The New and Enhanced DaVinci VPSS Drivers

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Goal

• Provide a high-level overview of the newly developed DaVinci VPSS drivers

• Discuss design requirement, architecture and supported features

• Targeted audience are DaVinci Linux application developers responsible for video capture/display, pre- and post-processing
Agenda

• Introduction
• Overview of DaVinci VPSS Drivers
• Driver Requirement & Architecture
• HW & Driver Feature Comparison
• Programming Considerations
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TI Video Expertise Enables Faster and Easier Product Innovation

TI has a long history covering the video market from end to end
R&D began on image processing in the early 80s

TI leverages video systems expertise and R&D across internal design teams to drive innovation and business development

Customers can leverage TI’s expertise in end-to-end video to quickly launch into multiple video markets
TI Expertise Covers
Full Digital Video Spectrum

Digital Still Camera
Personal Media Players
Cell Phones
Video Security

Automotive Entertainment & NAV
Automotive Vision

Machine Vision

Video Phones
Set-Top Box & Digital TV
Video Conferencing

Video Infrastructure
Medical Imaging

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Defining the Video Chain –
Working With Customers Throughout the Entire Video Chain

Capture
Acquisition of original video content including A/D and sampling

Process
Content is encoded, transcoded, transrated and/or analyzed

Deliver
Content is transported via private or public networks

Receive
Received content is stored, decoded and/or transcoded

View
Content is accessible through a viewing mechanism

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Technology for Innovators™
DaVinci™ ... a Revolutionary Platform for Video Applications

**Processors**
- Tuned for any video application

**Software**
- Optimized and ready to go

**Tools**
- Speed time to market

**Technology for Innovators™**

**Future Products**
- IP Video
- Security
- IP Set-Top
- Box
- Automotive
- Infotainment

**Future Innovations**
- VC-1
- H.264
- AAC

**Current Products**
- Portable Media Player
- Digital Camera
- IP Video Phone
- Video Security
- IP Set-Top Box
- Automotive Infotainment

**Platforms**
- Windows Media
- MPEG2
- AAC+
- H.263
- H.264
- MP3

**Formats**
- JPEG
- WMV
- G.711
- G.728
- G.729ab
- G.723.1
- WMA
- AAC
- AAC+
- WMV
- DIVX
- VC-1
- MPEG2
- JPEG

**Innovative Technologies**
- Texas Instruments
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VPSS Block Diagram

- VPFE
  - Resizer
  - Preview
  - H3A
  - Histogram
  - Control Bus I/F

- VPBE
  - Read Buffer
  - Write Buffer
  - OSD
  - Clk Gen
  - VENC

- EMIF -> DDRAM

- Video Port Interfaces (VPI)
- Analog data (DACS)
- Digital data (LCD)

- • CMOS/CCD
- • OR -
- • Video Dec

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VPSS Drivers

CCDC (V4L2) → Resizer → Preview Engine → H3A → HISTOGRAM → DDR Memory

VPBE (FBDev)
## VPSS Driver Support

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Requirement

• Completeness
  – 100% or nearly 100% coverage of available HW features

• Application centric
  – Multiple channel support for Resizer driver
  – Flexible buffer allocation and management scheme

• Efficiency
  – In general, not support features that are not available in HW
Driver Architecture

• Two layer architecture for easy customization
• Bottom layer: hardware abstraction layer
  – OS agonistic
  – HW configuration
• Top layer:
  – Driver registration, initialization
  – Buffer allocation and management
  – Logical channel => HW mapping
  – ISR handling
Agenda

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VPSS Driver architecture

- Application
  - Initialization
  - Channel Management
  - Configuration/Control
  - Buffer Management
  - ISR
  - Resizer HW

- Linux Character Driver API
- Logical Layer
- Hardware Abstraction Layer

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CCDC Features

• Input format
  – 8 or 10-bit BT.656
  – 8 or 16-bit Y/Cb/Cr with external syncs.
  – RGB Bayer pattern

• Frame & field format
  – Interlaced
  – Progressive

• Timing mode
  – Master
  – Slave

• Output path
  – DDR
  – Resizer
  – Preview Engine

• Other
  – Cropping
  – 10-bit to 8-bit A-law compression
  – Fault pixel correction
  – Optical & digital black clamping and black level compensation
  – LPF & Culling
Previous V4L2 Driver

- **Input format**
  - 8 or 10-bit BT.656
  - 8 or 16-bit Y/Cb/Cr with external syncs.
  - RGB Bayer pattern
- **Frame & field format**
  - Interlaced
  - Progressive
- **Timing mode**
  - Master
  - Slave
- **Output path**
  - DDR
  - Resizer
  - Preview Engine
- **Other**
  - Cropping
  - 10-bit to 8-bit A-law compression
  - Fault pixel correction
  - Optical & digital black clamping and black level compensation
  - LPF & Culling
Enhanced V4L2 Driver

- **Input format**
  - 8 or 10-bit BT.656
  - 8 or 16-bit Y/Cb/Cr with external syncs.
  - RGB Bayer pattern

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  - Interlaced
  - Progressive

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  - Master
  - Slave

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  - DDR
  - Resizer
  - Preview Engine

- **Other**
  - Cropping
  - 10-bit to 8-bit A-law compression
  - Fault pixel correction
  - Optical & digital black clamping and black level compensation
  - LPF & Culling
Resizer Features

- **Data format**
  - 8-bit Y/Cb/Cr 4:2:2
  - 8-bit color separated

- **Input path**
  - DDR
  - Preview Engine
  - CCDC

- **Scaling range and ratios**
  - ¼X–4X
  - 256/N with N=64-1024

- **Operations**
  - Horizontal
  - Vertical (with separate scaling factors)

- **Luminance processing**
  - 4-tap 8-phase for ½X–4X
  - 7-tap 4-phase for ¼X–½X

- **Chrominance processing**
  - Bi-linear interpolation
  - Filtered with luminance

- **Edge enhancement**
  - Luminance sharpening
Resizer Driver

- **Data format**
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  - Luminance sharpening
Preview Engine Features

- **Input**
  - 8-10 bit RGB Bayer pattern

- **Output**
  - 8-bit Y/Cb/Cr 4:2:2 interleaved

- **Input path**
  - CCDC
  - DDR

- **Output path**
  - Resizer
  - DDR

- **Input down-sampling**
  - 1x, 2x, 4x & 8x

- **Core processing**
  - CFA interpolation
  - RGB to Y/Cb/Cr color space conversion

- **Other pre-processing features**
  - Invert A-law transform
  - Dark frame capture & subtraction
  - Noise filter
  - Digital gain and white balancing
  - Gamma correction
  - RGB-RGB blending
  - Luminance enhancement
  - Chrominance suppression
Preview Engine Drivers

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  – 8-10 bit RGB Bayer pattern

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  – CCDC
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• **Other features**
  – Invert A-law transform
  – Dark frame capture & subtraction
  – Length Shading Compensation
  – Noise Filter
  – Digital gain and white balancing
  – Gamma correction
  – RGB-RGB blending
  – Luminance enhancement
  – Chrominance suppression
Auto Focus Engine Features

• Paxel Mode
  – Peak mode
  – Accumulation/sum mode

• # of Paxels
  – Up to 36 Paxels in the horizontal direction
  – Up to 128 Paxels in the vertical direction.

• Paxel programmability
  – Width & Height
  – Horizontal start
  – Horizontal & vertical line increments

All features supported by driver
Auto Exposure/Auto White Balancing Engine Features

• # of Windows
  – Up to 36 horizontal windows
  – Up to 128 vertical windows
  – Additional row of window for black pixel data

• Windows Programmability
  – Programmable width and height
  – Separate vertical start and height for a black row of window
  – Horizontal Sampling Points
  – Vertical Sampling Points

All features supported by driver
Previous VPBE Driver Features

• **Windows**
  – Video window 0
  – Video window 1
  – OSD window 0
  – Attribute window

• **DAC outputs**
  – NTSC
  – PAL

• **Input**
  – Y/Cb/Cr 4:2:2 for video window
  – RGB565 for OSD window
Enhanced VPBE Driver Features

- **Windows**
  - Video window 0
  - Video window 1
  - OSD window 0
  - Attribute window

- **DAC outputs**
  - NTSC
  - PAL

- **Input**
  - Y/Cb/Cr 4:2:2 for video window
  - RGB565 for OSD window

- **Other**
  - RAM LUT
  - Hardware Ping-pong buffer
  - Component/Composite/S-Video

- **Windows**
  - OSD window 1 vs. Attribute window
  - Cursor window
  - Enable vs. disable
  - Progressive vs. Interlaced
  - Global vs. pixel level blending
  - Size/position/pitch configuration

- **DAC output**
  - 480p
  - 576p
  - Non standard

- **Digital output**
  - 8/16-bit Y/Cb/Cr
  - RGB 888 or 666
  - PRGB/SRGB
  - Digital LCD output

- **Input**
  - RGB888 input for video windows
  - Bit-map input (1/2/4/8 bit) for OSD windows.
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Parallel Processing

- VPSS modules can work in parallel.
- Different VPSS drivers should reside in different application threads.
- These threads must be set to be FIFO real-time scheduled.
- Example: An application uses CCDC, Resizer & VPBE drivers.
Buffer Management

- CCDC and VPBE drivers allocate their buffers internally and memory map them to user space using `mmap()` system call.

- Resizer, Preview Engine drivers can also allocate buffers internally. Alternatively, they can use buffers allocated elsewhere, e.g., by CCDC or VPBE drivers.
Multi-Channel Operations

• The Resizer driver supports multi-channel operations such that the front-end and back-end processing can share the same Resizer HW
  – E.g., D1->CIF for capture & CIF->D1 for display
  – Each LOGICAL channel maintains its own file descriptor, parameters and buffers
  – Jobs submitted by each LOGICAL channel are prioritized and queued up by the driver

• Other VPSS drivers do not have multi-channel support
The Resizer Driver Utility

- This utility is used in conjunction with the driver to generate the filter coefficients and other parameters specific for the driver.
- Three methods for coefficients calculation:
  - Windowed sinc function (Hann, Blackman etc)
  - Bi-cubic
  - Bi-linear
- Calculation can be based on output size and either of the following:
  - Input size
  - rsz value
- Can generate only the filter coefficients or the complete driver parameter settings
  - The output of the utility is typically saved to a header file to be included in the application source code
- The function is separated from the driver because it involves mainly floating point arithmetic
The Utility Usage

Usage: ./calccoef [options]

Options:
-\h | -\-help        print this message
-\i | -\-insize      input image size(eg. 720x240, -1 for ignore)
-\o | -\-outsize     output image size(eg. 352x288)
-\r | -\-rsz         resizing factor: hrsz x vrsz(eg. 512x512, -1 for ignore)
-\j | -\-sph         horizontal starting phase (0:7)[4]
-\k | -\-spv         vertical starting phase (0:7)[4]
-\w | -\-window      window type (HANN|BLACKMAN|TRIANGULAR|RECTANGULAR)
-\z | -\-horz_filter horizontal filter type (BICUBIC|BILINEAR|LOWPASS))
-\f | -\-vert_filter vertical filter type (BICUBIC|BILINEAR|LOWPASS))
-n | -\-filename    file name for custom window coefficients
-p | -\-print_param print out the complete resizer driver parameter settings
-s | -\-in_pitch    input image line pitch in bytes
-y | -\-out_pitch   output image line pitch in bytes
-t | -\-hstart      horizontal starting pixel #[0]
-v | -\-vstart      vertical starting line #[0]
-c | -\-cbillin     enable bi-linear interpolation for horizontal chroma processing
-g | -\-grayscale   input image is 8-bit grayscale
-x | -\-pixel_format input pixel format([UYVY]|YUYV)
-a | -\-no_array    output data without array headers, can be used to generate multiple sets of coefficients.
The Utility Usage Examples

• Example 1, ½D1->CIF
  - ./calccoeff -i720x240 -o352x288 > coefs_720x240_to_352x288.h

• Example 2, CIF->D1
  - ./calccoeff -i352x288 -o720x480 > coefs_352x288_to_720x480.h

• Example 3, VGA->QVGA with exact 2:1 down-scaling:
  - ./calccoeff -r 512x512 -o352x240 -s1312 > coefs_VGA_to_QVGA.h
Output of Example 3

/* input image pixels/line  = 646 */
/* output image pixels/line  = 320 */
/* horizontal starting phase = 4 */
/* horizontal filter type = LOWPASS */
/* window type = BLACKMAN */
/* hrsz = 512 */

/* horizontal resizing filter coefficients: */
const short horz_coefs[] =
{
    39,
    178,
    39,
    0,
    25,
    174,
    57,
    0,
    ...
};

/* input image # lines  = 483 */
/* output image # lines  = 240 */
/* vertical starting phase = 4 */
/* vertical filter type = LOWPASS */
/* window type = BLACKMAN */
/* vrsz = 512 */

/* vertical resizing filter coefficients: */
const short vert_coefs[] =
{
    39,
    178,
    39,
    0,
    25,
    174,
    57,
    0,
    ...
};
For More Information

• Peripheral Reference Guide for DM644x VPFE & VPBE
• TI DVEVM customer web site
• Montavista Zone