Hybrid TDI Cameras Technology
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1/ **HYBRID TDI CAMERAS TECHNOLOGY**
TDI Sensor Concept

Time Delay and Integration (TDI)

- Sensor design that uses multiple line scan stages (up to 512)
- Captures an image of a moving object while transferring integrated signal charges synchronously line by line with the object’s movement
- The collected signal increases by a factor equivalent to the number of TDI stages or transfers

![Sensitivity (TDI Stage)]

- **Line Rate**: 34 KHz ➔ 300 KHz
- **Resolution**: 4k ➔ 8k ➔ 12k ➔ 18k ➔ 23k
- **Pixel Size**: 14 ➔ 10 ➔ 7 ➔ 5 ➔ 3.5 μm
TDI Sensor Concept

Signal Transfer Object Move

Time 1 | Time 2 | Time 3

Charge

Vieworks
TDI Sensor Concept

✓ Single Line Image vs 256 TDI Image

16K Line Scan Image

18K 256 Stage TDI Image

SNR 5.9

SNR 73.1
Conventional CMOS TDI Sensor

✓ Features of CMOS TDI Linear Sensor
  
  • Faster Speed
  • Higher Noise
  • Built-in ADC
  • Lower Power Consumption
  • Digital Output

Accumulating the signal electronically, increasing sensitivity
Conventional CCD TDI Sensor

✓ Features of CCD TDI Linear Sensor
  • Noiseless charge transfer & accumulation
  • Complex additional external circuitry
    (ADC, H-Driver, Vertical Driver, CCD Amp etc.)
  • High signal-to-noise ratio
  • High power consumption
  • Analog Output
Hybrid TDI Sensor Technology

Vieworks’ Hybrid TDI

High Sensitivity  +  High Speed
(Advantage of CCD)  (Advantage of CMOS)
Hybrid TDI Sensor Technology

✓ Combine Advantage of CCD and CMOS
Hybrid TDI Sensor Technology

✓ Features of Hybrid TDI Linear Sensor

• CCD + CMOS Structure

• Combines a light sensitivity CCD-based TDI pixel array with CMOS readout electronics

• CCD pixel structure delivers low-noise, high dynamic range

• CMOS technology enables low-power consumption, fast readouts
Hybrid TDI Sensor Technology Advantages

✓ Combination of best features of CCD and CMOS
  
  • Better Sensitivity
  • Higher Dynamic Range
  • Higher Speed
  • Lower Power Consumption
2/ VIEWORKS TDI CAMERAS
Vieworks Hybrid TDI Camera Lineup

VT Series
High Sensitivity &
High Speed TDI Line Scan Cameras
Vieworks Hybrid TDI Camera Lineup

**M42 mount**
- VT-3K7C-E100
- VT-3K7C-H100
- VT-4K5C-E100
- VT-4K5C-H100
- VT-6K3.5C-E100
- VT-6K3.5C-H100

**M72 mount**
- VT-4K7C-H120
- VT-4K14C-H120
- VT-9K7C-H80
- VT-12K5C-H60
- VT-18K3.5C-H40
- VT-6K10X-H170
- VT-9K7X-H120
- VT-9K7X-H250
- VT-12K5X-H100
- VT-12K5X-H200
- VT-18K3.5X-H80
- VT-18K3.5X-H140

**M95 mount**
- VT-16K5X-H140
- VT-23K3.5X-H100
Vieworks Hybrid TDI Camera Lineup

VTDI - M42 Mount

- Supporting M42 / F mounts
- Dimension: 60 mm × 60 mm × 36 mm
- Cost effective
- Up to 256 TDI stages
- Microscopy
- Compact size and design
- Dedicated strobe controller (optional)
**Vieworks Hybrid TDI Camera Lineup**

**VTDI - M72 & M95 Mount**

- **M72**: 90 mm × 90 mm × 43 mm
- **M95**: 100 mm × 100 mm × 42 mm

- **High Quality & High Performance**
- **Up to 256 TDI Stages**
Vieworks Next Generation TDI

VT-DI Series

Dual Imaging Hybrid TDI

✓ Two Images at once
✓ High Sensitivity
VT-DI Dual Imaging Hybrid TDI

Acquiring two different images at once!

Bright Field (General)

Dark Field (Specializing for Defect)
VT-DI Dual Imaging Hybrid TDI

If you want to get two different images…

1) Use 2 cameras

OR

2) Inspect 2 times
VT DI Dual Imaging Hybrid TDI

If you use Dual Imaging TDI…

Acquiring two images at once!

- Costs Saving
- Time Reducing
- Detection Rates Increasing
3/ TECHNICAL FEATURES
VT Series Technical Features

Summary

- 8/10/12 bit Pixel Format
- Programmable TDI Stage Count (256 /192 /128 / 64 / 32)
- Advanced PRNU, DSNU Correction
- Pre-emphasis Output for Camera-Link (10m cable @ 85MHz)
- Bi-direction Scanning
- Coax-Express Interface(4 CH, 25Gbps)
- Area Scan Mode for Camera Alignment
- Built-in Trigger Sync Converter
- Built-in Programmable Strobe control
- X2 Binning(H & V), ROI, Horizontal Flip, LUT Function
Area Mode

✓ Area Scan mode for camera alignment

Area Mode
- Focusing Lens
- Camera Alignment
- Lens adjustment (magnification, Tilt)

TDI Mode
- Image Calibration
- Image Evaluation

300% Image

Area Mode Output Image
Trigger Rescaler Function

✓ Correct Encoder Trigger Input

Trigger regenerating Function
- Encoder speed corrections (confirm lens magnification)
- Selectable Noise filter 16 ~ 512
LUT Function

✓ WDR, Gamma, Histogram Preprocessing
Multi Link

✓ Support Multi-Link Functions (1 : 2 output Functions)

- When required 2 PCs per 1 Camera for faster processing
- Euresys DF board Solution: 4 channel bandwidth and Data forwarding

<table>
<thead>
<tr>
<th>Master PC</th>
<th>Slave PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Streaming</td>
<td>Image Streaming</td>
</tr>
<tr>
<td>Camera Control</td>
<td></td>
</tr>
</tbody>
</table>

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Multi Link   Configure

Data Forwarding Configure
Strobe Output Control

✓ Strobe Output Control for Exposure Changing

- Strobe Duration: 1 ~ 1000 us
- Strobe Delay: 0 ~ 1000 us
- Strobe Polarity

- TDI Camera should be taken only in uniform motion speed? No!
Strobe Output Control

✓ Strobe Output Control for Exposure Changing

Image output at motion changes

[Continuous illumination] Output level differs depending on line speed

[Strobe illumination] Output level is constant
Strobe Output Control

✓ Strobe Controller Module for M42 TDI

- Current Controller
- High efficiency
- Fast response speed (1μs)
- No need of shunt resistance
- Up to 2A DC current (Max. pulse 10A)

<table>
<thead>
<tr>
<th>Current</th>
<th>DC (0 ~ 2A), Pulse (0 ~ 10A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Frequency</td>
<td>300 kHz</td>
</tr>
<tr>
<td>Min. Current Pulse Width</td>
<td>1 μs</td>
</tr>
<tr>
<td>Strobe Delay</td>
<td>0.5 μs</td>
</tr>
<tr>
<td>LED Voltage</td>
<td>Auto (Max. 35V, Max. = Vin)</td>
</tr>
<tr>
<td>LED Power Consumption</td>
<td>DC 30W (Pulse 300W)</td>
</tr>
</tbody>
</table>

M42 TDI Line Scan + Strobe Controller + LED
**Strobe Output Control**

✓ Strobe Controller Module for M42 TDI

Supporting Multiple Strobes by Combining SCMs
Universal LED Strobe Controller

- **Model**: VLS-PS-40W, VLS-PS-150W
- **Current**
  - DC (0 – 2 A)
  - Pulse (0 – 20 A)
- **Max. Frequency**: 300 KHz
- **Min. Current Pulse Width**: 1 us
- **Strobe Delay**: 0.5 us
- **LED Voltage**: Auto (Max 70V)
- **LED Power**: DC 30 W (Pulse 1000W)

- **Model**: VLS-PS-40W, VLS-PS-150W
- **Current**
  - DC (0 – 5 A)
  - Pulse (0 – 25 A)
- **Max. Frequency**: 300 KHz
- **Min. Current Pulse Width**: 1 us
- **Strobe Delay**: 0.5 us
- **LED Voltage**: Auto (Max 48V)
- **LED Power**: DC 150 W (Pulse 1000W)
4/ APPLICATIONS
Applications

✓ TDI Cameras are useful for…

- Applications where it is desired to record a linear movement
- Applications which operate under low brightness, requiring high-resolution
- In-line applications requiring high-speed operation with high sensitivity
- High-speed imaging for low light applications i.e. fluorescence imaging
- Semiconductor inspection
- Electronics manufacturing and inspection
- Letter and film scanning
- High-speed scanning for large size samples i.e. flat panel displays
- Continuous imaging of high-speed moving object i.e. satellite imaging
- Fast automatic sorting of letters and parcels
- Glass sorting with glass recycling applications
- Web Inspections
Applications
5/ COMPARISONS
## Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>VT-12K</th>
<th>Comparison TDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Hybrid (CCD + CMOS)</td>
<td>CCD</td>
</tr>
<tr>
<td>Resolution</td>
<td>12480 × 256</td>
<td>12000 × 256</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>5.0 μm × 5.0 μm</td>
<td>5.2 μm × 5.2 μm</td>
</tr>
<tr>
<td>Responsivity (nJ/cm²)</td>
<td>550 DN (@620 nm)</td>
<td>300 DN (@500 nm)</td>
</tr>
<tr>
<td>Saturation Capacity</td>
<td>40 Ke-</td>
<td>24 Ke-</td>
</tr>
<tr>
<td>Dark Noise</td>
<td>23 e- 13 e- (@ Analog Gain ×4)</td>
<td>33 e-</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>64 dB</td>
<td>57 dB</td>
</tr>
<tr>
<td>Max. Line Rate</td>
<td>100 kHz</td>
<td>90.8 kHz</td>
</tr>
<tr>
<td>Max. Line Rate @ ×2 Binning</td>
<td>100 kHz</td>
<td>82 kHz</td>
</tr>
<tr>
<td>Trigger Interface</td>
<td>CoaXPress / External</td>
<td>LVDS (Camera Control Port)</td>
</tr>
<tr>
<td>Camera Interface</td>
<td>CoaXPress</td>
<td>HSLink</td>
</tr>
<tr>
<td>Grabber Compatibility</td>
<td>Euresys, Kaya, Silicon Software, Active Silicon, Matrox</td>
<td>Dalsa (Xcelera-HS)</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>9 W (PoCXP Compliant – No need for external power supplies)</td>
<td>36 W (An external power supply is required)</td>
</tr>
<tr>
<td>Max. Cable Length</td>
<td>40 m (CXP6 – 2 cables)</td>
<td>10 m (HSLink – 1 cable)</td>
</tr>
<tr>
<td>Mechanical Dimension</td>
<td>90 mm × 90 mm × 38 mm</td>
<td>180 mm × 90 mm × 92.1 mm</td>
</tr>
</tbody>
</table>
VT-12K has better responsivity at overall wavelength.
Responsivity

VT-12K has better responsivity at all the colors

- Measures the input–output gain of a detector system
- In the specific case of a photodetector, responsivity measures the electrical output per optical input
Shot Noise

- VT-12K has less shot noise

![Shot Noise Graph](image)
**Random Noise**

- VTDI has less random noise, getting better std. deviation

<table>
<thead>
<tr>
<th>Model</th>
<th>VTDI</th>
<th>Comparison TDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td><img src="image1.png" alt="VTDI Image" /></td>
<td><img src="image2.png" alt="Comparison TDI Image" /></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.6 DN</td>
<td>2.0 DN</td>
</tr>
</tbody>
</table>

*Test Condition:* 5500K White Lighting / 8-bit pixel format / 200 target level
Random Noise

✓ VT-12K5X shows the less standard deviation than compared camera (i.e. VT-12K5X has better random noise characteristics)
Dark Noise

- VT-12K has about 2 times less dark noise

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<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>13 e 1.24 DN</td>
<td>30 e 2.8 DN</td>
</tr>
</tbody>
</table>

*Test Conditions: 10x (20 dB) Gain / Dark Condition*
## Comparing Images

✓ VTDI 12K vs Comparison TDI

<table>
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</tr>
<tr>
<td>Standard Deviation</td>
<td>2.5 DN</td>
<td>3.7 DN</td>
</tr>
</tbody>
</table>

*Test Conditions: 10x Gain / 120 Target Grey Level*
Comparing Images

✓ Single line scan vs 256 TDI line scan
Comparing Images

✓ Dual line scan vs 128 TDI line scan
Advantages and Unique features of VTDI

✓ You can get **advantages** from VTDI such as…
  • Low power consumption (25% compared to CCD TDI cameras)
  • Faster line rate and higher sensitivity
  • Higher SNR output (200:1)
  • Supporting longer cable distance with CoaXpress interface
  • Compact design
  • Easy to use and reliable correction features
  • Consistent and Superior Image Quality
  • No tap mismatch issues typically occurring in the CCD imaging sensors

✓ You can use **unique features** of VTDI such as…
  • Trigger Rescaler
  • Strobe output mode
  • Lookup Table (Knee Control)
  • PRNU Auto Target Level
Vieworks Hybrid TDI Cameras

VT Series
High Sensitivity & High Speed TDI Line Scan Cameras
Thank You

Hybrid TDI Cameras Technology