Si APD (avalanche photodiode)

High-speed, high sensitivity photodiodes having an internal gain mechanism

- APD module C10508-01
- Surface mount type S14645-02, S14645-05
- Near infrared type S2385

HAMAMATSU PHOTONICS K.K.
Si APD

High-speed, high sensitivity photodiodes having an internal gain mechanism
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Si APD (avalanche photodiode)

The APD is a high-speed, high-sensitivity photodiode that internally multiplies photocurrent when reverse voltage is applied. The APD, having a signal multiplication function inside its element, achieves higher S/N than the PIN photodiode and can be used in a wide range of applications such as high-accuracy rangefinders and low-light-level detection that use scintillators. Though the APD can detect lower level light than the PIN photodiode, it does require special care and handling such as the need for higher reverse voltage and more detailed consideration of its temperature-dependent gain characteristics.

<table>
<thead>
<tr>
<th>Type</th>
<th>Recommended wavelength (nm)</th>
<th>Peak sensitivity wavelength (nm)</th>
<th>Type no.</th>
<th>Package</th>
<th>Features</th>
<th>Applications</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short wavelength type</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Low-bias operation</td>
<td>200 to 650</td>
<td>620</td>
<td>S12053 series, etc.</td>
<td>Metal</td>
<td>Enhanced sensitivity in the UV to visible region</td>
<td>Low-light-level detection, Analytical instruments</td>
<td>5</td>
</tr>
<tr>
<td>Low terminal capacitance</td>
<td>320 to 650</td>
<td>600</td>
<td>S8664-K series</td>
<td>Metal</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>S8664-55/1010</td>
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<td></td>
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<td>S8550-02</td>
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<tr>
<td></td>
<td>Low-bias operation</td>
<td>600 to 800</td>
<td>800</td>
<td>Metal</td>
<td>High sensitivity in the near IR region and low bias voltage (operating voltage)</td>
<td>FSO, Optical rangefinders, Laser communication</td>
<td>7</td>
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<tr>
<td>Low terminal capacitance</td>
<td>600 to 800</td>
<td></td>
<td>S14644 series</td>
<td>Surface mount type</td>
<td>Compact, thin, low cost</td>
<td>Optical rangefinders, Laser communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S14643-02</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Low temperature coefficient</td>
<td>600 to 800</td>
<td>800</td>
<td>Metal</td>
<td>Low temperature coefficient of the bias voltage, easy gain adjustment</td>
<td>FSO, Optical rangefinders, Laser communication</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S12060 series, etc.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>900 nm band, low terminal capacitance</td>
<td>800 to 1000</td>
<td>860</td>
<td>Metal</td>
<td>Enhanced sensitivity in the 900 nm band</td>
<td>Optical rangefinders, Laser communication</td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>S12426 series, etc.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>840</td>
<td>Surface mount type</td>
<td>Compact, thin</td>
<td>Laser communication</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>S14645-02/05</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>1000 nm band, high sensitivity</td>
<td>900 to 1150</td>
<td>960</td>
<td>Metal</td>
<td>Enhanced sensitivity in the 1000 nm band, low bias voltage (operating voltage)</td>
<td>YAG laser detection, etc.</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S11519 series</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>TE-cooled type</td>
<td>400 to 1000</td>
<td>800</td>
<td>Metal</td>
<td>High S/N</td>
<td>Low-light-level detection</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>S4315 series</td>
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<td></td>
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</tr>
</tbody>
</table>

**APD modules**

<table>
<thead>
<tr>
<th>Type</th>
<th>Type no.</th>
<th>Features</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard type</td>
<td>C12702 series</td>
<td>Contains near infrared type or short wavelength type APD, FC/SMA fiber adapters are also available.</td>
<td>12</td>
</tr>
<tr>
<td>High-sensitivity type</td>
<td>C12703 series</td>
<td>High gain for low-light-level detection</td>
<td></td>
</tr>
<tr>
<td>High-stability type</td>
<td>C10508-01</td>
<td>Digital temperature compensation type, high stability APD module</td>
<td>13</td>
</tr>
<tr>
<td>High-speed type</td>
<td>C5658</td>
<td>Can be used over a wide frequency range (up to 1 GHz)</td>
<td></td>
</tr>
</tbody>
</table>

**Principle of avalanche multiplication**

The photocurrent generation mechanism of the APD is the same as that of a normal photodiode. When light enters a photodiode, electron-hole pairs are generated if the light energy is higher than the band gap energy. The ratio of the number of generated electron-hole pairs to the number of incident photons is defined as the quantum efficiency (QE), expressed in percent (%). The mechanism by which carriers are generated inside an APD is the same as in a photodiode, but the APD is different from a photodiode in that it has a function to multiply the generated carriers. When electron-hole pairs are generated in the depletion layer of an APD with a reverse voltage applied to the PN junction, the electric field causes the electrons to drift toward the N⁺ side and the holes to drift toward the P⁺ side. The higher the electric field strength, the higher the drift speed of these carriers. However, when the electric field reaches a certain level, the carriers are more likely to collide with the crystal lattice so that the drift speed becomes saturated at a certain speed. If the electric field is increased even further, carriers that escaped the collision with the crystal lattice will have a great deal of energy. When these carriers collide with the crystal lattice, a phenomenon takes place in which new electron-hole pairs are generated. This phenomenon is called ionization. These electron-hole pairs then create additional electron-hole pairs, which generate a chain reaction of ionization.

**Principle of APD operation**

Generated carriers produce new electron-hole pairs while being accelerated by high electric field, ionization. Newly generated carriers are also accelerated to produce further electron-hole pairs, and this process repeats itself. Gain proportional to the applied reverse bias voltage can be obtained.
Spectral response (Si APD) For the absolute sensitivity values, see the individual datasheets.

Cutoff frequency vs. recommended wavelength (typical example)

Sensitivity vs. response speed (APD modules)
These are short wavelength Si APDs with enhanced sensitivity in the UV to visible region. They offer high gain, high sensitivity, and low noise in the short wavelength region. They are suitable for applications such as low-light-level measurement and analytical instruments.

### Low-bias operation

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*1 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. I0=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*2 RL=50 Ω (MHz)</th>
<th>Rise time*2 RL=50 Ω (ns)</th>
<th>Terminal capacitance*2 (pF)</th>
<th>Gain λ=650 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12053-02</td>
<td>0.2</td>
<td>200 to 1000</td>
<td>900</td>
<td>0.4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12053-05</td>
<td>0.5</td>
<td></td>
<td>400</td>
<td>0.9</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>TO-8</td>
</tr>
<tr>
<td>S12053-10</td>
<td>1.0</td>
<td></td>
<td>250</td>
<td>1.5</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S9075</td>
<td>1.5</td>
<td></td>
<td>100</td>
<td>3.5</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S5344</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TO-8</td>
</tr>
<tr>
<td>S5345</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

### Spectral response

![Spectral response graph](Typ. Ta=25 °C, M at 650 nm)

### Quantum efficiency vs. wavelength

![Quantum efficiency graph](Typ. Ta=25 °C, M=1)

### Gain vs. reverse voltage

![Gain graph](Typ. λ=650 nm)
Low terminal capacitance

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. Io=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*4 RL=50 Ω (MHz)</th>
<th>Rise time*4 RL=50 Ω (ns)</th>
<th>Terminal capacitance*4 (pF)</th>
<th>Gain λ=420 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8664-02K</td>
<td>φ0.2</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>700</td>
<td>0.5</td>
<td>0.8</td>
<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S8664-05K</td>
<td>φ0.5</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>680</td>
<td>0.52</td>
<td>1.6</td>
<td></td>
<td>TO-8</td>
</tr>
<tr>
<td>S8664-10K</td>
<td>φ1.0</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>530</td>
<td>0.66</td>
<td>4</td>
<td></td>
<td>Ceramic</td>
</tr>
<tr>
<td>S8664-20K</td>
<td>φ2.0</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>280</td>
<td>1.3</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-30K</td>
<td>φ3.0</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>140</td>
<td>2.5</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-50K</td>
<td>φ5.0</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>60</td>
<td>6</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-55</td>
<td>5 × 5</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>40</td>
<td>9</td>
<td>80</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>S8664-1010</td>
<td>10 × 10</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>11</td>
<td>32</td>
<td>270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S11051-20</td>
<td>φ2.0</td>
<td>326</td>
<td>250</td>
<td>1.4</td>
<td>9</td>
<td>11</td>
<td>50</td>
<td></td>
<td>TO-8</td>
</tr>
</tbody>
</table>

4 × 8 element array

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. Io=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*4 RL=50 Ω (MHz)</th>
<th>Rise time*4 RL=50 Ω (ns)</th>
<th>Terminal capacitance*4 (pF)</th>
<th>Gain λ=420 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8550-02</td>
<td>1.6 × 1.6 (× 32 elements)</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>250</td>
<td>9</td>
<td>50</td>
<td></td>
<td>Ceramic</td>
</tr>
</tbody>
</table>

*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

Spectral response

Quantum efficiency vs. wavelength

Gain vs. reverse voltage
# Near infrared type Si APD

## Low-bias operation

These are near infrared Si APDs that operate with low bias voltage. Since high gain can be attained with a bias voltage of 200 V or less, they are suitable for applications such as FSO, laser radar, and optical fiber communication.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area(^1) (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. ID=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/^\circ\text{C})</th>
<th>Cutoff frequency(^2) RL=50 Ω (MHz)</th>
<th>Terminal capacitance(^2) (pF)</th>
<th>Gain λ=800 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12023-02</td>
<td>φ0.2</td>
<td>400 to 1000</td>
<td>200</td>
<td>0.65</td>
<td>1000</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S12023-05</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>S12051</td>
<td>φ0.5</td>
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<td></td>
<td></td>
<td>100</td>
<td>TO-18</td>
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<tr>
<td>S12023-10</td>
<td>φ1.0</td>
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<td></td>
<td></td>
<td></td>
<td>600</td>
<td>6</td>
<td></td>
</tr>
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<td>S12023-10A</td>
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<tr>
<td>S3884</td>
<td>φ1.5</td>
<td></td>
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<td></td>
<td></td>
<td>400</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>S2384</td>
<td>φ3.0</td>
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<td></td>
<td></td>
<td>120</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>S2385</td>
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<td></td>
<td></td>
<td>40</td>
<td>95</td>
<td>40</td>
</tr>
</tbody>
</table>

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

## Surface mount type

These are low cost, small size Si APDs with a surface-mount plastic package suitable for mass production.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area(^1) (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. ID=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/^\circ\text{C})</th>
<th>Cutoff frequency(^2) RL=50 Ω (MHz)</th>
<th>Terminal capacitance(^2) (pF)</th>
<th>Gain λ=800 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14644-02</td>
<td>φ0.2</td>
<td>400 to 1000</td>
<td>180</td>
<td>0.63</td>
<td>1200</td>
<td>0.6</td>
<td></td>
<td>Plastic</td>
</tr>
<tr>
<td>S14644-05</td>
<td>φ0.5</td>
<td></td>
<td>400 to 1000</td>
<td>0.63</td>
<td>1000</td>
<td>1.6</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S14643-02</td>
<td>φ0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2000</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>
**Spectral response**

[S12023 series, S12051, S12086, S3884, S2384, S2385]  

[Typ. Ta=25 °C, M=100 at 800 nm]

**Quantum efficiency vs. wavelength**

[S12023 series, S12051, S12086, S3884, S2384, S2385]  

[Typ. Ta=25 °C, M=1]

**Gain vs. reverse voltage**

[S12023/S14644 series, S12051, S12086, S3884, S2384, S2385]  

[Typ. λ=800 nm]

[S14643-02]  

[Typ. λ=760 nm]
These are near infrared Si APDs featuring low temperature coefficient of the bias voltage. They produce stable gain over a wide temperature range. They are suitable for applications such as FSO, laser radar, and optical fiber communication.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*1</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. ID=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*2 RL=50 Ω (MHz)</th>
<th>Terminal capacitance*2 (pF)</th>
<th>Gain ( \lambda=800 \text{ nm} )</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12060-02</td>
<td>φ0.2</td>
<td></td>
<td>400 to 1000</td>
<td>300</td>
<td>1000</td>
<td>1</td>
<td>100</td>
<td>TO-18</td>
</tr>
<tr>
<td>S12060-05</td>
<td>φ0.5</td>
<td></td>
<td></td>
<td></td>
<td>900</td>
<td>2.5</td>
<td>100</td>
<td>TO-18</td>
</tr>
<tr>
<td>S12060-10</td>
<td>φ1.0</td>
<td></td>
<td></td>
<td></td>
<td>600</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S6045-04</td>
<td>φ1.5</td>
<td></td>
<td></td>
<td></td>
<td>350</td>
<td>12</td>
<td>100</td>
<td>TO-5</td>
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<tr>
<td>S6045-05</td>
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<td>80</td>
<td>50</td>
<td>60</td>
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<tr>
<td>S6045-06</td>
<td>φ5.0</td>
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<td></td>
<td>35</td>
<td>120</td>
<td>40</td>
<td>TO-8</td>
</tr>
</tbody>
</table>

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

**Spectral response**

**Quantum efficiency vs. wavelength**

**Gain vs. reverse voltage**
This series is used in laser radar and other applications. It features a gradual curve of gain versus reverse voltage curve, providing stable operation.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max.</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency**4 RL=50 Ω (MHz)</th>
<th>Terminal capacitance**4 (pF)</th>
<th>Gain λ=900 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12426-02</td>
<td>φ0.2</td>
<td>400 to 1100</td>
<td>200</td>
<td>1.1</td>
<td>650</td>
<td>0.5</td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12426-05</td>
<td>φ0.5</td>
<td>400 to 1100</td>
<td>200</td>
<td>1.1</td>
<td>600</td>
<td>1.1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S9251-10</td>
<td>φ1.0</td>
<td>440 to 1100</td>
<td>350</td>
<td>1.85</td>
<td></td>
<td></td>
<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S9251-15</td>
<td>φ1.5</td>
<td>440 to 1100</td>
<td>350</td>
<td>1.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Surface mount type**

The small, thin leadless package allows reducing the mounting area on a printed circuit board. The S14645-02F and S14645-05F have an on-chip filter matched to a 900 nm light source.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max.</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency**4 RL=50 Ω (MHz)</th>
<th>Terminal capacitance**4 (pF)</th>
<th>Gain λ=900 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14645-02</td>
<td>φ0.2</td>
<td>400 to 1100</td>
<td>195</td>
<td>1.1</td>
<td>600</td>
<td>0.5</td>
<td></td>
<td>Plastic</td>
</tr>
<tr>
<td>S14645-02F</td>
<td>φ0.2</td>
<td>850 to 950</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S14645-05</td>
<td>φ0.5</td>
<td>400 to 1100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plastic</td>
</tr>
<tr>
<td>S14645-05F</td>
<td>φ0.5</td>
<td>850 to 950</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

**Spectral response**

[S12426/S14645 series]

[Tip. Ta=25 °C, M=100 at λ=900 nm]

**Gain vs. reverse voltage**

[S12426/S14645 series]

[Tip. λ=900 nm]
The S11519 series incorporates MEMS technology to enhance the sensitivity in the near IR region for YAG laser (1.06 μm) detection.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*1 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. ID=100 μA (V)</th>
<th>Temp. coeff. of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*2 RL=50 Ω (MHz)</th>
<th>Terminal capacitance*2 (pF)</th>
<th>Gain λ=890 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S11519-10</td>
<td>φ1.0</td>
<td>600 to 1150</td>
<td>500</td>
<td>1.7</td>
<td>400</td>
<td>2</td>
<td>100</td>
<td>TO-5</td>
</tr>
<tr>
<td>S11519-30</td>
<td>φ3.0</td>
<td></td>
<td></td>
<td></td>
<td>230</td>
<td>12</td>
<td></td>
<td>TO-8</td>
</tr>
</tbody>
</table>

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

**Spectral response**

[Graph showing spectral response](#)

**Quantum efficiency vs. wavelength**

[Graph showing quantum efficiency vs. wavelength](#)

**Gain vs. reverse voltage**

[Graph showing gain vs. reverse voltage](#)

The S4315 series is a low-bias operation thermoelectrically-cooled type APD capable of high accuracy detection.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Cooling temperature ΔT (°C)</th>
<th>Built-in APD</th>
<th>Effective photosensitive area*1 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. ID=100 μA (V)</th>
<th>Cutoff frequency*2 RL=50 Ω (MHz)</th>
<th>Terminal capacitance*2 (pF)</th>
<th>Gain λ=800 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S4315</td>
<td></td>
<td>S12023-02</td>
<td>φ0.2</td>
<td></td>
<td></td>
<td>1000</td>
<td>1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S4315-01</td>
<td>40</td>
<td>S12023-05</td>
<td>φ0.5</td>
<td>400 to 1000</td>
<td>200</td>
<td>900</td>
<td>2</td>
<td>100</td>
<td>TO-8</td>
</tr>
<tr>
<td>S4315-02</td>
<td></td>
<td>S12023-10</td>
<td>φ1.0</td>
<td></td>
<td></td>
<td>600</td>
<td>6</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S4315-04</td>
<td></td>
<td>S2384</td>
<td>φ3.0</td>
<td></td>
<td></td>
<td>120</td>
<td>40</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table
APD modules

Standard type

The APD module consists of an amplifier and bias power supply assembled in a compact form to facilitate the use of the Si APD. Running on a +5 V power supply, it can be used for a variety of light detection applications up to 100 MHz of frequency bandwidth.

Near infrared type

Features
- Peak sensitivity wavelength: 800 nm
- Wide bandwidth
- Optical fiber adapters are also available (sold separately).

Applications
- Si APD evaluation
- FSO
- Barcode readers
- Laser radars
- Optical rangefinders
- Optical communication

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area* (mm)</th>
<th>Built-in APD</th>
<th>Cutoff frequency</th>
<th>Photoelectric conversion sensitivity M=30, ( \lambda=800 \text{ nm} ) (V/W)</th>
<th>Minimum detection limit M=30, ( \lambda=800 \text{ nm} ) (nW rms)</th>
<th>Temperature stability of gain 25 ± 10 °C (%)</th>
<th>Supply voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C12702-03</td>
<td>( \phi 1.0 )</td>
<td>S12023-10</td>
<td>4 kHz</td>
<td>100 MHz</td>
<td>-6.8 × 10^4</td>
<td>3</td>
<td>±5 max.</td>
</tr>
<tr>
<td>C12702-04</td>
<td>( \phi 3.0 )</td>
<td>S2384</td>
<td>100 MHz</td>
<td>80 MHz</td>
<td>-2.3 × 10^4</td>
<td>3.6</td>
<td>±5 max.</td>
</tr>
</tbody>
</table>

Short wavelength type

Features
- Peak sensitivity wavelength: 620 nm
- Wide bandwidth
- Optical fiber adapters are also available (sold separately).

Applications
- Si APD evaluation
- Film scanners
- Laser monitoring

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area* (mm)</th>
<th>Built-in APD</th>
<th>Cutoff frequency</th>
<th>Photoelectric conversion sensitivity M=30, ( \lambda=620 \text{ nm} ) (V/W)</th>
<th>Minimum detection limit M=30, ( \lambda=620 \text{ nm} ) (nW rms)</th>
<th>Temperature stability of gain 25 ± 10 °C (%)</th>
<th>Supply voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C12702-11</td>
<td>( \phi 1.0 )</td>
<td>S12053-10</td>
<td>4 kHz</td>
<td>100 MHz</td>
<td>-2.5 × 10^4</td>
<td>5</td>
<td>±5 max.</td>
</tr>
<tr>
<td>C12702-12</td>
<td>( \phi 3.0 )</td>
<td>S5344</td>
<td>100 MHz</td>
<td>40 MHz</td>
<td>-1.9 × 10^4</td>
<td>6.3</td>
<td>±5 max.</td>
</tr>
</tbody>
</table>

High-sensitivity type

These are high-gain APD modules suitable for low-light-level detection. They can be used for DC light detection.

Features
- Low-light-level detection
- DC light detection
- High gain

Applications
- Si APD evaluation
- Fluorescence measurement
- Barcode readers
- Particle counters
- Film scanners

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area* (mm)</th>
<th>Internal APD</th>
<th>Cutoff frequency</th>
<th>Photoelectric conversion sensitivity M=30, ( \lambda=800 \text{ nm} ) (V/W)</th>
<th>Minimum detection limit M=30, ( \lambda=800 \text{ nm} ) (nW rms)</th>
<th>Temperature stability of gain 25 ± 10 °C (%)</th>
<th>Supply voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C12703</td>
<td>( \phi 1.5 )</td>
<td>S3884</td>
<td>DC</td>
<td>10 MHz</td>
<td>1.5 × 10^6</td>
<td>0.63</td>
<td>±5 max.</td>
</tr>
<tr>
<td>C12703-01</td>
<td>( \phi 3.0 )</td>
<td>S2384</td>
<td>100 kHz</td>
<td>100 kHz</td>
<td>-1.5 × 10^8</td>
<td>0.0063</td>
<td>±5 max.</td>
</tr>
</tbody>
</table>

*3: Area in which a typical gain can be obtained
The C10508-01 consists of an APD, current-voltage converter, high-voltage power supply circuit as well as a microcontroller for adjusting the APD gain and controlling temperature compensation with high accuracy. This makes it easy to adjust the APD gain and even at high gain, stable detection is possible even under temperature fluctuating conditions.

**Features**
- Gain: adjustable by switch or PC command
- Gain temperature stability: ±5% or less (Gain=250, Ta=0 °C to +40 °C)
- Easy handling: only ±5 V power supply

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area* (mm)</th>
<th>Internal APD</th>
<th>Cutoff frequency</th>
<th>Photoelectric conversion sensitivity M=250, λ=800 nm (V/W)</th>
<th>Minimum detection limit M=250, λ=800 nm (pW rms)</th>
<th>Temperature stability of gain 0 to 40 °C (%)</th>
<th>Supply voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C10508-01</td>
<td>ø1.0 S12023-10A</td>
<td>DC 10 MHz</td>
<td>1.25 x 10^-7</td>
<td>63</td>
<td>±5 max.</td>
<td>±5</td>
<td></td>
</tr>
</tbody>
</table>

**Applications**
- Si APD evaluation
- Power meters
- Low-light-level detection

**FC/SMA fiber adapter (sold separately)**

FC or SMA fiber adapters can be attached to the following APD modules to allow FC or SMA optical fiber cables to be connected to the modules.

<table>
<thead>
<tr>
<th>APD module</th>
<th>FC fiber adapter</th>
<th>SMA fiber adapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>C12702-03</td>
<td>A8407-18</td>
<td>A8424-18</td>
</tr>
<tr>
<td>C12702-04</td>
<td>A8407-05A</td>
<td>A8424-05A</td>
</tr>
<tr>
<td>C12702-11</td>
<td>A8407-18</td>
<td>A8424-18</td>
</tr>
<tr>
<td>C12702-12</td>
<td>A8407-05A</td>
<td>A8424-05A</td>
</tr>
<tr>
<td>C12703</td>
<td>A8407-05</td>
<td>A8424-05</td>
</tr>
<tr>
<td>C12703-01</td>
<td>A8407-05A</td>
<td>A8424-05A</td>
</tr>
<tr>
<td>C10508-01</td>
<td>A12855-01</td>
<td>A12855-02</td>
</tr>
</tbody>
</table>

**High-speed type**

This device can be used in a wide frequency range (up to 1 GHz).

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area* (mm)</th>
<th>Internal APD</th>
<th>Cutoff frequency</th>
<th>Photoelectric conversion sensitivity M=100, λ=800 nm (V/W)</th>
<th>Minimum detection limit M=100, λ=800 nm (nW rms)</th>
<th>Temperature stability of gain 25 ± 10 °C (%)</th>
<th>Supply voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5658</td>
<td>ø0.5 S12023-05</td>
<td>50 kHz 1 GHz</td>
<td>2.50 x 10^5</td>
<td>16</td>
<td>±5</td>
<td>+12</td>
<td></td>
</tr>
</tbody>
</table>

* Area in which a typical gain can be obtained
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- MPPC
- Photo IC
- Image sensors
- PSD
- Infrared detectors
- Optical communication devices
- Automotive devices
- X-ray flat panel sensors
- Mini-spectrometers
- Opto-semiconductor modules

Electron tubes
- Photomultiplier tubes
- Photomultiplier tube modules
- Microchannel plates
- Image intensifiers
- Xenon lamps / Mercury xenon lamps
- Deuterium lamps
- Light source applied products
- Laser applied products
- Microfocus X-ray sources
- X-ray imaging devices

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- Cameras / Image processing measuring systems
- X-ray products
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- Medical systems
- Semiconductor failure analysis systems
- FPD / LED characteristic evaluation systems
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