Digital CCD Cameras for Microscopy
Fast frame rates and high sensitivity
EM-CCD (Electron multiplication CCD) cameras

**High dynamic range**

**ImagEM Enhanced**

Ideal format for short exposures, fast frame rates and high dynamic range

- Back-thinned 512 x 512 frame transfer CCD with greater than 90% QE
- 16 μm pixels with large full well capacity
- Optimized EM-CCD readout and stabilized dual mode cooling

- Short exposures and fast frame rates
- Large dynamic range in both NORMAL-CCD and EM-CCD readout modes
- Highly stabilized gain and minimal dark noise

**High resolution**

**C9100-02**

Front illuminated format for fast high resolution imaging

- High EM gain factor (2000 times)
- 1000 x 1000 x 8 μm pixel format and 30 frames/s readout
- -50 °C air cooling stabilized up to 40 °C ambient

- Great low signal detection
- High spatial resolution well matched to high NA objectives
- Consistent data regardless of ambient temperature

**ImagEM-1K**

Back-thinned format for high QE and high resolution

- Back-thinned 1024 X 1024 frame transfer CCD with greater than 90% QE
- 13 μm pixels and 11 MHz readout
- Optimized EM-CCD readout and stabilized dual mode cooling

- Short exposures and high resolution
- Well matched to high NA objectives and fast readout
- Highly stabilized gain and minimal dark noise
## Specifications

<table>
<thead>
<tr>
<th>Model name</th>
<th>High dynamic range</th>
<th>High resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type number</strong></td>
<td>C9100-13</td>
<td>C9100-02</td>
</tr>
<tr>
<td>Camera head type</td>
<td>Hermetic vacuum-sealed air/water-cooled head</td>
<td>Hermetic vacuum-sealed air-cooled head</td>
</tr>
<tr>
<td>Window</td>
<td>Anti-reflection (AR) coatings on both sides, single window</td>
<td>Single window</td>
</tr>
<tr>
<td>AR mask</td>
<td>Yes</td>
<td>–</td>
</tr>
<tr>
<td>Imaging device</td>
<td>Electron multiplication back-thinned frame transfer CCD</td>
<td>Electron multiplication frame transfer CCD</td>
</tr>
<tr>
<td>Effective number of pixels</td>
<td>512 (H) × 512 (V)</td>
<td>1024 (H) × 1024 (V)</td>
</tr>
<tr>
<td>Cell size (square format)</td>
<td>16 μm (H) × 16 μm (V)</td>
<td>8 μm (H) × 8 μm (V)</td>
</tr>
<tr>
<td>Effective area</td>
<td>8.19 mm (H) × 8.19 mm (V)</td>
<td>8.0 mm (H) × 8.0 mm (V)</td>
</tr>
<tr>
<td>Pixel clock rate</td>
<td>11 MHz, 2.75 MHz, 0.69 MHz</td>
<td>11 MHz, 2.75 MHz, 0.69 MHz</td>
</tr>
<tr>
<td>EM (electron multiplication) gain</td>
<td>2000x (C9100-02)</td>
<td>6x (C9100-02)</td>
</tr>
<tr>
<td>Lens mount</td>
<td>C-mount</td>
<td>–</td>
</tr>
<tr>
<td>Power consumption</td>
<td>Approx. 140 V A</td>
<td>Approx. 60 V A</td>
</tr>
<tr>
<td>Ambient storage temperature</td>
<td>-10°C to +50°C</td>
<td>–</td>
</tr>
<tr>
<td>Ambient operating temperature</td>
<td>0°C to +40°C</td>
<td>–</td>
</tr>
<tr>
<td>Performance guaranteed temperature</td>
<td>0°C to +30°C</td>
<td>0°C to +40°C</td>
</tr>
</tbody>
</table>

### Additional Notes:
- The hermetic sealed head maintains a high degree of vacuum 10⁻⁸ Torr, without re-evacuation.
- The cooling temperature may not reach to this temperature depends on the operation condition.
- Water volume 1.2 liter/min.
- Typical thermal charge value (not guaranteed).
- Image smear may appear when the exposure time is short.
- 8 x 8 and 16 x 16 binning are available on special order. Please consult with our sales office.
- C-MOS 3.3 V with reversible polarity.
- Recursive filter, frame averaging, spot noise reducer cannot be used simultaneously.
### High speed and high sensitivity

**ORCA-R²**  
**Maximum versatility**
- 1.37 million pixel interline CCD with maximum QE over 70%  
- 14 MHz and 28 MHz readout modes included  
- 12 bit and 16 bit digitizers are included and software selectable  
- Air and water cooling capabilities are standard  
- High resolution and short exposure times combined  
- Choice of very low noise or very fast readout to suit applications  
- Choice of bit depth to suit data and precision needs  
- Long exposures with very low dark current and no vibration

### Low noise and very long integration

**ORCA II-ERG**  
**Low noise and very long integration**
- 1.37 million pixel interline CCD with maximum QE over 70%  
- 12 bit and 14 bit digitizers are included and software selectable  
- Very low dark current (0.0045 electron/pixel/s) from -60 °C air cooling  
- Very low readout noise (4 electrons r.m.s.) in high precision mode  
- High resolution and short exposure times combined  
- Choice of very low noise or very fast readout to suit applications  
- Exposure times of hours are possible  
- Even the dimmest signals are detectable without signal multiplication

### Affordable price and low noise

**ORCA-03G, ORCA-05G**  
**Affordable price and low noise**
- 1.37 million pixel interline CCD with maximum QE over 70%  
- Compact head size with single cable and no controller  
- Wide spectral range from 400 nm to NIR region  
- 14.7 MHz readout at 12 bits  
- High resolution and short exposure times combined  
- Fits into any laboratory space or setup  
- Good for both bright fluorescence and NIR-DIC  
- Fast frame rates and good precision  
- ORCA-03 model includes peltier cooling for extended exposures

### Large format, High resolution

**ORCA-HR**  
**Large fields of view with excellent resolution**
- Multi-megapixel interline CCD with 4000 x 2624 x 5.9 μm pixel format  
- Large format detector: 23.6 mm x 15.5 mm  
- Low readout noise even at 20 MHz readout  
- Very high resolution images in micro and macro applications  
- Large field of view reduces tiling of images  
- High quality images from shadow to highlight areas
### Speciality high QE, Low noise

**ORCA II-BT-512G**

**Huge dynamic range and great sensitivity**
- Back thinned 512 x 512 x 24 μm full frame CCD with over 90 % QE
- Large well capacity
- Very low dark current (0.032 electron/pixel/s) with stabilized -75 °C cooling
- Very efficient light collection of dim signals
- Dynamic range of 32 875:1
- Suitable for fluorescence and luminescence

### ORCA II-BT-1024G

**High resolution, large dynamic range and great sensitivity**
- Back thinned 1024 x 1024 x 13 μm pixel full frame CCD with over 90 % QE
- Wide spectral sensitivity from 200 nm to 1000 nm
- Very low dark current (0.0012 electron/pixel/s) with stabilized -75 °C cooling
- High resolution and fast exposure times for microscopy
- Broad range of applications including UV imaging
- Suitable for high resolution fluorescence and luminescence

### Color

**ORCA-3CCD**

**Simultaneous but independent exposures on R, G, and B channels**
- Total 4.13 million pixels on 3 progressive scan interline CCD chips
- 36 bit color resolution
- Cooled R, G and B CCDs with independent exposure settings
- High spatial resolution images of multicolor specimens in brightfield and fluorescence
- Great color fidelity with superb backgrounds
- Tremendous dynamic range of separate fluorophores

### High speed

**C9300-221**

**High frame rates and high IR sensitivity**
- High speed progressive scan VGA interline CCD
- Single or dual tap readout modes are software selectable
- 33 microsecond shutter capability
- High NIR sensitivity
- Good spatial resolution even at 694 frames/s
- Full frame readout of 82 frames/s or 150.2 frames/s
- Stop action imaging of fast moving specimens
- Good choice for moving fluorescence and NIR-DIC specimens
## Specifications

<table>
<thead>
<tr>
<th>Model name</th>
<th>High speed and high sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORCA-R2</strong></td>
<td>C10600-10B</td>
</tr>
<tr>
<td><strong>Type number</strong></td>
<td>C4742-98-24ERG</td>
</tr>
<tr>
<td><strong>Camera head type</strong></td>
<td>ORCA-II-ERG</td>
</tr>
<tr>
<td><strong>Mechanical shutter</strong></td>
<td>ORCA-03G</td>
</tr>
<tr>
<td><strong>Imaging device</strong></td>
<td>ORCA-05G</td>
</tr>
<tr>
<td><strong>Effective number of pixels</strong></td>
<td><strong>Passive air-cooled head</strong></td>
</tr>
<tr>
<td><strong>Cell size (square format)</strong></td>
<td><strong>Hermetic vacuum-sealed air/water-cooled head (5)</strong></td>
</tr>
<tr>
<td><strong>Effective area</strong></td>
<td><strong>Hermetic vacuum-sealed air cooled head (6)</strong></td>
</tr>
<tr>
<td><strong>Pixel clock rate</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>Frame rate</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Readout noise (r.m.s.) typ.</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>Full well capacity typ.</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Dynamic range typ.</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>Cooling method</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Cooling temperature (at +20 °C ambient temperature)</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>Dark current</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>A/D converter</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>Interface / Output signal (digital output)</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Exposure time</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>External control</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Sub-array</strong></td>
<td><strong>ORCA-03G</strong></td>
</tr>
<tr>
<td><strong>External trigger</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Contrast enhancement</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Lens mount</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Line voltage</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Ambient storage temperature</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Ambient operating temperature</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
<tr>
<td><strong>Ambient operating / storage humidity</strong></td>
<td><strong>ORCA-05G</strong></td>
</tr>
</tbody>
</table>

### Notes
- **ORCA 3CCD Digital Color Camera w/front cable mount** for the C7780-10
- **ORCA 3CCD Digital Color Camera w/rear cable mount** for the C7780-20
- **Hamamatsu is a member of 1394 Trade Association**

### High speed and high sensitivity

<table>
<thead>
<tr>
<th>Model name</th>
<th>ORCA-R2</th>
<th>ORCA-II-ERG</th>
<th>ORCA-03G</th>
<th>ORCA-05G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type number</td>
<td>C10600-10B</td>
<td>C4742-98-24ERG</td>
<td>C8484-03G02</td>
<td>C8484-05G02</td>
</tr>
<tr>
<td>Camera head type</td>
<td>Hermetic vacuum-sealed air/water-cooled head (5)</td>
<td>Hermetic vacuum-sealed air-cooled head (6)</td>
<td>Passive air-cooled head</td>
<td>Passive air-cooled head</td>
</tr>
<tr>
<td>Effective number of pixels</td>
<td>1344 (H) x 1024 (V)</td>
<td>6.45 μm (H) x 6.45 μm (V)</td>
<td>6.5 μm (H) x 6.5 μm (V)</td>
<td>6.5 μm (H) x 6.5 μm (V)</td>
</tr>
<tr>
<td>Effective area</td>
<td>8.87 mm (H) x 6.80 mm (V)</td>
<td>8.87 mm (H) x 6.80 mm (V)</td>
<td>8.87 mm (H) x 6.80 mm (V)</td>
<td>8.87 mm (H) x 6.80 mm (V)</td>
</tr>
<tr>
<td>Pixel clock rate</td>
<td>28.0 MHz/pixel</td>
<td>10 MHz/pixel</td>
<td>14.7 MHz/pixel</td>
<td></td>
</tr>
<tr>
<td>Frame rate</td>
<td>8.5 frames/s</td>
<td>2.90 frames/s</td>
<td>4.39 frames/s</td>
<td></td>
</tr>
<tr>
<td>Readout noise (r.m.s.) typ.</td>
<td>8 electrons</td>
<td>4 electrons</td>
<td>6 electrons</td>
<td></td>
</tr>
<tr>
<td>Full well capacity typ.</td>
<td>18,000 electrons</td>
<td>18,500 electrons</td>
<td>15,000 electrons</td>
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</tr>
<tr>
<td>Dynamic range typ.</td>
<td>38,000 electrons (at high dynamic range mode)</td>
<td>40,500 electrons</td>
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</tr>
<tr>
<td>Cooling method</td>
<td>Forced air/water peltier cooling, with hermetic sealing</td>
<td>Forced air/water peltier cooling, with hermetic sealing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling temperature (at +20 °C ambient temperature)</td>
<td>–40 °C (absolute value) (Water cooled)</td>
<td>–60 °C (absolute value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark current</td>
<td>0.0005 electrons/pixel/s</td>
<td>0.0045 electrons/pixel/s</td>
<td>0.1 electrons/pixel/s</td>
<td></td>
</tr>
<tr>
<td>A/D converter</td>
<td>12 bit or 16 bit</td>
<td>12 bit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface / Output signal (digital output)</td>
<td>IEEE1394-2002</td>
<td>IEEE1394-1995 / Non-compressed data (more 16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure time</td>
<td>10 μs to 4200 s</td>
<td>30 μs to 7200 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External control</td>
<td>IDsC 1394-Based Digital Camera Specification Ver.1.31 **</td>
<td>IDsIC 1394-Based Digital Camera Specification Ver.1.30 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-array</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External trigger</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrast enhancement</td>
<td>High speed readout</td>
<td>Analog gain (10 times max.) and offset function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lens mount</td>
<td>C-mount</td>
<td>High precision readout</td>
<td>Analog gain (10 times max.) and offset function</td>
<td></td>
</tr>
<tr>
<td>Line voltage</td>
<td>AC 100 V to 240 V, 50 Hz / 60 Hz</td>
<td>DC +12 V 2A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td>approx. 60 W</td>
<td>approx. 220 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient storage temperature</td>
<td>–10 °C to +50 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient operating temperature</td>
<td>0 °C to +40 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient operating / storage humidity</td>
<td>70 % max (with no condensation)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Additional Information
- **ORCA II-ERG**
- **C4742-98-24ERG**
- **C8484-03G02**
- **C8484-05G02**

### Notes
- **High speed and high sensitivity**
- **Hamamatsu is a member of 1394 Trade Association**

### Image

- **The hermetic sealed head maintains a high degree of vacuum 10^-8 Torr, without re-evacuation.**
- **The resolution of outline scan is 664(H) x 422(V).**
- **Calculated from the ratio of the full well capacity and average readout noise.**
- **The hermetic vacuum-sealed air-cooled head is available. Please consult with our sales office.**
- **The sub-array setting is available only with binning mode.**

### Diagram

- Structure of the hermetic vacuum-sealed head
- CCD
- Input window
- Peltier

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*ORCA 3CCD Digital Color Camera w/front cable mount* for the C7780-10
*ORCA 3CCD Digital Color Camera w/rear cable mount* for the C7780-20

**Hamamatsu is a member of 1394 Trade Association**

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**High speed and high sensitivity**

<table>
<thead>
<tr>
<th>Binning Mode</th>
<th>Horizontal Width</th>
<th>Horizontal Offset</th>
<th>Vertical Width</th>
<th>Vertical Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
<tr>
<td>2 x 2 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
<tr>
<td>4 x 4 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
</tbody>
</table>

**ORCA II-ERG**

<table>
<thead>
<tr>
<th>Binning Mode</th>
<th>Horizontal Width</th>
<th>Horizontal Offset</th>
<th>Vertical Width</th>
<th>Vertical Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 2 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
<tr>
<td>4 x 4 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
<tr>
<td>8 x 8 binning</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
<td>8 x n</td>
</tr>
<tr>
<td>Large format, High resolution</td>
<td>Speciality high QE, Low noise</td>
<td>Color</td>
<td>High speed</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------------</td>
<td>-------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>ORCA-HR</td>
<td>ORCA II-BT-512G</td>
<td>ORCA II-BT-1024G</td>
<td>ORCA-3CCD</td>
<td>C9300-221</td>
</tr>
<tr>
<td>C4742-95-12HR</td>
<td>C4742-98-26LG2</td>
<td>C4742-98-26KWG2</td>
<td>C7780-10, C7780-20</td>
<td>C9300-221</td>
</tr>
<tr>
<td>Passive air-cooled head</td>
<td>Hermetic vacuum-sealed water-cooled head</td>
<td>Passive air-cooled head</td>
<td>Forced air-cooled head</td>
<td></td>
</tr>
</tbody>
</table>

- ORCA II-BT-512G:
  - Full-frame transfer CCD
  - 1024 (H) x 1024 (V)
  - 13 mm (H) x 13 mm (V)
  - 5 MHz/pixel
  - 312.5 kHz/pixel
  - 3.05 frame/s
  - 4.58 frame/s
  - 6.12 frame/s
  - 7.36 frame/s
  - 0.28 frame/s
  - 0.54 frame/s
  - 1.01 frame/s
  - 1.83 frame/s
  - 3.75 frame/s

- ORCA II-BT-1024G:
  - Full-frame transfer CCD
  - 2048 (H) x 2048 (V)
  - 15 mm (H) x 15 mm (V)
  - 5 MHz/pixel
  - 312.5 kHz/pixel
  - 3.05 frame/s
  - 4.58 frame/s
  - 6.12 frame/s
  - 7.36 frame/s
  - 0.28 frame/s
  - 0.54 frame/s
  - 1.01 frame/s
  - 1.83 frame/s
  - 3.75 frame/s

- ORCA-3CCD:
  - Full-frame transfer CCD
  - 2048 (H) x 2048 (V)
  - 15 mm (H) x 15 mm (V)
  - 5 MHz/pixel
  - 312.5 kHz/pixel
  - 3.05 frame/s
  - 4.58 frame/s
  - 6.12 frame/s
  - 7.36 frame/s
  - 0.28 frame/s
  - 0.54 frame/s
  - 1.01 frame/s
  - 1.83 frame/s
  - 3.75 frame/s

- C9300-221:
  - Full-frame transfer CCD
  - 2048 (H) x 2048 (V)
  - 15 mm (H) x 15 mm (V)
  - 5 MHz/pixel
  - 312.5 kHz/pixel
  - 3.05 frame/s
  - 4.58 frame/s
  - 6.12 frame/s
  - 7.36 frame/s
  - 0.28 frame/s
  - 0.54 frame/s
  - 1.01 frame/s
  - 1.83 frame/s
  - 3.75 frame/s

Advantages of an interline transfer CCD (ER-150 CCD)

New interline transfer CCDs like the Hamamatsu ER-150 CCD (Figure 1) used in the ORCA series of cameras, offer characteristics ideally suited to many scientific applications.

Fig. 1 QE of the ER-150 interline transfer CCD (See line in red.)
**Spectral response characteristics**

* These are typical, not guaranteed.

### EM-CCD (Electron multiplication CCD) cameras

- **ImagEM Enhanced, ImagEM-1K**
- **C9100-02**

### Integrating cameras

- **ORCA-HR**
- **ORCA II-BT-512G**
- **ORCA II-BT-1024G**

**System configurations**

- **ImagEM Enhanced, ImagEM-1K**
- **Commercial Frame Grabber Board**
- **C9100-02**
- **Commercial Frame Grabber Board**
- **ORCA-R2**
- **Commercial Frame Grabber Board**
- **ORCA2-ERG, ORCA2-BT-512G, ORCA2-BT-1024G**
- **ORCA-03G**
- **AC Adaptor**
- **ORCA-05G**
- **ORCA-HR**
- **Commercial Frame Grabber Board**
- **ORCA-3CCD**
- **Commercial Frame Grabber Board**
- **C9300-221**

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