HDMI on OMAP4  PANDA

Design, Challenges and  Lessons Learned

Mythri P K
Agenda

• HDMI in a Nutshell
• OMAP4 HDMI hardware
• High level software requirements
• Compliance dependent HDMI features
• Current software design
• Issues faced while enabling HDMI
• Possible Design Enhancements
HDMI in a Nutshell
HDMI in a Nutshell - 1

- High-Definition Multimedia Interface
- Compact Audio/Video interface for transmitting digital data
- Backward compatible with DVI (Digital Visual Interface)
HDMI in a Nutshell - 2

Three physically separated communication channels

- **DDC** - To read E-EDID information.
- **TMDS** – Carry video audio and auxiliary data at TMDS clock rate
- **CEC** (Optional) – high level control function across audiovisual products.
# HDMI in a Nutshell - 3

<table>
<thead>
<tr>
<th>HDMI version</th>
<th>1.0-1.2a</th>
<th>1.3</th>
<th>1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum clock rate (MHz)</td>
<td>165</td>
<td>340</td>
<td>340[51]</td>
</tr>
<tr>
<td>Maximum TMDS throughput per channel (Gbit/s) including 8b/10b overhead</td>
<td>1.65</td>
<td>3.40</td>
<td>3.40</td>
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<tr>
<td>Maximum total TMDS throughput (Gbit/s) including 8b/10b overhead</td>
<td>4.95</td>
<td>10.2</td>
<td>10.2</td>
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<tr>
<td>Maximum throughput (Gbit/s) with 8b/10b overhead removed</td>
<td>3.96</td>
<td>8.16</td>
<td>8.16</td>
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<tr>
<td>Maximum audio throughput (Mbit/s)</td>
<td>36.86</td>
<td>36.86</td>
<td>36.86</td>
</tr>
<tr>
<td>Maximum color depth (bit/px)</td>
<td>24</td>
<td>48[5]</td>
<td>48</td>
</tr>
<tr>
<td>Maximum resolution over single link at 24-bit/px[6]</td>
<td>1920×1200p60</td>
<td>2560×1600p75</td>
<td>4096×2160p24</td>
</tr>
<tr>
<td>Maximum resolution over single link at 30-bit/px[6]</td>
<td>N/A</td>
<td>2560×1600p60</td>
<td>4096×2160p24</td>
</tr>
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<td>Maximum resolution over single link at 36-bit/px[6]</td>
<td>N/A</td>
<td>1920×1200p75</td>
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<td>Maximum resolution over single link at 48-bit/px[6]</td>
<td>N/A</td>
<td>1920×1200p60</td>
<td>1920×1200p60</td>
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<table>
<thead>
<tr>
<th>Feature</th>
<th>1.0</th>
<th>1.1</th>
<th>1.2</th>
<th>1.2a</th>
<th>1.3</th>
<th>1.3a</th>
<th>1.3b</th>
<th>1.3c</th>
<th>1.4</th>
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<tbody>
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<td>sRGB</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>YCbCr</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8 channel LPCM, 192 kHz, 24 bit audio capability</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Blu-ray Disc and HD DVD video and audio at full resolution[7]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Consumer Electronic Control (CEC)[6]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>DVD-Audio support</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Super Audio CD (SACD) support[8]</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Deep Color</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>xvYCC</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Auto lip-sync</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Dolby TrueHD bitstream capable</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DTS-HD Master Audio bitstream capable</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Updated list of CEC commands[8]</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3D Over HDMI</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Ethernet Channel</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Audio Return Channel</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4k × 2k Resolution Support</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table courtesy: Olivero, Fabrice" <f-olivero@ti.com>
OMAP4 HDMI Hardware
OMAP4 HDMI Hardware - 1

- Part of Display Sub-System (DSS) that provides the logic to display a video frame from the memory frame buffer on to TV / LCD.
- HDMI-PLL can generate the appropriate pixel clock using the reference clock (sysclk).
OMAP4 HDMI hardware - 2
OMAP4 HDMI hardware - 3

- Video Data Path
  - Display controller (DISPC)
  - HDMI module
  - HDMI complex input/output (I/O)

- Audio Data Path
  - Level 3 (L3) interconnect
  - HDMI module
  - HDMI complex input/output (I/O)
Software Requirements
High Level Software Requirements

- Audio and video synchronization with respect to data, synchronization and power management
- Frame buffer and v4l2 support for video and graphics data
- Clock/PLL configuration (specific to SoC)
Compliance dependent HDMI features

- EDID parsing
  - Detailed/Established/standard timings
  - Vendor specific data block
  - Audio data block
  - Video data block
- AVI Info-frame configuration/read
- Audio Info-frame configuration/read
- VSI Info-frame configuration/read
- CEC protocol
- Hot-plug detect/modify notification
HDMI Driver Design - OMAP4
DSS2 Software Design

User space
- UI / Graphics Userspace app
- Video playback Userspace app
- Framebuffer APIs
  - /dev/fb0
  - /dev/fb1
- V4L2 APIs
  - /dev/video1
  - /dev/video2
- Control
  - sysfs

Kernel space
- omapfb driver
- omap_vout driver
- DSS2
  - gfx
  - vid1
  - vid2
  - vid3
  - lcd1-mgr
  - lcd2-mgr
  - tv-mgr
- OMAP DSS hardware

Display hardware
- HDMI TV
- LCD panels

Image Courtesy: Sumit Semwal" <sumit.semwal@ti.com>
HDMI Driver Design – OMAP4 -1

HDMI as a DSS driver

– HDMI Panel driver
  • Acts as a Interface between HDMI interface driver and audio driver
  • Provides generic API’s to configure HDMI for A/V
  • Sends user-space/Kernel Notification on suspend/Hot-plug

– HDMI Interface driver
  • DSS specific clock computation
  • DSS configuration
HDMI Driver Design – OMAP4 - 2

– HDMI IP driver
  • Configuration of HDMI h/w registers
  • Simpler to plug and play with different IP’s

– EDID library
  • Parsing EDID for VESA / CEA extension

– HDMI Audio ASOC Driver
  • configuration for Audio transfer
  • configuration of sDMA
Use Case – HDMI Hot-plug Enable

- HDMI Audio driver
- HDMI panel driver
- HDMI DSS driver
- HDMI IP driver

Phy config

Minimal clocks

phy connect followed by HPD

hpd_enable

Notify user space

Notify Audio

Configure pll AV registers

hdmi_enable

hmi_power_on

User space

HDMI HARDWARE
Use Case – HDMI Suspend

- **User space**
  - *hdmi_suspend*
  - *hdmi_audio_stop*
    - Notifiy done
  - *Stop Audio DMA*

- **HDMI Audio driver**
  - *hdmi_suspend*
  - *hdmi_video_stop*

- **HDMI panel driver**
  - *hdmi_video_stop*
  - Notifiy done

- **HDMI DSS driver**
  - *hdmi_video_stop*
  - *Turn off clocks*
  - *hdmi_suspend*
  - *hdmi_pll_off*
OMAP4 HDMI Issues
## HDMI Issues OMAP4 - 1

<table>
<thead>
<tr>
<th>Issues</th>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Timing Issues</td>
<td>Wrong EDID read</td>
<td>Default to VGA if EDID is not valid</td>
</tr>
<tr>
<td></td>
<td>No Audio over HDMI as DVI timing selected</td>
<td>If CEA extension + VSDB present select CEA timing.</td>
</tr>
<tr>
<td>2. Hot-plug</td>
<td>Multiple connect disconnect interrupts</td>
<td>Optimal debounce time to avoid jitter while avoiding delays.</td>
</tr>
</tbody>
</table>

### HDMI Issues Pie Chart

- **HDMI-HPD**: 35
- **HDMI-EDID**: 40
- **HDMI-Misc**: 25
<table>
<thead>
<tr>
<th>Issues</th>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Power management Audio Video sync</td>
<td>Audio crash as Video/Display shut-off clocks</td>
<td>• Single controller to manage both Audio/Video power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Callback Notification from controller to Audio/Video on suspend/Hot-plug disconnect before cutting clocks</td>
</tr>
<tr>
<td>4. Miscellaneous</td>
<td>Bandwidth/clocking issues</td>
<td>• Manage FIFO thresholds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tool to calculate pll for all supported timings.</td>
</tr>
<tr>
<td></td>
<td>Code duplication</td>
<td>Common IP driver to make use of code across platforms</td>
</tr>
</tbody>
</table>
Possible Design Enhancements
Possible Design Enhancements - 1

- Common EDID parsing code across kernel
  - Reduce interoperability issues
  - Increase re-usability
  - Plug-and-play for any framework
  - Helps concentrate more on Actual driver than reinventing the wheel
Possible Design Enhancements - 2

• Standardize Hot-plug notification mechanism
  – To user space to have application interoperability
  – To kernel space to Notify Audio/Any dependent driver to shut off on Hot-plug disconnect/Suspend

• Standardize API’s for Compliance dependent code
  – At the driver level
  – V4I2 API RFC for the same
  – Interoperability across supporting framework DRM/ FB / V4I2
References

• TI OMAP4 TRM
  http://focus.ti.com/general/docs/wtbu/wtbudocumentcenter.tsp?templateld=6123&navigationId=12667
  http://omappedia.org/wiki/Main_Page

• HDMI 1.3 specification
  http://www.hdmi.org/learningcenter/faq.aspx

• EDID information
  http://en.wikipedia.org/wiki/Extended_display_identification_data
  http://www.hdmi.org/learningcenter/presentations.aspx
  (Implementing EDID that works)

• Connector Diagram copyright
  http://electronics.howstuffworks.com/hdmi2.htm

• V4I2 API RFC
  http://permalink.gmane.org/gmane.linux.drivers.video-input-infrastructure/30401

• EDID Library RFC
  http://www.mail-archive.com/linux-omap@vger.kernel.org/msg47259.html
Q & A