- ADC
- FSB J83.B QAM
- Tuner Control
- FDC QPSK Demod
- SRAM
- FEC
- Microcontroller
• ATSC “T3S10” committee created in ‘03 at request of FCC and NAB. Participants include...
  • Broadcasters, CE Manufacturers, and Component Providers (ATI, Zenith, Broadcom, Panasonic, LINX)

• Charter: Generate ATSC Performance Guidelines/Recommendations
  • “What are the signal conditions under which receivers should operate?”
  • Applies to the RF front end and VSB demodulator
  • Generate set of vectors for ATSC performance testing

• Vectors are used to assess performance of CE manufacturer’s TVs
Building
- Urban, suburban, rural
- High rise, single family home, apartment buildings
- Wood, brick, metal, concrete construction

Environment
- Flat, trees, hills
- Moving vehicles – cars & planes
- Sunny, cloudy weather

Antenna
- Indoor, outdoor antenna
- Bow tie, rabbit ears, Yagi, silver sensor
- Close to tower (2 miles), far away (50 miles)
- Adjacent channels (NTSC & VSB)

Total of 50 vectors. Some vectors too difficult for any demodulator to receive.
RF Player

Hard Drive → D/A → RF Modulator

Splitter

VHF / UHF, -60 to -30 dBm

DTV Receiver #1

DTV Receiver #2
Video Performance Criteria

4 - Error Free
(no visible reception problems)

3 - Mostly Error Free
(viewable video with single defect)

2 - Some Errors
(semi-viewable with >50% video)

1 - Many Errors
(un-viewable, <50% video)

0 - Little or No Video
(un-viewable or no picture)

Japan 2 x 2 Belgium
T3S10 RF Vector Performance

Rx #1
- 2: Error Free
- 7: Almost Error Free
- 33: Little or No Video

Rx #2
- 2: Error Free
- 7: Almost Error Free
- 3: Many Errors
- 8: Little or No Video

Rx #3
- 3: Error Free
- 4: Almost Error Free
- 4: Some Errors
- 7: Little or No Video
Goal:

Evaluation of demodulator performance in difficult field conditions. Several difficult sites selected from prior studies:

- Philadelphia, PA (12 channels, 15 outdoor sites, 8 indoor sites)
- Baltimore, MD – Washington DC (11 channels, 8 outdoor sites)
- Raleigh, NC (8 channels, 7 outdoor sites)

Focus

- Ability to handle multipath
- Ability of the receiver to demodulate the signal with non-optimal antenna bearing
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Side-by-Side Video Test

(N, S, W, E)

Prior gen. EVB

Demod EVB

Comm’l product w/ different demod
Field test results

Philadelphia (Center City) PHL-10A DTV Reception
(Alternative Site, Ritz Carlton Parking Lot at 15th St. and Chestnut St.)

Performance

- (4) - Error Free
- (3) - Almost Error Free
- (2) - Some Errors
- (1) - Many Errors
- (0) - Little to No Video
Summary Baltimore/Washington Outdoor Sites

![Bar Chart]

- Connected visual world

### Connected Sites

- T313 MEV
- Nxt2004 MEV
- Samsung Sir-T150

- Viewable
- Unviewable
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Open Cable
Open Cable / Digital Cable Ready

- DTVs can decrypt premium cable content by using CableCard
- PCMCIA slot in DTV accepts decryption card available from cable service provider
- Forward Data Channel (aka Out-of-band) carries control information used by CableCard
- Requires a separate tuner and QPSK demod
DTV presents a significant technology challenge:

- High performance, very complex electronics at consumer-acceptable price points

Front-end technology has advanced rapidly, new demod front-end solutions approach near-theoretical performance

Interesting challenges remain

- How will DTV’s integrate with home network / media PC?
- Can Digital Cable-ready TV’s replace digital cable set-tops?
- What is the DTV of the future? PVR? Media Center? Media server?
- What is the role of Mobile Digital Television?

Have fun addressing these and other DTV opportunities!