Foreign materials, such as pieces of metal, glass, or stone, can be detected inside an object in an instant.
Line-scan cameras are ideal for in-line X-ray photography, enabling capture of high resolution X-ray images of objects moving on equipment such as belt conveyors. Used for a wide range of x-ray observations, for example detection of objects mixed in with food products and electronic components. The wide inspection width (up to approximately 4029mm) facilitates internal observation of large items not previously able to be readily inspected.

Area-scan cameras employ high resolution characteristics (minimum 25m), and as such are ideal for in-line non-destructive testing of small electronic components and PCBs. When fitted with an image intensifier the high sensitivity allows real-time acquisition of high contrast images even with the extremely small currents generated by micro-focus X-ray tubes. The various image processing functions of the controller may be selected at the press of a button for enhancement of image quality.
MEASUREMENT EXAMPLES

LINE-SCAN CAMERA

Line-scan cameras allow superior high-speed processing, and provide imaging functions with a single scan. They are therefore used frequently for inspection on continuous conveyor belts in applications such as in-line inspection of food products.

2D AREA-SCAN CAMERA

Area-scan cameras allow acquisition of high-sensitivity images at high resolution using 2D sensors, and are frequently used for in-line inspection of small electronic components and PCBs, and in applications such as biological research.
The US publishing house Laser & Optronics Ltd selects 15 new products annually from throughout the world for its Lasers & Optronics Technology Award. The C7390 X-ray Line Sensor Camera was selected for the 2000 award.

1. Detection of foreign objects, cracking, and defects in biscuits.
2. Detection of foreign objects and shape defects in lipstick.
3. Detection of foreign objects, shape changes in, and volume measurement of, canned coffee.
4. Detection of foreign objects in, and burning of, noodles.
5. Detection of foreign objects, and measurement of air spaces, in cheese.
6. Detection of knots and insect damage in planks.
7. Detection of foreign objects and bones in cuts of meat.
8. Detection of foreign objects and defects in pies.
10. Detection of nails and defects in boots.
The X-ray line-scan camera can take a high-sensitivity, high-resolution transparent X-ray image of an inspected object transported on a belt conveyor or similar apparatus.

The ability to inspect the contents of packages non-destructively and without contact makes the X-ray line-scan camera ideal for a wide range of applications, including detection of foreign objects in food products and electronic components.

The Hamamatsu Photonics X-ray line-scan camera line-up includes the standard C7390 and the low-cost C8133 for OEM applications. These X-ray line-scan cameras employ the 50mm thin sensor head, ideal for installation within belt conveyors.

The wide inspection width possible facilitates observation of the contents of large items, a process which has proved extremely difficult in the past. The digital signal output may be sent to a computer via a commercially available frame grabber board for processing and analysis, and to form a high added-value system in combination with measuring and packaging equipment.

### FEATURES

- **Only 50mm in thickness**
  By adopting a line sensor as a detector, the thickness of the sensor head is reduced to a maximum of 50mm. Installation inside a belt conveyor is also possible.

- **Pausing the image**
  Using the optional processor board (installed into a computer), the image can be paused or scrolled, and the sensor head controlled arbitrarily.

- **Detection width of 256mm or 512mm**
  An area of 256mm or 512mm (0.4mm pitch) can be inspected. Moreover, the area can be expanded to the maximum detection width of 4,096mm (optional).

- **Spatial resolution 1/640**
  In addition to a high sensitivity, a high spatial resolution (pitch size: 0.4mm) of 1/640 is realized. Even low-contrast or small-sized foreign bodies inside an object can be clearly observed.

- **Spatial resolution 1/1280**
  In addition to a high sensitivity, a high spatial resolution (pitch size: 0.4mm) of 1/1280 is realized. Even low-contrast or small-sized foreign bodies inside an object can be clearly observed.

- **Low cost**
  The total cost was reduced by integrating the main components and adopting DC power, which can be supplied externally.

- **An automation of dark correction, and a long life time**
  An area of 256mm (0.4mm pitch) can be inspected. Moreover, the area can be expanded to the maximum detection width of 4,096mm (optional).

- **Connection to a computer is possible.**
  Using the commercial frame grabber board, the 10-bit digital output enables easy connection to a computer or other external instrument. Acquired image processing, data processing and filing can be performed, allowing the configuration of any system.

- **Detection width of 256mm**
  An area of 256mm or 512mm (0.4mm pitch) can be inspected. Moreover, the area can be expanded to the maximum detection width of 4,096mm (optional).
**SYSTEM CONFIGURATION EXAMPLE**

---

**Standard**

C8133 X-ray Line-Scan camera

- X-ray source
- Shield box
- Object
- Belt conveyor
- RS-232C cable
- Computer
- Power supply unit (optional)
- Data transfer cable
- Frame grabber board (installed into a computer)

**OEM**

C8133 X-ray Line-Scan camera

- X-ray source
- Shield box
- Object
- Belt conveyor
- RS-232C cable
- Computer
- Power supply unit (optional)
- Data transfer cable
- Frame grabber board (installed into a computer)

---

**Note**

- The C8133 X-ray Line-Scan camera consists of only an X-ray line sensor head. The image display equipment (computer and frame grabber board) and the X-ray source, etc should be ordered separately.
- The data transfer cable and RS-232C cable are optional. Please consult with us about connector formats.
- The power supply unit is also optional.

---

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th></th>
<th>C7390</th>
<th>C8133</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection method</td>
<td>Scintillator method (GdO₂)</td>
<td></td>
</tr>
<tr>
<td>Effective X-ray tube voltage range</td>
<td>40 to 160 KVP</td>
<td></td>
</tr>
<tr>
<td>Sensor element pitch</td>
<td>0.4 mm</td>
<td></td>
</tr>
<tr>
<td>Detection width</td>
<td>0.4/820mm/max</td>
<td>0.4/1024mm/max</td>
</tr>
<tr>
<td></td>
<td>0.8/1638mm/max</td>
<td>0.8/2048mm/max</td>
</tr>
<tr>
<td></td>
<td>1.6/3277mm/max</td>
<td>1.6/4096mm/max</td>
</tr>
<tr>
<td>Smallest detectable object size</td>
<td>SUS φ 0.3mm x L=2mm</td>
<td>φ 0.3mm</td>
</tr>
<tr>
<td>Line speed</td>
<td>4 to 40 m/min</td>
<td></td>
</tr>
<tr>
<td>A/D conversion</td>
<td>12 bits</td>
<td>10 bits</td>
</tr>
<tr>
<td>Digital interface</td>
<td>RS-422</td>
<td></td>
</tr>
<tr>
<td>External control</td>
<td>RS-232C</td>
<td></td>
</tr>
<tr>
<td>Correction functions</td>
<td>Analog processing : dark correction (offset)</td>
<td>Digital processing : dark correction (offset), sensitivity correction</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0 to 40°C</td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td>AC100/117/220/240V±10%</td>
<td>DC +5V / DC +15V / DC -15V</td>
</tr>
</tbody>
</table>

---

**DIMENSIONAL OUTLINE (Unit:mm)**

- **C7390 X-ray line sensor head (512mm)** (Weight : Approx. 9.0 kg)

- **C8133 X-ray line sensor head** (Weight : Approx. 9.0 kg)
The X-ray area-scan camera series produces high-resolution and high-sensitivity 2D images for use with real-time image processing equipment to allow X-ray observation and detection from microscopic images.

The Hamamatsu Photonics X-ray area-scan camera series is small and light-weight. Available in 2/3, 1, 1.5, and 2.5 inch to provide four effective fields of view, the line-up consists of the standard C6086 Series X-ray CCD cameras, the C6086-30 Series X-ray CCD cameras fitted with image intensifier and fibre optic plate for high-sensitivity detection, and the C4742-56 Series high-sensitivity digital CCD cameras fitted with fibre optic plate.

**SYSTEM CONFIGURATION EXAMPLE**

**FEATURES**

- **On-chip Integration**
  Integration on the CCD chip allows extended exposure time with dramatically improved sensitivity.

- **Handles Low Contrast**
  Enhancing analog contrast allows low-contrast images to be displayed clearly. Processing removes noise and irregularities from the image as a matter of course.

- **Image Intensification (C6086-30 Series)**
  The use of image intensification allows for a high-sensitivity video system. High sensitivity imaging capabilities allow detection of weak X-rays, and operation at low line weight settings. Imaging at low line weight settings simplifies system development and reduces equipment size, thus minimizing the effect on the human body.

- **Real-time Image Processing**
  Four types of mask processing available for X-ray image analysis as standard.
  - Sharpening (edge enhancement)
  - Smoothing
  - Laplacian processing
  - Differential processing (diagonal image differentiation)
The C6086 series is a compact, lightweight, high resolution X-ray CCD camera. It consists of an X-ray sensitive scintillator (P43) coated on a tapered fiber optic bundle direct coupled to a CCD camera. The C6086-90 camera controller incorporates a 10-bit A/D converter for precise image acquisition and is also capable of a number of realtime image processing functions such as averaging, background subtraction and edge enhancement.

**FEATURES**
- High Spatial Resolution
  - 25 µm (C6086-03,04)
  - 43 µm (C6086-13,14)
  - 62 µm (C6086-23,24)
  - 30 µm (C6086-03,04)
- Effective X-ray tube voltage range 10 to 100 kVp
- 10-bit A/D converter
- Contrast Enhancement
- Real Time Image Processing

**DIMENSIONAL OUTLINE (Unit:mm)**

**Camera head**
- C6086-03,04 (Weight: Approx. 0.4 kg)
- C6086-23,24 (Weight: Approx. 0.7 kg)
- C6086-13,14 (Weight: Approx. 0.6 kg)
- C6086-53,54 (Weight: Approx. 0.5 kg)

**Control Box A6649**
(Weight: Approx. 0.9 kg)
The C6086-30 camera series is a newly developed, highly sensitive, X-ray image intensified CCD camera. This camera is specifically designed for micro focus X-ray source applications, which typically require greater sensitivity than standard X-ray sensitive CCD cameras. By coupling a proximity focused image intensifier with a tapered fiber optic plate (FOP) the C6086-30 series realizes excellent sensitivity while maintaining high resolution and image quality.

FEATURES
- High spatial resolution
  43 \( \mu \text{m} \) (typical value, not guaranteed)
- Effective X-ray tube voltage range: 10 to 100kVp
- Proximity focused II: Low image distortion.
- FOP coupled to the CCD; High coupling efficiency
- P43 (GdO\(_2\)S:Tb) scintillator
- High sensitivity

DIMENSIONAL OUTLINE (Unit:mm)

Camera Controller C6086-90

<table>
<thead>
<tr>
<th>A/D converter</th>
<th>10-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame memory</td>
<td>16-bit memory ( \times 2 ) planes</td>
</tr>
<tr>
<td>Digital interface</td>
<td>SCS12 (optional): Image acquisition software (VDMS) supplied as standard.</td>
</tr>
<tr>
<td>Image processing functions</td>
<td>Gain/Offset, On-chip integration, Image accumulation, Recursive average, Zoom, Background subtraction, Edge enhancement mask (selectable)</td>
</tr>
<tr>
<td>Operating / Storage temperature</td>
<td>0°C to 40 °C / -10 °C to 40 °C</td>
</tr>
<tr>
<td>Operating / Storage humidity</td>
<td>Less than 70% (no condensation)</td>
</tr>
<tr>
<td>Line voltage / Power consumption</td>
<td>AC 100V, 117V, 220V, 240V ( \pm 10% ) 50/60Hz / Approx. 60VA</td>
</tr>
</tbody>
</table>

DIMENSIONAL OUTLINE (Unit:mm)
**IMAGE PROCESSING FUNCTION OF C6086-90**

- **Image (Image Processing Commands)**

  - **GAIN**
    - Gain MIN
      - Without on-chip integration
    - Gain MAX
      - Without on-chip integration
  
  - **RECUR**
    - Contrast remains unchanged, and noise ceases to be a problem.
    - The latent image increases.
  
  - **LIVE**
    - Edges enhanced
      - Enhancement of edges in low-contrast images produces a sharp and clear image.
  
  - **MASK**
    - **SHARP**
      - Image differentiated diagonally.
      - Diagonal differentiation ensures clear representation of vertical and horizontal changes, and enhances low-contrast images.
The C4742-56 is High Resolution Digital B/W CCD Camera using a progressive scan interline CCD chip with no mechanical shutter. In addition to a high resolution of 1.3 million pixels, a wide dynamic range and a high sensitivity, these cameras serve a wide application range, down to low-light level imaging. Peltier cooling drastically reduces dark noise and minimizes thermal drift. RS422A digital out-put ensures compatibility with a large number of commercially available frame grabber boards.

**SYSTEM CONFIGURATION EXAMPLE**

![System Configuration Example Diagram](Image)

- **X-ray source**
- **Shield Box**
- **C4742-56 camera head**

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>C4742-56 Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOP</td>
<td>3.7 : 1</td>
</tr>
<tr>
<td>Scintillator</td>
<td>P43(GdO2S:Tb)</td>
</tr>
<tr>
<td>Imaging device</td>
<td>Progressive scan interline CCD</td>
</tr>
<tr>
<td>Effective no. of pixels</td>
<td>1280 (H) x 1024 (V) or 1024 (H) x 1024 (V)</td>
</tr>
<tr>
<td>Cell size</td>
<td>6.7 µm x 6.7 µm (square format)</td>
</tr>
<tr>
<td>Effective area (mm²)</td>
<td>31.6 x 25.3 or 25.3 x 25.3</td>
</tr>
<tr>
<td>Pixel clock rate</td>
<td>14.75 MHz/pixel</td>
</tr>
<tr>
<td>Frame rate</td>
<td>9 Hz</td>
</tr>
<tr>
<td>2 x 2 binning</td>
<td>18 Hz</td>
</tr>
<tr>
<td>4 x 4 binning</td>
<td>32 Hz</td>
</tr>
<tr>
<td>8 x 8 binning</td>
<td>53 Hz (option)</td>
</tr>
<tr>
<td>Readout noise (r.m.s.)</td>
<td>8 to 12 electrons</td>
</tr>
<tr>
<td>Full well capacity</td>
<td>13000 electrons</td>
</tr>
<tr>
<td>Cooling method</td>
<td>Peltier cooling air radiation system</td>
</tr>
<tr>
<td>Cooling temperature</td>
<td>+10 °C</td>
</tr>
<tr>
<td>Dark current</td>
<td>1 electron/pixel/sec</td>
</tr>
<tr>
<td>A/D converter</td>
<td>12 bit</td>
</tr>
<tr>
<td>Output signal (digital output)</td>
<td>RS-422A 10/12-bit parallel output</td>
</tr>
<tr>
<td>Exposure time</td>
<td>130 usec to 10 sec</td>
</tr>
<tr>
<td>External control</td>
<td>RS 232C (full remote for all camera functions)</td>
</tr>
<tr>
<td>External trigger</td>
<td>yes</td>
</tr>
<tr>
<td>Contrast enhancement</td>
<td>1 to 10 times</td>
</tr>
<tr>
<td>Power consumption</td>
<td>70 VA</td>
</tr>
<tr>
<td>Ambient storage temperature</td>
<td>-10 to +50 °C</td>
</tr>
<tr>
<td>Ambient operating temperature</td>
<td>0 to +40 °C</td>
</tr>
<tr>
<td>Ambient operating/storage humidity</td>
<td>70% max. (no condensation)</td>
</tr>
</tbody>
</table>

**DIMENSIONAL OUTLINE (Unit:mm)**

- **Camera head** (this example shows the head fitted with a flange)
  - Weight: Approx. 2.1 kg

- **Camera control unit** (Weight: Approx. 6.3 kg)

---

- M6662-04 image acquisition set available.
- M6662-04: Hipic + IC-PC board
Microfocus X-ray sources L6731-01 / L7901-01 / L6622-01 / L8121-01 / L8601-01

FEATURES
- Micro focal spot
- RS-232C interface
- Easy handling

The Hamamatsu microfocus X-ray sources were developed specifically for X-ray non-destructive inspection. These X-ray sources use an X-ray tube with a small focal spot of several microns to 10 microns capable of producing a clear X-ray image even at a high magnification. The RS-232C interface is provided as a standard feature, allowing automatic operation by external control. The X-ray tube has an air-cooled and hermetically sealed structure, and is integrated with its high voltage power supply for easy handling. (High voltage cables are not required.)

When an object is magnified, the image taken with a conventional X-ray source is blurred. With a microfocus X-ray source, a clear image still can be obtained.

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Tube Voltage</th>
<th>Focal Spot Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>L8121-01</td>
<td>40 to 150kV</td>
<td>5 µm</td>
</tr>
<tr>
<td>L6622-01</td>
<td>20 to 130kV</td>
<td>10 µm</td>
</tr>
<tr>
<td>L7901-01</td>
<td>40 to 100kV</td>
<td>5 µm</td>
</tr>
<tr>
<td>L8601-01</td>
<td>20 to 90kV</td>
<td>5 µm</td>
</tr>
<tr>
<td>L6731-01</td>
<td>20 to 80kV</td>
<td>8 µm</td>
</tr>
</tbody>
</table>

NOTICE!
This catalog includes X-ray images of some commercial products. These X-ray images were taken by Hamamatsu for experimental purpose of Hamamatsu X-ray imaging system. Note these X-ray images do not explain quality of the commercial products. No image of this catalog may be transmitted in any from, electronic, photocopying.

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