Time Delay Integration (TDI), The Answer to Demands for Increasing Frame Rate/Sensitivity?

Welcome

Craige Palmer - Assistant Sales Manager
Laser Scanning Microscope

High Speed Gated PMT Module

- High Speed Gating: 30nS~DC
- High Repetition: ~100kHz
- Input voltage: 15Vdc
- Protection Circuits
- Gain adjustable

<table>
<thead>
<tr>
<th>Parameter</th>
<th>C1392</th>
<th>New Gated PMT module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Width</td>
<td>1uS to 10uS</td>
<td>30nS to DC</td>
</tr>
<tr>
<td>Repetition</td>
<td>10kHz</td>
<td>100kHz max</td>
</tr>
<tr>
<td>Switching Ratio</td>
<td>1e4</td>
<td>1e7</td>
</tr>
<tr>
<td>Gate Noise</td>
<td>3.5 to 35mV</td>
<td>20mV</td>
</tr>
</tbody>
</table>

PMT
HVPS
GATE
Timing
Protect
Power Supply Circuits

Signal
Vcont
Gate Pulse
+15V
GND

LED

H7680
Applications

MTP Reader

PHOTOSENSOR MODULE

Excitation Lasers

MTP

Printing Process Control
(include Banknote Printing)

PHOTOSENSOR MODULE

Cell Analyzer

PHOTOSENSOR MODULE

Sample

Excitation Laser

PHOTOSENSOR MODULE

Color Selection of Pearl

Pearl
What are NMOS/CMOS Image Sensors?

- Self Scanning Photodiode Array
- Large Sensitive Area
- Direct UV Sensitivity (stable)
- Wide Dynamic Range
- High Saturation Charge
- Good Linearity
- Low Power Consumption
• What benefits does this give?

• Simpler circuit
• Low voltage operation
• Smaller package dimensions
Back Thinned CCD Modules

High Speed Camera Module

Features 1k x 1k back thinned CCD Chip

> 90 % QE

10 MHz pixel readout rate

LVDS interface
TDI (Time Delay Integration):

Time Delay Integration is a method of scanning in which a frame transfer device produces a continuous video image of a moving object by means of a stack of linear arrays aligned with and synchronized to the movement of the object to be imaged in such a way that, as the image moves from one line to the next, the integrated charge moves along with it, providing higher resolution at lower light levels than is possible with a line scan camera.
Line Sensor Operation

[Sample]  [Output signal from a line sensor]

Output image

Line sensor

Optical image
TDI Operation

[Sample]

Output image → [TDI sensor (4 stages)]

Signal intensity

Optical image →
TDI vs Line Sensor Comparison

[Sample] [Line sensor] [TDI sensor (4 stages)]

TDI stages = Higher Output
Advantage of TDI operation

● Higher sensitivity than line sensor
  High sensitivity is realized by multiplication of exposure and charge accumulation due to a number of vertical stages.

● Higher speed than area sensor
  High-speed readout is realized by synchronization of moving object and multi-tap.

![Diagram showing bi-directional transfer with numbers 1, 2, 3, 4 and 512, 128, 128]
• OEM camera w/o chassis
• Front illuminated or back thinned SSD rectangular CCD chips with 1TE (0 Deg C)
• USB2.0
• TDI or Vertical binning (Factory setting)
• Frame readout for focusing
• DC 12V
• DCAM-API support and sample software for spectroscopic imaging
Appearance

Standard configurations

*Sensor head  96(H)x84(V)x65(D)
*Control PCB  54(H)x38(V)x140(D)

Chassis for demo use
C10000 Series TDI Camera

- SSD Back Thinned TDI CCD
- Higher speed (50 kHz)
- 12 bit / 8 bit ADC
- Board Level
  - Already Available
C10000 Series TDI Camera

C10000-301 / -401 (1K x 128/2TAP, 2k x 128/4TAP)
- DSP (Tap difference and shading correction)
- DC+12V (DC-DC Converter)

C10000-601 / -701 (4K x 128/8TAP, 4K x 128/16TAP)
- DSP (Tap difference and shading correction)
- DC+12V (DC-DC Converter)
C10000 Series TDI Camera

RAW IMAGE

Shading correction by DSP

C10000-301 / -401
C10000-601 / -701
Back thinned sensor/High QE

- Maximum QE: Higher than 90%
- Higher than 50% at 200 nm
- Higher than 20% at 1000 nm
Features

● Frame readout mode
   Easy for focusing and alignment

● Bi-directional readout in TDI mode
   Object can move in either direction

● Anti-blooming with lateral overflow drain
   Overflow charge from saturation pixels can be drained.
   Upto 100x of saturation level.
C10650 Series

- High Resolution/High Sensitivity
  3072 (1536 x 2 chips) x 128
  4608 (1536 x 3 chips) x 128

- Direct X-Ray Imaging (FOP+CsI)

- Realtime Dark Current/Shading Correction

- CameraLink Interface
**OPERATING PRINCIPLE OF TDI**

**TDI (Time Delay Integration):**

Time Delay Integration is a technology of scanning in which a frame transfer device produces a continuous video image of a moving object by means of a stack of linear arrays aligned with and synchronized to the motion of the object to be imaged in such a way that, as the image moves from one line to the next, the integrated charge moves along with it, providing higher resolution at lower light levels than is possible with a line-scan camera.
C10650 Series

- Dark current (background) correction
  - To get higher Dynamic range
  - To correct dark current range in each module

- Sensitivity (Brightness) correction
  - X-ray source shading correction
  - Sensitivity correction on sensor
  - Sensitivity correction on scintillator
Applications

- Dimensions control e.g. Cans, Boxes
- Dental
- Aerial Reconnaissance
• Simple stage control for 2D measurement.

• Inexpensive TDI sensor for a large area scanning with high resolution imaging.

• High speed imaging with high resolution by TDI.
- Wafer Defects/Voids

TDI camera

Motion stage/Rotation

Light source
Flow Cytometry

- **PMT system**
  - Excitation
  - Fluorescence
  - PMT
  - Mean intensity only can be measured

- **TDI system**
  - Excitation
  - Fluorescence
  - TDI camera
  - Both intensity and image can be determined
MTP Reader

- Increase speed
- Minimise sample damage

- Conventional PMT or camera
  - Excitation
  - Fluorescence
  - PMT or camera

- TDI system TDI camera
  - Excitation
  - Fluorescence
On line Inspection

• Conventional - strobe flash light and electrical shutter of CCD sensor.
• CMOS sensor is used for these purpose. (S/N is bad!!)
• LED light source (limited intensity)
• TDI technology = Speed, sensitivity and continuous acquisition.
Steel Inspection

Possible to detect: Scratches, Seams, Cracks
Letter Sorting

Barcode reading
Character Recognition
Stamp detection
Print quality verification
Possible to inspect blemish or scratch on a large size glass with high speed by bi-directional readout.
X-Ray Non-Destructive Testing

- Microfocus X-ray source + X-ray TDI Camera
- Magnify the defect for detailed analysis
- Good dynamic range for speed variation

Components Inspection
Components Inspection

Only digital zoom!
X-Ray Non-Destructive Testing

Components Inspection

Stainless Steel Ball

X-ray TDI Camera (48 μm)  

X-ray Line Scan Camera (200 μm)
X-Ray Non-Destructive Testing

Can Inspection

Foreign object

Detection of fish bone in the can
(Even small bone can be seen)
Drug Inspection
X-Ray Non-Destructive Testing

Weld Inspection
Hamamatsu Systems Products

- Scientific Digital Cameras
- AquaCosmos for Biotechnology
- Board Cameras for Industry
- Nanozoomer Slide Scanner
- FDSS Drug Screening System
- NIRO Oxygenation Monitor
- Semiconductor Failure Analysis
- X-ray Sensors & Cameras
- Streak Cameras and Ultra High Speed Imaging
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or Contact Our Office:
Hamamatsu Photonics U.K. Ltd      Tel: 01707 294888