



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## General Description

The MAX4376/MAX4377/MAX4378 single, dual, and quad precision high-side current-sense amplifiers are available in space-saving packages. They feature buffered voltage outputs that eliminate the need for gain-setting resistors and are ideal for today's notebook computers, cell phones, and other systems where current monitoring is critical. These precision devices are offered in three fixed-gain versions of 20, 50, and 100:

GAIN	SUFFIX
20	T
50	F
100	H

For example, MAX4376TAUK is a single high-side amplifier with a gain of 20.

High-side current monitoring is especially useful in battery-powered systems since it does not interfere with the ground path of the battery charger. The input common-mode range of 0 to +28V is independent of the supply voltage and ensures that the current-sense feedback remains viable even when connected to a battery pack in deep discharge.

The full-scale current reading can be set by choosing the appropriate voltage gain and external-sense resistor. This capability offers a high level of integration and flexibility, resulting in a simple and compact current-sense solution.

The MAX4376/MAX4377/MAX4378 operate over a supply voltage range of +3V to +28V, draw 1mA of supply current per amplifier, and operate over the full automotive temperature range of -40°C to +125°C. These devices have a wide bandwidth of 2MHz, making them suitable for use inside battery-charger control loops. The buffered outputs drive up to 2mA of output current into a ground-referenced load.

The MAX4376 is available in a tiny 5-pin SOT23 package. The MAX4377/MAX4378 are available in space-saving 8-pin  $\mu$ MAX and 14-pin TSSOP packages, respectively.

## Applications

Notebook Computers	Portable/Battery-Powered Systems
Current-Limited Power Supplies	Cell Phones
Fuel Gauges in PC	Smart Battery Packages
General-System/Board-Level Current Monitoring	Automotive Current Detect
Battery Chargers	Power Management Systems
	PA Bias Control

## Features

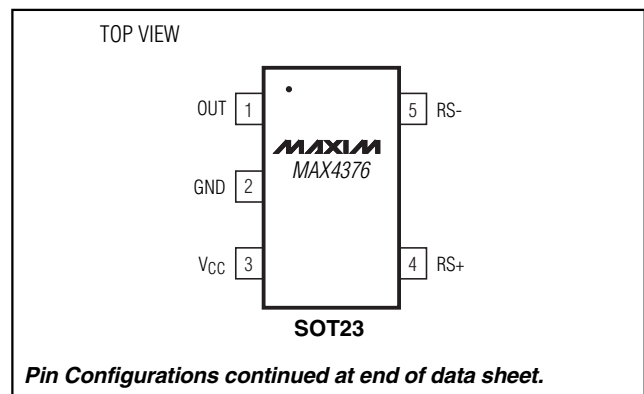
- ◆ Low-Cost Single/Dual/Quad High-Side Current-Sense Amplifiers
- ◆  $\pm 0.5\%$  Typical Full-Scale Accuracy
- ◆ +3V to +28V Supply Operation
- ◆ Adjustable Current-Sense Capability with External Sense Resistor
- ◆ Buffered Output Voltage with 2mA Drive
- ◆ 1mA (typ) Supply Current
- ◆ 2.0MHz Bandwidth (Gain = +20V/V)
- ◆ Automotive Temperature Range (-40°C to +125°C)
- ◆ Full 0 to 28V Common-Mode Range, Independent of Supply Voltage
- ◆ Three Gain Versions Available
  - +20V/V (MAX437\_T)
  - +50V/V (MAX437\_F)
  - +100V/V (MAX437\_H)
- ◆ Available in Space-Saving 5-pin SOT23 (Single), 8-pin  $\mu$ MAX (Dual), and 14-pin TSSOP (Quad)

## Ordering Information

PART	GAIN (+V/+V)	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX4376TAUK-T	20	-40°C to +125°C	5 SOT23-5	ADOG
MAX4376FAUK-T	50	-40°C to +125°C	5 SOT23-5	ADOH
MAX4376HAUK-T	100	-40°C to +125°C	5 SOT23-5	ADOI
MAX4376TASA	20	-40°C to +125°C	8 SO	—
MAX4376FASA	50	-40°C to +125°C	8 SO	—
MAX4376HASA	100	-40°C to +125°C	8 SO	—

Ordering Information continued at end of data sheet.

## Pin Configurations



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> , RS+, RS- to GND .....	-0.3V to +30V	14-pin SO (derate 8.33mW/°C above +70°C).....	667mW
OUT to GND .....	-0.3V to (V <sub>CC</sub> + 0.3V)	14-pin TSSOP (derate 9.1mW/°C above +70°C) .....	727mW
Differential Input Voltage (V <sub>RS+</sub> - V <sub>RS-</sub> ).....	±8V	Operating Temperature Range .....	-40°C to +125°C
Output Short Circuit to V <sub>CC</sub> .....	Continuous	Junction Temperature .....	+150°C
Output Short Circuit to GND .....	1s	Storage Temperature Range .....	-65°C to +150°C
Current into Any Pin.....	±20mA	Lead Temperature (soldering, 10s) .....	+300°C
Continuous Power Dissipation (T <sub>A</sub> = +70°C)			
5-pin SOT23 (derate 7.1mW/°C above +70°C).....	571mW		
8-pin μMAX (derate 4.5mW/°C above +70°C).....	362mW		
8-pin SO (derate 5.88mW/°C above +70°C).....	471mW		

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<sub>RS+</sub> = 0 to 28V, V<sub>SENSE</sub> = (V<sub>RS+</sub> - V<sub>RS-</sub>) = 0, V<sub>CC</sub> = +3.0V to +28V, R<sub>L</sub> = ∞, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = 25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
Operating Voltage Range	V <sub>CC</sub>	Guaranteed by PSR test	3		28	V	
Common-Mode Input Range	V <sub>CM</sub>	Guaranteed by total OUT voltage error test	0		28	V	
Common-Mode Rejection	CMR	2V ≤ V <sub>RS+</sub> ≤ 28V, V <sub>SENSE</sub> = 100mV		90		dB	
Supply Current per Amplifier	I <sub>CC</sub>	V <sub>SENSE</sub> = 5mV, V <sub>RS+</sub> > 2.0V, V <sub>CC</sub> = 12V		1	2.2	mA	
Leakage Current	I <sub>RS+</sub> , I <sub>RS-</sub>	V <sub>CC</sub> = 0, V <sub>RS+</sub> = 28V			8	μA	
Input Bias Current	I <sub>RS+</sub>	V <sub>RS+</sub> > 2.0V	0		60	μA	
		V <sub>RS+</sub> ≤ 2.0V	-400		60		
	I <sub>RS-</sub>	V <sub>RS+</sub> > 2.0V	0		120		
		V <sub>RS+</sub> ≤ 2.0V	-800		120		
Full-Scale Sense Voltage	V <sub>SENSE</sub>			150		mV	
Total OUT Voltage Error (Note 2)		I <sub>OUT</sub> ≤ 2mA	V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 12V			±6.75	%
			V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, T <sub>A</sub> = +25°C		±0.5	±3.25	
			V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 28V, V <sub>RS+</sub> = 28V			±11	
			V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 28V, V <sub>RS+</sub> = 28V, T <sub>A</sub> = +25°C		±0.5	±5	
			V <sub>SENSE</sub> = 100mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 0.1V		±9	±32	
			V <sub>SENSE</sub> = 6.25mV, V <sub>CC</sub> = 12V, V <sub>RS+</sub> = 12V (Note 3)		±7		
OUT High Voltage (Note 4)	(V <sub>CC</sub> - V <sub>OUT</sub> )	V <sub>CC</sub> = 3V, I <sub>OUT</sub> = 2mA		0.9	1.2	V	
OUT Low Voltage	V <sub>OL</sub>	I <sub>OUT</sub> = 200μA, V <sub>CC</sub> = 3V, V <sub>SENSE</sub> = 0		30		mV	

# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

MAX4376/MAX4377/MAX4378

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{RS+} = 0$  to 28V,  $V_{SENSE} = (V_{RS+} - V_{RS-}) = 0$ ,  $V_{CC} = +3.0V$  to +28V,  $R_L = \infty$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = 25^\circ C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS	
Bandwidth	BW	$V_{CC} = 12V$ $V_{RS+} = 12V$ $C_{LOAD} = 15pF$	$V_{SENSE} = 100mV$ (gain = +20V/V)		2		MHz	
			$V_{SENSE} = 100mV$ (gain = +50V/V)		1.7			
			$V_{SENSE} = 100mV$ (gain = +100V/V)		1.2			
			$V_{SENSE} = 6.25mV$ (Note 3)		0.5			
Slew Rate	SR	$V_{SENSE} = 20mV$ to 100mV, $C_{LOAD} = 15pF$			10		V/ $\mu s$	
Gain	$A_V$	MAX437_T			+20		V/V	
		MAX437_F			+50			
		MAX437_H			+100			
Gain Accuracy	$\Delta A_V$	$V_{SENSE} = 10mV$ to 150mV, $V_{CC} = 12V$ , $I_{OUT} = 2mA$ , gain = 20 and 50	$T_A = T_{MIN}$ to $T_{MAX}$			$\pm 5.5$	%	
			$T_A = +25^\circ C$		$\pm 0.5$	$\pm 2.5$		
		$V_{SENSE} = 10mV$ to 150mV, $V_{CC} = 20V$ , $I_{OUT} = 2mA$ , gain = 100	$T_A = T_{MIN}$ to $T_{MAX}$			5.5		
			$T_A = +25^\circ C$		$\pm 0.5$	$\pm 2.5$		
OUT Setting Time to 1% of Final Value		$V_{CC} = 12V$ , $V_{RS+} = 12V$ , $C_{LOAD} = 15pF$	$V_{SENSE} = 6.25mV$ to 100mV		400		ns	
			$V_{SENSE} = 100mV$ to 6.25mV		800			
Maximum Capacitive Load	$C_{LOAD}$	No sustained oscillation			1000		pF	
Output Resistance	$R_{OUT}$	$V_{SENSE} = 100mV$			5		$\Omega$	
Power-Supply Rejection	PSR	$V_{RS+} > 2V$ , $V_{OUT} = 1.6V$ , $V_{CC} = 3V$ to 28V		66	90		dB	
Power-Up Time to 1% of Final Value		$V_{SENSE} = 100mV$ , $C_{LOAD} = 15pF$			2		$\mu s$	
Saturation Recovery Time to 1% of Final Value		$V_{CC} = 12V$ , $V_{RS+} = 12V$ , $C_{LOAD} = 15pF$ , $V_{SENSE} = 100mV$			1		$\mu s$	
Reverse Recovery Time to 1% of Final Value		$V_{CC} = 12V$ , $V_{RS-} = 12V$ , $C_{LOAD} = 15pF$ , $V_{SENSE} = -100mV$ to +100mV			1		$\mu s$	

**Note 1:** All devices are 100% production tested at  $T_A = +25^\circ C$ . All temperature limits are guaranteed by design.

**Note 2:** Total OUT Voltage Error is the sum of gain and offset errors.

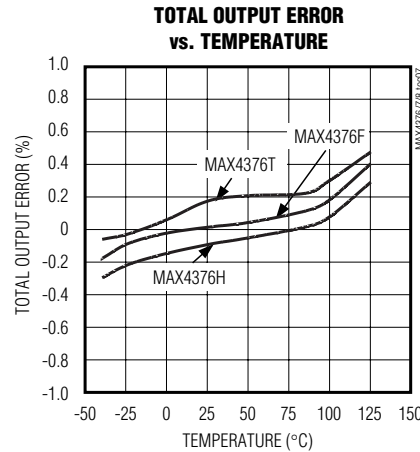
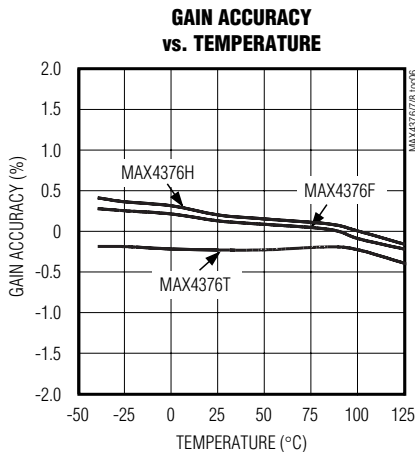
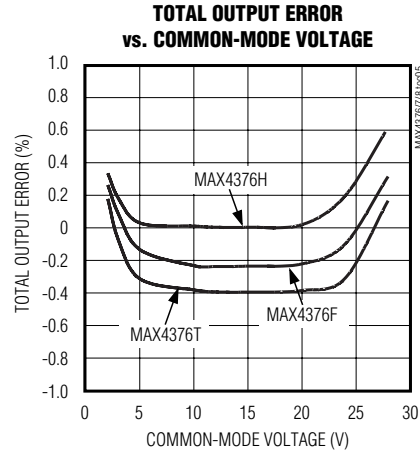
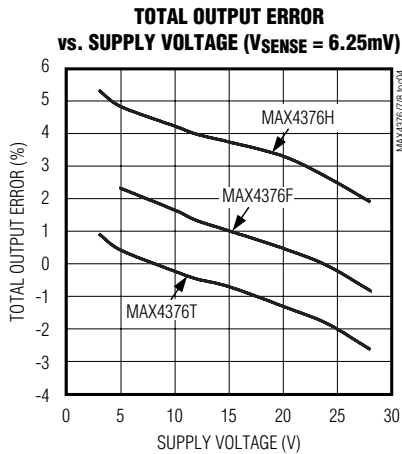
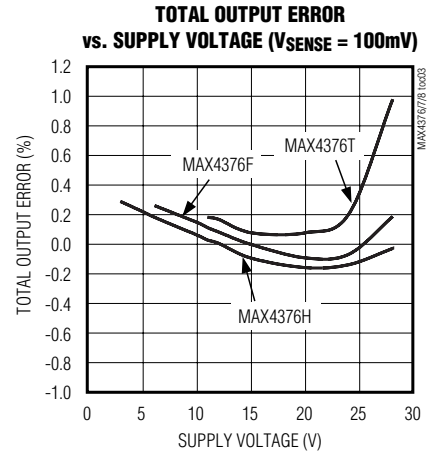
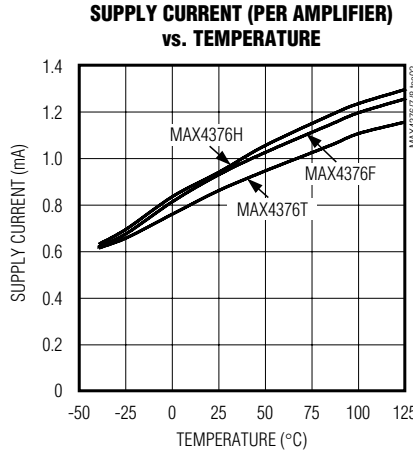
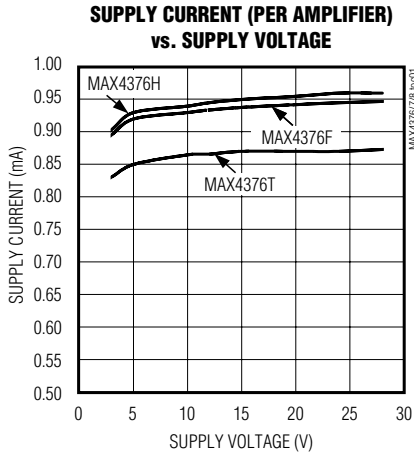
**Note 3:** 6.25mV = 1/16 of 100mV full-scale sense voltage.

**Note 4:**  $V_{SENSE}$  such that  $V_{OUT}$  is in saturation.

# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## Typical Operating Characteristics

( $V_{CC} = V_{RS+} = 12V$ ,  $V_{SENSE} = 100mV$ ,  $T_A = +25^{\circ}C$ .)

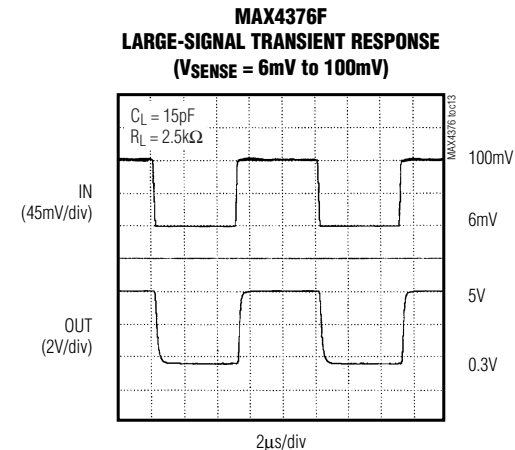
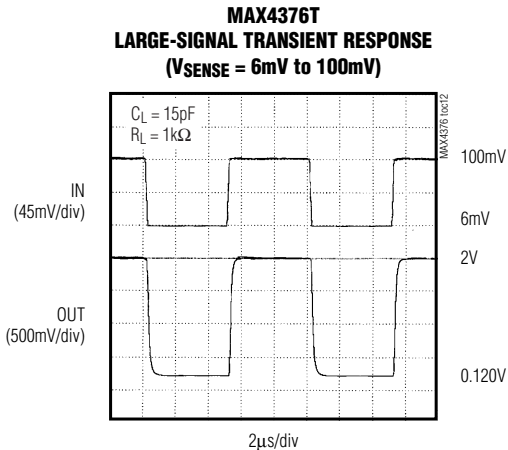
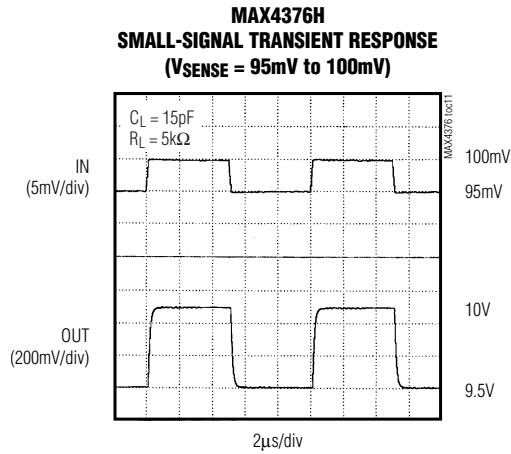
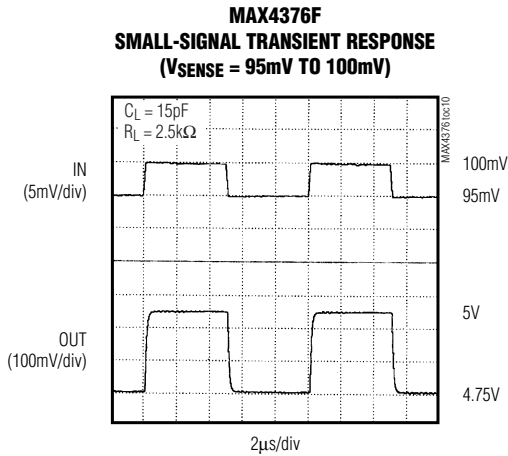
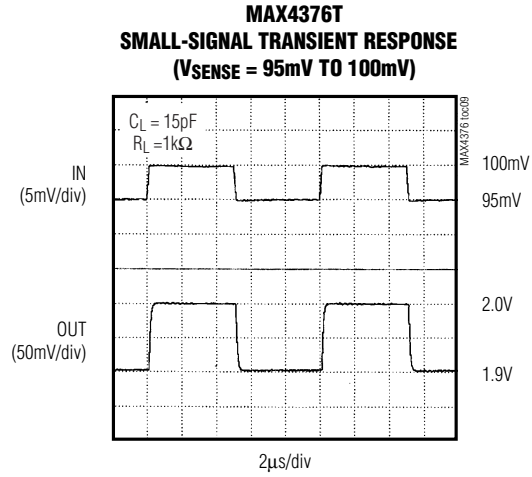
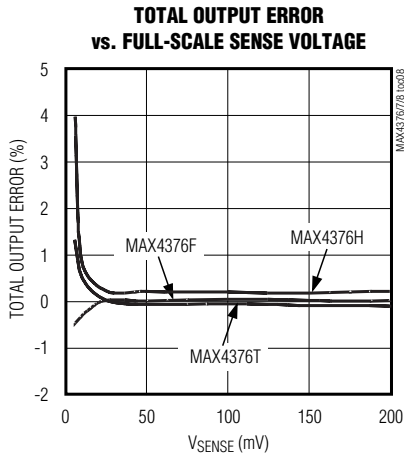


# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## Typical Operating Characteristics (continued)

( $V_{CC} = V_{RS+} = 12V$ ,  $V_{SENSE} = 100mV$ ,  $T_A = +25^{\circ}C$ .)

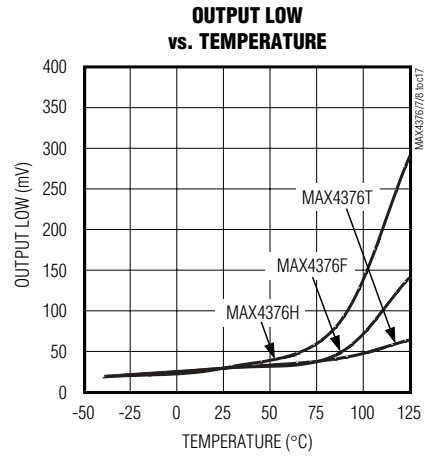
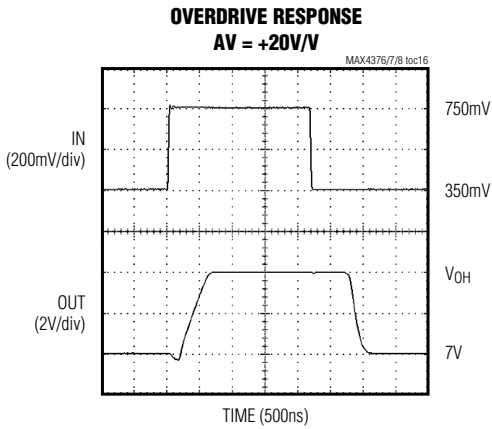
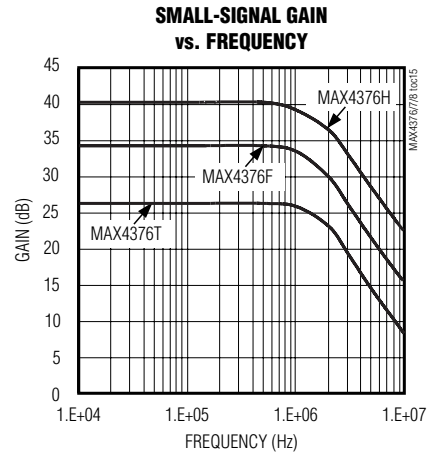
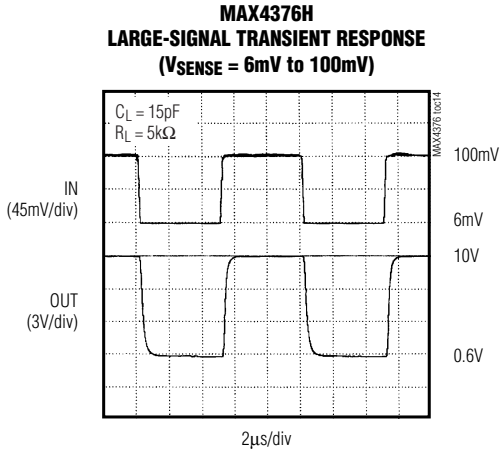
MAX4376/MAX4377/MAX4378



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## Typical Operating Characteristics (continued)

( $V_{CC} = V_{RS+} = 12V$ ,  $V_{SENSE} = 100mV$ ,  $T_A = +25^{\circ}C$ .)



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

## Pin Description

PIN				NAME	FUNCTION
MAX4376	MAX4376	MAX4377	MAX4378		
SOT23-5	SO-8	μMAX-8/ SO-8	SO-14/ TSSOP-14		
1	4	1, 7	1, 7, 8, 14	OUT, OUT_	Output Voltage. $V_{OUT}$ is proportional to the magnitude of the sense voltage ( $V_{RS+} - V_{RS-}$ ). $V_{OUT}$ is approximately zero when $V_{RS-} > V_{RS+}$ (no phase reversal).
2	3	4	11	GND	Ground
3	1	8	4	VCC	Supply Voltage
4	8	3, 5	3, 5, 10, 12	RS+, RS_+	Power connection to the external sense resistor
5	6	2, 6	2, 6, 9, 13	RS-, RS_-	Load-side connection to the external sense resistor
—	2, 5, 7	—	—	N.C.	No Connection. Not internally connected.

## Detailed Description

The MAX4376/MAX4377/MAX4378 high-side current-sense amplifiers feature a 0 to +28V input common-mode range that is independent of supply voltage. This feature allows the monitoring of current out of a battery in deep discharge and also enables high-side current sensing at voltages greater than the supply voltage (VCC).

The MAX4376/MAX4377/MAX4378 operate as follows: current from the source flows through RSENSE to the load (Figure 1). Since the internal sense amplifier's inverting input has high impedance, negligible current flows through RG2 (neglecting the input bias current). Therefore, the sense amplifier's inverting-input voltage equals  $V_{SOURCE} - (I_{LOAD})(R_{SENSE})$ .

The amplifier's open-loop gain forces its noninverting input to the same voltage as the inverting input. Therefore, the drop across RG1 equals  $(I_{LOAD})(R_{SENSE})$ . Since  $I_{RG1}$  flows through RG1,  $I_{RG1} = (I_{LOAD})(R_{SENSE})/RG1$ . The internal current mirror multiplies  $I_{RG1}$  by a current gain factor,  $\beta$ , to give  $I_{RGD} = \beta \times I_{RG1}$ . Solving  $I_{RGD} = \beta \times (I_{LOAD})(R_{SENSE})/RG1$ . Therefore:

$$V_{OUT} = \beta \times (RGD/RG1)(R_{SENSE} \times I_{LOAD}) \times \text{amp gain}$$

where amp gain is 2, 5, or 10.

The part's gain equals  $(\beta \times RGD / RG1) \times \text{amp gain}$ .

Therefore:

$$V_{OUT} = (GAIN)(R_{SENSE})(I_{LOAD})$$

where GAIN = 20 for MAX437\_T.

GAIN = 50 for MAX437\_F.

GAIN = 100 for MAX437\_H.

Set the full-scale output range by selecting RSENSE and the appropriate gain version of the MAX4376/MAX4377/MAX4378.

## Applications Information

### Recommended Component Values

The MAX4376/MAX4377/MAX4378 sense a wide variety of currents with different sense resistor values. Table 1 lists common resistor values for typical operation of the MAX4376/MAX4377/MAX4378.

### Choosing RSENSE

To measure lower currents more accurately, use a high value for RSENSE. The high value develops a higher sense voltage that reduces offset voltage errors of the internal op amp.

In applications monitoring very high currents, RSENSE must be able to dissipate the  $I^2R$  losses. If the resistor's rated power dissipation is exceeded, its value may drift or it may fail altogether, causing a differential voltage across the terminals in excess of the absolute maximum ratings.

If ISENSE has a large high-frequency component, minimize the inductance of RSENSE. Wire-wound resistors have the highest inductance, metal-film resistors are somewhat better, and low-inductance metal-film resistors are best suited for these applications.

### Bidirectional Current-Sense Amplifier

Systems such as laptop computers and other devices that have internal charge circuitry require a precise bidirectional current-sense amplifier to monitor accurately the battery's current regardless of polarity. Figure 2 shows the MAX4377 used as a bidirectional current

MAX4376/MAX4377/MAX4378



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

Table 1. Recommended Component Values

FULL-SCALE LOAD CURRENT, $I_{LOAD}$ (A)	CURRENT-SENSE RESISTOR, $R_{SENSE}$ (m $\Omega$ )	GAIN (+V/V)	FULL-SCALE OUTPUT VOLTAGE (FULL-SCALE $V_{SENSE} = 100$ mV), $V_{OUT}$ (V)
0.1	1000	20	2.0
		50	5.0
		100	10.0
1	100	20	2.0
		50	5.0
		100	10.0
5	20	20	2.0
		50	5.0
		100	10.0
10	10	20	2.0
		50	5.0
		100	10.0

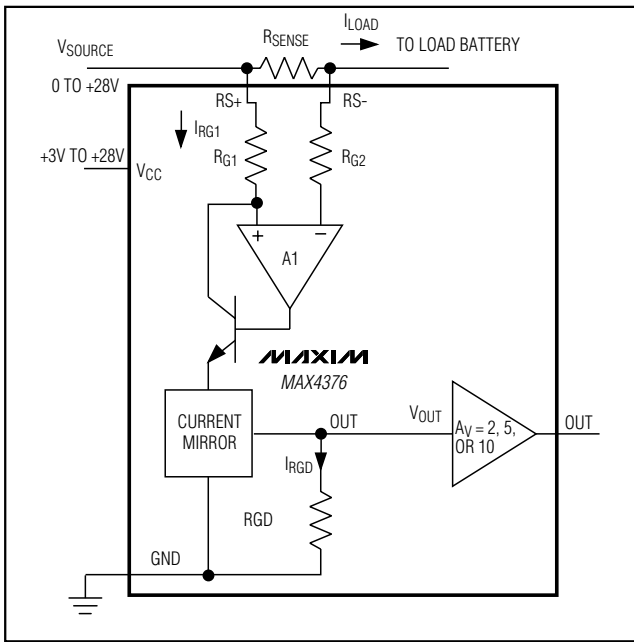


Figure 1. Functional Diagram

monitor. This is useful for implementing either smart battery packs or fuel gauges.

### Current Source Circuit

Figure 3 shows a block diagram using the MAX4376 with a switching regulator to make a current source.

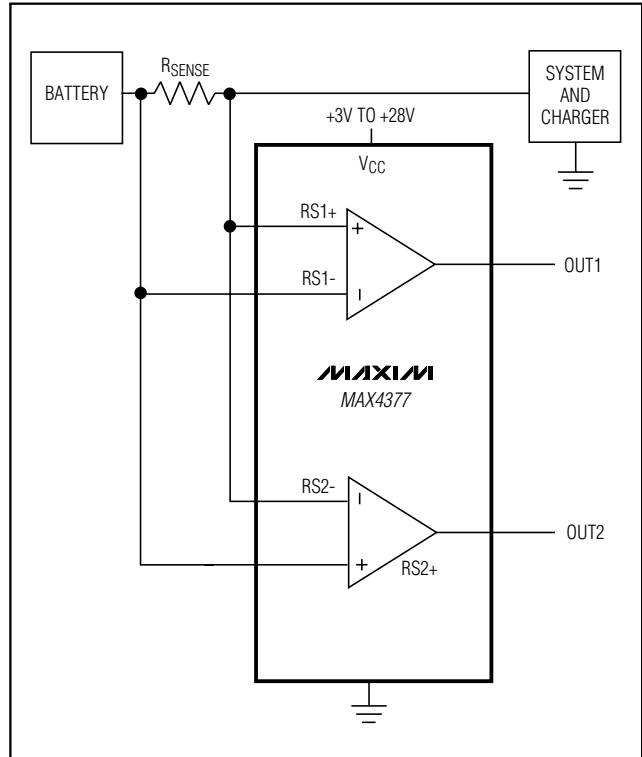


Figure 2. Bidirectional Current Monitor



# Single/Dual/Quad High-Side Current-Sense Amplifiers with Internal Gain

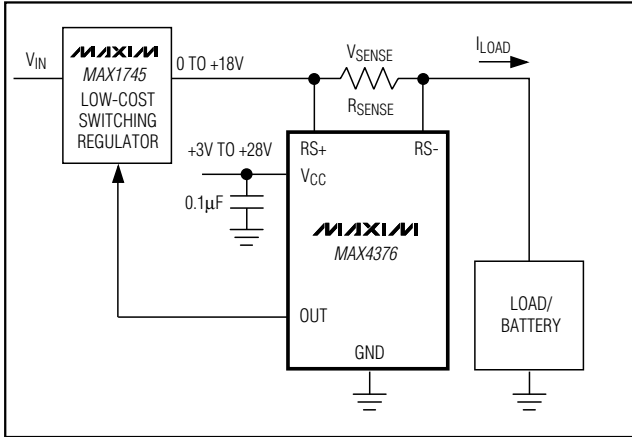


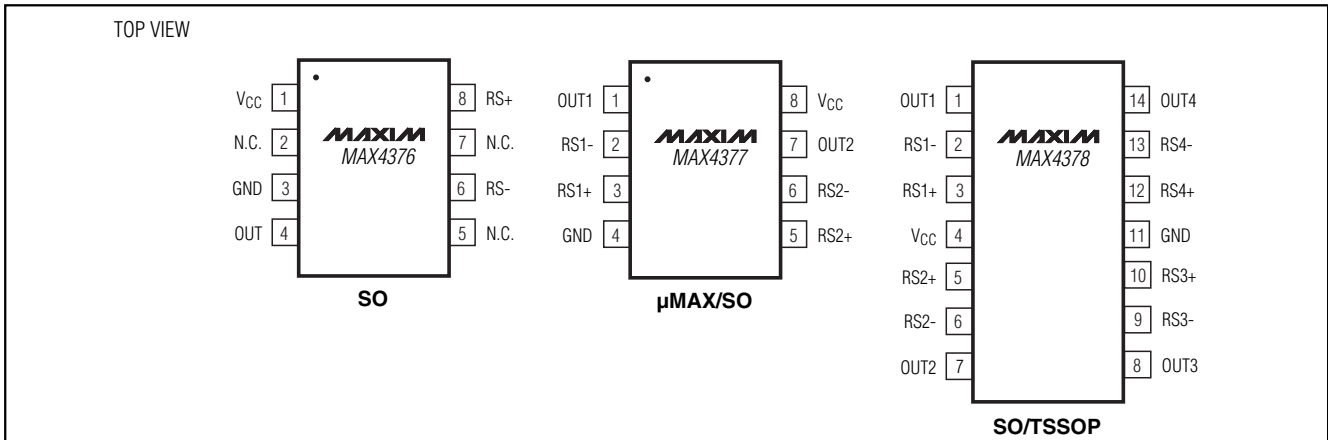
Figure 3. Current Source

## Chip Information

TRANSISTOR COUNT: MAX4376\_: 162  
 MAX4377\_: 324  
 MAX4378\_: 648  
 PROCESS: BiCMOS

MAX4376/MAX4377/MAX4378

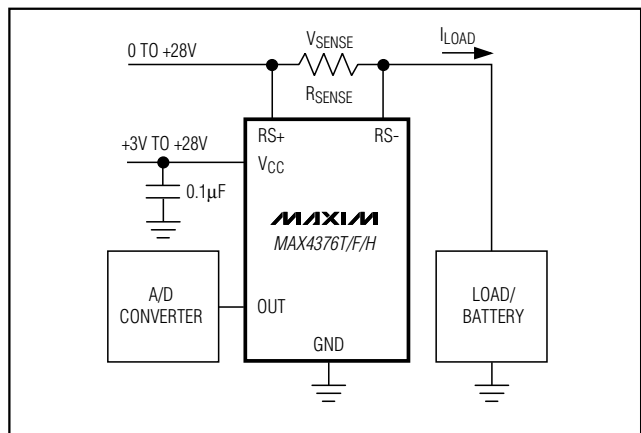
## Pin Configurations (continued)



## Ordering Information (continued)

PART	GAIN (+V/+V)	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX4377TAUA	20	-40°C to +125°C	8 µMAX	—
MAX4377FAUA	50	-40°C to +125°C	8 µMAX	—
MAX4377HAUA	100	-40°C to +125°C	8 µMAX	—
MAX4377TASA	20	-40°C to +125°C	8 SO	—
MAX4377FASA	50	-40°C to +125°C	8 SO	—
MAX4377HASA	100	-40°C to +125°C	8 SO	—
MAX4378TAUD	20	-40°C to +125°C	14 TSSOP	—
MAX4378FAUD	50	-40°C to +125°C	14 TSSOP	—
MAX4378HAUD	100	-40°C to +125°C	14 TSSOP	—
MAX4378TASD	20	-40°C to +125°C	14 SO	—
MAX4378FASD	50	-40°C to +125°C	14 SO	—
MAX4378HASD	100	-40°C to +125°C	14 SO	—

## Typical Operating Circuit



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

9 Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600

SUNSTAR商斯达实业集团是集研发、生产、工程、销售、代理经销、技术咨询、信息服务等为一体的高科技企业，是专业高科技电子产品生产厂家，是具有 10 多年历史的专业电子元器件供应商，是中国最早和最大的仓储式连锁规模经营大型综合电子零部件代理分销商之一，是一家专业代理和分销世界各大品牌 IC 芯片和电子元器件的连锁经营综合性国际公司。在香港、北京、深圳、上海、西安、成都等全国主要电子市场设有直属分公司和产品展示展销窗口门市部专卖店及代理分销商，已在全国范围内建成强大统一的供货和代理分销网络。我们专业代理经销、开发生产电子元器件、集成电路、传感器、微波光电元器件、工控机/DOC/DOM 电子盘、专用电路、单片机开发、MCU/DSP/ARM/FPGA 软件硬件、二极管、三极管、模块等，是您可靠的一站式现货配套供应商、方案提供商、部件功能模块开发配套商。专业以现代信息产业（计算机、通讯及传感器）三大支柱之一的传感器为主营业务，专业经营各类传感器的代理、销售生产、网络信息、科技图书资料及配套产品设计、工程开发。我们的专业网站——中国传感器科技信息网（全球传感器数据库）[www.SENSOR-IC.COM](http://www.SENSOR-IC.COM) 服务于全球高科技生产商及贸易商，为企业科技产品开发提供技术交流平台。欢迎各厂商互通有无、交换信息、交换链接、发布寻求代理信息。欢迎国外高科技传感器、变送器、执行器、自动控制产品厂商介绍产品到中国，共同开拓市场。本网站是关于各种传感器-变送器-仪器仪表及工业自动化大型专业网站，深入到工业控制、系统工程计 测量、自动化、安防报警、消费电子等众多领域，把最新的传感器-变送器-仪器仪表买卖信息，最新技术供求，最新采购商，行业动态，发展方向，最新的技术应用和市场资讯及时的传递给广大科技开发、科学研究、产品设计人员。本网站已成功为石油、化工、电力、医药、生物、航空、航天、国防、能源、冶金、电子、工业、农业、交通、汽车、矿山、煤炭、纺织、信息、通信、IT、安防、环保、印刷、科研、气象、仪器仪表等领域从事科学研究、产品设计、开发、生产制造的科技人员、管理人员、和采购人员提供满意服务。我们公司专业生产、代理、经销、销售各种传感器、变送器、敏感元器件、开关、执行器、仪器仪表、自动化控制系统：专门从事设计、生产、销售各种传感器、变送器、各种测控仪表、热工仪表、现场控制器、计算机控制系统、数据采集系统、各类环境监控系统、专用控制系统应用软件以及嵌入式系统开发及应用等工作。如热敏电阻、压敏电阻、温度传感器、温度变送器、湿度传感器、湿度变送器、气体传感器、气体变送器、压力传感器、压力变送、称重传感器、物（液）位传感器、物（液）位变送器、流量传感器、流量变送器、电流（压）传感器、溶氧传感器、霍尔传感器、图像传感器、超声波传感器、位移传感器、速度传感器、加速度传感器、扭距传感器、红外传感器、紫外传感器、火焰传感器、激光传感器、振动传感器、轴角传感器、光电传感器、接近传感器、干簧管传感器、继电器传感器、微型电泵、磁敏（阻）传感器、压力开关、接近开关、光电开关、色标传感器、光纤传感器、齿轮测速传感器、时间继电器、计数器、计米器、温控仪、固态继电器、调压模块、电磁铁、电压表、电流表等特殊传感器。同时承接传感器应用电路、产品设计和自动化工程项目。

更多产品请看本公司产品专用销售网站：

商斯达中国传感器科技信息网：<http://www.sensor-ic.com/>

商斯达工控安防网：<http://www.pc-ps.net/>

商斯达电子元器件网：<http://www.sunstare.com/>

商斯达微波光电产品网：[HTTP://www.rfoe.net/](http://www.rfoe.net/)

商斯达消费电子产品网：<http://www.icasic.com/>

商斯达军工产品网：<http://www.junpinic.com/>

商斯达实业科技产品网：<http://www.sunstars.cn/> 传感器销售热线：

地址：深圳市福田区福华路福庆街鸿图大厦 1602 室

电话：0755-83607652 83376489 83376549 83370250 83370251 82500323

传真：0755-83376182 (0) 13902971329 MSN: [SUNS888@hotmail.com](mailto:SUNS888@hotmail.com)

邮编：518033 E-mail: [szss20@163.com](mailto:szss20@163.com) QQ: 195847376

深圳赛格展销部：深圳华强北路赛格电子市场 2583 号 电话：0755-83665529 25059422

技术支持：0755-83394033 13501568376

欢迎索取免费详细资料、设计指南和光盘；产品凡多，未能尽录，欢迎来电查询。

北京分公司：北京海淀区知春路 132 号中发电子大厦 3097 号

TEL: 010-81159046 82615020 13501189838 FAX: 010-62543996

上海分公司：上海市北京东路 668 号上海赛格电子市场 D125 号

TEL: 021-28311762 56703037 13701955389 FAX: 021-56703037

西安分公司：西安高新开发区 20 所(中国电子科技集团导航技术研究所)

西安劳动南路 88 号电子商城二楼 D23 号

TEL: 029-81022619 13072977981 FAX:029-88789382