ISUAL Imager

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Outline

• Imager technical objectives
• Detector design and specification
• CCD clocking and readout
• Mechanical layout / detailed description
• Electronic design and interface
• Functional parameters
Imager Objectives

• Provide high temporal and spatial resolution imaging of Sprites and other emissions related to lightning storms

• Provide imaging of aurora and airglow
Optical Specifications

- Filters
  - 1: 670 - 750 nm
  - 2: 762 nm
  - 3: 427.8 nm
  - 4: 630 nm
  - 5: 557.7 nm
  - 6: 732 nm
Optical Specifications, con’t.

• Lens
  – Focal length: 62.5 mm
  – Focal ratio: f/1.56
  – Image format: 25 mm diagonal
  – Spectral band: 420 - 780 nm
Detector specifications

• Image Intensifier
  – Type: 25 mm Gen II
  – Manufacturer: DEP
  – Photocathode: Super S25, 6 mm quartz window
  – MCP: Single, 100 ns gating
  – Phosphor: P46, fiber optic window
  2 µs decay time constant

• Fiber Optic Taper
  – Input diameter 25 mm
  – Output diameter 14 mm
  – Ratio 1.8 : 1
Detector specifications, con’t.

• CCD
  – Type: 1024 x 1024, frame transfer
  – Manufacturer: Dalsa, IA-D4
  – Antiblooming: Vertical anti-blooming (VAB)
  – Primary mode: 512 x 80 (binned 2x2 and masked)
  – Pixel size (unbinned): 12 µm x 12 µm
  – Pixel size (binned): 24 µm x 24 µm
  – # of Outputs: 2
  – Pixel readout rate: 8 MHz
CCD Active Area Masking

- Imaging Earth Limb
  - Narrow, 6:1 Aspect Ratio
  - CCD Active Area
  - Mask applied to f/o window
  - Size: 1024 x 170 (unbinned)
  - Size: 512 x 85 (binned)
  - FOV: 20° x 3°

Top view of Dalsa CCD with f/o window
CCD Camera Imaging Modes

- Sprite Burst Mode
- Sprite Continuous Mode
- Aurora Mode
Sprite Burst Mode

- **Highest temporal resolution**
  - Frame interval as low as 1 ms
  - Frame interval largely set by exposure duration, EXP = 1~100ms

- **Triggered by event, take N images, N<12**
  - Images stacked in CCD vertical storage register

- **Readout of data after image acquisition**
  - Data stored in memory

- **Dead time between events**
  - Dead time during image readout
  - Dead time can be minimized by changing N
Sprite Burst Mode Timing

Begin acquisition of N images at leading edge of Event Trigger

Image readout time \( \sim N \cdot T_{\text{readout}} \)

\[ T_{\text{frame}} \]

\[ N \cdot T_{\text{frame}} \]

\[ T_{\text{readout}} \]
Sprite Burst Mode Event Timing

- $T_{\text{frame}}$
  - Period of one Sprite frame depends on Exposure duration, EXP
  - EXP can vary from 1 ~ 100 ms

- $T_{\text{readout}}$
  - Time to readout one frame

- For $F_{\text{vertical}} = 500$ kHz and $F_{\text{horizontal}} = 8$ MHz
  - $T_{\text{readout}} \sim 6$ ms

- No Image Acquisition during readout
  - Dead time $\sim N \cdot T_{\text{readout}}$, where $N =$ number of images acquired
Sprite Continuous Mode

- CCD camera is continuously taking images
  - Image data is readout simultaneously with each image exposure
  - Exposure duration of 1~100 ms
  - Image data is continuously stored in Memory circular buffer
  - Event trigger simply causes a new buffer allocation

- No Dead Time between events
  - But temporal resolution reduced to ~ 6 ms
Sprite Continuous Mode Clocking

Image Area

Storage Area

Expose Image

Shift & Read image from Storage Area

AND

Shift Image & Storage Areas

Repeat Cycle

Transfer another image into Storage Area

Note: Storage area is shifted twice as often
Sprite Continuous Mode Timing

Event occurs

Data for that event starts on 8\textsuperscript{th} frame afterwards

$9 \cdot T_{\text{frame}}$

First frame of event available in memory
Continuous Mode Event Timing

- $T_{\text{frame}}$
  - Period of one Sprite frame depends on Exposure duration, EXP, and the time to readout one frame, whichever is longer

- For $F_{\text{vertical}} = 500 \text{ kHz}$ and $F_{\text{horizontal}} = 8 \text{ MHz}$
  - minimum $T_{\text{frame}} \approx 6 \text{ ms}$
  - $T_{\text{frame}}$ could be longer if EXP > frame readout period
  - EXP can be $< T_{\text{frame}}$, since we use gating to control exposure
Aurora Mode Imaging

The time to shift and readout one image: \(~9\) ms
Exposure duration can be as long as \(~1\) second
Filter Wheel (heated)

Auxiliary Electronics PC Board

Thermoelectric Cooler

Front End Electronics PC Boards

CCD Radiation Shield
Front End Electronics Interface

- **Data[0..11]**
  - 12 bits per pixel
- **PixelClock**
  - pixel data strobe
- **FrameClock**
  - start of frame signal
- **Acquire**
  - signals start of exposure in Aurora mode
  - signals Event in Sprite mode
- **CommandData**
  - serial data interface for upload of camera parameters
- **VoltageMonitor**
  - switched analog output
- **Power**
  - dc voltages
Auxiliary Electronics Interface

- Thermistors
  - TEC hot side
  - Lens
  - Filter Wheel
  - Filter Motor

- Heater Circuits
  - Lens
  - Filter Wheel

- Photocathode PS
  - On/off control
  - Gated

- TEC Power Supply
  - On/off control

- Sun Sensor
  - Analog output

- Filter Wheel Motor
  - Stepper motor (4 phases)
Principal Camera Parameters

- Gated operation enable
- Photocathode gate open/close
- Sprite Burst Mode enable
- Set Burst mode number of images, N
- Sprite Continuous Mode enable
- Aurora Mode enable
- Dark image acquire
- Set Exposure (EXP) duration
- Set repetition (REPTIME) period