March 2007

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
- SOT23-5 package
- 6-lead MicroPak™ future package option

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 PC's, 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.

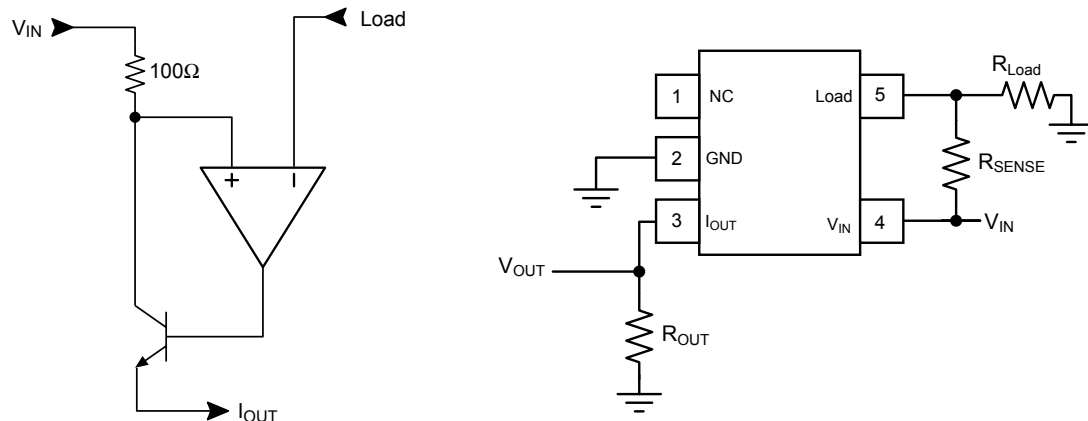## Functional Block Diagram and Typical Circuit

Figure 1. Functional Block Diagram and Typical Circuit

Ordering Information

Part Number	Package	Pb-Free	Operating Temperature Range	Packaging Method
FAN4010IS5X	SOT23-5	Yes	-40°C to +85°C	Reel
FAN4010IL6X*	MicroPak-6	Yes	-40°C to +85°C	Reel

Moisture sensitivity level for all parts is MSL-1.
MicroPak™ is a trademark of Fairchild Semiconductor Corporation.
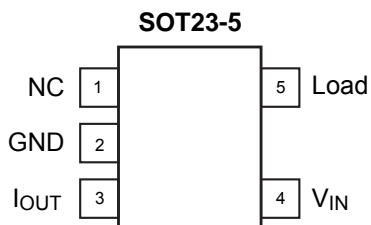*Future package option.

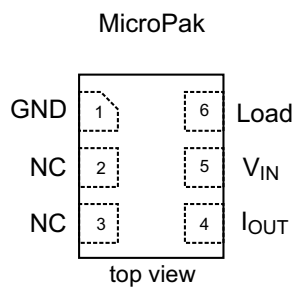## Pin Configurations

SOT23-5

Figure 2. SOT23-5 Pin Configuration

MicroPak

top view

Figure 3. MicroPak™-5 Pin Configuration

Pin Assignments

SOT Pin #	MicroPak™ Pin #	Name	Description
1	2, 3	NC	No Connect; leave pin floating
2	1	GND	Ground
3	4	I_{OUT}	Output current, proportional to V_{IN} - V_{Load}
4	5	V_{IN}	Input voltage (supply voltage)
5	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
V_s	Supply Voltage	0	6.3	V
V_{IN}	Input Voltage Range	0	6.3	V

Reliability Information

Symbol	Parameter		Min.	Typ.	Max.	Unit
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	MicroPak™-5		271		°C/W
		SOC23-5		191		°C/W

Note:

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

ESD Protection

Symbol	Electrostatic Discharge 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	Min.	Typ.	Max.	Unit
T_A	Operating Temperature Range	-40		+85	°C
V_s	Supply Voltage Range	2		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} = 100Ω, R_{SENSE} = 100Ω, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
Frequency Domain Response						
BW_{ss}	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
I_{OUT}	Output Current[1,4]	V_{SENSE} = 0V	0	1	4	µA
		V_{SENSE} = 10mV	93	100	107	µA
		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
I_{SENSE}	Load Pin Input Current			2		nA
A_{CY}	Accuracy	R_{SENSE} = 100Ω, R_{SENSE} = 200mV[1]	-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 = 6.3mV$_{pp}$ into 50Ω.
3. -20dBm = 63mV$_{pp}$ into 50Ω.
4. Includes input offset voltage contribution.

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Typical Performance Characteristics

$T_A = 25°C$, $V_s = V_{IN} = 5V$, $R_{OUT} = 100Ω$, $R_{SENSE} = 100Ω$, unless otherwise noted.
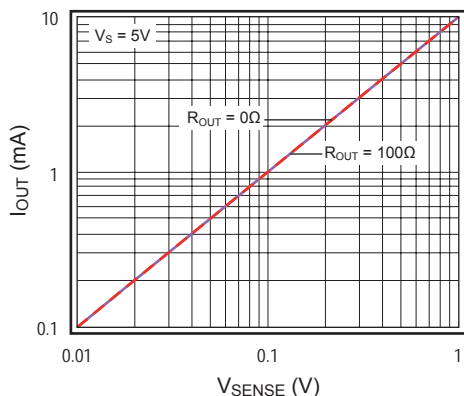
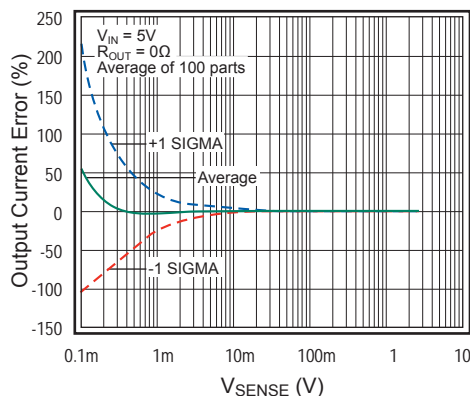**Figure 4. V$_{SENSE}$ vs. Output Current**

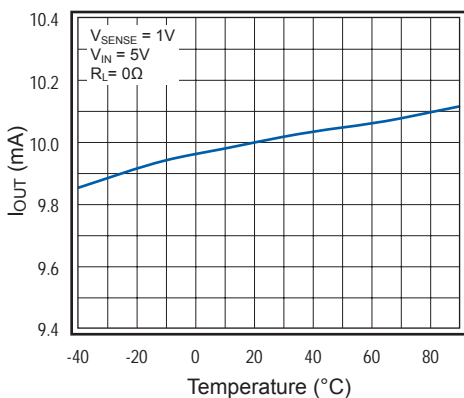**Figure 5. Output Current Error vs. V$_{SENSE}$**
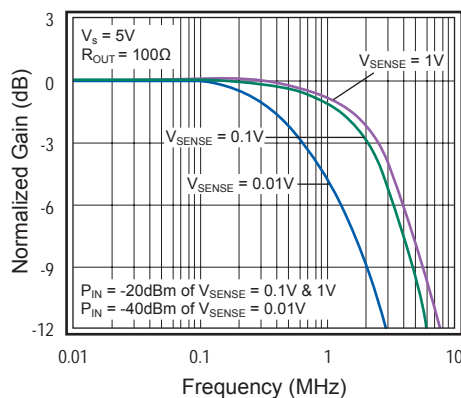
Figure 6. Output Current vs. Temperature

Figure7. Frequency Response
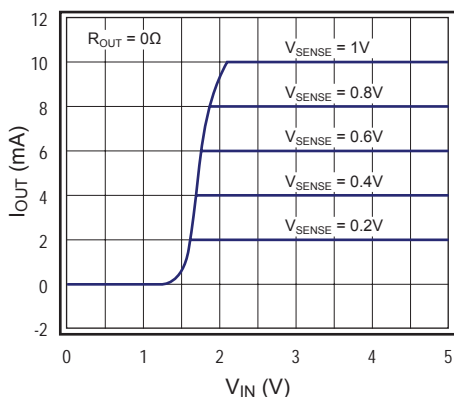
Figure 8. Transfer Characteristics
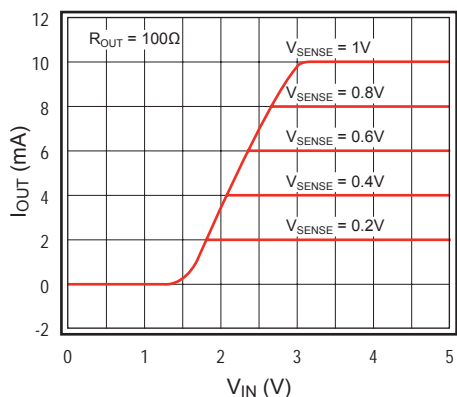
Figure 9. Transfer Characteristics

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Typical Performance Characteristics (Continued)

$T_A = 25°C$, $V_s = V_{IN} = 5V$, $R_{OUT} = 100Ω$, $R_{SENSE} = 100Ω$, unless otherwise noted.
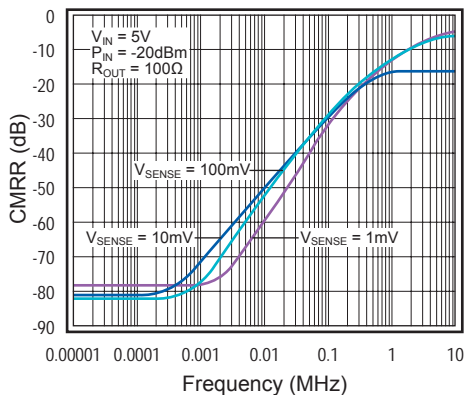

Figure 10. CMRR vs. Frequency
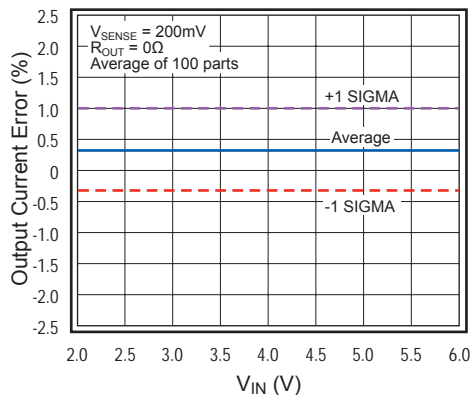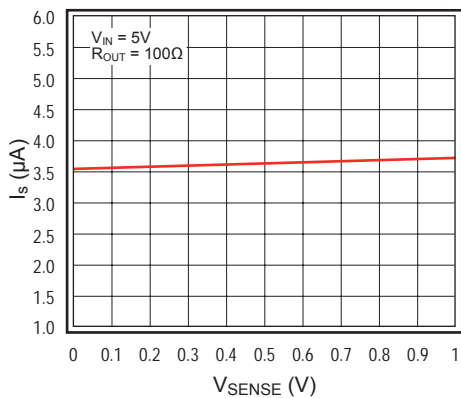

Figure 11. V_{IN} vs. Output Current Error

Figure 12. Supply Current vs. V_{SENSE}

Application Information

Detailed Description

The FAN4010 measures the voltage drop (V_{SENSE}) across an external sense resistor located in the high voltage side of the circuit. V_{SENSE} is converted to a linear current via an internal operational amplifier and precision 100Ω resistor. The value of this current is $V_{SENSE}/100Ω$ (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:

$$V_{SENSE} = I_{Load} * R_{SENSE} \qquad \text{EQ.1}$$

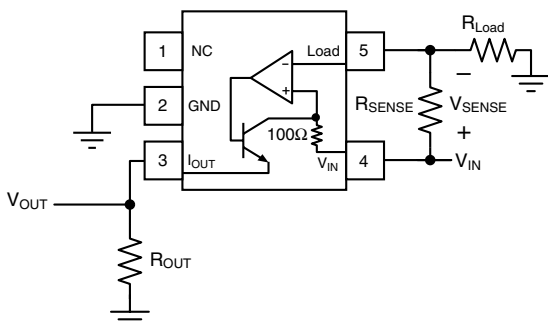$$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT} \qquad \text{EQ.2}$$

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:

$$10mV < V_{SENSE} < 200mV \qquad \text{EQ. 3}$$

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 30mΩ/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.
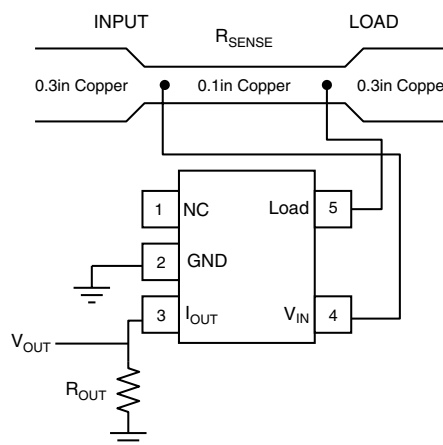

Figure 14. Using PCB Trace for R$_{SENSE}$

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 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 1Ω 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 200Ω 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:

$(R_{OUT} * I_{OUT\_FS})$ such that

$$V_{IN} - V_{SENSE} - (R_{OUT} * I_{OUT\_FS}) > 1.2V \qquad \text{EQ. 4}$$

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.

Mechanical Dimensions

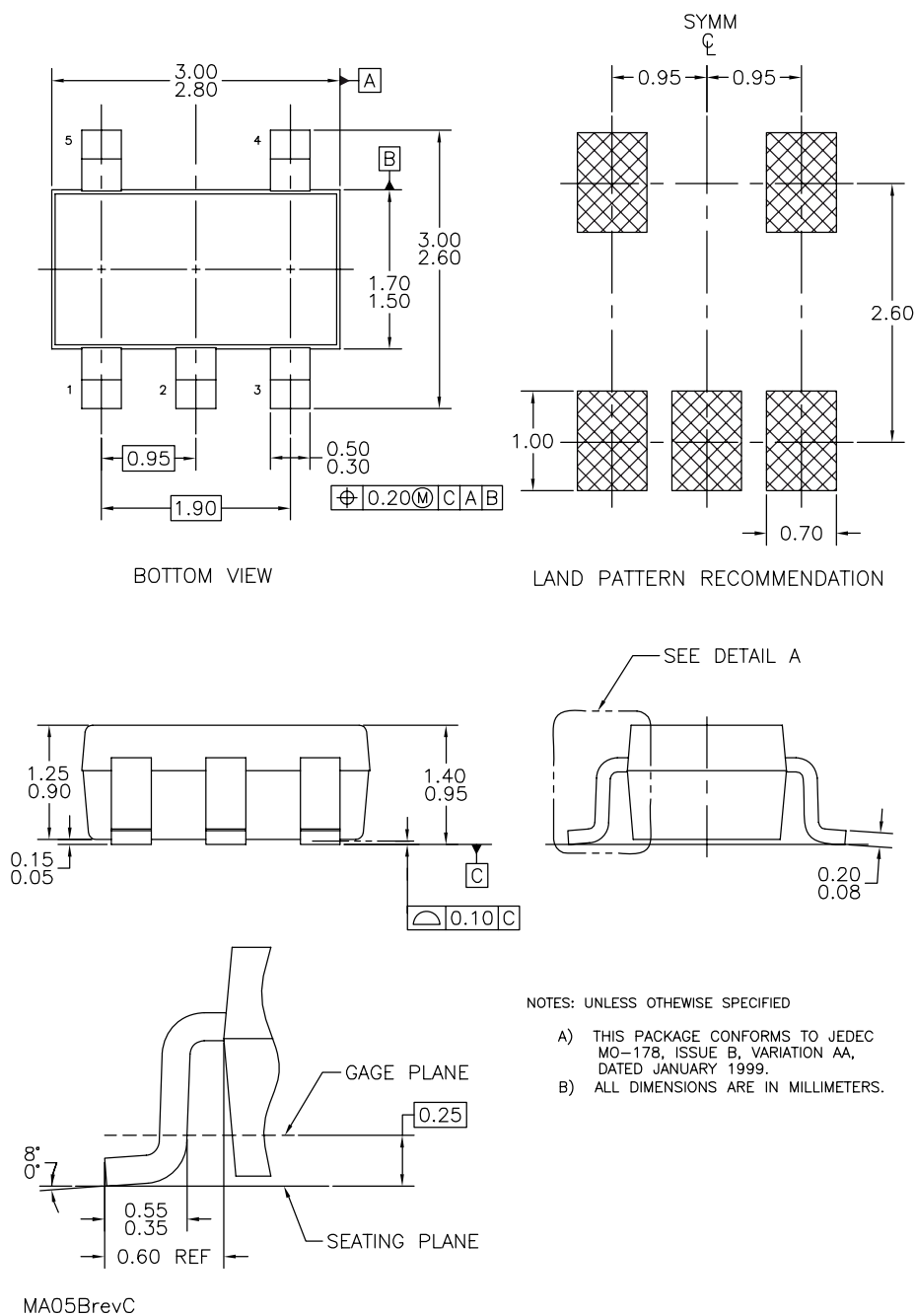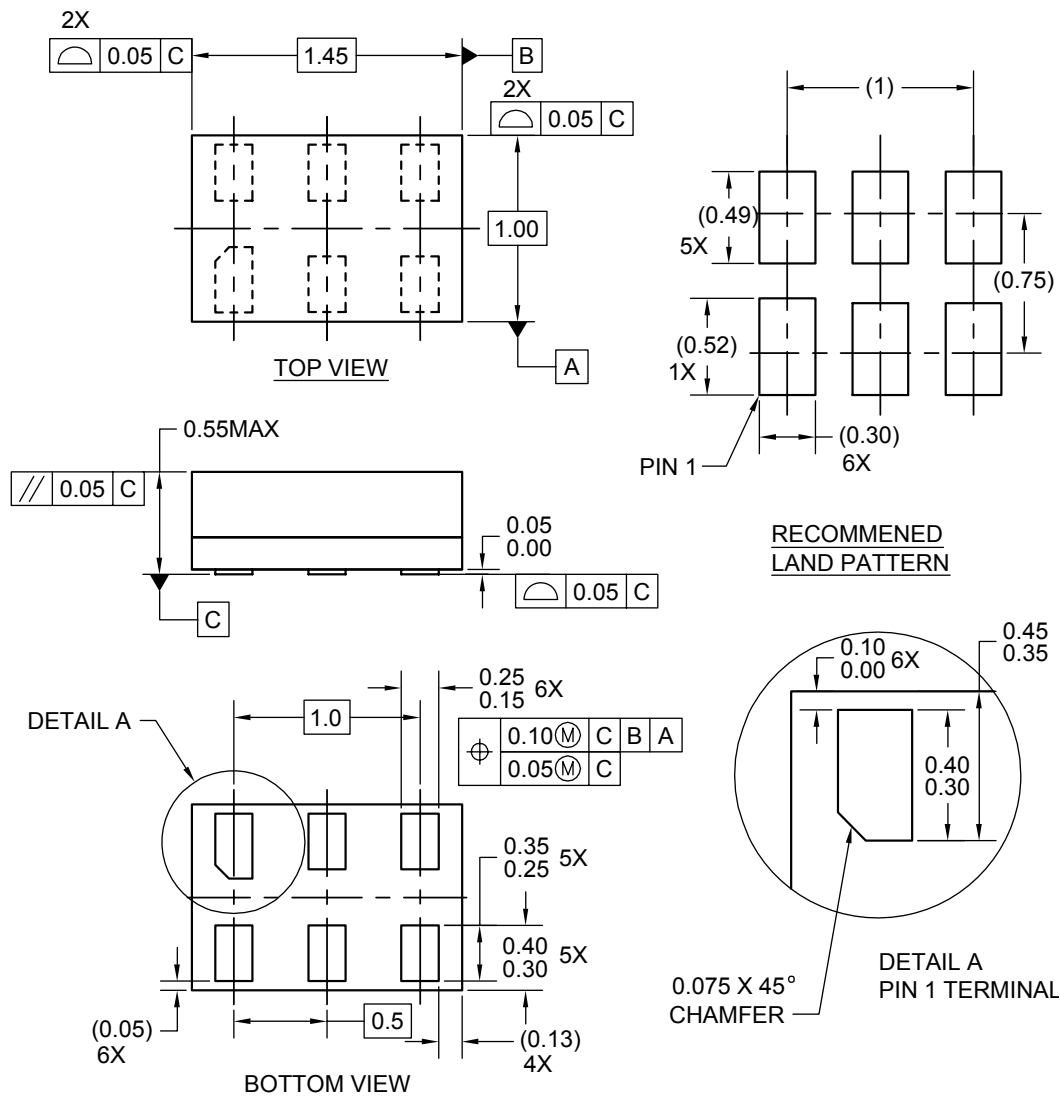Dimensions are in millimeters unless otherwise noted.

BOTTOM VIEW

LAND PATTERN RECOMMENDATION

SEE DETAIL A

NOTES: UNLESS OTHEWISE SPECIFIED

A) THIS PACKAGE CONFORMS TO JEDEC
MO−178, ISSUE B, VARIATION AA,
DATED JANUARY 1999.
B) ALL DIMENSIONS ARE IN MILLIMETERS.

GAGE PLANE

SEATING PLANE

MA05BrevC

Figure 15. 5-Lead SOT23 Package

Mechanical Dimensions

Dimensions are in millimeters unless otherwise noted.

2X

0.05 C ← 1.45 → ▶ B

2X

0.05 C

1.00

TOP VIEW

A

(1)

(0.49)
5X

(0.75)

(0.52)
1X

(0.30)
6X

PIN 1

RECOMMENED
LAND PATTERN

0.55MAX

// 0.05 C

0.05
0.00

0.05 C

C

DETAIL A

0.25
0.15 6X

1.0

⊕ 0.10 Ⓜ C B A
0.05 Ⓜ C

0.35
0.25 5X

0.40
0.30 5X

0.5

(0.05)
6X

(0.13)
4X

BOTTOM VIEW

0.10
0.00 6X

0.45
0.35

0.40
0.30

0.075 X 45°
CHAMFER

DETAIL A
PIN 1 TERMINAL

Notes:

1. CONFORMS TO JEDEC STANDARD M0-252 VARIATION UAAD
2. DIMENSIONS ARE IN MILLIMETERS
3. DRAWING CONFORMS TO ASME Y14.5M-1994

MAC06AREVC

Figure 16. 6-Lead MicroPak™ Package

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ActiveArray™	ImpliedDisconnect™	QS™	TinyPower™
Bottomless™	IntelliMAX™	QT Optoelectronics™	TinyWire™
Build it Now™	ISOPLANAR™	Quiet Series™	TruTranslation™
CoolFET™	MICROCOUPLER™	RapidConfigure™	µSerDes™
CROSSVOLT™	MicroPak™	RapidConnect™	UHC®
CTL™	MICROWIRE™	ScalarPump™	UniFET™
Current Transfer Logic™	MSX™	SMART START™	VCX™
DOME™	MSXPro™	SPM®	Wire™
E²CMOS™	OCX™	STEALTH™	
EcoSPARK®	OCXPro™	SuperFET™	
EnSigna™	OPTOLOGIC®	SuperSOT™-3	
FACT Quiet Series™	OPTOPLANAR®	SuperSOT™-6	
FACT®	PACMAN™	SuperSOT™-8	
FAST®	POP™	SyncFET™	
FASTr™	Power220®	TCM™	
FPS™	Power247®	The Power Franchise®	
FRFET®	PowerEdge™	⏻™	
GlobalOptoisolator™	PowerSaver™	TinyBoost™	
GTO™	PowerTrench®	TinyBuck™	

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Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This 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	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild Semiconductor. The datasheet is printed for reference information only.

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