Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor’s system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (_), the underscore (_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at www.onsemi.com. Please email any questions regarding the system integration to Fairchild_questions@onsemi.com.
FAN4010 High-Side Current Sensor

Features at +5 V
- Low Cost, Accurate, High-Side Current Sensing
- Output Voltage Scaling
- Up to 2.5 V Sense Voltage
- 2 V to 6 V Supply Range
- 2 μA Typical Offset Current
- 3.5 μA Quiescent Current
- -0.2% Accuracy
- 6-Lead MicroPak™ MLP Package

Applications Battery Chargers
- Battery Chargers
- Smart Battery Packs
- DC Motor Control
- Over-Current Monitor
- Power Management
- Programmable Current Source

Description
The FAN4010 is a high-side current sense amplifier designed for battery-powered systems. Using the FAN4010 for high-side power-line monitoring does not interfere with the battery charger’s ground path. The FAN4010 is designed for portable PCs, cellular phones, and other portable systems where battery / DC power-line monitoring is critical.

To provide a high level of flexibility, the FAN4010 functions with an external sense resistor to set the range of load current to be monitored. It has a current output that can be converted to a ground-referred voltage with a single resistor, accommodating a wide range of battery voltages and currents. The FAN4010 features allow it to be used for gas gauging as well as uni-directional or bi-directional current monitoring.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating Temperature Range</th>
<th>Top Mark</th>
<th>Package</th>
<th>Packing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN4010IL6X</td>
<td>-40°C to +85°C</td>
<td>PX</td>
<td>6-Lead, Molded Leadless Package (MLP)</td>
<td>Tape &amp; Reel</td>
</tr>
<tr>
<td>FAN4010IL6X_F113</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Legacy product number; please order FAN4010IL6X for new designs.
2. All packages are lead free per JEDEC: J-STD-020B standard.
3. Moisture sensitivity level for all parts is MSL-1.

MicroPak™ is a trademark of Fairchild Semiconductor Corporation.
Block Diagram and Typical Circuit

Figure 1. Functional Block Diagram

Figure 2. Typical Circuit

Pin Configuration

Figure 3. Pin Assignment (Top Through View)

Pin Descriptions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 4</td>
<td>NC</td>
<td>No Connect; leave pin floating</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>IOUT</td>
<td>Output Current, proportional to $\frac{V_{IN}}{V_{LOAD}}$</td>
</tr>
<tr>
<td>1</td>
<td>V_IN</td>
<td>Input Voltage, Supply Voltage</td>
</tr>
<tr>
<td>6</td>
<td>Load</td>
<td>Connection to load or battery</td>
</tr>
</tbody>
</table>
Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_S$</td>
<td>Supply Voltage</td>
<td>0</td>
<td>6.3</td>
<td>6.3</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Input Voltage Range</td>
<td>0</td>
<td>6.3</td>
<td>6.3</td>
<td>V</td>
</tr>
<tr>
<td>$T_J$</td>
<td>Junction Temperature</td>
<td></td>
<td></td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{STG}$</td>
<td>Storage Temperature Range</td>
<td>-65</td>
<td></td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>$T_L$</td>
<td>Reflow Temperature, Soldering</td>
<td></td>
<td></td>
<td>+260</td>
<td>°C</td>
</tr>
<tr>
<td>$\Theta_{JA}$</td>
<td>Package Thermal Resistance$^{(4)}$</td>
<td></td>
<td>456</td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic Discharge Protection</td>
<td></td>
<td>5000</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

**Note:**
4. Package thermal resistance ($\Theta_{JA}$), JEDEC standard, multi-layer test boards, still air.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_A$</td>
<td>Operating Temperature Range</td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>$V_S$</td>
<td>Supply Voltage Range</td>
<td>2</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Input Voltage</td>
<td>2</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{SENSE}$</td>
<td>Sensor Voltage Range, ( V_{SENSE} = V_{IN} \cdot V_{LOAD}, R_{OUT} = 0 \ \Omega )</td>
<td>2.5</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>
Electrical Characteristics at +5 V

$T_A = 25^\circ C$, $V_S = V_{IN} = 5$ V, $R_{OUT} = 100$ Ω, $R_{SENSE} = 100$ Ω, unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_{WSS}$</td>
<td>Small Signal Bandwidth</td>
<td>$P_{IN}=-40$ dBm(5), $V_{SENSE}=10$ mV</td>
<td>600</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>$B_{WLS}$</td>
<td>Large Signal Bandwidth</td>
<td>$P_{IN}=-20$ dBm(6), $V_{SENSE}=100$ mV</td>
<td>2</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Input Voltage Range</td>
<td>$V_{IN}=V_S$</td>
<td>2</td>
<td>6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>Output Current(7,8)</td>
<td>$V_{SENSE}=0$ mV</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{SENSE}=10$ mV</td>
<td>90</td>
<td>100</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{SENSE}=100$ mV</td>
<td>0.975</td>
<td>1.000</td>
<td>1.025</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{SENSE}=200$ mV</td>
<td>1.95</td>
<td>2.00</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{SENSE}=1$ V</td>
<td>9.7</td>
<td>10.0</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>$I_S$</td>
<td>Supply Current(7)</td>
<td>$V_{SENSE}=0$ V, GND Pin Current</td>
<td>3.5</td>
<td>5.0</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>$I_{SENSE}$</td>
<td>Load Pin Input Current</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>nA</td>
</tr>
<tr>
<td>$A_{CY}$</td>
<td>Accuracy</td>
<td>$R_{SENSE}=100$ Ω, $R_{SENSE}=200$ mV(7)</td>
<td>-2.5</td>
<td>-0.2</td>
<td>2.5</td>
<td>%</td>
</tr>
<tr>
<td>$G_m$</td>
<td>Transconductance</td>
<td>$I_{OUT}/V_{SENSE}$</td>
<td>10000</td>
<td></td>
<td></td>
<td>µA/V</td>
</tr>
</tbody>
</table>

Notes:
5. -40 dBm = 6.3 mVpp into 50 Ω.
6. -20 dBm = 63 mVpp into 50 Ω.
7. 100% tested at 25°C.
8. Includes input offset voltage contribution.
Typical Performance Characteristics

\( T_A = 25°C, \ V_S = \ V_{IN} = 5 \text{ V}, \ R_{OUT} = 100 \ \Omega, \ R_{SENSE} = 100 \ \Omega, \) unless otherwise noted.

**Figure 4.** \( V_{SENSE} \) vs. Output Current

**Figure 5.** Output Current Error vs. \( V_{SENSE} \)

**Figure 6.** Output Current vs. Temperature

**Figure 7.** Frequency Response

**Figure 8.** Transfer Characteristics

**Figure 9.** Transfer Characteristics
Typical Performance Characteristics (Continued)

$T_A = 25^\circ$C, $V_S = V_{IN} = 5$ V, $R_{OUT} = 100$ $\Omega$, $R_{SENSE} = 100$ $\Omega$, unless otherwise noted.

Figure 10. CMRR vs. Frequency

Figure 11. $V_{IN}$ vs. Output Current Error

Figure 12. Supply Current vs. $V_{SENSE}$
Application Information
Detailed Description
The FAN4010 measures the voltage drop ($V_{SENSE}$) across an external sense resistor in the high-voltage side of the circuit. $V_{SENSE}$ is converted to a linear current via an internal operational amplifier and precision 100 Ω resistor. The value of this current is $V_{SENSE}/100$ Ω (internal). Output current flows from the $I_{OUT}$ pin to an external resistor $R_{OUT}$ to generate an output voltage proportional to the current flowing to the load.

Use the following equations to scale a load current to an output voltage:

$$V_{SENSE} = I_{LOAD} \cdot R_{SENSE}$$  \hspace{1cm} (1)

$$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT}$$  \hspace{1cm} (2)

Selecting $R_{SENSE}$
Selection of $R_{SENSE}$ is a balance between desired accuracy and allowable voltage loss. Although the FAN4010 is optimized for high accuracy with low $V_{SENSE}$ values, a larger $R_{SENSE}$ value provides additional accuracy. However, larger values of $R_{SENSE}$ create a larger voltage drop, reducing the effective voltage available to the load. This can be troublesome in low-voltage applications. Because of this, the maximum expected load current and allowable load voltage should be well understood. Although higher values of $V_{SENSE}$ can be used, $R_{SENSE}$ should be chosen to satisfy the following condition:

$$10\text{mV} < V_{SENSE} < 200\text{mV}$$  \hspace{1cm} (3)

For low-cost applications where accuracy is not as important, a portion of the printed circuit board (PCB) trace can be used as an $R_{SENSE}$ resistor. Figure 14 shows an example of this configuration. The resistivity of a 0.1-inch wide trace of two-ounce copper is about 30 mΩ/ft. Unfortunately, the resistance temperature coefficient is relatively large (approximately 0.4%/°C), so systems with a wide temperature range may need to compensate for this effect. Additionally, self heating due to load currents introduces a nonlinearity error. Care must be taken not to exceed the maximum power dissipation of the copper trace.

Selecting $R_{OUT}$
$R_{OUT}$ can be chosen to obtain the output voltage range required for the particular downstream application. For example, if the output of the FAN4010 is intended to drive an analog-to-digital convertor (ADC), $R_{OUT}$ should be chosen such that the expected full-scale output current produces an input voltage that matches the input range of the ADC. For instance, if expected loading current ranges from 0 to 1 A, an $R_{SENSE}$ resistor of 1 Ω produces an output current that ranges from 0 to 10 mA. If the input voltage range of the ADC is 0 to 2 V, an $R_{OUT}$ value of 200 Ω should be used. The input voltage and full-scale output current ($I_{OUT,FS}$) needs to be taken into account when setting up the output range. To ensure sufficient operating headroom, choose:

$$(R_{OUT} \cdot I_{OUT,FS}) \text{ such that } V_{IN} - V_{SENSE} - (R_{OUT} \cdot I_{OUT,FS}) > 1.6V$$  \hspace{1cm} (4)

Output current accuracy for the recommended $V_{SENSE}$ between 10 mV and 200 mV are typically better than 1%. As a result, the absolute output voltage accuracy is dependent on the precision of the output resistor.

Make sure the input impedance of the circuit connected to $V_{OUT}$ is much higher than $R_{OUT}$ to ensure accurate $V_{OUT}$ values.

Since the FAN4010 provides a trans-impedance function, it is suitable for applications involving current rather than voltage sensing.
Physical Dimensions

Figure 15. 6-Lead MicroPak™ Molded Leadless Package (MLP)
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SuperQOT™
SuperQOT™-6
SuperQOT™-8
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PRODUCT STATUS DEFINITIONS
Definition of Terms

<table>
<thead>
<tr>
<th>Datasheet Identification</th>
<th>Product Status</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance Information</td>
<td>Formative / In Design</td>
<td>Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.</td>
</tr>
<tr>
<td>Preliminary</td>
<td>First Production</td>
<td>Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.</td>
</tr>
<tr>
<td>No Identification Needed</td>
<td>Full Production</td>
<td>Datasheet contains final specifications. Fairchild reserves the right to make changes at any time without notice to improve the design.</td>
</tr>
<tr>
<td>Obsolete</td>
<td>Not In Production</td>
<td>Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.</td>
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</tbody>
</table>

Rev. 7/2
NOTES:

1. CONFORMS TO JEDEC STANDARD MO-252 VARIATION UAAD
2. DIMENSIONS ARE IN MILLIMETERS
3. DRAWING CONFORMS TO ASME Y14.5M-2009
4. LANDPATTERN RECOMMENDATION PER FSC
5. PIN ONE IDENTIFIER IS 2X LENGTH OF ANY OTHER LINE IN THE MARK CODE LAYOUT.
6. FILENAME AND REVISION: MAC06AREV6