The INs and OUTs of the TI Video Interfaces

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Texas Instruments Incorporated
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 Agenda

• **Video Port Road Roadmap**

• **Video standards and concepts**
  • Standard Display Resolution and Formats
  • Concept of Color and Color Reduction

• **Popular Video Interfaces**
  • Digital Interface
  • Analog Interface

• **TI Video Ports and Video Port Subsystems**
  • VPSS Front End and Back End
  • DM6467 VPIF
  • DM647/8 and DM642 VPIF

• **Video Port Interface Example - Interfacing to real world**
  • Video In/Out Signal Chain
  • SD Video Capture
  • HD Video Capture
  • SD/HD Video Display
  • HDMI/DVI Interface

• **TI Video Port Summary**
## TI Video Port Road Map

### Integrated Video Port
- Digital Video In/Out
- Digital Video In/Out & Analog Video Out

**DM6467 HD**
- H.264 HP, MPEG-4, VC1, MPEG2
- Multi-SD enc & dec
- 1080p 30fps dec, 720p enc or dec

### 1080p

**DM6467 (HD)**
- H.264 HP, MPEG-4, VC1, MPEG2
- Multi-SD enc & dec
- 1080p 30fps dec, 720p enc or dec

### 720p

**DM355**
- MPEG4 720p enc or dec

**DM365**
- 720p enc/dec
- Low Power
- Limited 1080p

**OMAP35x**
- MPEG4 720p enc or dec
- H.264 MP VGA decode
- H.264BP/VC1/WMV9 D1 enc or dec

### 480p

**DM64x**
- 64x+ core
- Integrated video ports

**DM644x**
- SD enc/dec
- Limited 720P
- OSD Capable

**DM643x**
- Low-cost SD video

**DM357**
- SD enc/dec
- Enet

**DM647/8**
- Multi-Video Interface
- SD/HD Video

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*Texas Instruments*
change this green bubble to purple. Label as "DM64xx Next"

Remove the red text under the bubble

Rita Sulma, 8/25/2008
Video standards and concepts
# Standard Display Resolutions

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<thead>
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<th>Format</th>
<th>Application</th>
<th>NTSC</th>
<th>PAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Full Analog Television Resolution</td>
<td>720 x 480</td>
<td>720 x 576</td>
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<tr>
<td>SIF</td>
<td>Resolution VHS VCR is capable of</td>
<td>352 x 240</td>
<td>352 x 288</td>
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</table>

### ATSC

<table>
<thead>
<tr>
<th>Format</th>
<th>Application</th>
<th>18 different resolutions/rates (three most common are shown)</th>
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</thead>
<tbody>
<tr>
<td>ATSC</td>
<td>Digital Television</td>
<td>720 x 480</td>
</tr>
<tr>
<td></td>
<td>Standard Definition (SDTV)</td>
<td></td>
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<tr>
<td></td>
<td>High Definition (HDTV)</td>
<td>1280 x 720, 1920 x 1080</td>
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### 4CIF

<table>
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<th>Format</th>
<th>Application</th>
<th>NTSC</th>
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<tbody>
<tr>
<td>CIF</td>
<td>Often used in Video Conferencing or for small screen applications (specified for various codecs, e.g. H.261)</td>
<td>704 x 576</td>
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<tr>
<td>QCIF</td>
<td></td>
<td>352 x 288</td>
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<tr>
<td></td>
<td></td>
<td>176 x 144</td>
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</table>
# NTSC, PAL, and CIF Formats

<table>
<thead>
<tr>
<th>Format</th>
<th>Resolution</th>
<th>Frame Rate</th>
<th>I/P</th>
<th>Data Rate</th>
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<tr>
<td>NTSC</td>
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<td></td>
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<tr>
<td>D1</td>
<td>720 x 576</td>
<td>50 fields/sec</td>
<td>I</td>
<td>10M pix/sec</td>
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<tr>
<td>SIF</td>
<td>352 x 288</td>
<td>59.94 fields/sec</td>
<td>I</td>
<td>2.5M pix/sec</td>
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<tr>
<td>D1</td>
<td>720 x 480</td>
<td>59.94 fields/sec</td>
<td>I</td>
<td>10M pix/sec</td>
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<td>352 x 240</td>
<td>50 fields/sec</td>
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<td>2.5M pix/sec</td>
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<td>CIF</td>
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<tr>
<td>4CIF</td>
<td>704 x 576</td>
<td>30 frames/sec</td>
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<td>12M pix/sec</td>
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<tr>
<td>CIF</td>
<td>352 x 288</td>
<td>30 frames/sec</td>
<td>P</td>
<td>3M pix/sec</td>
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<td>QCIF</td>
<td>176 x 144</td>
<td>30 frames/sec</td>
<td>P</td>
<td>760K pix/sec</td>
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- **NTSC**
- **PAL**
- **CIF**
## ATSC Formats

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<thead>
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<th>ATSC</th>
<th>Name</th>
<th>Resolution</th>
<th>Frame Rate (per second)</th>
<th>I/P</th>
<th>Data Rate (pixels/sec)</th>
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<td>60 frames</td>
<td>P</td>
<td>20 M</td>
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<td>1280 x 720</td>
<td>60 frames</td>
<td>P</td>
<td>55 M</td>
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<tr>
<td></td>
<td>1080i</td>
<td>1920 x 1080</td>
<td>60 fields</td>
<td>I</td>
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<td>1080p</td>
<td>1920 x 1080</td>
<td>60 frames</td>
<td>P</td>
<td>124 M</td>
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### Key
- SDTV = Standard Definition Television
- HDTV = High Definition Television
- I = Interlaced
- P = Progressive

### Standard supports both NTSC rates and integer rates:
- i.e. 60.00, 59.94, 30.00, 29.97, 24.00, and 23.98
• All color can be composed by adding specific amounts of R, G, & B
• 8-bits ($2^8$) specifies the amount of each color
• This is the scheme used by most electronic displays to generate color; e.g. we often call our computer monitors, "RGB displays"
Color Reduction

Human eye is not as sensitive to color as it is to Luminance (dark vs light).

To this end, to save costs the various standards decided to:

- Maintain **luminance** information in our images, but
- Reduce **color** information

- Using RGB, though, how do we easily reduce color information without removing luminance?
- For this, and other technical reasons, a separate color space was chosen by most video standards ...
What is YCbCr?

- Even though most displays actually use RGB to create the image, YCbCr is used most often in consumer electronics for transmission of the image.
- Historically, B/W televisions transmitted only luminance (Y).
- The color signals were added later.
Popular Digital Video Interfaces And How they Work
Digital Video Interface – BT.656

Transmitter
Processor or Video Decoder

BT.656 Stream
SAV-Start of Active Video
EAV-End of Active Video

8 bit data bus

Clock (27Mhz Typ)

Synchronization Codes

Receiver
Processor or Video Encoder

SAV Line of Data EAV Blanking SAV Line of Data EAV Etc…

Clock (27Mhz Typ)
Digital Video Interface – BT.1120

Transmitter Processor or Video Decoder

BT.1120 Stream
SAV-Start of Active Video
EAV-End of Active Video

16 bit data bus
Clock (74.25 or 148.5 MHz)

Synchronization Codes
SAV
EAV
Blanking
SAV
Line of Data...
EAV
Etc...

Clock (74.25 or 148.5 MHz)

Receiver Processor or Video Encoder
Digital Video Interface - RAW

There can also be a Vertical Sync Edge at the start of a field/frame.

- Raw Stream
- 8-16 bit data bus
- Clock (up to ~99Mhz Typ)
- Horizontal Sync
- Vertical Sync

Transmitter Processor or Video Decoder

Receiver Processor or Video Encoder

Line of Data… Blanking Line of Data… Etc…

Horizontal Sync Edge
Digital Video Interface - HDMI

HDMI Source

HDMI Transmitter

- Video
- Audio
- Control/Status

TMDS Clock Channel

Display Data Channel (DDC)

CEC Line

HDMI Sink

HDMI Receiver

- Video
- Audio
- Control/Status

TMDS Channel 0
TMDS Channel 1
TMDS Channel 2

EDID ROM

Source: www.hardwaresecrets.com
Popular Analog Video Interfaces
Analog Video Interfaces

Source: http://www.ntsc-tv.com/ntsc-index-02.htm
Analog Video Interface – Component (YPbPr)

- When YCbCr values are converted to analog signals, they are called YPbPr.
- Video DAC encoder converts the YCBCR digital input to YPbPr output.
TI Video Ports and Video Port Subsystems
VPSS Front End – CCDC
DM644x, DM643x, DM3xx, OMAP35x

- Interfaces to analog CCD imagers, CMOS imagers, and BT.656 (8 bit) or BT.1120 (16 bit) Devices
- 10-bit to 8-bit A-law compression
- Downsampling (via programmable culling patterns)
- Fault pixel correction
- Interlaced or progressive sensors

[Diagram of VPSS Front End with CCDC, Timing Gen, A/D, and External Memory connections]
VPSS Back End (Video Encoder)
DM644x, DM643x, DM3xx, OMAP35xx

- **Analog Video Encoder:**
  - Supports NTSC/PAL standards including 480P/576P
  - Four 10-bit D-to-A output (OMAP35x – two 10b DACs; DM355 – one 10b DAC)
    - Composite PAL/NTSC
    - S-Video (Split Luma/Chroma)
    - Component RGB (not present on OMAP35x and DM355)
    - Interlaced and Progressive Modes (OMAP35x Interlace only)

- **Digital LCD Controller**
  - Various output formats (RGB565, RGB888, YUV422, BT.656)
  - OMAP35xx output formats (RGB888)
Benefits
• Provides a direct digital connection to popular Video Encoders, Decoders, ADCs, and DACs

Features
• 16-bit Digital Interface to capture/display High-Definition Video Content from/to Video ADCs/Decoders/DACs/Encoders
• Dual 8-bit BT.656 interfaces for Multi-Channel Standard Definition Video Capture/Display
• 8/10/12-bit RAW Capture Interface to CMOS Sensors
• Supports up to 1080i/1080p30 (1080p60 in evaluation)

Documentation
• VPIF User’s Guide
Video Port - DM647/8 and DM642

**Benefits**
- Provides a direct digital connection to popular Video Encoders, Decoders, ADCs, DACs

**Features**
- 16-bit Configurable as Capture or Display Port
- Single HD Video (up to 1080i) capture or display (YCbCr 4:2:2 or BT.1120)
- 8-bit Dual SD Video Capture or Single SD Video Display (BT.656)
- Single Channel SD Video Capture or Display (8-bit Y/C 4:2:2 or Raw mode)
- 8 bit Transport Channel (TC) – upto 30MHz
- 8/16-bit RAW Capture or Display mode for interfacing with CMOS sensors, ADCs and DACs
- DM647/8 has Video 5 ports
- DM642 has 1 port

**Documentation**
- VPIF User’s Guide
Video Port Interface Example - Interfacing to real world
Video in/Out Signal Chain

Capture
- Sensor
- Camera
- Video Player

Digital Signal Processor

Video Decoder & ADCs

Video Encoder & DACs

Video Amps

Display
- TV / Monitor
- Projector
Analog SD Video Capture
(Composite/S-Video/Component)

Input:
- Composite (NTSC, PAL, SECAM)
- S-Video (Y/C)
- Component Video - 480i and 576i

Output:
- YCbCr (8/10 bit or 16/20-bit)
- ITU-R BT656 (8/10 bit)

Features:
- Two 10-bit ADC with 2x over sampling
- Color Space Conversion (RGB to YCbCr)
- VBI data processing (Teletext, CC)
- I²C port for host interface
- 3.3-V tolerant digital I/O

Similar Decoders:
- TVP5146M2, TVP5150AM1
- TVP5160
Analog HD/SD Video Capture
(Component – RGB/YPbPr)

**Input:**
- SDTV (480i and 576i)
- EDTV (480p and 576p)
- HDTV (720p, 1080i, and 1080p)
- Component RGB (VGA to UXGA)

**Output:**
- R’G’B’/YCbCr 4:4:4 (30-bit) – ext. sync
- ITU-R BT.1120 (20-bit YCbCr 4:2:2)

**Features:**
- Three 8/10-bit, 165/110MSPS Video ADC
- Color Space Conversion (RGB to YCbCr)
- I²C port for host interface
- 3.3-V digital I/O

**Similar Decoders:**
- TVP7000
- TVP7001
HD/SD Video Display (Component)

**Input:**
- 1x10-bit and 2x10-bit 4:2:2 YCbCr
- 3x10-bit 4:4:4 YCbCr/RGB
- 15 or 16-bit RGB

**Output:**
- Analog RGB; Analog YPbPr; Generic DAC
- SDTV (480i and 576i) and EDTV (480p and 576p)
- HDTV (720p, 1080i, and 1080p)
- PC Graphics (up to UXGA @ 75Hz)

**Features:**
- Three 11-bit 205 MSPS DAC.
- Programmable Input and output Sync (H/V)
- Programmable digital color space conversion circuit
- I²C port for host interface
- 3.3-V digital I/O

**Similar Encoders:**
- THS8133
- THS8135
HDMI/DVI Transmission

Input:
- 12/24/30/36-bit RGB YCbCr 4:4:4
- 16/20/24/30/36-bit YCbCr 4:2:2
- 8/10/12-bit YCbCr 4:2:2 (ITU-R BT.601 & BT.656)

Output:
- 1080p @ 60Hz or 720p/1080i @ 120Hz
- Deep Color (36-bit depth)

Features:
- HDMI 1.3, DVI 1.0, and HDCP 1.1 compliant
- 4:2:2 to 4:4:4 up-converter
- 2 to 8-channel audio at 192kHz
- I²C port for host interface
- 3.3-V digital I/O

TI Video Port Summary
### Video Port Summary (Input)

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<thead>
<tr>
<th>VPIF</th>
<th>DM642</th>
<th>DM647</th>
<th>DM648</th>
<th>DM6437</th>
<th>DM6446</th>
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<th>DM355</th>
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<th>DM6467</th>
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