DS3920

Fast Current Mirror

General Description

The DS3920 precision current mirror is designed for avalanche photodiode (APD) and PIN photodiode biasing and monitoring applications. The device offers a current clamp to limit current through the APD and a current mirror output that produces a signal proportional (5:1) to the APD current. A diode is also provided to limit the voltage at the current mirror output.

The device accepts a +2.97V to +76V current mirror supply voltage. Internal current limiting (4.4mA or 20mA, typ) protects the monitored device from a short circuit to ground. The provided internal clamp diode protects the current mirror output from overvoltage. Additionally, the device features thermal shutdown if the die temperature reaches +150°C.

The device is available in a 6-pin SOT23 package, and operates over the -40°C to +85°C extended temperature range.

Features

- Wide Voltage Input Range: 2.97V to 76V
- Current Monitor
  - Wide 250nA to 2mA Range
  - 5:1 Mirror Ratio
  - Fast 50ns Time Constant
- Current Clamp (4.4mA or 20mA, typ)
- Voltage Clamp Protects Subsequent Output Circuitry
- 6-Pin SOT23 (MAX4007 Compatible)

Applications

Avalanche Photodiode (APD) Biasing
PIN Photodiode Monitoring
GEPON, GPON, 10GEPON, XGPON: ONU and OLT

Ordering Information appears at end of data sheet.

Typical Application Circuit

For related parts and recommended products to use with this part, refer to: www.maximintegrated.com/DS3920.related

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated’s website at www.maximintegrated.com.
ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Range on MIRIN, MIROUT, and DIODE Relative to GND</td>
<td>$V_{MIRIN}$</td>
<td>-0.3V to +80V</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Voltage Range on MIR</td>
<td>$I_{MIRIN}$</td>
<td>$I_{MIROUT} = 2.5mA$</td>
<td>2.97</td>
<td>76</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Diode Forward Current</td>
<td>$I_{DF}$</td>
<td>$I_{DF} = 100\mu A, T_A = +25^\circ C$</td>
<td>1.25</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Diode Forward Voltage</td>
<td>$V_{DF}$</td>
<td>$I_{DF} = 5mA, T_A = +25^\circ C$</td>
<td>0.6</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>MIROUT Current Limit</td>
<td>$I_{MIROUT}$</td>
<td>DS3920T-001 version, $T_A = +25^\circ C$</td>
<td>10</td>
<td>20</td>
<td>40</td>
<td>mA</td>
</tr>
<tr>
<td>MIROUT Series Resistance</td>
<td>$R_{AGC}$</td>
<td>(Note 1)</td>
<td>100</td>
<td></td>
<td></td>
<td>\Omega</td>
</tr>
<tr>
<td>MIR to MIROUT Ratio</td>
<td>$K_{MIR}$</td>
<td>$1\mu A$ to $2.5mA$</td>
<td>0.190</td>
<td>0.200</td>
<td>0.210</td>
<td>A/A</td>
</tr>
<tr>
<td>Power-Supply Rejection Ratio</td>
<td>$(\Delta I_{MIR}/\Delta V_{MIRIN})$</td>
<td>$V_{MIRIN} = 3V$ (Note 2)</td>
<td>4800</td>
<td>15,000</td>
<td></td>
<td>ppm/V</td>
</tr>
<tr>
<td>MIR Current Rise Time (20%/80%)</td>
<td>$t_{RC}$</td>
<td>(Note 4)</td>
<td>30</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Thermal Shutdown Temperature</td>
<td>$T_{SHDN}$</td>
<td>(Note 3)</td>
<td>+150</td>
<td></td>
<td></td>
<td>\degree C</td>
</tr>
<tr>
<td>Thermal Shutdown Hysteresis</td>
<td>$T_{HYST}$</td>
<td>(Note 3)</td>
<td>20</td>
<td></td>
<td></td>
<td>\degree C</td>
</tr>
</tbody>
</table>

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

$(V_{MIRIN} = 2.97V$ to $76V, T_A = -40^\circ C$ to $+85^\circ C, unless otherwise noted.)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIRIN Voltage</td>
<td>$V_{MIRIN}$</td>
<td>$I_{MIROUT} &gt; 2.5mA$</td>
<td>0.180</td>
<td>0.200</td>
<td>0.220</td>
<td>A/A</td>
</tr>
<tr>
<td>MIR Current Rise Time (20%/80%)</td>
<td>$t_{RC}$</td>
<td>$V_{MIRIN} = 30V$ or 60V (Notes 2, 3)</td>
<td>100</td>
<td>500</td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

Note 1: See the Typical Application Circuit.
Note 2: 1V DC change applied to MIRIN; 100\mu A at MIROUT; 4.99k\Omega load to ground on MIR.
Note 3: Guaranteed by design; not production tested.
Note 4: Rising MIROUT transition from 10\mu A to 1mA; 15V < $V_{OUT} < 76V$. 

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Typical Operating Characteristics

\((T_A = +25^\circ C,\) unless otherwise noted.)

![MIRIN CURRENT vs. MIRIN VOLTAGE](image1)

![MIRIN CURRENT vs. TEMPERATURE](image2)

![GAIN ERROR vs. MIRIN VOLTAGE](image3)

![GAIN ERROR vs. MIROUT CURRENT](image4)

![MIRIN CURRENT vs. MIROUT CURRENT](image5)

![GAIN ERROR vs. MIROUT CURRENT](image6)

![MIRIN CURRENT vs. TEMPERATURE](image7)

![GAIN ERROR vs. TEMPERATURE](image8)
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Typical Operating Characteristics (continued)

($T_A = +25^\circ\text{C}$, unless otherwise noted.)

**STARTUP DELAY**

(V$_{\text{MIRIN}} = 5\text{V}$, $I_{\text{MIROUT}} = 1\mu\text{A}$)

**STARTUP DELAY**

(V$_{\text{BIAS}} = 40\text{V}$, $I_{\text{MIROUT}} = 2.5\text{mA}$)

**STARTUP DELAY**

(V$_{\text{MIRIN}} = 40\text{V}$, $I_{\text{MIROUT}} = 2.5\text{mA}$)

**STARTUP DELAY**

(V$_{\text{MIRIN}} = 40\text{V}$, $I_{\text{MIROUT}} = 1\mu\text{A}$)

**STARTUP DELAY**

(V$_{\text{MIRIN}} = 5\text{V}$, $I_{\text{MIROUT}} = 1\mu\text{A}$)

**STARTUP DELAY**

(V$_{\text{MIRIN}} = 5\text{V}$, $I_{\text{MIROUT}} = 2.5\text{mA}$)
**Typical Operating Characteristics (continued)**

(TA = +25°C, unless otherwise noted.)

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**Pin Configuration**

**Pin Description**

<table>
<thead>
<tr>
<th>PIN</th>
<th>NAME</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIODE</td>
<td>Protection Diode. External potential used for voltage clamping of V_MIR. If unused, this pin can be left unconnected.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>MIR</td>
<td>Mirror Current Monitor Output, 5:1 Ratio</td>
</tr>
<tr>
<td>4</td>
<td>MIROUT</td>
<td>Current Mirror Voltage Output. Connect to photodiode bias pin. Photodiode provides reference current for the mirror.</td>
</tr>
<tr>
<td>5</td>
<td>N.C.</td>
<td>No Connection. Not internally connected.</td>
</tr>
<tr>
<td>6</td>
<td>MIRIN</td>
<td>Current Voltage Bias</td>
</tr>
</tbody>
</table>

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**SHORT-CIRCUIT RESPONSE**

(V_MIRIN = 40V)

(A: MIROUT SHORTS TO GND THROUGH 10Ω  
B: CURRENT LIMIT ACTIVE  
C: THERMAL SHUTDOWN  
D: POST COOL-DOWN REENTRY  
E: THERMAL SHUTDOWN  
F: POST COOL-DOWN REENTRY)

**SHORT-CIRCUIT RESPONSE**

(V_MIRIN = 76V)

(A: MIROUT SHORTS TO GND THROUGH 10Ω  
B: CURRENT LIMIT ACTIVE  
C: THERMAL SHUTDOWN  
D: POST COOL-DOWN REENTRY  
E: THERMAL SHUTDOWN  
F: POST COOL-DOWN REENTRY)

**VOLTAGE DROP vs. MIROUT CURRENT**

**TOP VIEW**

DIODE  T  6  MIRIN
GND  5  N.C.
MIR  3  MIROUT
SOT23
**Detailed Description**

The DS3920 provides a fast, precision current mirror for photodiode-monitoring applications. The current mirror is accurate across a large dynamic range. The mirror response time is fast enough to comply with GPON Rx burst-mode monitoring requirements. The device has a built-in current limiting feature to protect photodiodes from large signal inputs, and an included thermal shutdown. A diode is provided to limit the voltage at the MIR output.

**Current Mirror**

The mirror output is typically connected to an analog-to-digital converter (ADC) using a resistor to convert the mirrored current into a voltage. The resistor to ground should be selected so that the ADC’s full-scale voltage is reached when the maximum mirrored current is reached. For example, given that the maximum monitored current through the APD is 2mA, 1.25V ADC full scale, and a 5:1 mirror ratio, the correct resistor is approximately 3.2kΩ. The mirror response time is dominated by the amount of capacitance placed on the output.

**Current Clamp**

The device features a current clamping circuit to protect the photodiode by limiting the amount of current from MIROUT to no more than IMIROUT. See the **Ordering Information** for available current clamp options.

**Diode Protection**

A diode is internally connected from the MIR to DIODE pins. This enables an external voltage applied to DIODE to limit the voltage on MIR. The voltage applied to DIODE should be equal to the desired VMIR limit minus the diode forward voltage drop, or VMIR - VDF.

**Thermal Shutdown**

As a safety feature, the device has a thermal shutdown circuit that turns off the MIROUT and MIR currents when the internal die temperature exceeds TSHDN. The thermal shutdown mechanism has a built-in hysteresis of THYST. Thus, the MIROUT and MIR currents resume once the device has cooled to TSHDN - THYST.

**Ordering Information**

<table>
<thead>
<tr>
<th>PART</th>
<th>TEMP RANGE</th>
<th>TYP CURRENT LIMIT (mA)</th>
<th>PIN-PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS3920T-001+</td>
<td>-40°C to +85°C</td>
<td>20</td>
<td>6 SOT23</td>
</tr>
<tr>
<td>DS3920T-001+T</td>
<td>-40°C to +85°C</td>
<td>20</td>
<td>6 SOT23</td>
</tr>
<tr>
<td>DS3920T-002+</td>
<td>-40°C to +85°C</td>
<td>4.4</td>
<td>6 SOT23</td>
</tr>
<tr>
<td>DS3920T-002+T</td>
<td>-40°C to +85°C</td>
<td>4.4</td>
<td>6 SOT23</td>
</tr>
</tbody>
</table>

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

**Package Information**

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a “+”, “#”, or “-” in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

<table>
<thead>
<tr>
<th>PACKAGE TYPE</th>
<th>PACKAGE CODE</th>
<th>OUTLINE NO.</th>
<th>LAND PATTERN NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 SOT23</td>
<td>U6SN+1</td>
<td>21-0058</td>
<td>90-0175</td>
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</tbody>
</table>
**DS3920**

**Fast Current Mirror**

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### Revision History

<table>
<thead>
<tr>
<th>REVISION NUMBER</th>
<th>REVISION DATE</th>
<th>DESCRIPTION</th>
<th>PAGES CHANGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3/11</td>
<td>Initial release</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>8/11</td>
<td>Changed the MIROUT -002 version current limit value from 2.9mA (typ) to 4.4mA (typ); updated the <em>Electrical Characteristics</em> I_{MIROUT} values for -002 version from 2mA (min), 2.9mA (typ), 4.4mA (max) to 2.8mA (min), 4.4mA (typ), 8mA (max) and added $T_A = +25^\circ$C test conditions</td>
<td>1, 2, 6</td>
</tr>
<tr>
<td>2</td>
<td>12/11</td>
<td>Added $R_{FILTER}$ and $R_{OUT}$ resistor values to the <em>Typical Application Circuit</em></td>
<td>1</td>
</tr>
</tbody>
</table>

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