Si APD (avalanche photodiode)

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

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

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### Si APD (for general measurement)

<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>Low-bias operation</td>
<td>200 to 650</td>
<td></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, S8664-55/-1010, S8550-02</td>
<td>Ceramic</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Low-bias operation</td>
<td>700 to 900</td>
<td>800</td>
<td>S12023 series, etc.</td>
<td>Metal</td>
<td>Low bias voltage operation</td>
<td>FSO (free space optics), Optical fiber communication, Analytical instruments</td>
<td>7</td>
</tr>
<tr>
<td>Low temperature coefficient</td>
<td>700 to 900</td>
<td>800</td>
<td>S12060 series, etc.</td>
<td>Metal</td>
<td>Low temperature coefficient of the bias voltage, easy gain adjustment</td>
<td>FSO, Optical fiber communication, Analytical instruments</td>
<td>8</td>
</tr>
<tr>
<td>800 nm band</td>
<td>700 to 1000</td>
<td>840</td>
<td>S12426-02/-05</td>
<td>Metal</td>
<td>Type with enhanced sensitivity in the 800 nm band (λp=840 nm)</td>
<td>FSO, Optical fiber communication, Analytical instruments</td>
<td>9</td>
</tr>
<tr>
<td>900 nm band</td>
<td>700 to 1000</td>
<td>860</td>
<td>S9251-10/-15, S12092-02/-05</td>
<td>Metal</td>
<td>Type with enhanced sensitivity in the 900 nm band (λp=860 nm)</td>
<td>FSO, Optical fiber communication, Analytical instruments</td>
<td>10</td>
</tr>
<tr>
<td>900 nm band</td>
<td>800 to 1100</td>
<td>940</td>
<td>S8890-02/-05</td>
<td>Metal</td>
<td>Type with enhanced sensitivity in the 900 nm band (λp=940 nm)</td>
<td>FSO, Optical fiber communication, Analytical instruments</td>
<td>10</td>
</tr>
<tr>
<td>TE-cooled type</td>
<td>700 to 900</td>
<td>800</td>
<td>S4315 series</td>
<td>Metal</td>
<td>High S/N</td>
<td>Low-light-level detection</td>
<td>11</td>
</tr>
</tbody>
</table>

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### Si APD (for LiDAR)

<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>700 nm band</td>
<td>600 to 800</td>
<td>760</td>
<td>S14643-02</td>
<td>Surface mount type</td>
<td>Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 700 nm band</td>
<td>LiDAR, Optical rangefinders</td>
<td>12</td>
</tr>
<tr>
<td>800 nm band</td>
<td>600 to 800</td>
<td>800</td>
<td>S14644-02/-05</td>
<td>Surface mount type</td>
<td>Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 800 nm band</td>
<td>LiDAR, Optical rangefinders</td>
<td>12</td>
</tr>
<tr>
<td>900 nm band</td>
<td>800 to 1000</td>
<td>840</td>
<td>S14645-02/-05</td>
<td>Surface mount type</td>
<td>Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 900 nm band</td>
<td>LiDAR, Optical rangefinders</td>
<td>12</td>
</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>14</td>
</tr>
<tr>
<td>High-sensitivity type</td>
<td>C12703 series</td>
<td>High gain type 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></td>
</tr>
<tr>
<td>High-speed type</td>
<td>C6658</td>
<td>Can be used over a wide frequency range (up to 1 GHz)</td>
<td></td>
</tr>
</tbody>
</table>
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.

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 principle of avalanche multiplication is as follows: Generated carriers produce new electron-hole pairs while being accelerated by high electric field, causing a chain reaction of 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.
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. Io=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*2 (MHz)</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>φ0.2</td>
<td>200 to 1000</td>
<td>900</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12053-05</td>
<td>φ0.5</td>
<td>200</td>
<td>400</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12053-10</td>
<td>φ1.0</td>
<td>200</td>
<td>250</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S9075</td>
<td>φ1.5</td>
<td>200</td>
<td>100</td>
<td>30</td>
<td></td>
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<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S5344</td>
<td>φ3.0</td>
<td>200</td>
<td>25</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td>TO-8</td>
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<tr>
<td>S5345</td>
<td>φ5.0</td>
<td>200</td>
<td>8</td>
<td>320</td>
<td></td>
<td></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

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### Spectral response

Spectral response vs. wavelength

### Quantum efficiency vs. wavelength

Quantum efficiency vs. wavelength

### Gain vs. reverse voltage

Gain vs. reverse voltage
Low terminal capacitance

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. to=100 μA (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency RL=50 Ω (MHz)</th>
<th>Terminal capacitance (pF)</th>
<th>Gain</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8664-02K</td>
<td>ø0.2</td>
<td>320 to 1000</td>
<td>500</td>
<td>0.78</td>
<td>700</td>
<td>0.8</td>
<td></td>
<td>TO-5</td>
</tr>
<tr>
<td>S8664-05K</td>
<td>ø0.5</td>
<td></td>
<td></td>
<td></td>
<td>680</td>
<td>1.6</td>
<td></td>
<td>TO-8</td>
</tr>
<tr>
<td>S8664-10K</td>
<td>ø1.0</td>
<td></td>
<td></td>
<td></td>
<td>530</td>
<td>4</td>
<td></td>
<td>Ceramic</td>
</tr>
<tr>
<td>S8664-20K</td>
<td>ø2.0</td>
<td></td>
<td></td>
<td></td>
<td>280</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-30K</td>
<td>ø3.0</td>
<td></td>
<td></td>
<td></td>
<td>140</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-50K</td>
<td>ø5.0</td>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-55</td>
<td>5 × 5</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8664-1010</td>
<td>10 × 10</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S14124-20</td>
<td>ø2.0</td>
<td>266</td>
<td></td>
<td></td>
<td>250</td>
<td>11</td>
<td>50 to 400 (λ=420 nm)</td>
<td>TO-8</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

4 × 8 element array

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency RL=50 Ω (MHz)</th>
<th>Terminal capacitance (pF)</th>
<th>Gain</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 (per element)</td>
<td>50</td>
<td>Ceramic</td>
</tr>
</tbody>
</table>

Quantum efficiency vs. wavelength

[S864 series, S8550-02]

Gain vs. reverse voltage

[Typ. λ=420 nm]
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 and optical fiber communication.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*&lt;sup&gt;1&lt;/sup&gt; (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&lt;sup&gt;2&lt;/sup&gt; RL=50 Ω (MHz)</th>
<th>Terminal capacitance*&lt;sup&gt;2&lt;/sup&gt; (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>1000</td>
<td>1</td>
<td></td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12023-05</td>
<td>φ0.5</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>Plastic</td>
</tr>
<tr>
<td>S10341-02</td>
<td>φ0.2</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S10341-05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>900</td>
<td></td>
<td></td>
<td>TO-18</td>
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<tr>
<td>S12051</td>
<td>φ0.5</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
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<td>S12086</td>
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<td></td>
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<td>900</td>
<td></td>
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<td>TO-18</td>
</tr>
<tr>
<td>S12023-10</td>
<td>φ1.0</td>
<td></td>
<td></td>
<td></td>
<td>600</td>
<td>6</td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12023-10A</td>
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<td></td>
<td></td>
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<tr>
<td>S3884</td>
<td>φ1.5</td>
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<td></td>
<td></td>
<td>400</td>
<td>10</td>
<td>100</td>
<td>TO-5</td>
</tr>
<tr>
<td>S2384</td>
<td>φ3.0</td>
<td></td>
<td></td>
<td></td>
<td>120</td>
<td>40</td>
<td>60</td>
<td>TO-8</td>
</tr>
<tr>
<td>S2385</td>
<td>φ5.0</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>95</td>
<td>40</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**

**Quantum efficiency vs. wavelength**

**Gain vs. reverse voltage**
## Low temperature coefficient

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 and optical fiber communication.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*4 (MHz)</th>
<th>Terminal capacitance*4 (pF)</th>
<th>Gain λ=800 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12060-02</td>
<td>φ0.2</td>
<td>400 to 1000</td>
<td>300</td>
<td>0.4</td>
<td></td>
<td></td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>S12060-05</td>
<td>φ0.5</td>
<td></td>
<td>900</td>
<td>2.5</td>
<td></td>
<td></td>
<td>600</td>
<td>6</td>
</tr>
<tr>
<td>S12060-10</td>
<td>φ1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>350</td>
<td>12</td>
</tr>
<tr>
<td>S6045-04</td>
<td>φ1.5</td>
<td></td>
<td>80</td>
<td></td>
<td></td>
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<td>80</td>
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<tr>
<td>S6045-05</td>
<td>φ3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td>120</td>
</tr>
<tr>
<td>S6045-06</td>
<td>φ5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td>40</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

![Spectral response graph](image1)

### Quantum efficiency vs. wavelength

![Quantum efficiency vs. wavelength graph](image2)

### Gain vs. reverse voltage

![Gain vs. reverse voltage graph](image3)
These are Si APDs with enhanced sensitivity in the 800 nm band in near infrared region. They are suitable for applications such as FSO, optical fiber communications, and analytical instruments.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area(^*1) (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (I_D=100 \mu A) (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency (R_L=50 \Omega) (MHz)</th>
<th>Terminal capacitance(^*2) (pF)</th>
<th>Gain (\lambda=900 \text{nm})</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12426-02</td>
<td>(\phi 0.2)</td>
<td>400 to 1100</td>
<td>200</td>
<td></td>
<td>650</td>
<td>0.5</td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12426-05</td>
<td>(\phi 0.5)</td>
<td></td>
<td></td>
<td></td>
<td>600</td>
<td>1.1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S12926-02</td>
<td>(\phi 0.2)</td>
<td>400 to 1150</td>
<td></td>
<td></td>
<td>650</td>
<td>0.6</td>
<td></td>
<td>Plastic</td>
</tr>
<tr>
<td>S12926-05</td>
<td>(\phi 0.5)</td>
<td></td>
<td></td>
<td></td>
<td>600</td>
<td>1.3</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

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**Spectral response**

[S12426 series]

[Typ. \(T_a=25 \text{°C}, M=100 \text{ at } \lambda=900 \text{nm}\)]

![Spectral response graph](image)

[Typ. \(T_a=25 \text{°C}, M=1 \text{ at } \lambda=900 \text{nm}\)]

![Spectral response graph](image)

**Quantum efficiency vs. wavelength**

[S12426 series]

[Typ. \(T_a=25 \text{°C}, M=1 \text{ at } \lambda=900 \text{nm}\)]

![Quantum efficiency vs. wavelength graph](image)

**Gain vs. reverse voltage**

[S12426 series]

[Typ. \(\lambda=900 \text{nm}\)]

![Gain vs. reverse voltage graph](image)

[S12926 series]

[Typ. \(\lambda=900 \text{nm}\)]

![Gain vs. reverse voltage graph](image)
These are Si APDs that offer enhanced 900 nm band near-infrared sensitivity. They are suitable for applications such as FSO, optical fiber communications, and analytical instruments.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</th>
<th>Temp. coefficient of breakdown voltage (V/°C)</th>
<th>Cutoff frequency*4 (MHz)</th>
<th>Terminal capacitance*4 (pF)</th>
<th>Gain λ=900 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S12092-02</td>
<td>φ0.2</td>
<td>440 to 1100</td>
<td>250</td>
<td>1.85</td>
<td>400</td>
<td>0.4</td>
<td></td>
<td>TO-18</td>
</tr>
<tr>
<td>S12092-05</td>
<td>φ0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S9251-10</td>
<td>φ1.0</td>
<td>440 to 1100</td>
<td></td>
<td></td>
<td>380</td>
<td>1.9</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>S9251-15</td>
<td>φ1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8890-02</td>
<td>φ0.2</td>
<td>500</td>
<td>3.5</td>
<td></td>
<td>280</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8890-05</td>
<td>φ0.5</td>
<td></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**

[S12092 series, S9251 series]

[Typ. Ta=25 °C, M at 860 nm]

**Quantum efficiency vs. wavelength**

[S12092 series, S9251 series]

[Typ. Ta=25 °C]

**Quantum efficiency vs. wavelength**

[S8890 series]

[Typ. Ta=25 °C]

**Gain vs. reverse voltage**

[S12092 series, S9251 series]

[Typ. λ=900 nm]

**Gain vs. reverse voltage**

[S8890 series]

[Typ.]
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* (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. IO=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>40</td>
<td>S12023-02</td>
<td>φ0.2</td>
<td>400 to 1000</td>
<td>1000</td>
<td>1</td>
<td>100</td>
<td></td>
<td>TO-8</td>
</tr>
<tr>
<td>S4315-01</td>
<td></td>
<td>S12023-05</td>
<td>φ0.5</td>
<td></td>
<td>900</td>
<td>2</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4315-02</td>
<td></td>
<td>S12023-10</td>
<td>φ1.0</td>
<td></td>
<td>600</td>
<td>6</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4315-04</td>
<td></td>
<td>S2384</td>
<td>φ3.0</td>
<td></td>
<td>120</td>
<td>40</td>
<td>60</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
Note: For the graphs of spectral response, quantum efficiency vs. wavelength, gain vs. reverse voltage, see P.7 where the built-in APD is written.
Si APD for LiDAR

These are Si APDs with reduced variation in breakdown voltage, reduced dark current, and expanded operating temperatures compared to the previous products.

### 700 nm band

This Si APD is suitable for detecting light in the 700 nm band.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</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=760 nm</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14643-02</td>
<td>φ0.2</td>
<td>400 to 1000</td>
<td>120</td>
<td>0.42</td>
<td>2000</td>
<td>0.7</td>
<td>100</td>
<td>Plastic</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

### 800 nm band

These Si APDs are suitable for detecting light in the 800 nm band.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</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=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>100</td>
<td>Plastic</td>
</tr>
<tr>
<td>S14644-05</td>
<td>φ0.5</td>
<td>400 to 1000</td>
<td>100</td>
<td>1.6</td>
<td>1000</td>
<td>1.6</td>
<td>100</td>
<td>Plastic</td>
</tr>
</tbody>
</table>

### 900 nm band

These Si APDs are suitable for detecting light in the 900 nm band.

<table>
<thead>
<tr>
<th>Type no.</th>
<th>Effective photosensitive area*3 (mm)</th>
<th>Spectral response range (nm)</th>
<th>Breakdown voltage max. (V)</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>100</td>
<td>Plastic</td>
</tr>
<tr>
<td>S14645-02F</td>
<td></td>
<td>850 to 950</td>
<td>195</td>
<td>1.1</td>
<td>600</td>
<td>0.5</td>
<td>100</td>
<td>Plastic</td>
</tr>
<tr>
<td>S14645-05</td>
<td>φ0.5</td>
<td>400 to 1100</td>
<td>195</td>
<td>1.1</td>
<td>600</td>
<td>0.5</td>
<td>100</td>
<td>Plastic</td>
</tr>
<tr>
<td>S14645-05F</td>
<td></td>
<td>850 to 950</td>
<td>195</td>
<td>1.1</td>
<td>600</td>
<td>0.5</td>
<td>100</td>
<td>Plastic</td>
</tr>
</tbody>
</table>
**Spectral response**

**[ S14643-02 ]**

(Typ. Ta=25 °C, M=100 at λ=760 nm)

**[ S14644 series ]**

(Typ. Ta=25 °C, M=100 at λ=800 nm)

**[ S14645 series ]**

(Typ. Ta=25 °C, M=100 at λ=900 nm)

**Quantum efficiency vs. wavelength**

**[ S14643-02 ]**

(Typ. Ta=25 °C, M=1 at λ=760 nm)

**[ S14644 series ]**

(Typ. Ta=25 °C, M=1 at λ=800 nm)

**[ S14645 series ]**

(Typ. Ta=25 °C, M=1 at λ=900 nm)

**Gain vs. reverse voltage**

**[ S14643-02 ]**

(Typ. λ=760 nm)

**[ S14644 series ]**

(Typ. λ=800 nm)

**[ S14645 series ]**

(Typ. λ=900 nm)
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.

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

**Applications**
- Si APD evaluation
- FSO
- Barcode readers
- LiDAR
- 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>Photodetector conversion sensitivity M=30, λ=800 nm (V/W)</th>
<th>Minimum detection limit M=30, 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>C12702-03</td>
<td>ϕ1.0</td>
<td>S12023-10</td>
<td>4 kHz</td>
<td>-6.8 × 10⁴</td>
<td>3</td>
<td>±5 max.</td>
<td>+5</td>
</tr>
<tr>
<td>C12702-04</td>
<td>ϕ3.0</td>
<td>S2384</td>
<td>100 MHz</td>
<td>-2.3 × 10⁴</td>
<td>3.6</td>
<td>±5 max.</td>
<td>+5</td>
</tr>
</tbody>
</table>

**Near infrared 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>Photodetector conversion sensitivity M=30, λ=620 nm (V/W)</th>
<th>Minimum detection limit M=30, λ=620 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>ϕ1.0</td>
<td>S12053-10</td>
<td>4 kHz</td>
<td>-2.5 × 10⁴</td>
<td>5</td>
<td>±5 max.</td>
<td>+5</td>
</tr>
<tr>
<td>C12702-12</td>
<td>ϕ3.0</td>
<td>S5344</td>
<td>100 MHz</td>
<td>-1.9 × 10⁴</td>
<td>6.3</td>
<td>±5 max.</td>
<td>+5</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>Photodetector conversion sensitivity M=30, λ=620 nm (V/W)</th>
<th>Minimum detection limit M=30, λ=620 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>ϕ1.5</td>
<td>S3884</td>
<td>DC</td>
<td>1.5 × 10⁶</td>
<td>0.63</td>
<td>±5 max.</td>
<td>±12</td>
</tr>
<tr>
<td>C12703-01</td>
<td>ϕ3.0</td>
<td>S2384</td>
<td>100 kHz</td>
<td>-1.5 × 10⁸</td>
<td>0.0063</td>
<td>±5 max.</td>
<td>±12</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>Photodetector conversion sensitivity M=30, λ=800 nm (V/W)</th>
<th>Minimum detection limit M=30, 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>C12703</td>
<td>ϕ1.5</td>
<td>S3884</td>
<td>DC</td>
<td>1.5 × 10⁶</td>
<td>0.63</td>
<td>±5 max.</td>
<td>±12</td>
</tr>
<tr>
<td>C12703-01</td>
<td>ϕ3.0</td>
<td>S2384</td>
<td>100 kHz</td>
<td>-1.5 × 10⁸</td>
<td>0.0063</td>
<td>±5 max.</td>
<td>±12</td>
</tr>
</tbody>
</table>

*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

**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>ϕ0.5</td>
<td>S12023-05</td>
<td>50 kHz</td>
<td>1 GHz</td>
<td>2.50 × 10^5</td>
<td>±5 max.</td>
<td>±12</td>
</tr>
</tbody>
</table>

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

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- Photomultiplier tube modules
- Microchannel plates
- Image intensifiers
- Xenon lamps / Mercury-xenon lamps
- Deuterium lamps
- X-ray imaging devices

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- X-ray products
- Life science systems
- Medical systems
- Semiconductor failure analysis systems
- FPD / LED characteristic evaluation systems
- Spectroscopic and optical measurement systems

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- Solid state lasers

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