F65
Digital Motion Picture Camera System

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CTO, V.P. Technology
Sony Professional Solutions of America
Agenda

• HDTV & Beyond
  4K Presentation: Theatrical & Home
• F65 enabling technologies
  Imaging characteristics
  High speed Storage
• F65 Post Workflow
  HDTV / 4K DI
HDTV & BEYOND

RESOLUTION
- 4K Cinema
- 3.8K / 7.6K UDTV

FRAME RATE
- 4K O.D.S

VIEW POINT
- 3D Stereo

COLOR SPACE
- HDR Imaging

D-RANGE
- O.D.S

HDTV “Main Stream” Production Tool Set
4K Digital Cinema System

Screening System

Management System

Service/Network

17,000 + Installations Worldwide, .... 36,000 by 2014
4K Resolution Rich Workflow

Acquisition

Production

Viewing

SRMASTER Products

SRM-L560

SRX-R320
4K Digital Motion Picture Camera “F65”

- Flagship Digital Motion Picture Camera with Sony 8K CMOS sensor S35mm (3-perf.)
- True 4K resolution by 20M pixels
- Film color reproduction with wide color gamut
- Up-to 60p (Normal Mode) / 120p (HFR mode)
- 16bit linear RAW output for On-board SRMemory
- New Rotary shutter eliminates motion artifacts
- Flexible file-based workflow: ACES / DPX / HD SStP
F65 Core Sony Technology
New 8K CMOS image sensor

- Super 35mm 3-perf.
- Total Pixel Count: 20.0M
- 1-120Fps
- Compatible with most PL Lenses

8K grid

F65 Sensor

Conventional 4K Bayer sensor

8K grid

24.7mm

28mm

13.1mm
Pixel Count Comparison: HDTV Cameras

- **Sony PMW-F3**
  - 2468x1398
  - 3.5M Pixels

- **Camera-A**
  - 2880x1620
  - 4.7M Pixels

- **Sony F35/SRW-9000PL**
  - 1920x1080x3
  - 6.2M Pixels

6.2M Pixels
1920 x 1080 x RGB
Pixel Count Comparison: Beyond HD Cameras

- Camera-B: 4520x2540, 11.5M Pixels
- Camera-C: 5120x2700, 13.8M Pixels
- Sony F65: 5120x2700, 20M Pixels

HDTV Cameras:
- 2.9M, 2.9M, 5.7M, 6.9M, 10M
- 0.9M, 1.2M, 2.1M, 2.1M, 2.1M

4K Cinema:
- 4096 x 2160 x RGB, 26.5M Pixels

HDTV:
- 1920 x 1080 x RGB, 6.2M Pixels
Imaging Sensor Design Challenges

**D-Range**
- High sensitivity
- Low noise

**Spatial**
- Pixel structure
- Finer process

**Temporal**
- High-speed readout
- Low power consumption

- Increase data read-out speed
- Reduce heat / power consumption
- Improve image quality

F65 Sensor
Max: 34.8Gbps
F65 Digital Motion Picture Camera

Super 35mm Size
20 Mpixel - 8K Sensor

1.9:1 Aspect Ratio

- 1.85:1
- 1.78:1
- 1.66:1
- 1.33:1
- 2.35 Spherical
- 1.3x Anamorphic
- 2x Anamorphic
F65 CMOS Image Sensor

Column Single Slope - ADCs
Column pitch: 2.97mm

2.3K

8.3K

Pixel Array

Pixels placed in a zigzag manner
Unique Sensor Structure

- Dedicated “G” photo cell for each 4K output pixel
- “G” is the most dominating component of Luminance
- “Y” = 0.21 “R” + 0.72”G”+ 0.07”B”

F65 Sensor

Max: 34.8Gbps

1. Dual Row Readout ⇒ Doubles readout speed
2. Hybrid Column Counters ⇒ Power reduction, improved signal
3. Scalable Low Voltage Signaling with Embedded Clock ⇒ Low power, high speed readout
Conventional CMOS Sensors

- Column-parallel ADC circuit -

Vertical Circuit

Horizontal Circuit

ADC

CDS

CDS

Select S/W

Amp.

Photo Diode

Differences of Column Circuits makes Column FPN

※CDS=Correlated Double Sampling For Noise Reduction

Digital data

Analog Signal

Analog/Digital Dual Noise Reduction

Circuit of “Exmor” TM CMOS Sensor
- Column-parallel ADC circuit -

Vertical Circuit

ADC

CDS

CDS

Horizontal Circuit

CDS

CDS

Column-Parallel A/D Conversion

Column-parallel ADC

Noiseless High Speed Data transfer

 Winner of IEEE Walter Kosonocky Award 2007

Higher Sensitivity

Cu Process and micro lens

(a) Conventional Al Process

(b) Cu Process

Target for High-Speed SS-ADC

Only 2.6\(\mu\)sec is left for ADC even in Dual Row Readout (DRR).

<table>
<thead>
<tr>
<th></th>
<th>Conventional Readout</th>
<th>DRR</th>
<th>ADC Target with DRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Readout</td>
<td>4.8(\mu)sec</td>
<td>7.4(\mu)sec</td>
<td>4.8(\mu)sec</td>
</tr>
<tr>
<td>ADC counting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.3(\mu)sec</td>
<td></td>
<td>2.6(\mu)sec</td>
</tr>
</tbody>
</table>

For 8k2k 120fps

ADC counting at 594MHz

ADC counting at 2376MHz

One horizontal scanning period of 8k2k 120fps
SLVS-EC Performance

SLVS-EC: Imaging Data at High Transmission Speed and High Reliability

Performance at 2.376Gbps/ch x 16ch

- Total power consumption: 200mW
  (Driver circuits: < 16mW)
- Jitter: 0.1UI
  (Bit Error Rate: < 1E-15 through a wire length of 300mm)
### Chip Specification

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabrication Process</td>
<td>90nm 1P 4M CMOS process</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>2.9V / 2.7V / 1.2V / 0.4V</td>
</tr>
<tr>
<td>Number of Effective pixels</td>
<td>20 Mpixels</td>
</tr>
<tr>
<td>Pixel size</td>
<td>4.2 μm (H) x 4.2 μm (V)</td>
</tr>
<tr>
<td>Max. data rate</td>
<td>34.8Gbits/s</td>
</tr>
<tr>
<td>Max. frame rate</td>
<td>120 frames per second</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>77.6dB at 120fps</td>
</tr>
<tr>
<td>Power consumption</td>
<td>3.0W at 120fps</td>
</tr>
</tbody>
</table>
Results

Five times faster than ever reported with high D-Range.

- Full pixel readout (20Mp/120fps)
- F65 8K Sensor
- D-Range: 80dB, 75dB, 70dB
- Data Rate [Gbit/s]
- 77.6dB
Wide color space

- F65 covers a wider color space over any other digital camera
- More headroom for color grading
- Future proof camera original material
- Ideal image source for IIF ACES
16bit RAW ⇒ AMPAS IIF-ACES

- IIF-ACES* Project by Academy
  - Total color management between film, digital cameras, VFX elements
  - 16bit half-float OpenEXR
  - Next generation post workflow for post & archive
  - F65 system designed with IIF-ACES workflow in mind

*S-Log/S-Gamut Digital Negative

*IIF-ACES Film Emulation

* Image Interchange Framework, Academy Color Encoding Specification
IIF-ACES: Challenges & Objectives

**CHALLENGES**
- Wide gamut displays
- High dynamic range imaging
- Increased precision
- Mixed media production
- 4K and greater pipelines
- Multiple distribution formats (film, digital, HDTV, etc.)

**OBJECTIVES**
- Merge digital-sourced and film-sourced material.
- Eliminate image conversion errors.
- Preserve cinematographer intent.
- Improved color management within pipelines and across facilities.
- Archival digital master
Rolling Shutter ( Jello-O-Cam Effect )

Each Frame recorded is NOT from single instance in time. Thus Rolling Shutter effect.
Rotary Shutter with internal ND Filters

- Eliminates sensor motion artifact
- Runs at 1-60Fps
- Variable shutter angle 10-180°
- Exposure control for speed-ramp
- Behind the lens ND filter wheel
  0.3 (1/2), 0.6 (1/4), 1.2 (1/16), 1.8 (1/64)
- Shutter pulse for 3D / Motion Control-Rig
On-set Monitoring

HDVF-C30WR
x2 / x4 Magnification
For critical focusing

- Two HD-SDI Monitor Outputs + One HD VF out
- Simple rendering from 16bit Camera RAW
- Apply viewing LUT`s
  -- Preset LUT`s
  -- User definable monitoring LUT`s

Editorial Proxy Recording
In-camera Focus Assist

- x2 & x4 Magnification on HD Monitoring output and Viewfinder
- HDVF-C30WR can add another x2 magnification
**Control and Metadata**

- Wireless control
- Graphical Application
- Additional Metadata
- LUT control
- ASC CDL adjustment
- All camera setup with Browser
- RM-B150/B750
- MSU-1000/1500

**Lens Metadata**
- Cooke /i
- ARRI LDS
F65 iPad/Sony S1 Android Application

- WiFi operation on set
- Touch Based GUI, iPad, iPad2
- Free download from Apple Store
- F65 Operation manual is packed in this application
- Wireless connection with XDCAM Wi-Fi Adapter
- V1.0 Dec/2011 (F65 Status/Menu, R4 TC/REC)
- V1.1 March 2012 (R4 Full Menu support)
- Sony Tablet S1 in April 2012
- V2.0 July 2012
  -- Clip list and playback control
  -- On-set metadata
    -- Circle/NG, DP name, Reel number, Camera ID
    -- Recorded as XML file with RAW MXF
F65 iPad/Sony S1 Android Application

**Status**
- Frame Rate: 24FPS
- Format: S29.97P
- Comp Mode: AC
- Shutter: 4180.0
- Exposure Index: 800EI
- ND Filter: Clear
- Color Temperature: 3200K
- Diagnosis: Shutdown Cam
- Media Remain: 999min
- TCR: 00:00:00:00

**Menu**
- Base Setting
  - Shoot Mode
  - Format
  - Shutter / FPS
  - Shutter Assign
  - ND Filter
  - Bump
  - Gain
  - Gamma
  - Monitor LUT
  - Exponential Index
  - VF Detail
  - Lens File No.
  - Metadata
  - Iris Close
  - Image Invert
  - Auto Black Balance
  - Automatic Pixel Noise Reduction

**F65 iPad/Sony S1 Android Application**
F65 + SR-R4: 16bit Linear Recording

- 16bit Linear RAW Data from F65
- Two Drive modes
  - Normal Drive: 1-60 Fps
  - HFR Drive: 1-120 Fps
- HFR (High Frame Rate) Drive
  - Full camera aperture up to 120P
4K F65 RAW Workflow

• Maximum use of 20M pixel Imager
  • Utilize full range in Contrast, Resolution and Color
• File Size
  • Smaller than uncompressed RGB data
• 16 bit RAW File = Digital negative
• Render multiple resolutions in post
  • HDTV
  • 2K DCI (2048 x 1080)
  • 4K DCI (4096 x 2160)
  • UDTV (3840 x 2160 / 7680 x 4320 @60Fps)
Workflows
And
Processing Devices
4K SRMASTER Workflow

On-set Dailies

Post Production

F65RAW Recording

HD SStP Recording

F65RAW NATIVE

HD SStP NATIVE

SRMASTER
F65RAW Workflow

RAW Acquisition ➔ RAW Cloning ➔ Material Transcode ➔ Ingest ➔ Conform ➔ Color Grading ➔ Finishing

- RAW files
- RGB files
- Low Res files
- EDL

On-set side ➔ Post side

RAW Cloning ➔ Dailies Screening ➔ Ingest ➔ Conform ➔ Color Grading ➔ Finishing

Editorial ➔ VFX

Data flow:

- RAW files
- RGB files
- Low Res files
- EDL
F65RAW Workflow

On-set Dailies System

RAW Acquisition → RAW Cloning → F65RAW SDK → Material Transcode → Ingest → Conform → Color Grading → Finishing

Post System

F65RAW SDK → Editorial → VFX → Finishing

On-set side

SR-D1

Post side

SR-PC4

RAW files

RGB files

Low Res files

EDL
F65 RAW + ACES Workflow

On-set Dailies System

RAW Acquisition ➔ RAW Cloning ➔ Material Transcode ➔ Dailies Screening

Ingest ➔ Conform ➔ Grading ➔ Finishing

Post / DI System

RAW ➔ ACES ➔ Others

RAW processing SDK to NLE / DI tool manufacturers
F65 HD SSstP File based Workflow

SSstP Acquisition
SSstP Cloning

On-set

Dailies Screening

Post / DI System

Ingest
Conform
Grading
Finishing

Editorial

SSstP File based editing already supported by major NLE vendors
F65 RAW + DPX Workflow

On-set Dailies System

- RAW Acquisition
- RAW Cloning
- Material Transcode
- Dailies Screening
- Editorial
- VFX

Post / DI System

- Ingest
- Conform
- Grading
- Finishing
- DPX File based post

Current Film based DI workflow
- Compact, Removable memory cartridge
- Guaranteed Transfer rate up to 5.5Gbps
- Storage capacity 256GB ~ 1TB
- HD~3D~4K Mastering quality recording
- Multi-Channel HD, High frame rate recording
- Data security & integrity
SRMemory classes, speeds and applications

Guaranteed Sustained Write Speeds

<table>
<thead>
<tr>
<th>Class</th>
<th>Speed</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>S15</td>
<td>1.5Gbps</td>
<td>HD</td>
</tr>
<tr>
<td>S25</td>
<td>2.5Gbps</td>
<td>Up to 4K 25P</td>
</tr>
<tr>
<td>S55</td>
<td>5.5Gbps</td>
<td>4K 30P and beyond</td>
</tr>
</tbody>
</table>

All read at a guaranteed sustained rate of 5.5Gbps (Max. 8Gbps)
# SRMemory Line-up

- 6 line-up for 3 speeds

<table>
<thead>
<tr>
<th>SRMemory</th>
<th>256GB</th>
<th>512GB</th>
<th>1TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>8Gbps*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>S15</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5Gbps**</td>
<td>SR-256S15</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>S25</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5Gbps**</td>
<td></td>
<td>SR-512S25</td>
<td>SR-1TS25</td>
</tr>
<tr>
<td><strong>S55</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5Gbps**</td>
<td>SR-256S55</td>
<td>SR-512S55</td>
<td>SR-1TS55</td>
</tr>
</tbody>
</table>

* Nominal Speed  **Guaranteed Write Speed
# F65 & SR-R4 Recording Time

<table>
<thead>
<tr>
<th>Format</th>
<th>Operating Point</th>
<th>Compress. Ratio</th>
<th>Frame Rate</th>
<th>Data Rate</th>
<th>Recording Time 256GB</th>
<th>Recording Time 512GB</th>
<th>Recording Time 1TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>F65RAW</td>
<td>F65RAW-Lite</td>
<td>1/6</td>
<td>24p</td>
<td>1.2Gbps</td>
<td>25min</td>
<td>50min</td>
<td>1H40min</td>
</tr>
<tr>
<td></td>
<td>F65RAW-SQ</td>
<td>1/3.6</td>
<td>24p</td>
<td>2Gbps</td>
<td>15min</td>
<td>30min</td>
<td>1H</td>
</tr>
<tr>
<td></td>
<td>F65RAW-SQ</td>
<td>1/3.6</td>
<td>60p</td>
<td>5Gbps</td>
<td>6min</td>
<td>12min</td>
<td>24min</td>
</tr>
<tr>
<td></td>
<td>F65RAW-HFR</td>
<td>1/3.6</td>
<td>120p</td>
<td>5Gbps</td>
<td>6min</td>
<td>12min</td>
<td>24min</td>
</tr>
<tr>
<td>HD SStP</td>
<td>SR-Lite</td>
<td>1/5.4</td>
<td>24p</td>
<td>175Mbps</td>
<td>2H 22min</td>
<td>4H 45min</td>
<td>9H 31min</td>
</tr>
<tr>
<td></td>
<td>SR-SQ</td>
<td>1/4*</td>
<td>24p</td>
<td>350Mbps</td>
<td>1H 17min</td>
<td>2H 35min</td>
<td>5H 11min</td>
</tr>
<tr>
<td></td>
<td>SR-HQ</td>
<td>1/2</td>
<td>24p</td>
<td>700Mbps</td>
<td>40min</td>
<td>1H 20min</td>
<td>2H 40min</td>
</tr>
</tbody>
</table>

* RGB SR-SQ
SR-R4
SR-R4

F65RAW
- 16 bit Linear RAW
- Mild compression
- Up to 120p
- 4K file-based workflow
- MOVIE & HIGH END COMMERCIAL PRODUCTION

SRFile (SSnP)
- 4:4:4
- 4:2:2
- 10 bit/12 bit
- HD file-based workflow
- Direct-to-Edit
- TV PRODUCTION
SR-R4

F65RAW Recording

- 16 Bit Linear RAW
- Mild compression
- Up to 120 fps
- 4K file-based workflow
- Approx. 50 minutes 24P RAW recording / 1TB
- Approx. 20 minutes @ 120 fps
- Instant Rec. review in camera VF & HD monitoring outputs
- Movie & High End Commercial Production
SR-R1 - SRMemory HD Portable Recorder
SR-R1 - SRMemory HD Portable Recorder

SR-R1 Main Features

Superb Picture Quality
-- MPEG4 SStP (Simple Studio Profile)
  -- SR-Lite (220Mbps), SR-SQ (440Mbps),
  -- SR-HQ (880Mbps) (option)
  -- Uncompressed DPX recording (option)

HD-SDI/3G-SDI dual-link In/Out
-- 10 Bit 4:2:2 / 10 Bit 4:4:4 RGB recording
  -- 12 Bit 4:4:4 RGB recording (option)
  -- 4:2:2 1080 50p/60p recording

3D stereoscopic (dual stream) recording
-- 1080 30p 4:2:2 3D and 1080 30p RGB 4:4:4 3D

Works with any HD-SDI Camera
-- PMW-F3
-- HDW-F900
-- XDCAM HD/EX
-- ARRI ALEXA
-- etc…..
SR-PC4 Data Transfer Unit

- DC Operation (AC Adaptor)
- READ & WRITE
- DATA Interface
  - GbE
    - 10GbE, eSATA (host): 3rd party PCIe card
- Supported File Formats
  - F65RAW, SSStP, DPX (Uncompressed HD)
- Web GUI Control
- F65RAW Monitoring (software option)
- SDI output (3G-SDI / HD-SDI)
  - 1D LUT, 444 / 422 conversion
- Direct Data Copy to Shuttle Drives
SR-PC4 RAW Ingest Solution

- Direct RAW File Copy to Shuttle Drives
- Shuttle DRIVE
- RAW File

- eSATA
- Web GUI

- Clip List
- RAW Viewing
- Trim (IN/OUT point)
SRPC-5 Data Transfer Unit

• Specifications:
  ✓ SR Memory Slot x1
  ✓ HKSR-5804 AUX IN/OUT
  ✓ Network GbE I/F (Built-in)
  ✓ 10GbE (Option, commodity type)
  ✓ USB port for maintenance

✓ CIFS, NFS built-in support
✓ File/Clip name listing via Web GUI
✓ 1U Compact size
Simple and Fast Ingest from SRMemory

Stand Alone Configuration
- PC Workstation / SRPC-5 via GbE
- 10GbE Option

Control
- Web GUI provided by SRPC-5

Transfer direction
- SR Memory to NLE/Server

Simple HD Playback (Viewing): Optional
Simple and Fast Ingest from SRMemory & Tape

Connection:
- SRPC-5 / SRW-5800/2 via HKSR-5804; BNC x 4
- PC Workstation / SRPC-5000 via GbE

Control:
- Web GUI provided by SRPC-5

Transfer direction:
- SR Memory to NLE/Server
- Tape to NLE/Server

GbE
MXF/DPX
10GbE
MXF/DPX

Web GUI on SRPC-5
AUX IN/OUT
Easy Back-up

- On-set Back-up
- Media Conversion: Memory to Tape

Connection
-- SRPC-5 / SRW-5800/2 via HKSR-5804
-- BNC x 4

Control
-- VTR Control Panel

Transfer direction
-- SR Memory to Tape

SR Video Tape
SRMaster Studio Deck

MULTI PORT Configurations
- Includes 1 x SRK-R202 as standard
- SRK-R201 ENCODER BOARD, SRK-R202 DECODER BOARD
- 3 IN/1 OUT, 2 IN/2 OUT, 1IN/3 OUT, 4 OUT

DUAL HD / 3G-SDI
- 2D, 3D, KEY/FILL, etc..

SR CODEC
- SRLite (220), SR-SQ (440), SR-HQ (880)
- 720P, 1080 & 2K

UNCOMPRESSED

SIMULTANEOUS REC / PLAY

FAST RANDOM ACCESS: 6 FRAMES

FILE TRANSFER
- GbE (x2) or 10GbE (option)

16 AUDIO CHANNELS

INTERNAL MEMORY (option)

UP TO 100 HOURS STORAGE

REAL-TIME 4K REC / PLAY

CONTROL PROTOCOLS
- RS-422 VTR, DISK, VDCP
- NET API
SRMaster Studio Deck: Instant Replay

2D or 3D
HD/3G-SDI REC/PLAY
TV studios, OB trucks
Tested at UEFA & WIMBLEDON
SRMaster Studio Deck: ISO Record & File Export

2D or 3D
Native SR-File edit
Sitcom, Game shows
4K Recorder Phase 1 (quad HD/2K)
4K Recorder Phase 2 (Real 4K Raster)
### SRK-R401 4K / QFHD Recording Format

<table>
<thead>
<tr>
<th>Signal</th>
<th>Frame Rate</th>
<th>SR Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SR-SQ</td>
</tr>
<tr>
<td>3840x2160/422</td>
<td>50/59.94p</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>23.98/24/25/29.97p</td>
<td>-</td>
</tr>
<tr>
<td>4096x2160/422</td>
<td>50/59.94p</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>23.98/24/25/29.97p</td>
<td>-</td>
</tr>
<tr>
<td>4096x2160/444</td>
<td>23.98/24p</td>
<td>1.76Gbps</td>
</tr>
</tbody>
</table>
4K Non-Cinema Application

CINEMA (4K/24p)  NON-CINEMA (4K/59.94p, 50p)
4K For HD Production

4K / 59.94p

4K down-converted HD
1080/59.94i
720/59.94p

HD cut-out
1080/59.94i
720/59.94p