dicam pro
intensified digital 12 bit CCD camera system

- fast shutter down to 3 ns
- excellent sensitivity of the system allows single photon detection
- 12 bit dynamic range
- high resolution MCP–image intensifier & CCD (1280 x 1024 pixel)
- exposure time settings from 3 ns – 1000 s
- spectral sensitivity from UV to NIR
- PCI interface board “plug & play”
- binning (horizontal & vertical)
- thermoelectrical cooling of CCD image sensor down to -12 °C
- optical or electrical triggering
- various MCP photocathodes – S20, S25, GaAs, GaAsP
- two discrete images with an interframing time of 500 ns (PIV)
- multiple exposures
- serial high speed data transfer via fiber optic link (FOL)
- free software camware and software development kit included
dicam pro

This is a high speed intensified CCD camera system with gating times down to 3 ns. With its 12 bit dynamic range and a high resolution CCD image sensor it features an excellent signal-to-noise-ratio and the ability of single photon detection. The system is suited for applications in environments with high electromagnetic disturbances. A high speed serial fiber optic data link connects the system to the PC. The camera can be triggered by light or electrical input. This intensified digital CCD camera system is perfectly suited for demanding high and ultra speed camera applications, such as spray imaging, laser induced fluorescence imaging or ballistics.

**technical data**

<table>
<thead>
<tr>
<th></th>
<th>unit</th>
<th>setpoint</th>
<th>dicam pro</th>
</tr>
</thead>
<tbody>
<tr>
<td>resolution (hor x ver)</td>
<td>pixel</td>
<td></td>
<td>1280 x 1024</td>
</tr>
<tr>
<td>pixel size (hor x ver)</td>
<td>µm²</td>
<td></td>
<td>6.7 x 6.7</td>
</tr>
<tr>
<td>sensor format / diagonal</td>
<td>inch / mm</td>
<td></td>
<td>2/3&quot; / 11.0</td>
</tr>
<tr>
<td>peak quantum efficiency</td>
<td>%</td>
<td>depends on photocathode material</td>
<td>up to 50</td>
</tr>
<tr>
<td>full well capacity</td>
<td>e⁻</td>
<td></td>
<td>25 000</td>
</tr>
<tr>
<td>image sensor</td>
<td></td>
<td>ICX085AL</td>
<td></td>
</tr>
<tr>
<td>dynamic range</td>
<td>dB</td>
<td>CCD + camera</td>
<td>69.3</td>
</tr>
<tr>
<td>dynamic range A/D²</td>
<td>bit</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>readout noise</td>
<td>e⁻ rms</td>
<td>@ pixel scan rate 12.5MHz</td>
<td>7.8</td>
</tr>
<tr>
<td>imaging frequency, frame rate</td>
<td>fps</td>
<td>@ full frame</td>
<td>8</td>
</tr>
<tr>
<td>pixel scan rate</td>
<td>MHz</td>
<td></td>
<td>12.5</td>
</tr>
<tr>
<td>A/D conversion factor</td>
<td>e⁻ / count</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>spectral range</td>
<td>nm</td>
<td>depending on photocathode material of MCP</td>
<td>160 .. 1300</td>
</tr>
<tr>
<td>exposure time</td>
<td>s</td>
<td>3 ns +/- 25 % FWHM³</td>
<td>3 ns .. 1000 s</td>
</tr>
<tr>
<td>anti-blooming factor</td>
<td></td>
<td>@ 100 ms exposure time</td>
<td>&gt; 1000</td>
</tr>
<tr>
<td>smear</td>
<td>%</td>
<td></td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>binning horizontal</td>
<td>pixel</td>
<td></td>
<td>1, 2, 4, 8</td>
</tr>
<tr>
<td>binning vertical</td>
<td>pixel</td>
<td></td>
<td>1, 2, 4, 8, 16, 32</td>
</tr>
<tr>
<td>region of interest</td>
<td>pixel</td>
<td>down to 32 x 32</td>
<td></td>
</tr>
<tr>
<td>extinction ratio</td>
<td></td>
<td>@ 1 ms exposure time (CCD sensor)</td>
<td>1 : 2000</td>
</tr>
<tr>
<td>non-linearity (differential)</td>
<td>%</td>
<td>full temperature range (CCD sensor)</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>uniformity darkness DSNU ⁴</td>
<td>count</td>
<td>@ 90% center zone (CCD sensor)</td>
<td>1</td>
</tr>
</tbody>
</table>

³ FWHM: Full Width at Half Maximum

⁴ DSNU: Dark Signal Non Uniformity
### technical data

<table>
<thead>
<tr>
<th></th>
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<th>setpoint</th>
<th>dicam pro</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniformity brightness</td>
<td>%</td>
<td>typical (CCD sensor)</td>
<td>0.6</td>
</tr>
<tr>
<td>PRNU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trigger, auxiliary signals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>power consumption</td>
<td>W</td>
<td></td>
<td>51</td>
</tr>
<tr>
<td>power supply</td>
<td>VAC</td>
<td></td>
<td>90 .. 260</td>
</tr>
<tr>
<td>mechanical dimensions camera (w x h x l)</td>
<td>mm³</td>
<td>120 x 180 x 340</td>
<td></td>
</tr>
<tr>
<td>weight</td>
<td>kg</td>
<td>camera</td>
<td>8</td>
</tr>
<tr>
<td>operating temperature range</td>
<td>°C</td>
<td></td>
<td>+5 .. +40</td>
</tr>
<tr>
<td>operating humidity range</td>
<td>%</td>
<td>non condensing</td>
<td>10 .. 90</td>
</tr>
<tr>
<td>storage temperature range</td>
<td>°C</td>
<td></td>
<td>-20 .. +70</td>
</tr>
<tr>
<td>optical input</td>
<td></td>
<td>Nikon F-mount, c-mount or special mounts</td>
<td></td>
</tr>
<tr>
<td>optical input window</td>
<td></td>
<td>fused silica (others on request)</td>
<td></td>
</tr>
<tr>
<td>data interface</td>
<td></td>
<td>PCI local bus, Rev. 2.1, burst rate 132 MByte/s</td>
<td></td>
</tr>
<tr>
<td>CE certified</td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>cooled CCD temperature</td>
<td>°C</td>
<td>-12</td>
<td></td>
</tr>
<tr>
<td>cooling method</td>
<td></td>
<td>2 stage Peltier cooler with forced air cooling</td>
<td></td>
</tr>
<tr>
<td>interframing time</td>
<td>ns</td>
<td>minimum</td>
<td>500</td>
</tr>
<tr>
<td>photocathode material</td>
<td></td>
<td>S20, S25, GaAs, GaAsP, others on request</td>
<td></td>
</tr>
<tr>
<td>phosphor screen material</td>
<td></td>
<td>P43, P46</td>
<td></td>
</tr>
<tr>
<td>image intensifier pitch distance</td>
<td>µm</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>image intensifier MCP type</td>
<td></td>
<td>single stage MCP</td>
<td></td>
</tr>
<tr>
<td>image intensifier diameter</td>
<td>mm</td>
<td>18 or 25</td>
<td></td>
</tr>
<tr>
<td>image intensifier system resolution</td>
<td>lp/mm</td>
<td>@ 5 % MTF typical (depends on phosphor)</td>
<td>&gt; 50</td>
</tr>
<tr>
<td>shortest gating time</td>
<td>ns</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

[1] horizontal versus vertical
[3] due to MCP intensifier performance tolerances
[5] photo response non-uniformity
[6] micro channel plate
[7] modulation transfer function
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>image intensifier</td>
<td>type HighRes MCP (6 µm channel)</td>
</tr>
<tr>
<td></td>
<td>output window glass</td>
</tr>
<tr>
<td>pwr &amp; gating supply</td>
<td>phosphor voltage 6 .. 7.5 kV internally adjusted, ripple ±15 mV</td>
</tr>
<tr>
<td></td>
<td>MCP voltage 0 .. 1100 V externally adjustable, ripple ±1 mV</td>
</tr>
<tr>
<td></td>
<td>photocathode voltage on: -180 V</td>
</tr>
<tr>
<td></td>
<td>off: + 80 V</td>
</tr>
<tr>
<td></td>
<td>two modes can be selected:</td>
</tr>
<tr>
<td></td>
<td>ultrafast gating mode: minimum pulse width 3 ns</td>
</tr>
<tr>
<td></td>
<td>highrate gating mode: minimum pulse width 20 ns, maximum pulsing frequency 2 MHz (in bursts)</td>
</tr>
<tr>
<td>optical coupling</td>
<td>“ultra speed tandem lens” between image intensifier &amp; CCD</td>
</tr>
<tr>
<td></td>
<td>transmission efficiency &gt; 20 %</td>
</tr>
<tr>
<td></td>
<td>vignetting &lt; 3 %</td>
</tr>
<tr>
<td></td>
<td>resolution &gt; 60 lp/mm</td>
</tr>
<tr>
<td></td>
<td>distortion free</td>
</tr>
<tr>
<td></td>
<td>scaling rates: different assemblies for the adaptation of SVGA CCD image sensors to 18 or 25 mm image intensifiers are available</td>
</tr>
<tr>
<td>system data</td>
<td>sensitivity &gt; 100 counts/photo-electron with P43 phosphor</td>
</tr>
<tr>
<td></td>
<td>&gt; 25 counts/photo-electron with P46 phosphor</td>
</tr>
<tr>
<td></td>
<td>this corresponds to &lt; 1 µLux (at 20 ms exposure time)</td>
</tr>
<tr>
<td></td>
<td>resolution up to 1000 lines</td>
</tr>
</tbody>
</table>
gate unit

ultra fast gating mode:

exposure times: $3 / 5^a, 10, 20, 25, 30 \text{ ns}$, $30 \text{ ns .. 100 \text{ ns}}$ (10 ns steps), $100 \text{ ns .. 1 s (20 ns steps)}$, $1 \text{ s .. 1000 \text{ s (1 \text{ \mu s steps)}}}$

delay times: $0 \text{ ns .. 50 ns (1 ns steps)}$, $50 \text{ ns .. 100 \text{ ns}}$ (5 ns steps), $100 \text{ ns .. 1 s (20 ns steps)}$, $1 \text{ s .. 1000 \text{ s (1 \mu s steps)}}$

maximum pulsing frequency: $3 \text{ kHz}$

highrate gating mode:

exposure times: $20 \text{ ns .. 1000 \text{ s}}$ (in 20 ns steps)

delay settings: $0 \text{ ns .. 1000 \text{ s}}$ (in 20 ns steps)

maximum pulsing frequency: $2 \text{ MHz}$

intrinsic delay (trigger input – shutter) is appr. $50 \text{ ns}$

jitter ($< 100 \text{ ns exposure time}$) < $0.5 \text{ ns}$

jitter ($> 100 \text{ ns exposure time}$) < $5 \text{ ns}$

exposure modes

single exposure for ultra fast gating, multiple exposure function: $(\text{delay} + \text{exposure}) \times 1 .. 256$

multi exposure for free programmable multiple exposures: $(\text{delay 1} + \text{exposure 1},..,\text{delay 10} + \text{exposure 10}) \times 1 .. 256$

double shutter function for two full resolution images, each exposure time $20 \text{ ns .. 1 s (20 ns steps)}$, each delay time $20 \text{ ns .. 1 s (20 ns steps)}$

interframing time between two images depends on phosphor decay time, the minimum delay time is $500 \text{ ns}$

camera interface

data transfer fiber optic link (FOL), double SC connector, length $10 \text{ m .. 1500 m}$

control output active while “photocathode on”, TTL level, BNC connector

trigger input electrical trigger (TTL level, BNC connector), light active or light pulse trigger (SC connector)

shutter disable high speed TTL input (for disabling the shutter), BNC connector

[8] depending on the selected image intensifier either $3 \text{ ns}$ or $5 \text{ ns}$ as shortest exposure time is available.
software
camware software for camera control, display, storage and printing of image data under Windows9x, ME, XP, Windows2000; software development kit (SDK) with demo software for the above mentioned operating systems; TWAIN driver

phosphor data

<table>
<thead>
<tr>
<th>phosphor</th>
<th>phosphor decay (typ.) to...</th>
<th>typical efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.. 10 %</td>
<td>.. 1 %</td>
</tr>
<tr>
<td>P43</td>
<td>1 ms</td>
<td>4 ms</td>
</tr>
<tr>
<td>P46</td>
<td>0.2 – 0.4 µs</td>
<td>2 µs</td>
</tr>
</tbody>
</table>

photocathode characteristics

<table>
<thead>
<tr>
<th>photo cathode material</th>
<th>peak wavelength [nm]</th>
<th>quantum efficiency at peak wavelength [%]</th>
<th>equivalent background input (EBI) [W/cm²]</th>
<th>dark counts [s⁻¹/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S20 (multialkali)</td>
<td>430</td>
<td>14 .. 18</td>
<td>3·10⁻¹⁴</td>
<td>1500</td>
</tr>
<tr>
<td>S25 (extended red multialkali)</td>
<td>600</td>
<td>8.3 .. 9.3</td>
<td>2·10⁻¹⁴</td>
<td>10 000</td>
</tr>
<tr>
<td>GaAs</td>
<td>530 – 750</td>
<td>23</td>
<td>4·10⁻¹⁴</td>
<td>30 000</td>
</tr>
<tr>
<td>GaAsP</td>
<td>480 – 530</td>
<td>50</td>
<td>2·10⁻¹⁴</td>
<td>10 000</td>
</tr>
</tbody>
</table>

(data courtesy of Hamamatsu Photonics)
spectral response of MCP

Spectral sensitivities of different MCP photocathode materials:
- S20 (multialkali)
- S25 (extended red multialkali)
- GaAs
- GaAsP

...with friendly permission of: Hamamatsu Photonics, Herrsching, Germany, www.hamamatsu.de

Typical transmittance of MCP input window materials

areas of application
- particle image velocimetry (PIV)
- fluorescence imaging
- high resolution microscopy
- spray imaging
- flame analysis
- short time physics
- bioluminescence / chemoluminescence
- low light level imaging
- time resolved spectroscopy
- luminescence spectroscopy
- spectroscopy
- fast flow analysis
- ballistics
- electrophoresis
- LIF laser induced fluorescence
- combustion imaging
- fusion plasma
- Laser induced breakdown spectroscopy (LIBS)
- pressure sensitive paint (PSP)
Analysis of carburation in engines by laser induced fluorescence, example: 2D distribution of fuel in a Diesel engine.

...with friendly permission of: Lehrstuhl für Technische Thermodynamik, Erlangen, Germany, www.ltt.uni-erlangen.de

Analysis of spray vaporization with laser induced fluorescence (LIF).

...with friendly permission of: Lehrstuhl für Technische Thermodynamik, Erlangen, Germany, www.ltt.uni-erlangen.de

OH–PLIF (planar laser induced fluorescence) – turbulent flame front structure visualization. An OH-radical is used as tracer of the flame front with OH–PLIF single shot measurements (single shot: 8ns laser pulse).

...with friendly permission of: Institute for Energy Technology, ETH Zurich, Switzerland, www.ltvv.ethz.ch

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