

FAN4010 High-Side Current Sensor

Features at +5V

- Low cost, accurate, high-side current sensing
- Output voltage scaling
- Up to 2.5V sense voltage
- 2V to 6V supply range
- 2µA typical offset current
- 3.5µA quiescent current
- -0.2% accuracy
- 6-lead MicroPak[™] MLP package

Applications

- 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.

Functional Block Diagram and Typical Circuit R_{sense} VIN > < Load 100 6 1 Load VIN R_{Load} 2 NC 5 GND V_{OUT} 3 4 lout NC <_{OU1} IOUT

Figure 1. Functional Block Diagram and Typical Circuit

Ordering Information

Part Number	Package	Operating Temperature Range	Packaging Method
FAN4010IL6X_F113	MicroPak™ MLP-6	-40°C to +85°C	Reel

All packages are lead free per JEDEC: J-STD-020B standard.

Moisture sensitivity level for all parts is MSL-1.

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February 2008

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Pin Configurations







Pin Assignments

Pin #	Name	Description	
2, 4	NC	No Connect; leave pin floating	
5	GND	Ground	
3	IOUT	Output current, proportional to VIN - VLoad	
1	VIN	Input voltage (supply voltage)	
6	Load	Connection to load or battery	

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.

Symbol	Parameter		Min.	Max.	Unit
Vs	Supply Voltage		0	6.3	V
V _{IN}	Input Voltage Range		0	6.3	V

Reliability Information

Symbol	Parameter	Min.	Тур.	Max.	Unit
TJ	Junction Temperature			+150	°C
T _{STG}	Storage Temperature Range			+150	°C
ΤL	Reflow Temperature (Soldering)			+260	°C
θ_{JA}	$ \theta_{JA} $ Package Thermal Resistance ⁽¹⁾		456		°C/W

Note:

1. Package thermal resistance (θ_{IA}) , JEDEC standard, multi-layer test boards, still air.

Electrostatic Discharge Protection

Symbol	ESD Standard	Value
HBM	Human Body Model	5kV
CDM	Charged Device Model	1kV

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.

Symbol	Parameter		Тур.	Max.	Unit
T _A	Operating Temperature Range			+85	°C
Vs	Supply Voltage Range			6	V
V _{IN}	Input Voltage Range	2		6	V
V _{SENSE}	Sensor Voltage Range, $V_{SENSE} = V_{IN} - V_{Load}$; $R_{OUT} = 0\Omega$	0		2.5	V

Electrical Characteristics at +5V

 T_{A} = 25°C, V_{s} = V_{IN} = 5V, R_{OUT} = 100 Ω , R_{SENSE} = 100 Ω , unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
Frequency I	Domain Response			1		1
BWss	Small Signal Bandwidth	P_{IN} = -40dBm ⁽²⁾ , V _{SENSE} = 10mV		600		kHz
BW_{Ls}	Large Signal Bandwidth	P _{IN} = -20dBm ⁽³⁾ , V _{SENSE} = 100mV 2			MHz	
V _{IN}	Input Voltage Range	$V_{IN} = V_{s}$	2		6	V
	Output Current ^(1,4)	V _{SENSE} = 0V	0	1	9	μA
		V _{SENSE} = 10mV	90	100	110	μA
I _{OUT}		V _{SENSE} = 100mV	0.975	1.000	1.025	mA
		V _{SENSE} = 200mV	1.95	2.00	2.05	mA
		V _{SENSE} = 1V	9.7	10.0	10.3	mA
I _s	Supply Current ⁽¹⁾	V _{SENSE} = 0V, GND pin current		3.5	5.0	μA
ISENSE	Load Pin Input Current			2		nA
A _{CY}	Accuracy	$\label{eq:Rsense} \begin{split} R_{SENSE} &= 100\Omega, \\ R_{SENSE} &= 200 m V^{(1)} \end{split}$	-2.5	-0.2	2.5	%
G _m	Transconductance	I _{OUT} /V _{SENSE}		10000		µA/V

Notes:

- 1. 100% tested at 25°C.
- 2. -40dBm = 6.3mVpp into 50Ω .
- 3. -20dBm = 63mVpp into 50Ω .
- 4. Includes input offset voltage contribution.

Typical Performance Characteristics

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







Figure 5. Output Current vs. Temperature



Figure 7. Transfer Characteristics



Figure 4. Output Current Error vs. VSENSE



Figure 6. Frequency Response



Figure 8. Transfer Characteristics

Typical Performance Characteristics (Continued)

 T_{A} = 25°C, V_{s} = V_{IN} = 5V, R_{OUT} = 100 Ω , R_{SENSE} = 100 Ω , unless otherwise noted.



Figure 9. CMRR vs. Frequency







Figure 10. VIN vs. Output Current Error

Application Information

V_{OUT} = 0.01 x V_{SENSE} x R_{OUT}

Detailed Description

The FAN4010 measures the voltage drop (V_{SENSE}) across an external sense resistor located 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:

 $V_{\text{SENSE}} = I_{\text{Load}} \cdot R_{\text{SENSE}} \tag{1}$



Figure 12. Functional Circuit

Selecting RSENSE

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:

$$10mV < V_{SENSE} < 200mV$$
 (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 13 shows an example of this configuration. The resistivity of a 0.1 inch wide trace of two-ounce copper is about $30m\Omega/ft$. 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.



Figure 13. Using PCB Trace for R_{SENSE}

Selecting ROUT

(2)

 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 1A, a R_{SENSE} resistor of 1 Ω produces an output current that ranges from 0 to 10mA. If the input voltage range of the ADC is 0 to 2V, a 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 head-room, choose:

 $V_{IN} - V_{SENSE} - (R_{OUT} \cdot I_{OUT_FS}) > 1.6V$

(4)

Output current accuracy for the recommended V_{SENSE} levels between 10mV and 200mV are typically much better than 1%. As a result, the absolute output voltage accuracy is dependent upon 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 ideal for applications involving current rather than voltage sensing.





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