

FAN4010 High-Side Current Sensor

Features a +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 μ A Typical Offset Current
- 3.5 μ A 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

Part Number	Operating Temperature Range	Top Mark	Package	Packing Method
FAN4010IL6X	-40°C to +85°C	PX	6-Lead, Molded Leadless Package (MLP)	Tape & Reel
FAN4010IL6X_F113 ⁽¹⁾				

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

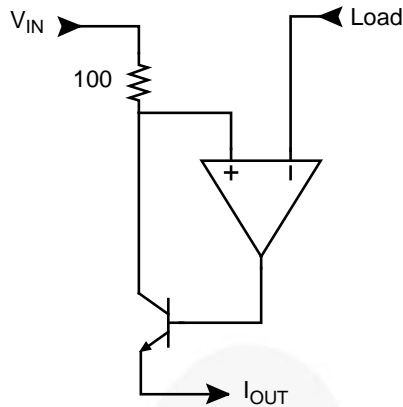


Figure 1. Functional Block Diagram

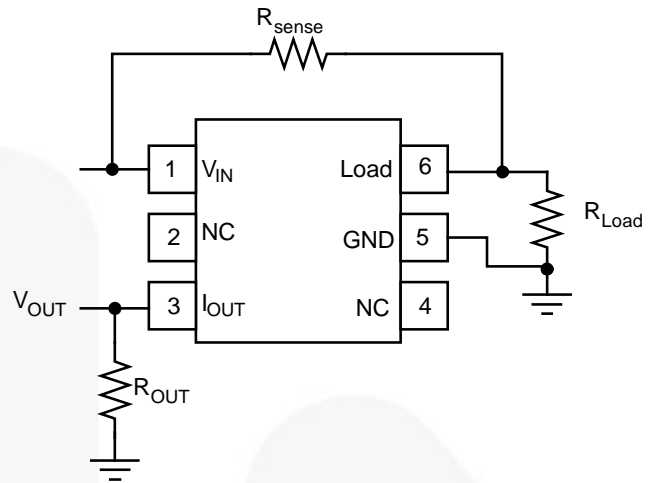


Figure 2. Typical Circuit

Pin Configuration

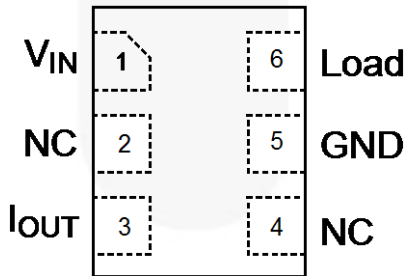


Figure 3. Pin Assignment (Top Through View)

Pin Descriptions

Name	Type	Description
2, 4	NC	No Connect; leave pin floating
5	GND	Ground
3	I _{OUT}	Output Current, proportional to $V_{IN} - V_{LOAD}$
1	V _{IN}	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.	Typ.	Max.	Unit
V _S	Supply Voltage		0		6.3	V
V _{IN}	Input Voltage Range		0		6.3	V
T _J	Junction Temperature				+150	°C
T _{STG}	Storage Temperature Range		-65		+150	°C
T _L	Reflow Temperature, Soldering				+260	°C
Θ _{JA}	Package Thermal Resistance ⁽⁴⁾			456		°C/W
ESD	Electrostatic Discharge Protection	Human Body Model, JESD22-A114			5000	V
		Charged Device Model, JESD22-C101			1000	

Note:

4. Package thermal resistance (Θ_{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.

Symbol	Parameter	Min.	Max.	Unit
T _A	Operating Temperature Range	-40	+85	°C
V _S	Supply Voltage Range	2	6	V
V _{IN}	Input Voltage	2	6	V
V _{SENSE}	Sensor Voltage Range, V _{SENSE} =V _{IN} -V _{LOAD} , R _{OUT} =0 Ω		2.5	V

Electrical Characteristics at +5 V

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

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

Notes:

5. $-40\text{ dBm} = 6.3\text{ mVpp}$ into $50\ \Omega$.
6. $-20\text{ dBm} = 63\text{ mVpp}$ into $50\ \Omega$.
7. 100% tested at 25°C .
8. Includes input offset voltage contribution.

Typical Performance Characteristics

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

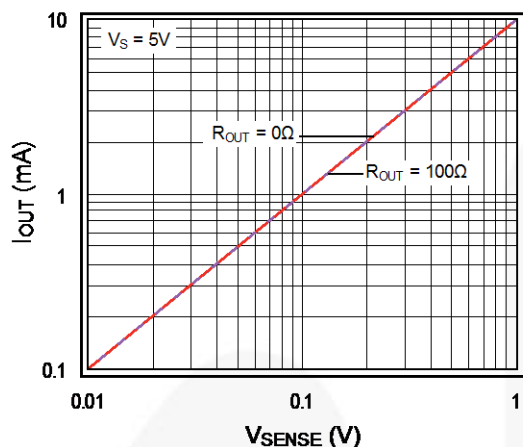


Figure 4. V_{SENSE} vs. Output Current

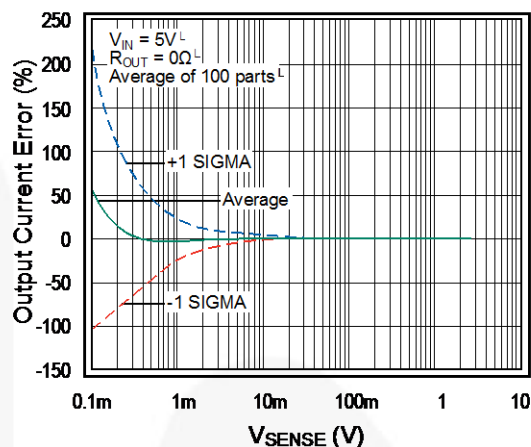


Figure 5. Output Current Error vs. V_{SENSE}

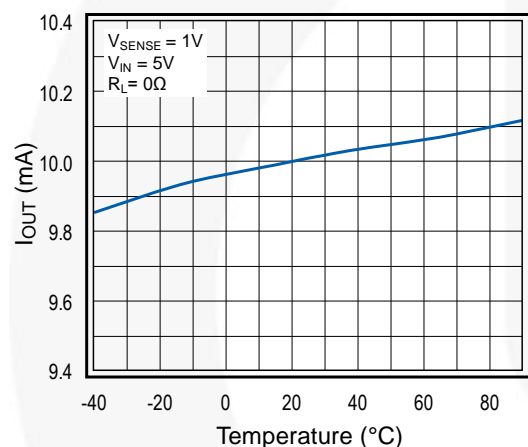


Figure 6. Output Current vs. Temperature

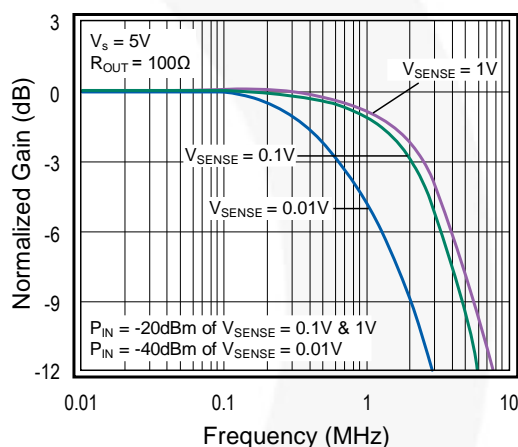


Figure 7. Frequency Response

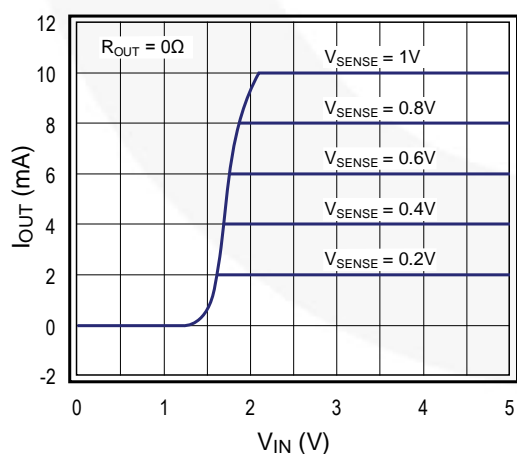


Figure 8. Transfer Characteristics

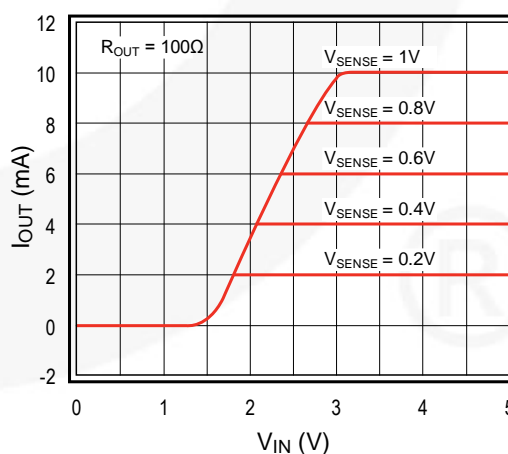


Figure 9. Transfer Characteristics

Typical Performance Characteristics (Continued)

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

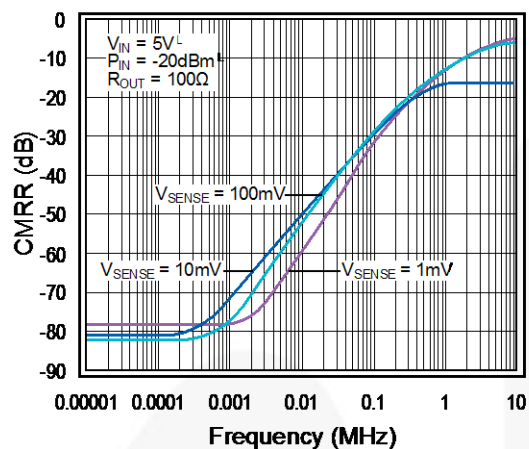


Figure 10. CMRR vs. Frequency

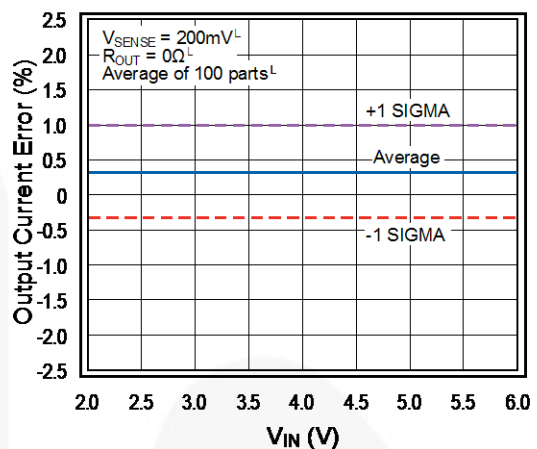


Figure 11. V_{IN} vs. Output Current Error

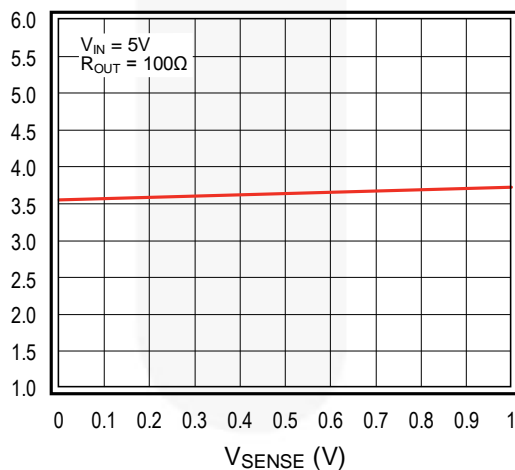


Figure 12. Supply Current vs. V_{SENSE}

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 $V_{SENSE}/100\ \Omega$ (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:

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

$$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT} \quad (2)$$

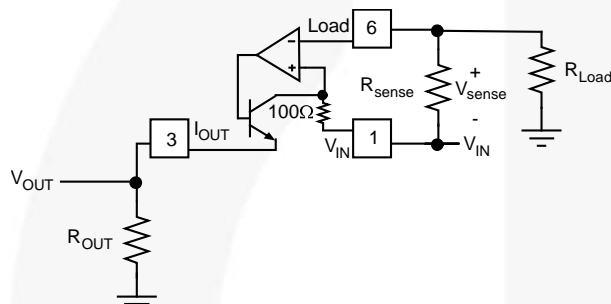


Figure 13. Functional Circuit

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:

$$10\text{mV} < V_{SENSE} < 200\text{mV} \quad (3)$$

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 m Ω /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.

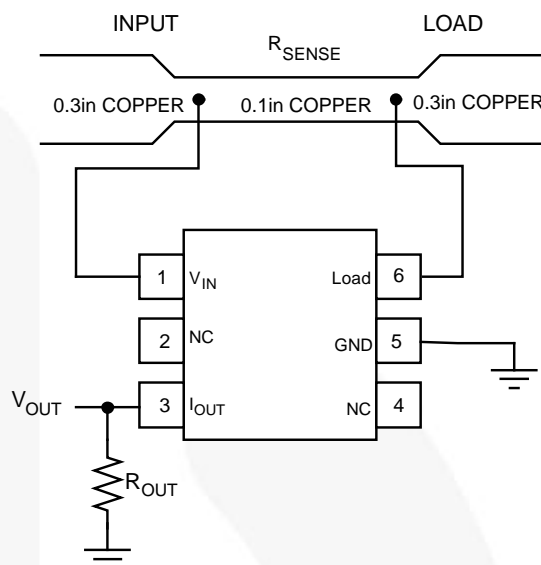


Figure 14. Using PCB Trace for R_{SENSE}

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 converter (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:

$$(R_{OUT} \cdot I_{OUT_FS}) \text{ such that } V_{IN} - V_{SENSE} - (R_{OUT} \cdot I_{OUT_FS}) > 1.6\text{V} \quad (4)$$

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

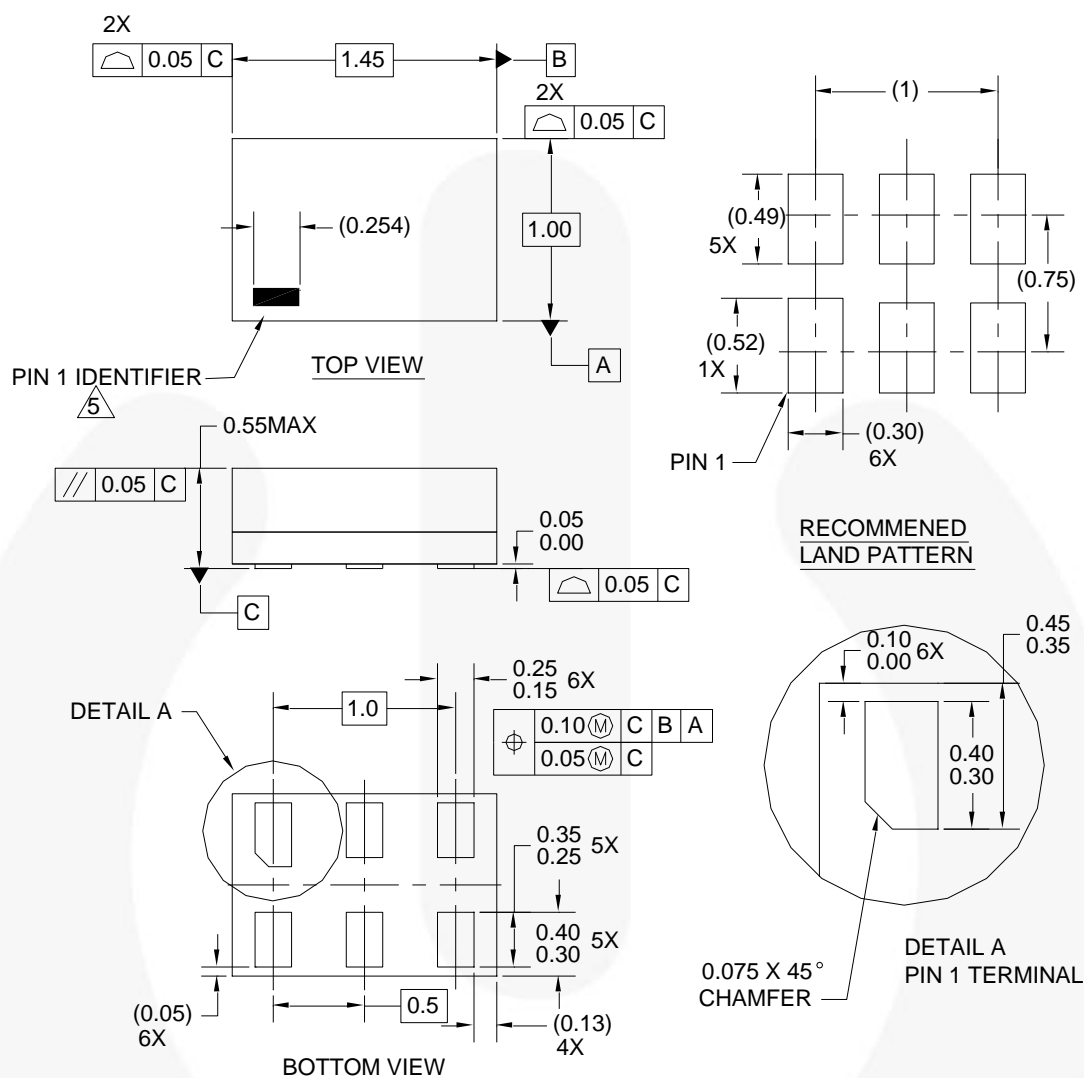


Figure 15. 6-Lead MicroPak™ Molded Leadless Package (MLP)

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.


Always visit Fairchild Semiconductor's online packaging area for the most recent package drawings:

<http://fsce132/dwg/MA/MAC06A.pdf>



TRADEMARKS

The following includes registered and unregistered trademarks and service marks, owned by Fairchild Semiconductor and/or its global subsidiaries, and is not intended to be an exhaustive list of all such trademarks.

AccuPower™	F-PFS™	PowerTrench®	Sync-Lock™
AX-CAP®*	FRFET®	PowerXS™	SYSTEM GENERAL®
BitSiC™	Global Power Resource™	Programable Active Droop™	TinyBoost®
Build it Now™	GreenBridge™	QFET®	TinyBuck®
CorePLUS™	Green FPS™	QS™	TinyCalc™
CorePOWER™	Green FPS™ e-Series™	Quiet Series™	TinyLogic®
CROSSVOLT™	Gmax™	RapidConfigure™	TINYOPTO™
CTL™	GTO™	Saving our world, 1mW/W/kW at a time™	TinyPower™
Current Transfer Logic™	IntelliMAX™	SignalWise™	TinyPwm™
DEUXPEED®	ISOPLANAR™	SmartMax™	TinyWire™
Dual Cool™	Making Small Speakers Sound Louder and Better™	SMART START™	TranSiC™
EcoSPARK®	MegaBuck™	Solutions for Your Success™	TriFault Detect™
EfficientMax™	MICROCOUPLER™	SPM®	TRUECURRENT®*
ESBC™	MicroFET™	STEALTH™	µSerDes™
	MicroPak™	SuperFET®	UHC™
Fairchild®	MicroPak2™	SuperSOT™-3	Ultra FRFET™
Fairchild Semiconductor®	MillerDrive™	SuperSOT™-6	UniFET™
FACT Quiet Series™	MotionMax™	SuperSOT™-8	VCX™
FACT®	mWSaver®	SupreMOS®	VisualMax™
FAST®	OptoHiT™	SyncFET™	VoltagePlus™
FastvCore™	OPTOLOGIC®		XS™
FETBench™	OPTOPLANAR®		
FPS™			

* Trademarks of System General Corporation, used under license by Fairchild Semiconductor.

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	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.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

Rev. I66