

概述

MAX4210/MAX4211是低成本、低功耗、高边功率/电流监视器，提供与负载功率成正比的模拟输出电压，负载功率用负载电流乘以源电压计算。MAX4210/MAX4211利用高边电流检测放大器来测量负载电流，由于不影响负载的接地通路，特别适合电池供电系统。

MAX4210是简单的小尺寸、6引脚功率监视器，专为电路板空间受限的应用而设计。MAX4210A/B/C内部集成了25:1的电阻分压网络，可以减少元件数目。MAX4210D/E/F使用外部电阻分压网络，提供更强设计灵活性。

MAX4211是功能完整的电流与功率监视器。该器件集成了高边电流检测放大器、1.21V带隙基准、两个带漏极开路输出的比较器，可以对功率过大、过流与/或过压条件进行监视。漏极开路输出可以与28V的高压连接，适用于电路断路器应用中高边开关的驱动。

MAX4210/MAX4211电流检测放大器具有三种不同的增益选项：16.67V/V、25.00V/V与40.96V/V。MAX4210提供3mm x 3mm的6引脚TDFN封装与8引脚 μ MAX[®]封装，MAX4211采用4mm x 4mm的16引脚薄型QFN封装与16引脚TSSOP封装。这些器件都工作在-40°C至+85°C扩展级温度范围。

应用

过功率电路断路器
智能电池组/充电器
智能外设控制器
短路保护
电源显示
测量仪表
基带模拟乘法器
VGA电路
功率电平检测器

μ MAX是Maxim Integrated Products, Inc.的注册商标。

引脚配置与选型指南在数据资料的最后给出。

特性

- ◆ 电流与功率实时监视
- ◆ $\pm 1.5\%$ (最大值) 电流检测精度
- ◆ $\pm 1.5\%$ (最大值) 功率检测精度
- ◆ 两个独立的比较器 (MAX4211)
- ◆ 1.21V基准输出 (MAX4211)
- ◆ 三种电流/功率增益选项
- ◆ 100mV/150mV电流检测满量程电压
- ◆ 输入源电压范围：+4V至+28V
- ◆ 电源电压范围：+2.7V至+5.5V
- ◆ 低电源电流：380 μ A (MAX4210)
- ◆ 220kHz带宽
- ◆ 小尺寸、6引脚TDFN与8引脚 μ MAX封装 (MAX4210)

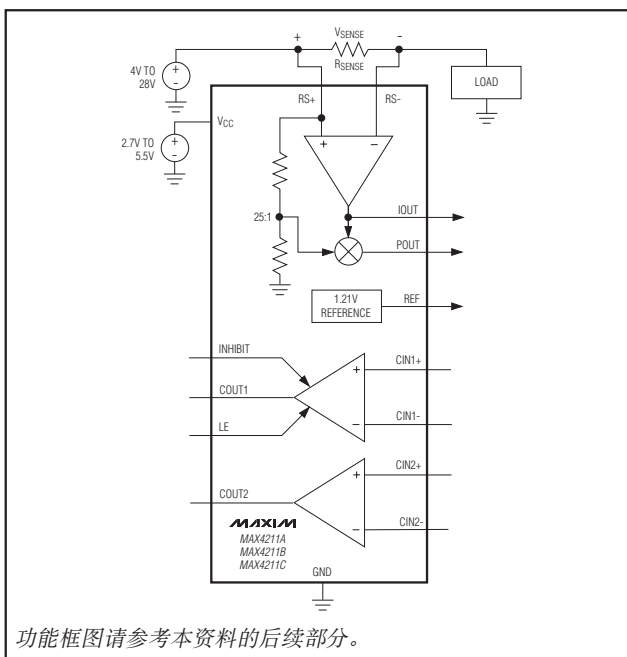
订购信息

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4210AETT-T	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHF
MAX4210AEUA	-40°C to +85°C	8 μ MAX	—

*EP = 裸焊盘。

订购信息在数据资料的最后有进一步说明。

功能框图



功能框图请参考本资料的后续部分。

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ABSOLUTE MAXIMUM RATINGS

V_{CC} , IN, CIN1, CIN2 to GND-0.3V to +6V
 $RS+$, $RS-$, INHIBIT, LE, COUT1, COUT2 to GND ...-0.3V to +30V
 IOUT, POUT, REF to GND-0.3V to ($V_{CC} + 0.3V$)
 Differential Input Voltage ($V_{RS+} - V_{RS-}$) $\pm 5V$
 Maximum Current into Any Pin..... $\pm 10mA$
 Output Short-Circuit Duration to V_{CC} or GND10s
 Continuous Power Dissipation ($T_A = +70^\circ C$)
 6-Pin TDFN (derate 24.4mW/ $^\circ C$ above +70 $^\circ C$)1951mW

8-Pin μMAX (derate 4.5mW/ $^\circ C$ above +70 $^\circ C$)362mW
 16-Pin TSSOP (derate 9.4mW/ $^\circ C$ above +70 $^\circ C$)754mW
 16-Pin Thin QFN (derate 25mW/ $^\circ C$ above +70 $^\circ C$)2000mW
 Operating Temperature Range-40 $^\circ C$ to +85 $^\circ C$
 Junction Temperature+150 $^\circ C$
 Storage Temperature Range-65 $^\circ C$ to +150 $^\circ C$
 Lead Temperature (soldering, 10s)+300 $^\circ C$

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

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^\circ C$ to +85 $^\circ C$, unless otherwise noted. Typical values are at $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Voltage Range (Note 2)	V_{CC}			2.7		5.5	V
Common-Mode Input Range (Note 3)	V_{CMR}	Measured at $RS+$		4		28	V
Supply Current	I_{CC}	$T_A = +25^\circ C$, $V_{CC} = +5.5V$	MAX4210		380	570	μA
			MAX4211		670	960	
		$V_{CC} = +5.5V$	MAX4210			670	
			MAX4211			1100	
Input Bias Current	I_{RS+}	$V_{SENSE} = 0mV$	MAX421_A/B/C		14	25	μA
			MAX421_D/E/F		3	8	
	I_{RS-}				3	8	
IN Input Bias Current	I_{IN}	MAX421_D/E/F			-0.1	-1	μA
Leakage Current	I_{RS+} , I_{RS-}	$V_{CC} = 0V$			0.1	1	μA
V_{SENSE} Full-Scale Voltage (Note 4)	V_{SENSE_FS}	MAX421_A/B/D/E		150			mV
		MAX421_C/F		100			
IN Full-Scale Voltage (Note 4)	V_{IN_FS}	MAX421_D/E/F, $V_{SENSE} = 10mV$ to 100mV		1			V
IN Input Voltage Range (Note 5)	V_{IN}	MAX421_D/E/F, $V_{SENSE} = 10mV$ to 100mV		0.16		1.10	V
V_{RS+} Full-Scale Voltage (Note 4)		MAX421_A/B/C, $V_{SENSE} = 10mV$ to 100mV		25			V
V_{RS+} Input Voltage Range (Note 5)	V_{RS+}	MAX421_A/B/C, $V_{SENSE} = 10mV$ to 100mV		4		28	V
Minimum IOUT/POUT Voltage	V_{OUT_MIN}	$V_{SENSE} = 0V$, $V_{RS+} = 25V$	Current into IOUT = 10 μA		1.5		mV
			Current into IOUT = 100 μA		2.5	80	
			Current into POUT = 10 μA		1.5		
			Current into POUT = 100 μA		2.5	80	
Maximum IOUT/POUT Voltage (Note 6)	V_{OUT_MAX}	$V_{SENSE} = 300mV$, $V_{RS+} = 25V$	Current out of IOUT = 500 μA			$V_{CC} - 0.25$	V
			Current out of POUT = 500 μA			$V_{CC} - 0.25$	

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Current-Sense Amplifier Gain	V_{IOUT}/V_{SENSE}	MAX4211A/D		16.67		V/V
		MAX4211B/E		25.00		
		MAX4211C/F		40.96		
Power-Sense Amplifier Gain	$V_{POUT}/(V_{SENSE} \times V_{RS+})$	MAX421_A		0.667		1/V
		MAX421_B		1.00		
		MAX421_C		1.64		
	$V_{POUT}/(V_{SENSE} \times V_{IN})$	MAX421_D		16.67		
		MAX421_E		25.00		
		MAX421_F		40.96		
IOUT Common-Mode Rejection	CMRI	MAX4211, $V_{RS+} = 4V$ to $28V$	60	80		dB
POUT Common-Mode Rejection	CMRP	MAX421_D/E/F, $V_{RS+} = 4V$ to $28V$	60	80		dB
IOUT Power-Supply Rejection	PSRI	$V_{CC} = 2.7V$ to $5.5V$	52	80		dB
POUT Power-Supply Rejection	PSRP	$V_{CC} = 2.7V$ to $5.5V$	52	70		dB
Output Resistance for POUT, IOUT, REF	R_{OUT}			0.5		Ω
IOUT -3dB Bandwidth	$BW_{IOUT/SENSE}$	$V_{SENSE} = 100mV$, V_{SENSE} AC source		220		kHz
POUT -3dB Bandwidth	$BW_{POUT/SENSE}$	$V_{SENSE} = 100mV$, V_{SENSE} AC source		220		kHz
	$BW_{POUT/MIN}$	$V_{SENSE} = 100mV$, V_{IN} AC source, MAX421_D/E/F		500		
	$BW_{POUT/RS+}$	$V_{SENSE} = 100mV$, V_{RS+} AC source, MAX421_A/B/C		250		
Capacitive-Load Stability (POUT, IOUT, REF)	C_{LOAD}	No sustained oscillations		450		pF
Current Output (IOUT) Settling Time to 1% of Final Value		MAX4211	$V_{SENSE} = 10mV$ to $100mV$	15		μs
			$V_{SENSE} = 100mV$ to $10mV$	15		
Power Output (POUT) Settling Time to 1% of Final Value		MAX421_A/B/C	$V_{SENSE} = 10mV$ to $100mV$	10		μs
			$V_{SENSE} = 100mV$ to $10mV$	10		
			$V_{RS+} = 4V$ to $25V$, $V_{SENSE} = 100mV$	15		
		$V_{RS+} = 25V$ to $4V$, $V_{SENSE} = 100mV$	15			
		MAX421_D/E/F	$V_{SENSE} = 10mV$ to $100mV$	10		
			$V_{SENSE} = 100mV$ to $10mV$	10		
	$V_{IN} = 160mV$ to $1V$, $V_{SENSE} = 100mV$		10			
	$V_{IN} = 1V$ to $160mV$, $V_{SENSE} = 100mV$		10			

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power-Up Time to 1% of Current Output Final Value		$V_{SENSE} = 100mV$, $C_{LOAD} = 10pF$, MAX4211		100		μs
Power-Up Time to 1% of Power Output Final Value		$V_{SENSE} = 100mV$, $C_{LOAD} = 10pF$		100		μs
Saturation Recovery Time for Current Out (Note 7)		$C_{LOAD} = 10pF$, $V_{SENSE} = -100mV$ to $+100mV$		35		μs
		$C_{LOAD} = 10pF$, $V_{SENSE} = 1.5V$ to $100mV$		35		
Saturation Recovery Time for Power Out (Note 7)		$V_{CC} = 5V$, $V_{RS+} = 10V$, $C_{LOAD} = 10pF$, $V_{SENSE} = -100mV$ to $+100mV$		25		μs
		$V_{CC} = 5V$, $V_{RS+} = 10V$, $C_{LOAD} = 10pF$, $V_{SENSE} = 1.5V$ to $100mV$		25		
Reference Voltage	V_{REF}	$I_{REF} = 0$ to $100\mu A$, $T_A = +25^{\circ}C$	1.20	1.21	1.22	V
		$I_{REF} = 0$ to $100\mu A$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$	1.19		1.23	
Comparator Input Offset		Common-mode voltage = REF		± 0.5	± 5	mV
Comparator Hysteresis				5		mV
Comparator Common-Mode Low		Functional test		0.1		V
Comparator Common-Mode High		Functional test		$V_{CC} - 1.15$		V
Comparator Input Bias Current	I_{BIAS}			-2		nA
Comparator Output Low Voltage	V_{OL}	$I_{SINK} = 1mA$		0.2	0.6	V
Comparator Output-High Leakage Current (Note 8)		$V_{PULLUP} = 28V$			1	μA
LE Logic Input-High Voltage Threshold	V_{IH}		$0.67 \times V_{CC}$			V
LE Logic Input-Low Voltage Threshold	V_{IL}				$0.33 \times V_{CC}$	V
LE Logic Input Internal Pulldown Current			0.68	1	2.20	μA
INHIBIT Logic Input-High Voltage Threshold			1.3			V
INHIBIT Logic Input-Low Voltage Threshold					0.5	V
INHIBIT Logic Input Hysteresis				0.6		V
INHIBIT Logic Input Internal Pulldown Current			0.68	1	2.20	μA

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Comparator Propagation Delay	t_{PD+} , t_{PD-}	$C_{LOAD} = 10pF$, $R_{LOAD} = 10k\Omega$ pullup to V_{CC} , 5mV overdrive		4		μs
Minimum INHIBIT Pulse Width				1		μs
Minimum LE Pulse Width				1		μs
Comparator Power-Up Blanking Time From V_{CC}	t_{ON}	V_{CC} from 0 to (2.7V to 5.5V)		300		μs
LATCH Setup Time	t_{SETUP}			3		μs
MAX4210A/MAX4211A (power gain = 0.667)						
POUT Gain Accuracy (Note 9)	$\frac{\Delta V_{POUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	
	$\frac{\Delta V_{POUT}}{\Delta V_{RS+}}$	$V_{SENSE} = 100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	
Total POUT Output Error (Note 10)	$\frac{\Delta V_{POUT_MAX}}{FSO}$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5	% FSO*
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	
	$\frac{\Delta V_{POUT_MAX}}{V_{POUT}}$	$V_{SENSE} = 150mV$, $V_{RS+} \geq 15V$	$T_A = +25^{\circ}C$	± 0.2	± 1.5	%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	
			$V_{SENSE} = 100mV$, $V_{RS+} \geq 4V$		± 2.5	
			$V_{SENSE} = 100mV$, $V_{RS+} \geq 9V$		± 1.2	
			$V_{SENSE} = 50mV$, $V_{RS+} \geq 6V$		± 1.8	
$V_{SENSE} = 25mV$, $V_{RS+} \geq 15V$		± 1.8				
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	1.5	5	mV
			$T_A = T_{MIN}$ to T_{MAX}		15	
MAX4210B/MAX4211B (power gain = 1.00)						
POUT Gain Accuracy (Note 9)	$\frac{\Delta V_{POUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	
	$\frac{\Delta V_{POUT}}{\Delta V_{RS+}}$	$V_{SENSE} = 100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0	

*FSO refers to full-scale output under the conditions: $V_{SENSE} = 100mV$, $V_{RS+} = +25V$, or $V_{IN} = 1V$.

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Total POUT Output Error (Note 10)	$\Delta V_{POUT_MAX}/FSO$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5	% FSO*	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT_MAX}/V_{POUT}$	$V_{SENSE} = 150mV$, $V_{RS+} > 15V$	$T_A = +25^{\circ}C$	± 0.2	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
			$V_{SENSE} = 100mV$, $V_{RS+} > 4V$		± 2.5		
			$V_{SENSE} = 100mV$, $V_{RS+} > 9V$		± 1.2		
		$V_{SENSE} = 50mV$, $V_{RS+} > 6V$		± 1.8			
		$V_{SENSE} = 25mV$, $V_{RS+} > 15V$		± 1.8			
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	2	6.5	mV	
			$T_A = T_{MIN}$ to T_{MAX}		20		
MAX4210C/MAX4211C (power gain = 1.64)							
POUT Gain Accuracy (Note 9)	$\Delta V_{POUT}/\Delta V_{SENSE}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT}/\Delta V_{RS+}$	$V_{SENSE} = 100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
Total POUT Output Error (Note 10)	$\Delta V_{POUT_MAX}/FSO$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 5V$ to $25V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5	% FSO*	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT_MAX}/V_{POUT}$	$V_{SENSE} = 100mV$, $V_{RS+} \geq 4V$		± 2.5	%		
			$V_{SENSE} = 100mV$, $V_{RS+} \geq 9V$	± 1.2			
			$V_{SENSE} = 50mV$, $V_{RS+} \geq 6V$	± 1.8			
		$V_{SENSE} = 25mV$, $V_{RS+} \geq 15V$	± 1.8				
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	3	10	mV	
			$T_A = T_{MIN}$ to T_{MAX}		30		
MAX4210D/MAX4211D (power gain = 16.67)							
POUT Gain Accuracy (Note 9)	$\Delta V_{POUT}/\Delta V_{SENSE}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT}/\Delta V_{IN}$	$V_{SENSE} = 100mV$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		

*FSO refers to full-scale output under the conditions: $V_{SENSE} = 100mV$, $V_{RS+} = +25V$, or $V_{IN} = 1V$.

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Total POUT Output Error (Note 10)	$\Delta V_{POUT_MAX}/FSO$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 25V$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5	% FSO*	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT_MAX}/V_{POUT}$	$V_{SENSE} = 150mV$, $V_{RS+} = 25V$, $V_{IN} = 600mV$	$T_A = +25^{\circ}C$	± 0.2	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
			$V_{SENSE} = 100mV$, $V_{RS+} = 15V$, $V_{IN} \geq 160mV$		± 2.5		
			$V_{SENSE} = 100mV$, $V_{RS+} = 15V$, $V_{IN} \geq 360mV$		± 1.2		
		$V_{SENSE} = 50mV$, $V_{RS+} = 15V$, $V_{IN} \geq 240mV$		± 1.8			
		$V_{SENSE} = 25mV$, $V_{RS+} = 15V$, $V_{IN} \geq 600mV$		± 1.8			
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	1.5	5	mV	
			$T_A = T_{MIN}$ to T_{MAX}		15		
MAX4210E/MAX4211E (power gain = 25.00)							
POUT Gain Accuracy (Note 9)	$\Delta V_{POUT}/\Delta V_{SENSE}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT}/\Delta V_{IN}$	$V_{SENSE} = 100mV$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
Total POUT Output Error (Note 10)	$\Delta V_{POUT_MAX}/FSO$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 25V$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5	% FSO*	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\Delta V_{POUT_MAX}/V_{POUT}$	$V_{SENSE} = 150mV$, $V_{RS+} = 25V$, $V_{IN} = 600mV$	$T_A = +25^{\circ}C$	± 0.2	± 1.5	%	
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
			$V_{SENSE} = 100mV$, $V_{RS+} = 15V$, $V_{IN} \geq 160mV$		± 2.5		
			$V_{SENSE} = 100mV$, $V_{RS+} = 15V$, $V_{IN} \geq 360mV$		± 1.2		
		$V_{SENSE} = 50mV$, $V_{RS+} = 15V$, $V_{IN} \geq 240mV$		± 1.8			
		$V_{SENSE} = 25mV$, $V_{RS+} = 15V$, $V_{IN} \geq 600mV$		± 1.8			
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	2	6.5	mV	
			$T_A = T_{MIN}$ to T_{MAX}		20		

*FSO refers to full-scale output under the conditions: $V_{SENSE} = 100mV$, $V_{RS+} = +25V$, or $V_{IN} = 1V$.

高边功率、电流监视器

MAX4210/MAX4211

ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
MAX4210F/MAX4211F (power gain = 40.96)							
POUT Gain Accuracy (Note 9)	$\frac{\Delta V_{POUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 10mV$ to $100mV$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\frac{\Delta V_{POUT}}{\Delta V_{IN}}$	$V_{SENSE} = 100mV$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
Total POUT Output Error (Note 10)	$\frac{\Delta V_{POUT_MAX}}{FSO}$	$V_{SENSE} = 5mV$ to $100mV$, $V_{RS+} = 25V$, $V_{IN} = 0.2V$ to $1V$	$T_A = +25^{\circ}C$	± 0.15	± 1.5		% FSO*
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\frac{\Delta V_{POUT_MAX}}{V_{POUT}}$	$V_{SENSE} = 100mV$, $V_{RS+} = 15V$, $V_{IN} \geq 160mV$	$T_A = +25^{\circ}C$	± 2.5		%	
			$T_A = T_{MIN}$ to T_{MAX}				± 1.2
	$V_{SENSE} = 50mV$, $V_{RS+} = 15V$, $V_{IN} \geq 240mV$		± 1.8				
	$V_{SENSE} = 25mV$, $V_{RS+} = 15V$, $V_{IN} \geq 600mV$		± 1.8				
POUT Output Offset Voltage (Note 11)		$V_{SENSE} = 0V$, $V_{RS+} = 25V$, $V_{IN} = 1V$	$T_A = +25^{\circ}C$	3	10		mV
			$T_A = T_{MIN}$ to T_{MAX}		30		
MAX4211A/MAX4211D (current gain = 16.67)							
IOUT Gain Accuracy	$\frac{\Delta V_{IOUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 20mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
Total IOUT Output Error (Note 10)	$\frac{\Delta V_{IOUT_MAX}}{FSO}$	$V_{SENSE} = 5mV$ to $100mV$	$T_A = +25^{\circ}C$	± 0.15	± 1.5		% FSO*
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
	$\frac{\Delta V_{IOUT_MAX}}{V_{IOUT}}$	$V_{SENSE} = 150mV$	$T_A = +25^{\circ}C$	± 0.2	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}		± 3.0		
$V_{SENSE} = 50mV$				± 1.2			
	$V_{SENSE} = 25mV$		± 1.8				
	$V_{SENSE} = 5mV$		± 20				

*FSO refers to full-scale output under the conditions: $V_{SENSE} = 100mV$, $V_{RS+} = +25V$, or $V_{IN} = 1V$.

高边功率、电流监视器

MAX4210/MAX4211

ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 5mV$, $V_{IN} = 1.0V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = GND$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
MAX4211B/MAX4211E (current gain = 25.00)							
IOUT Gain Accuracy	$\frac{\Delta V_{IOUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 20mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
Total IOUT Output Error (Note 10)	$\frac{\Delta V_{IOUT_MAX}}{FSO}$	$V_{SENSE} = 5mV$ to $100mV$	$T_A = +25^{\circ}C$	± 0.15	± 1.5		% FSO*
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
	$\frac{\Delta V_{IOUT_MAX}}{V_{IOUT}}$	$V_{SENSE} = 150mV$	$T_A = +25^{\circ}C$	± 0.2	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
			$V_{SENSE} = 50mV$			± 1.2	
$V_{SENSE} = 25mV$			± 1.8				
$V_{SENSE} = 5mV$			± 20				
MAX4211C/MAX4211F (current gain = 40.96)							
IOUT Gain Accuracy	$\frac{\Delta V_{IOUT}}{\Delta V_{SENSE}}$	$V_{SENSE} = 20mV$ to $100mV$, $V_{RS+} = 25V$	$T_A = +25^{\circ}C$	± 0.5	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
Total IOUT Output Error (Note 10)	$\frac{\Delta V_{IOUT_MAX}}{FSO}$	$V_{SENSE} = 5mV$ to $100mV$	$T_A = +25^{\circ}C$	± 0.15	± 1.5		% FSO*
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
	$\frac{\Delta V_{IOUT_MAX}}{V_{IOUT}}$	$V_{SENSE} = 100mV$	$T_A = +25^{\circ}C$	± 0.2	± 1.5		%
			$T_A = T_{MIN}$ to T_{MAX}			± 3.0	
			$V_{SENSE} = 50mV$			± 1.2	
$V_{SENSE} = 25mV$			± 1.8				
$V_{SENSE} = 5mV$			± 20				

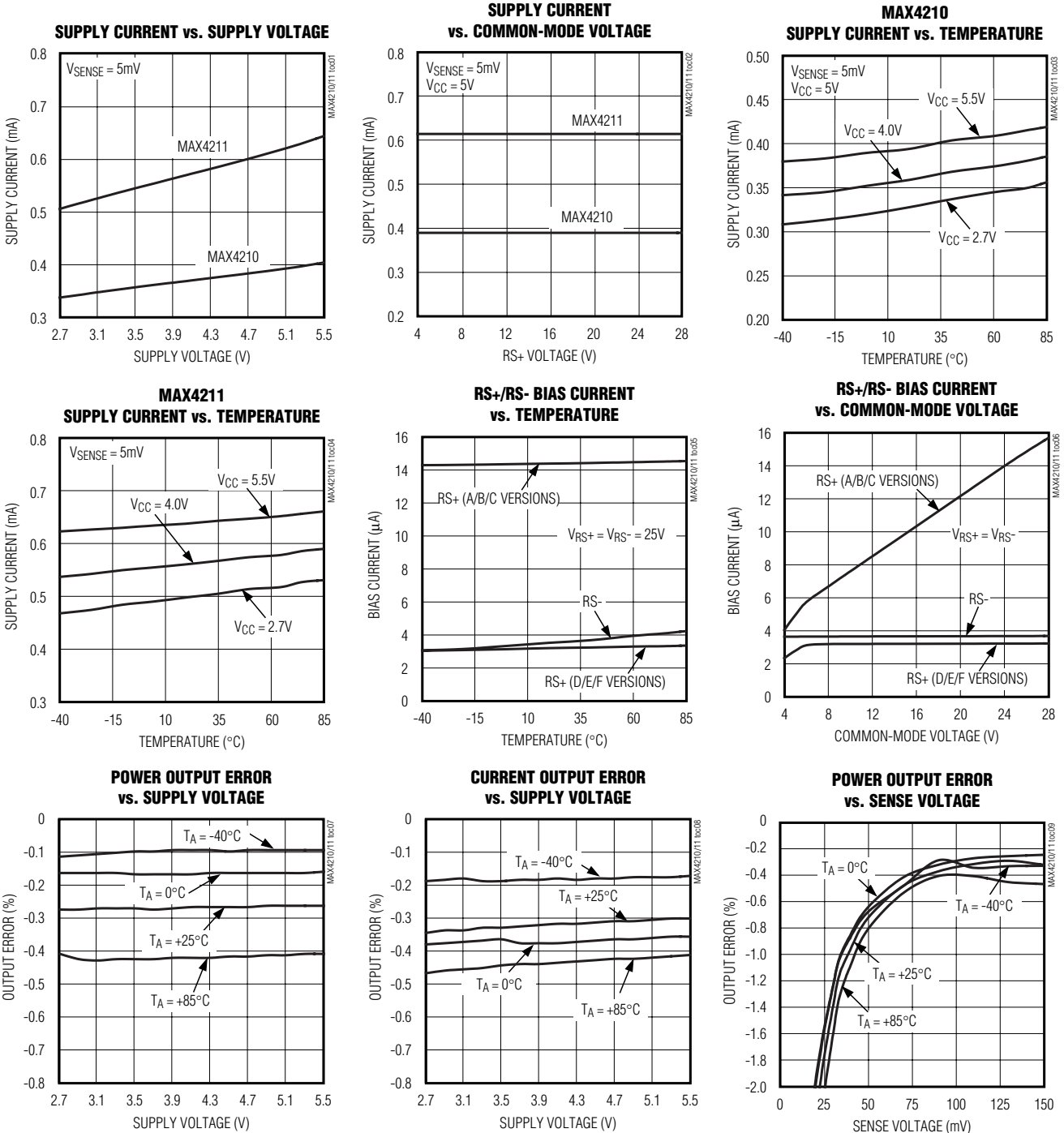
*FSO refers to full-scale output under the conditions: $V_{SENSE} = 100mV$, $V_{RS+} = +25V$, or $V_{IN} = 1V$.

- Note 1:** All devices are 100% production tested at $T_A = +25^{\circ}C$. All temperature limits are guaranteed by design.
- Note 2:** Guaranteed by power-supply rejection test.
- Note 3:** Guaranteed by output voltage error tests (IOUT).
- Note 4:** Guaranteed by output voltage error tests (IOUT or POUT, or both).
- Note 5:** IN Input Voltage Range (MAX421_D/E/F) and V_{RS+} Input Voltage Range (MAX421_A/B/C) are guaranteed by design (GBD) and not production tested. See Multiplier Transfer Characteristics graphs in the *Typical Operating Characteristics*.
- Note 6:** This test does not apply to the low gain options, MAX421_A/D, because OUT is clamped at approximately 4V.
- Note 7:** The device does not experience phase reversal when overdriven.
- Note 8:** V_{PULLUP} is defined as an externally applied voltage through a resistor, R_{PULLUP} , to pull up the comparator output.
- Note 9:** POUT gain accuracy is the sum of gain error and multiplier nonlinearity.
- Note 10:** Total output voltage error is the sum of gain and offset voltage errors.
- Note 11:** POUT Output Offset Voltage is the sum of offset and multiplier feedthrough.

高边功率、电流监视器

典型工作特性

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)



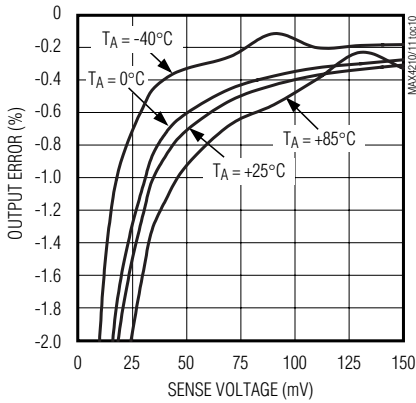
高边功率、电流监视器

典型工作特性 (续)

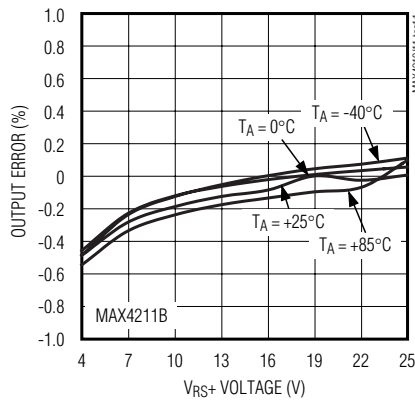
($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)

MAX4210/MAX4211

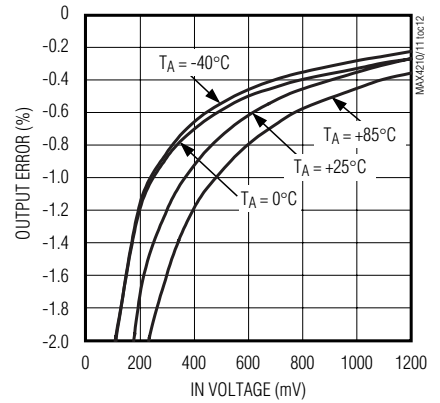
CURRENT OUTPUT ERROR vs. SENSE VOLTAGE



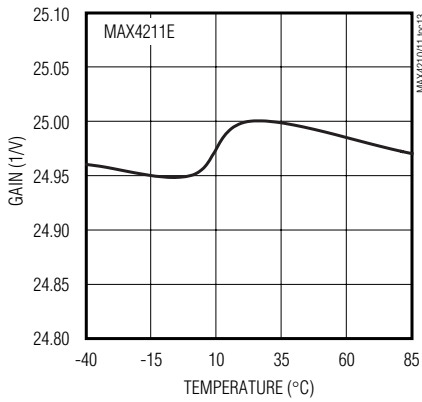
POWER OUTPUT ERROR vs. V_{RS+}



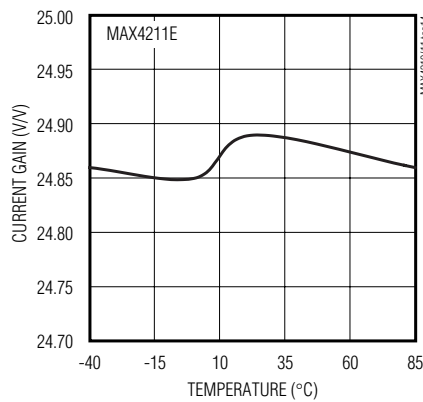
POWER OUTPUT ERROR vs. IN VOLTAGE



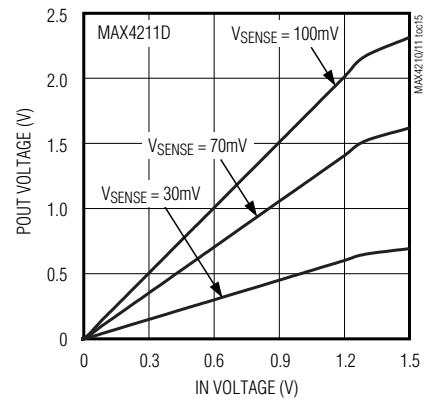
POWER GAIN vs. TEMPERATURE



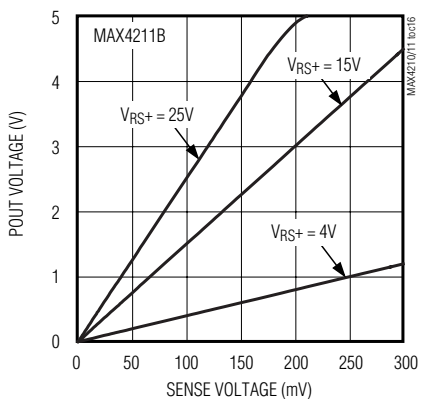
CURRENT GAIN vs. TEMPERATURE



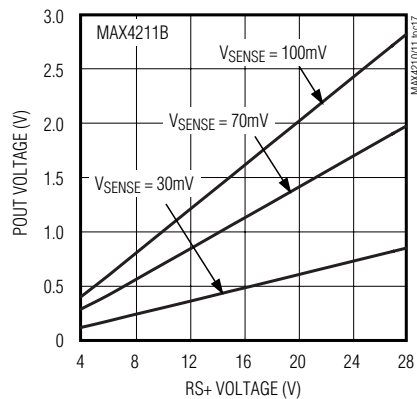
MULTIPLIER TRANSFER CHARACTERISTICS



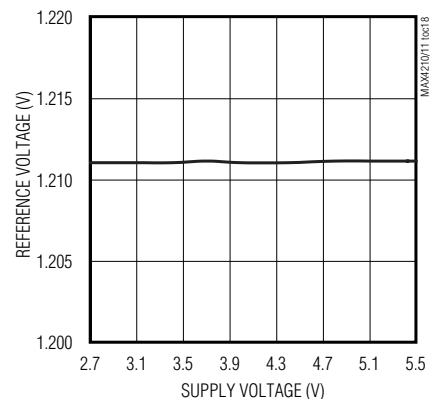
MULTIPLIER TRANSFER CHARACTERISTICS



MULTIPLIER TRANSFER CHARACTERISTICS



REFERENCE VOLTAGE vs. SUPPLY VOLTAGE

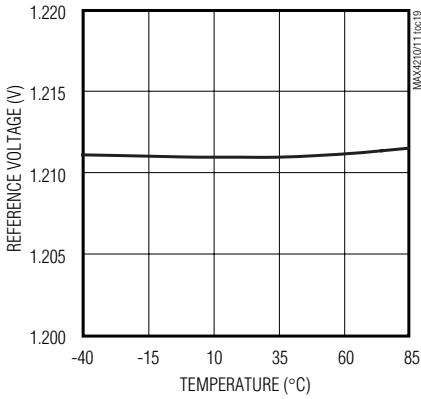


高边功率、电流监视器

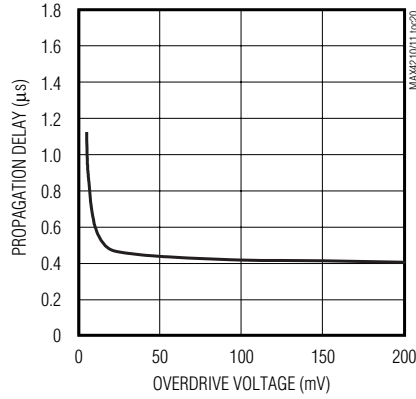
典型工作特性 (续)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)

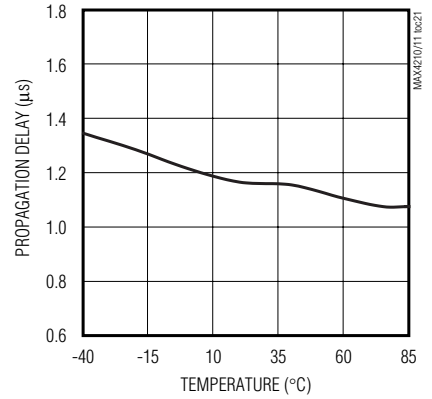
REFERENCE VOLTAGE vs. TEMPERATURE



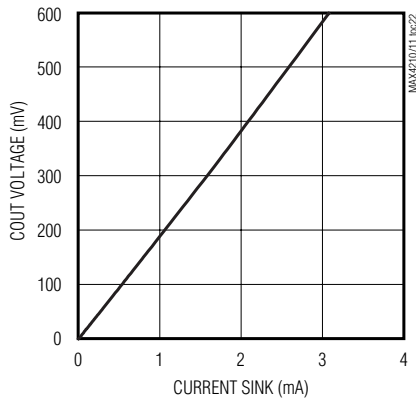
COMPARATOR PROPAGATION DELAY vs. OVERDRIVE VOLTAGE



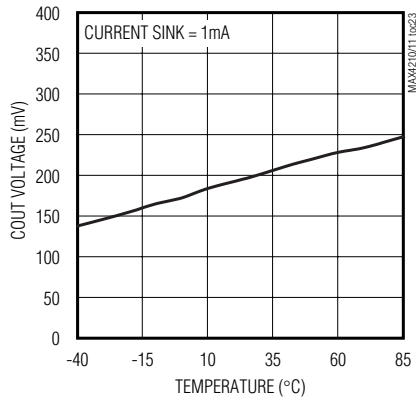
COMPARATOR PROPAGATION DELAY vs. TEMPERATURE



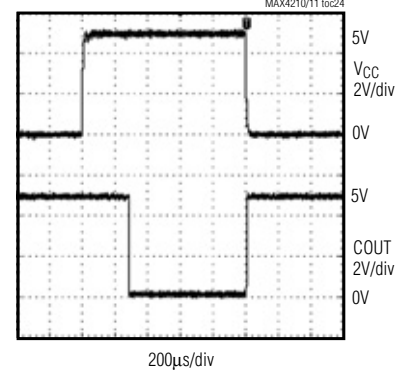
COMPARATOR OUTPUT VOLTAGE (V_{OL}) vs. CURRENT SINK



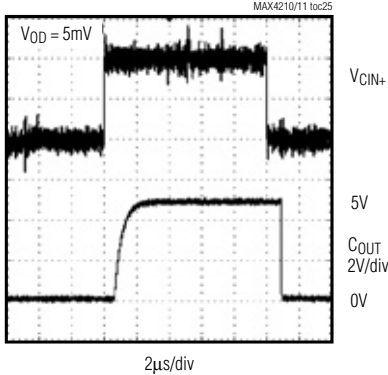
COMPARATOR OUTPUT VOLTAGE (V_{OL}) vs. TEMPERATURE



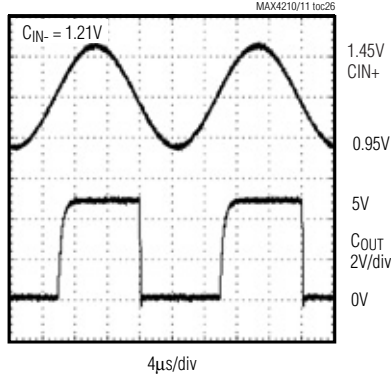
COMPARATOR POWER-UP DELAY



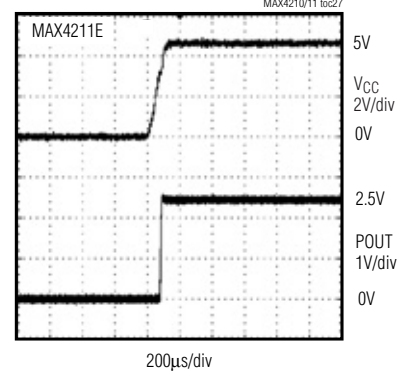
COMPARATOR PROPAGATION DELAY



COMPARATOR AC RESPONSE



POUT POWER-UP DELAY

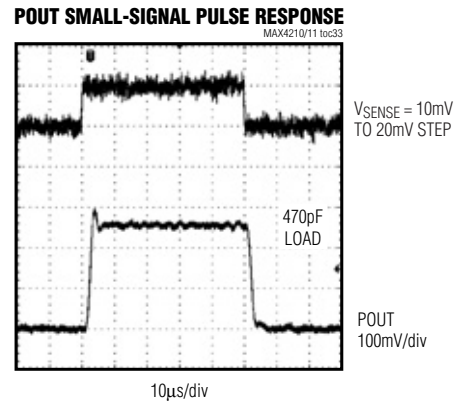
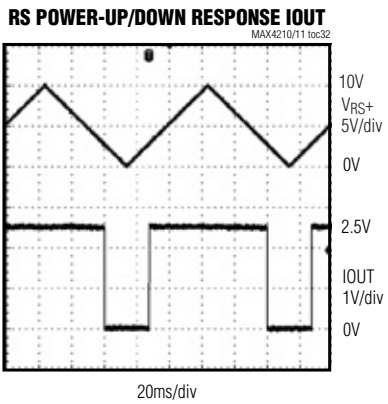
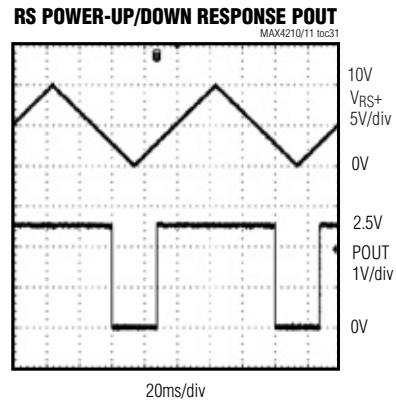
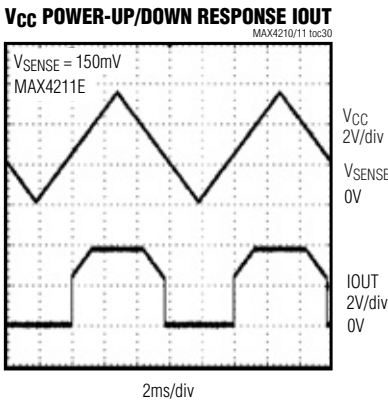
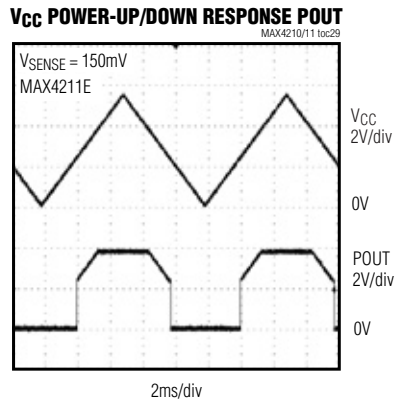
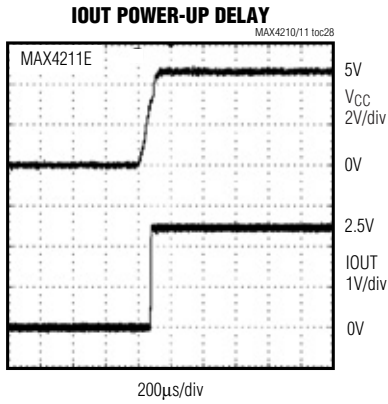


高边功率、电流监视器

典型工作特性 (续)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)

MAX4210/MAX4211

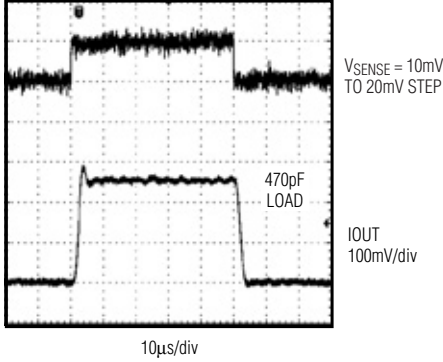


高边功率、电流监视器

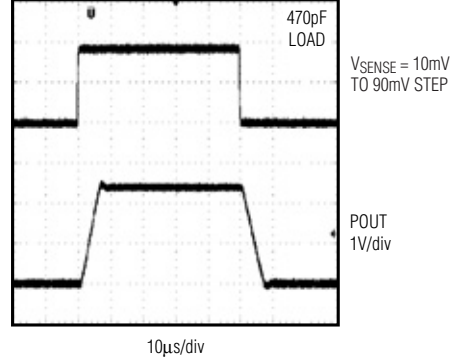
典型工作特性 (续)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)

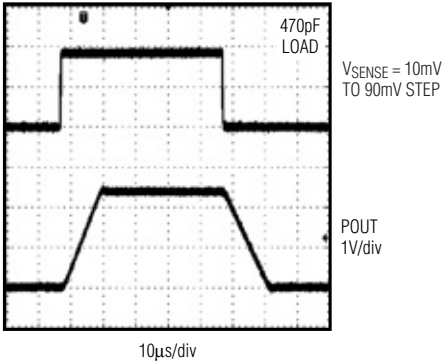
IOUT SMALL-SIGNAL PULSE RESPONSE
MAX4210/11 ttc34



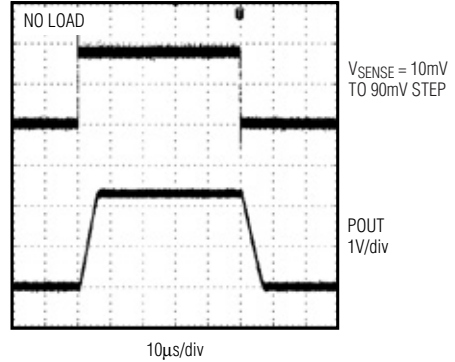
POUT LARGE-SIGNAL PULSE RESPONSE
MAX4210/11 ttc35



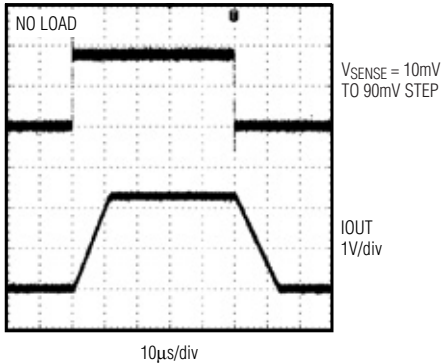
IOUT LARGE-SIGNAL PULSE RESPONSE
MAX4210/11 ttc36



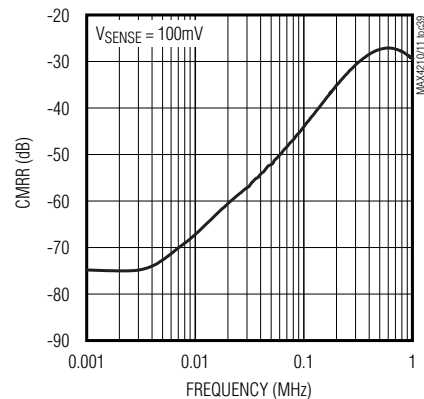
POUT SLEW-RATE PULSE RESPONSE
MAX4210/11 ttc37



IOUT SLEW-RATE PULSE RESPONSE
MAX4210/11 ttc38



POUT COMMON-MODE REJECTION RATIO vs. FREQUENCY

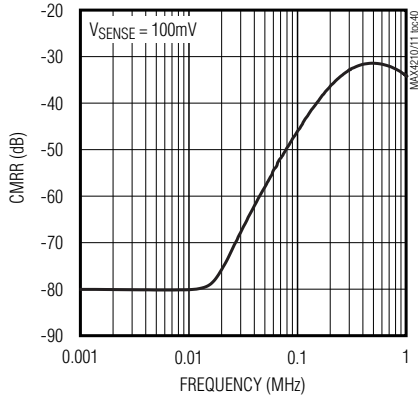


高边功率、电流监视器

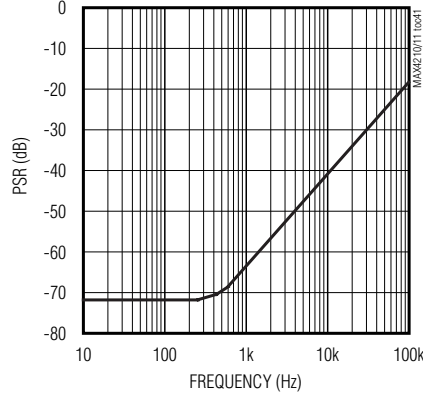
典型工作特性 (续)

($V_{CC} = 5.0V$, $V_{RS+} = 25V$, $V_{SENSE} = 100mV$, $V_{IN} = 1V$, $V_{LE} = 0V$, $R_{IOUT} = R_{POUT} = 1M\Omega$, $V_{CIN1+} = V_{CIN2+} = V_{REF}$, $V_{CIN1-} = V_{CIN2-} = 0V$, $V_{INHIBIT} = 0V$, $R_{COUT1} = R_{COUT2} = 5k\Omega$ connected to V_{CC} , $T_A = +25^\circ C$, unless otherwise noted.)

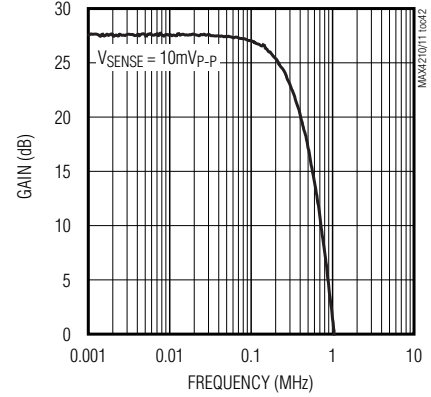
IOUT COMMON-MODE REJECTION RATIO vs. FREQUENCY



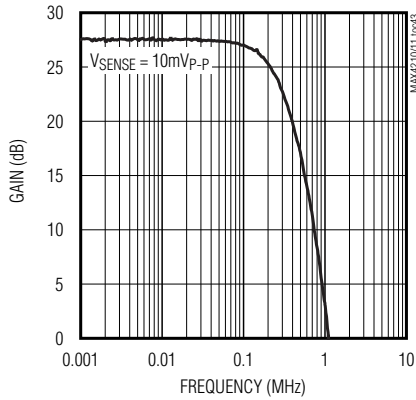
POWER-SUPPLY REJECTION vs. FREQUENCY



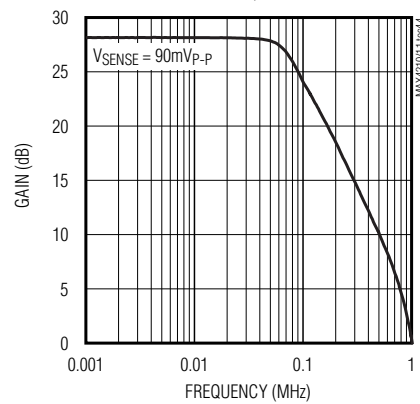
POUT SMALL-SIGNAL GAIN vs. FREQUENCY



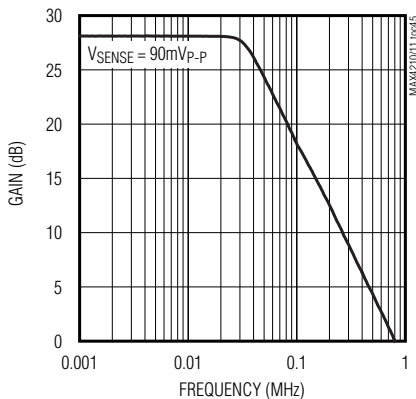
IOUT SMALL-SIGNAL GAIN vs. FREQUENCY



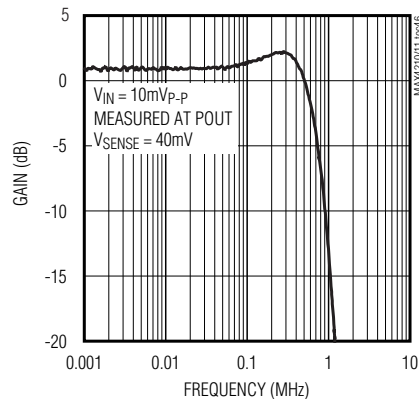
POUT LARGE-SIGNAL GAIN vs. FREQUENCY



IOUT LARGE-SIGNAL GAIN vs. FREQUENCY



IN SMALL-SIGNAL GAIN vs. FREQUENCY



MAX4210/MAX4211

高边功率、电流监视器

MAX4210A/B/C 引脚说明

引脚		名称	功能
6 TDFN	8 μ MAX		
1	1	GND	地。
2	2, 3, 6	N.C.	不连接。内部未连接。
3	4	V _{CC}	电源电压。V _{CC} 与GND之间连接一个0.1 μ F旁路电容。
4	5	RS+	接源电压，并与外部检流电阻和内部电阻分压器相连。
5	7	RS-	与外部检流电阻的负载端连接。
6	8	POUT	功率检测输出电压。电压输出与源功率(输入电压乘以负载电流)成正比。
EP	—	EP*	裸焊盘。EP内部连接至GND。

* 仅对 TDFN 封装。

MAX4210D/E/F 引脚说明

引脚		名称	功能
6 TDFN	8 μ MAX		
1	1	GND	地。
2	2	IN	乘法器输入电压。电压输入用于内部乘法器。
3	4	V _{CC}	电源电压。V _{CC} 与GND之间连接一个0.1 μ F旁路电容。
4	5	RS+	接源电压和外部检流电阻。
5	7	RS-	与外部检流电阻的负载端连接。
6	8	POUT	功率检测输出电压。电压输出与源功率(输入电压乘以负载电流)成正比。
EP	—	EP*	裸焊盘。EP内部连接至GND。
—	3, 6	N.C.	不连接。内部未连接。

* 仅对 TDFN 封装。

高边功率、电流监视器

MAX4211A/B/C 引脚说明

MAX4210/MAX4211

引脚		名称	功能
16 薄型 QFN	16 TSSOP		
1	3	V _{CC}	电源电压。V _{CC} 与GND之间连接一个0.1μF旁路电容。
2	4	N.C.	不连接。内部未连接。
3	5	LE	比较器1的锁存使能端。驱动至逻辑低电平使比较器处于透明模式(标准比较器)。驱动至逻辑高电平锁存输出。
4	6	COU1	比较器1开漏极输出。LE与INHIBIT控制比较器1输出。
5	7	INHIBIT	INHIBIT用于比较器1输出控制。驱动至逻辑高电平禁止比较器工作。驱动至逻辑低电平进入正常工作模式。
6	8	COU2	比较器2开漏极输出。
7	9	GND	地。
8	10	CIN2+	比较器2同相输入。
9	11	CIN2-	比较器2反相输入。
10	12	CIN1+	比较器1同相输入。
11	13	CIN1-	比较器1反相输入。
12	14	REF	1.21V内部基准输出。
13	15	POUT	功率检测输出电压。电压输出与源功率(输入电压乘以负载电流)成正比。
14	16	IOUT	电流检测输出电压。电压输出与V _{SENSE} (V _{RS+} - V _{RS-})，负载电流成正比。
15	1	RS-	与外部检流电阻的负载端连接。
16	2	RS+	接源电压，并与外部检流电阻和内部电阻分压器相连。
EP	—	EP*	裸焊盘。EP内部连接至GND。

* 仅对薄型QFN封装。

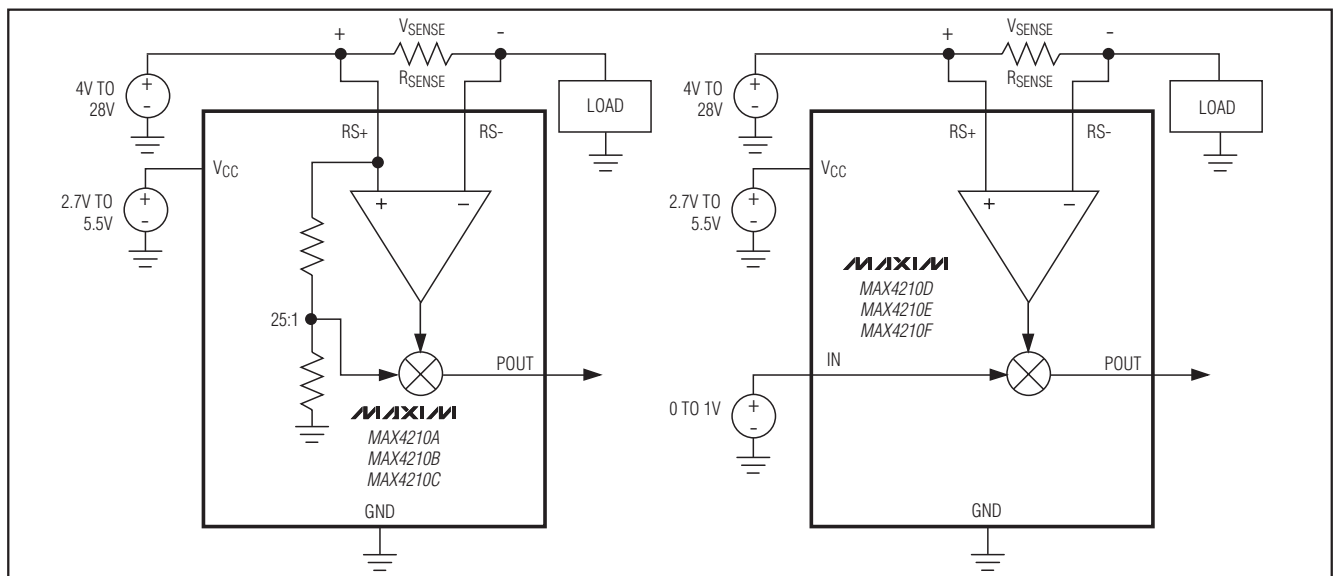
高边功率、电流监视器

MAX4211D/E/F 引脚说明

引脚		名称	功能
16 薄型 QFN	16 TSSOP		
1	3	V _{CC}	电源电压。V _{CC} 与GND之间连接一个0.1μF旁路电容。
2	4	IN	乘法器输入电压。电压输入用于内部乘法器。
3	5	LE	比较器1的锁存使能端。驱动至逻辑低电平使比较器处于透明模式(标准比较器)。驱动至逻辑高电平锁存输出。
4	6	COU1	比较器1开漏极输出。其输出由LE与INHIBIT共同控制。
5	7	INHIBIT	INHIBIT用于比较器1输出控制。驱动至逻辑高电平禁止比较器工作。驱动至逻辑低电平进入正常工作模式。
6	8	COU2	比较器2开漏极输出。
7	9	GND	地。
8	10	CIN2+	比较器2同相输入。
9	11	CIN2-	比较器2反相输入。
10	12	CIN1+	比较器1同相输入。
11	13	CIN1-	比较器1反相输入。
12	14	REF	1.21V内部基准输出。
13	15	POUT	功率检测输出电压。电压输出与源功率(输入电压乘以负载电流)成正比。
14	16	IOUT	电流检测输出电压。电压输出与V _{SENSE} (V _{RS+} - V _{RS-})，负载电流成正比。
15	1	RS-	与外部检流电阻的负载端连接。
16	2	RS+	接源电压和外部检流电阻。
EP	—	EP*	裸焊盘。EP内部连接至GND。

* 仅对薄型QFN封装。

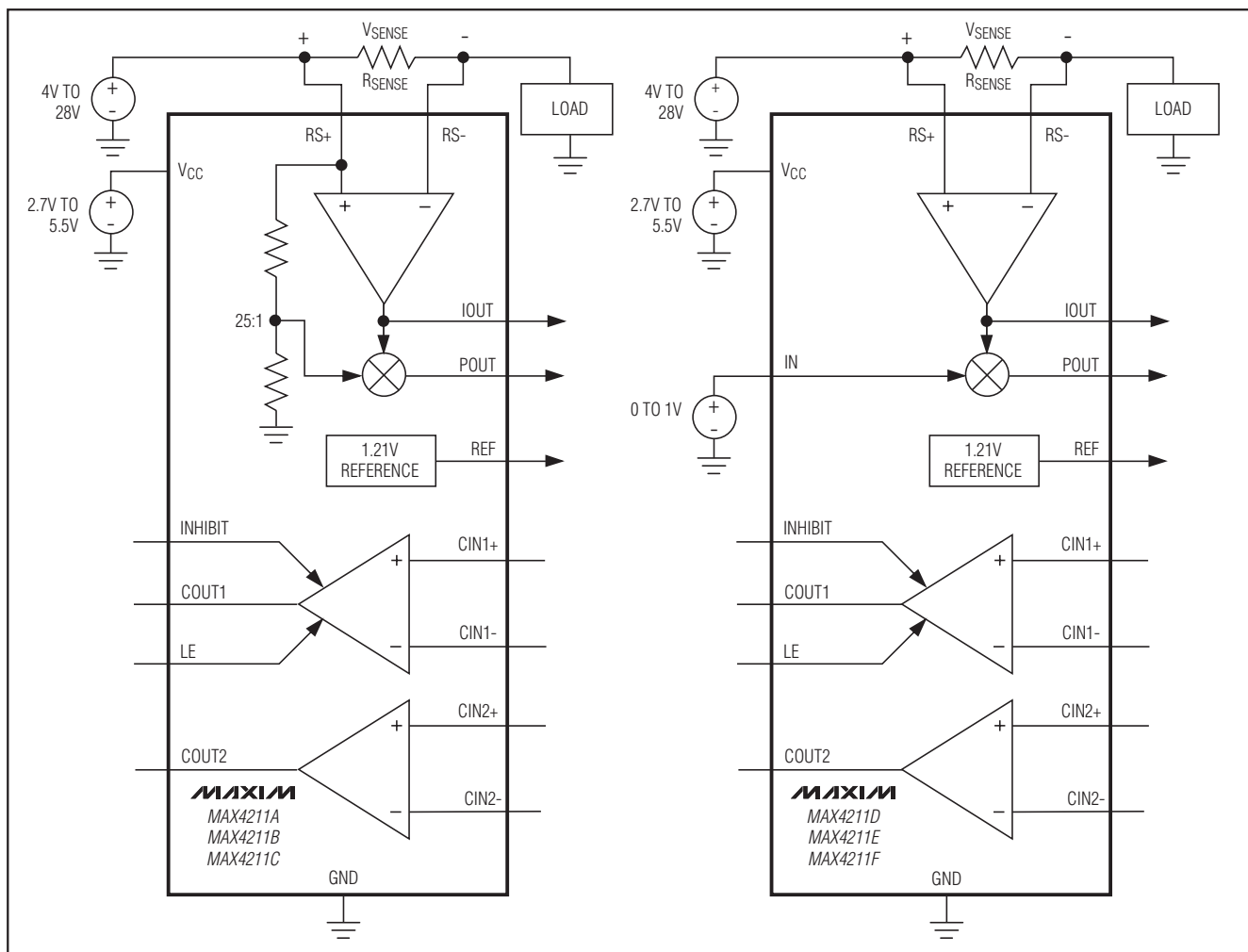
功能框图



高边功率、电流监视器

功能框图 (续)

MAX4210/MAX4211



详细说明

MAX4210/MAX4211 系列电流和功率监视 IC 集成了精密的电流检测放大器和模拟乘法器，用于实现变化的电流和功率测量。MAX4211 集成了额外的 1.21V 基准源和两个具有开漏极输出的比较器。利用这些功能可设计出监视功率过大、过流、过压或者任何故障条件组合的检测电路。MAX4210/MAX4211 提供不同的增益、封装和配置，从而可实现更强的设计灵活性，使总成本更低。

这些器件使用其内部的高边电流检测放大器来监视负载电流，并在 IOUT 端提供正比于该电流的模拟电压输出

(MAX4211)。该电压加至模拟乘法器，使负载电流与源电压相乘，并在 POUT 端获得正比于负载功率的电压。

电流检测放大器

所集成的电流检测放大器为差分放大器，用于放大 RS+ 和 RS- 两端的电压。检流电阻 R_{SENSE} 跨接在 RS+ 和 RS-。当负载电流流经 R_{SENSE} 时，其两端产生压差。该电压被放大，并且与负载电流成正比。该电压同时加至模拟乘法器，用于功率检测应用 (参考模拟乘法器部分)。电流检测放大器提供三种不同的增益选项：16.67V/V、25.0V/V 与 40.96V/V (见表 1)。

高边功率、电流监视器

共模电压范围从+4V至+28V，并且与电源电压无关。正因如此，该器件工作在典型值介于2.7V至5.5V的较低系统电压时仍然可以监视高电压源的输出电流。

MAX4211具有电流检测放大器输出。IOUT端的电压正比于V_{SENSE}电压：

$$V_{IOUT} = A_{VIOUT} \times V_{SENSE}$$

式中，V_{SENSE}为RS+与RS-两端的电压，A_{VIOUT}为表1所给出的器件的放大器增益值。

模拟乘法器

MAX4210/MAX4211集成了模拟乘法器，可实时监视负载功率。正比于负载电流的电压加到乘法器的一个输入端，正比于源电压的电压加到另一端。模拟乘法器将两个电压相乘，即可获得正比于负载功率的输出电压。该模拟乘法器仅设计工作于正象限，也就是说，输入和输出总是正电压。

对于MAX4210D/E/F和MAX4211D/E/F，其模拟乘法器在IN端的满量程输入大约为1V。这个独立的乘法器输入端，配合外部分压器时可提供更强设计灵活性。对于MAX4210A/B/C和MAX4211A/B/C，集成的分压器以标称值为25的分压比来分压RS+引脚的源电压，并且将分压后的电压送至乘法器。因此，RS+引脚的满量程输入电压为25V。集成并经过微调的电阻分压器减少了外部元件数并降低了成本。

POUT的电压输出正比于输出功率：

对于MAX4210A/B/C和MAX4211A/B/C：

$$V_{POUT} = A_{VPOUT} \times V_{SENSE} \times V_{RS+}$$

表1. MAX4211电流检测放大器增益和满量程检测电压

PART	CURRENT-SENSE AMPLIFIER GAIN (A _{VIOUT} , V/V)	FULL-SCALE SENSE VOLTAGE (mV)
MAX4211A/D	16.67	150
MAX4211B/E	25.00	150
MAX4211C/F	40.96	100

对于MAX4210D/E/F和MAX4211D/E/F：

$$V_{POUT} = A_{VPOUT} \times V_{SENSE} \times V_{IN}$$

式中，V_{SENSE}为RS+与RS-两端的电压，A_{VPOUT}为表2所给出的器件的放大器增益值。

内部比较器 (MAX4211)

MAX4211具有两个独立的开漏极输出比较器。比较器可以配置为在负载电流或者功耗达到设定门限时进行翻转。比较器还可以配置为具有“线或”输出的窗口比较器。比较器1 (COUT1)具有锁存使能 (LE)和禁止 (INHIBIT)输入控制。当LE为低电平时，比较器为透明模式 (其功能与非锁存的标准比较器相同)。当LE为高电平时，比较器输出 (COUT1)锁存。INHIBIT输入为高电平时，比较器会挂起，并且将输出锁存为当前状态。INHIBIT的功能与LE类似，只是具有不同的输入门限和更宽的滞回。INHIBIT的逻辑高门限为1.21V，逻辑低门限为0.6V，并具有0.6V的滞回。INHIBIT在快速RS+瞬变期间可以避免比较器产生错误的输出。INHIBIT通常由连接至RS+的RC网络来触发 (见应用信息)。两个比较器在上电时都具有内置的300μs屏蔽周期，以防止错误输出。比较器输出为开漏极，可以上拉至V_{CC}、RS+或者任何低于+28V的电压。LE和INHIBIT由内部1μA电流源拉低。

表2. MAX4210/MAX4211功率检测放大器增益和满量程检测电压

PART	POWER-SENSE AMPLIFIER GAIN (A _{VPOUT} , 1/V)	FULL-SCALE SENSE VOLTAGE (mV)
MAX4210A	0.667	150
MAX4210B	1.000	150
MAX4210C	1.640	100
MAX4210D	16.670	150
MAX4210E	25.000	150
MAX4210F	40.960	100
MAX4211A	0.667	150
MAX4211B	1.000	150
MAX4211C	1.640	100
MAX4211D	16.670	150
MAX4211E	25.000	150
MAX4211F	40.960	100

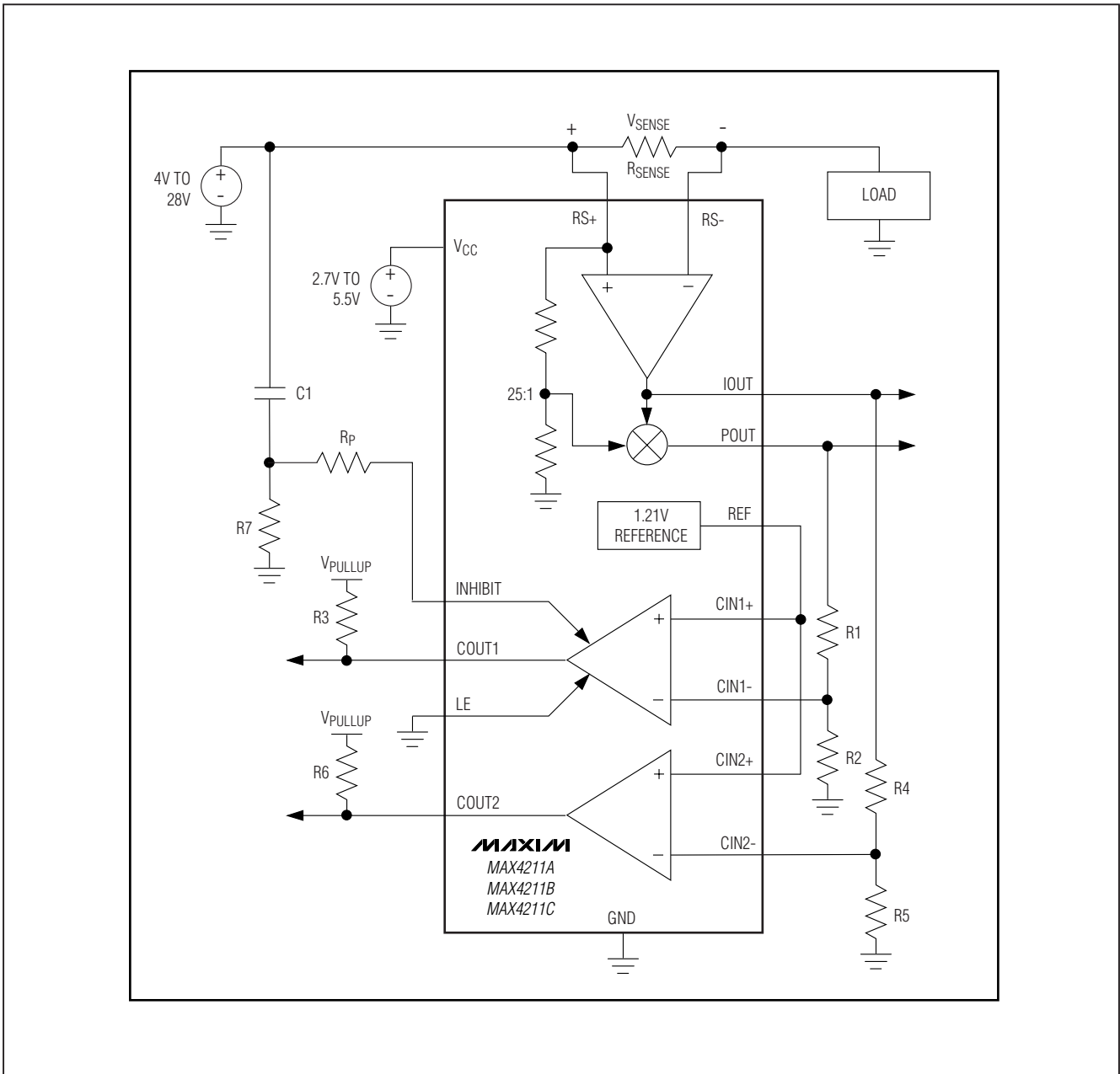
高边功率、电流监视器

内部基准 (MAX4211)

MAX4211 具有 1.21V 带隙基准输出，在整个输入电压和温度范围内保持稳定。典型情况下，将基准输出连接至

比较器的一个输入上，以作为比较基准电压。如果需要较低的基准电压，可以采用外部分压器。该基准可以供出或者吸收最高 100 μ A 的负载电流。

典型工作电路



MAX42110/MAX42111

高边功率、电流监视器

应用信息

推荐元件值

理想情况下，最大负载电流在检流电阻两端产生满量程检测电压。选择所需的增益型号，以获得最大的电流检测放大器输出电压，且不会使其饱和。典型的高边饱和电压大约为 $V_{CC} - 0.25V$ 。电流检测放大器输出电压由如下公式计算：

$$V_{IOUT} = V_{SENSE} \times A_{VIOUT}$$

式中， V_{IOUT} 为加到模拟乘法器或者在 $IOUT$ 端的电压。 V_{SENSE} 为检测电压。 A_{VIOUT} 为器件的电流检测放大器增益，如表 1 所示。计算 R_{SENSE} 的最大值，使 $RS+$ 和 $RS-$ 两端的差分电压不超出满量程检测电压：

$$R_{SENSE} = \frac{V_{SENSE(FULL-SCALE)}}{I_{LOAD(FULL-SCALE)}}$$

尽可能选择高阻值的电阻以使 V_{SENSE} 最大，从而使总输出误差最小。在监视大电流的应用中，应确保 R_{SENSE} 能够消耗其自身的 I^2R 功耗。如果超出了电阻的功率耗散能力，那么其阻值会漂移或者完全坏掉，这会使得两引线端的差分电压超过极限参数。应使用专门用于电流检测的电阻。

窗口比较器

在一些应用中，需要对电流或者功率过小（开路故障），以及电流或者功率过大（短路故障）进行监视。此时，窗口比较器是必须的。图 1 给出了用于窗口检测的简要电路。将 P_{OVER} 设置为对应所需的最大负载电流，以在 $COUT2$ 产生低状态，并且将 P_{UNDER} 设置为对应所需的最低负载功率，以在 $COUT1$ 产生高状态：

$$P_{UNDER(WATTS)} = \frac{V_{REF}}{A_{VPOUT} \times R_{SENSE}} \left(\frac{R1 + R2}{R2} \right)$$

$$P_{OVER(WATTS)} = \frac{V_{REF}}{A_{VPOUT} \times R_{SENSE}} \left(\frac{R4 + R5}{R5} \right)$$

式中， A_{VPOUT} 为表 2 所给出的功率检测放大器增益， V_{REF} 为内部基准电压 (1.2V，典型值)。当电流在电流窗口以内时，比较器输出结果为高，而电流在窗口之外时输出为低。注意将 $COUT1$ 和 $COUT2$ 线或连接在一起。

过功率电路断路器

图 2 所示为电路断路器，当检测到过功率故障时，电路断路器会关断负载电流（同样的电路可以用于检测过电流情况，将与 $POUT$ 连接的 $R1-R2$ 电阻分压器改接至 $IOUT$ 即可）。该电路可有效保护电池不受短路或者过功率情况导致的损害。当检测到功率故障时， $P-MOSFET$ ， $M1$ ，将会关断并且保持关断状态，直到按下手动复位按钮。同时，循环输入功率会使 LE 引脚变为低电平，这不再锁存比较器输出 $OUT1$ 并且复位电路断路器。

在上电过程，或者当负载特性改变时，负载上可能会产生浪涌电流。这种瞬时的浪涌电流会在 $POUT$ 上产生较高的电压。这会使 $CIN+$ 的电压超过 $CIN-$ 的基准电压，这样 $COUT1$ 会拉高并触发电路断路器功能。可以通过将比较器 1 的 $INHIBIT$ 输入高电平来消除这种不必要的动作。加入一个 RC 网络 ($R4$ 和 $C1$) 并接至 $INHIBIT$ ，能够在瞬变期间挂起比较器 1 的工作。这样一来，对于电路断路器功能来说，负载功率的短暂冲击可以忽略掉，而长时间的负载功率过大（或者负载短路）仍旧可以“触发断路器”。

$INHIBIT$ 的逻辑高电平门限典型值为 1.2V，逻辑低电平门限为 0.6V。在上电过程中， $INHIBIT$ 通过 $C1$ 很快超过 1.2V，从而禁止 $COUT1$ 改变状态。始终“禁止”比较器输入，直到 $INHIBIT$ 电压放电至 0.6V。 $R3$ 为限流电阻，典型值为 10k Ω ，可以保护 $INHIBIT$ 输入。由于 $INHIBIT$ 为高阻抗输入， $R3$ 不会影响 $R4-C1$ 充/放电时间。比较器挂起的时间大约为：

$$t_{INHIBIT} = R4 \times C1 \ln \left(\frac{\Delta V}{0.6V} \right)$$

式中， ΔV 为负载的电压改变值。为了提高瞬态抑制性， $t_{INHIBIT}$ 可以根据需要增加，要明确的是断路器功能在此期间将会挂起。

如果比较器未被使用，其输入必须偏置为已知状态。比如，将 $CIN+$ 接至 V_{CC} ， $CIN-$ 接至 GND 。

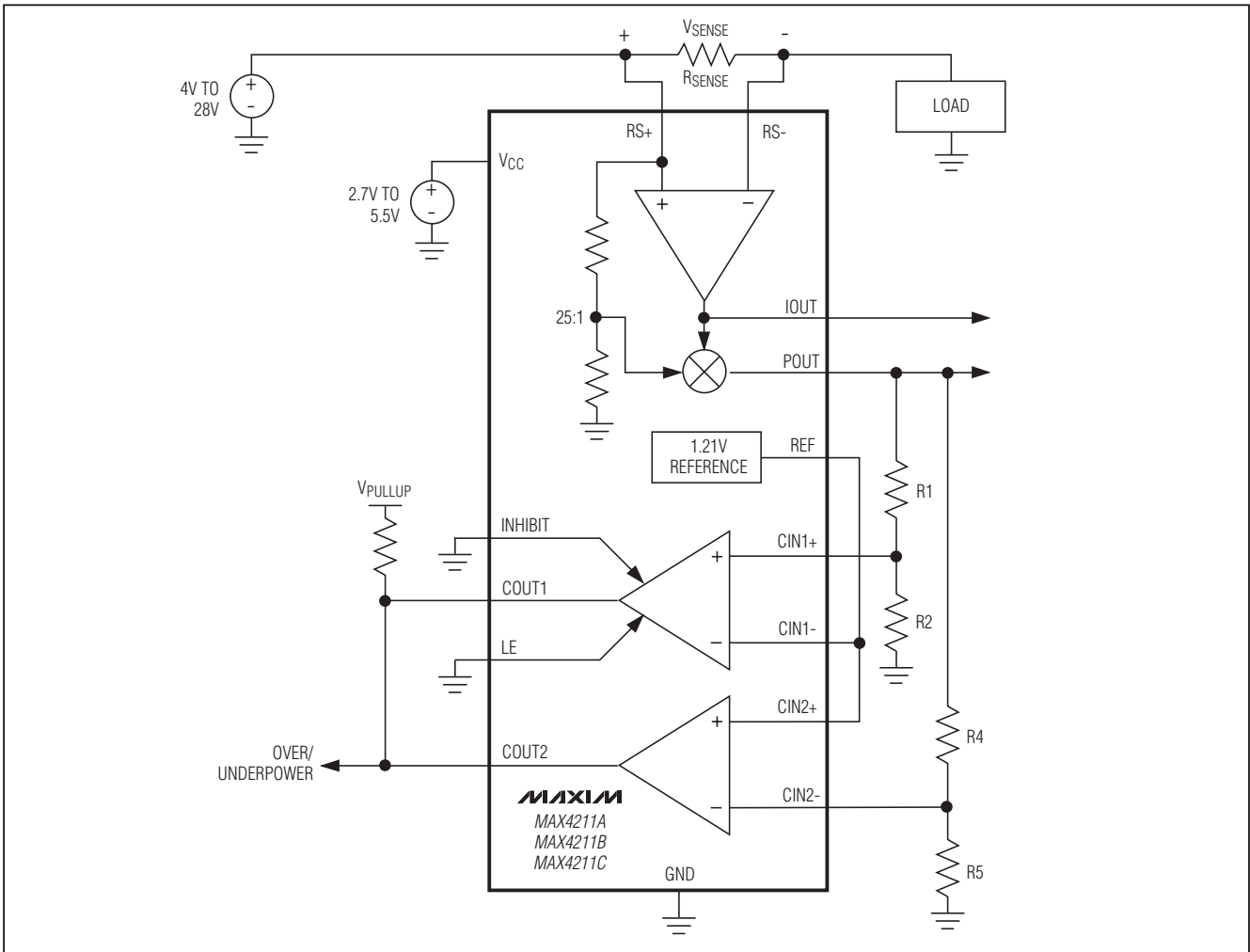


图1. 窗口比较器用于检测功率过小和过大故障 (通过将接到POUT的R1和R4改接至IOUT, 即可以检测欠电流和过电流故障)

可变增益放大器

图3所示为单端输入, 可变增益放大器(VGA)。这种VGA具有超过200kHz的带宽, 非常适合基带处理器中常见的自动增益控制电路。通过在MAX4210D/E/F的IN(V_{GC})引脚加0至1V的电压来控制增益; 0V对应于最小增益, 1V对应于最大增益。

测量负载功率

MAX4210A/B/C和MAX4211A/B/C具有内部分压器电阻, 并连接至RS+和模拟乘法器输入。这种配置可以精确测量电源功率, 并为电源(例如电池)提供保护。要精确测

量负载功率, 使用具有外部电阻分压器的MAX4210D/E/F和MAX4211D/E/F, 分压器直接与负载相连, 如图4所示。这种配置排除了R_{SENSE}消耗的额外功率影响, 从而提高了负载功率的测量精度。

电源旁路

采用一个0.1μF陶瓷电容将V_{CC}旁路至GND, 以实现IC与电源电压瞬变的隔离。为防止高频耦合, 用0.1μF电容旁路RS+或RS-。对于TDFN和薄型QFN封装, 具有不承载任何电流的裸露焊盘, 但是也应该将其连接到地层, 以实现额定的功率耗散。

高边功率、电流监视器

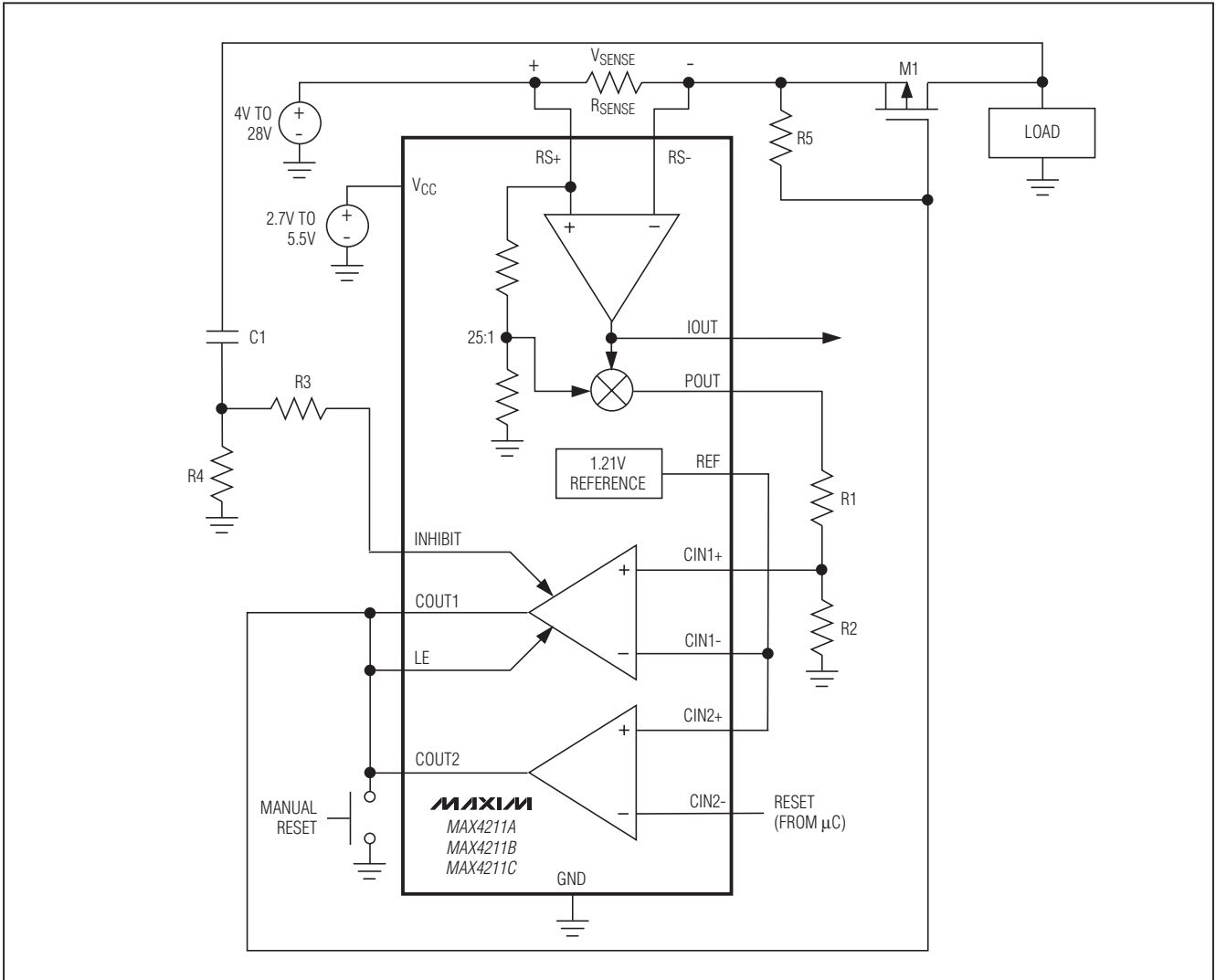


图2. 过功率电路断路器 (详细的示例, 可以参考MAX4211E评估板)

高边功率、电流监视器

MAX4210/MAX4211

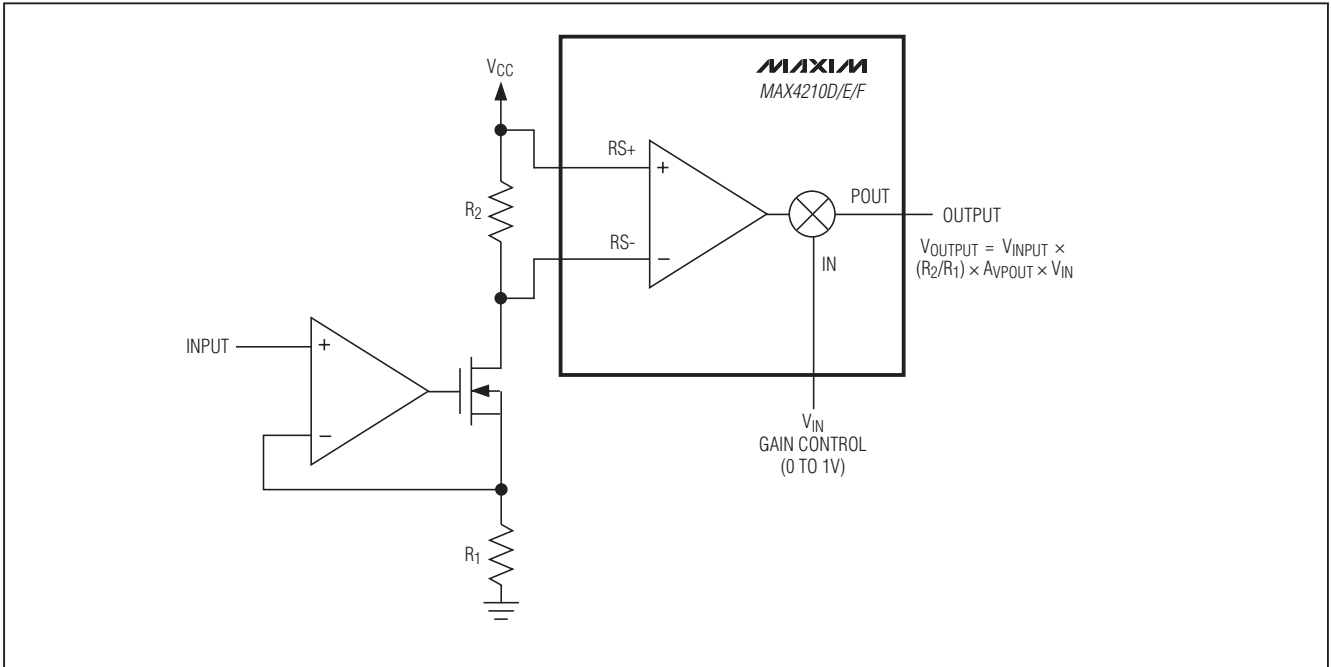


图3. 单端输入，可变增益放大器

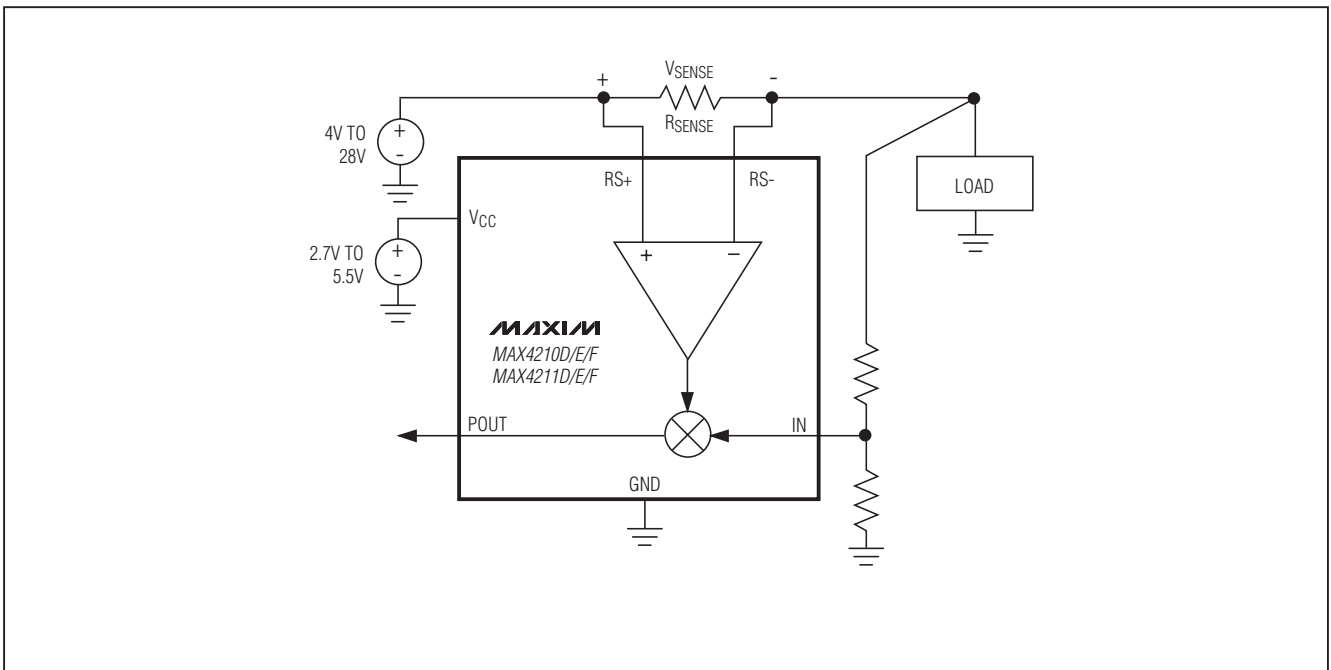


图4. 使用外部分压器实现负载功率测量

高边功率、电流监视器

MAX4210/MAX4211

选型指南

PART	PIN-PACKAGE	CURRENT GAIN (V/V)	POWER GAIN (1/V)	CURRENT/POWER MEASUREMENT OUTPUT	NO. OF COMPARATORS	INTERNAL REFERENCE	VOLTAGE-MULTIPLIER INPUT (INTERNAL RESISTOR-DIVIDER/EXTERNAL INPUT)	FULL-SCALE V _{SENSE} VOLTAGE (mV)
MAX4210AETT	6 TDFN	—	0.667	P	None	N	INT	150
MAX4210AEUA	8 μMAX	—	0.667	P	None	N	INT	150
MAX4210BETT	6 TDFN	—	1.000	P	None	N	INT	150
MAX4210BEUA	8 μMAX	—	1.000	P	None	N	INT	150
MAX4210CETT	6 TDFN	—	1.640	P	None	N	INT	100
MAX4210CEUA	8 μMAX	—	1.640	P	None	N	INT	100
MAX4210DETT	6 TDFN	—	16.670	P	None	N	EXT	150
MAX4210DEUA	8 μMAX	—	16.670	P	None	N	EXT	150
MAX4210EETT	6 TDFN	—	25.000	P	None	N	EXT	150
MAX4210EEUA	8 μMAX	—	25.000	P	None	N	EXT	150
MAX4210FETT	6 TDFN	—	40.960	P	None	N	EXT	100
MAX4210FEUA	8 μMAX	—	40.960	P	None	N	EXT	100
MAX4211AETE	16 Thin QFN	16.67	0.667	C/P	2	Y	INT	150
MAX4211AEUE	16 TSSOP	16.67	0.667	C/P	2	Y	INT	150
MAX4211BETE	16 Thin QFN	25.00	1.000	C/P	2	Y	INT	150
MAX4211BEUE	16 TSSOP	25.00	1.000	C/P	2	Y	INT	150
MAX4211CETE	16 Thin QFN	40.96	1.640	C/P	2	Y	INT	100
MAX4211CEUE	16 TSSOP	40.96	1.640	C/P	2	Y	INT	100
MAX4211DETE	16 Thin QFN	16.67	16.670	C/P	2	Y	EXT	150
MAX4211DEUE	16 TSSOP	16.67	16.670	C/P	2	Y	EXT	150
MAX4211EETE	16 Thin QFN	25.00	25.000	C/P	2	Y	EXT	150
MAX4211EEUE	16 TSSOP	25.00	25.000	C/P	2	Y	EXT	150
MAX4211FETE	16 Thin QFN	40.96	40.960	C/P	2	Y	EXT	100
MAX4211FEUE	16 TSSOP	40.96	40.960	C/P	2	Y	EXT	100

C = 提供电流测量输出 (IOUT)

P = 提供功率测量输出 (POUT)

Y = 是

N = 否

INT = 内部电阻分压器

EXT = 外部输入引脚

高边功率、电流监视器

订购信息 (续)

芯片信息

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4210BETT	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHG
MAX4210BEUA	-40°C to +85°C	8 μ MAX	—
MAX4210CETT	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHH
MAX4210CEUA	-40°C to +85°C	8 μ MAX	—
MAX4210DETT	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHI
MAX4210DEUA	-40°C to +85°C	8 μ MAX	—
MAX4210EETT	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHJ
MAX4210EEUA	-40°C to +85°C	8 μ MAX	—
MAX4210FETT	-40°C to +85°C	6 TDFN-6-EP* (3mm x 3mm)	AHK
MAX4210FEUA	-40°C to +85°C	8 μ MAX	—
MAX4211AETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211AEUE	-40°C to +85°C	16 TSSOP	—
MAX4211BETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211BEUE	-40°C to +85°C	16 TSSOP	—
MAX4211CETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211CEUE	-40°C to +85°C	16 TSSOP	—
MAX4211DETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211DEUE	-40°C to +85°C	16 TSSOP	—
MAX4211EETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211EEUE	-40°C to +85°C	16 TSSOP	—
MAX4211FETE	-40°C to +85°C	16 Thin QFN-EP* (4mm x 4mm)	—
MAX4211FEUE	-40°C to +85°C	16 TSSOP	—

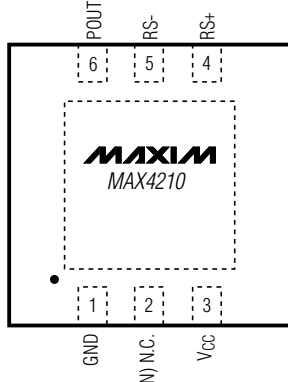
*EP = 裸焊盘。

MAX4210 TRANSISTOR COUNT: 515
MAX4211 TRANSISTOR COUNT: 1032
PROCESS: BiCMOS

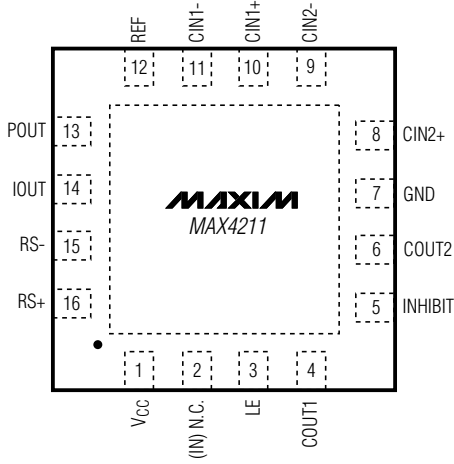
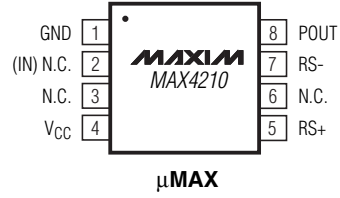
MAX4210/MAX4211

高边功率、电流监视器

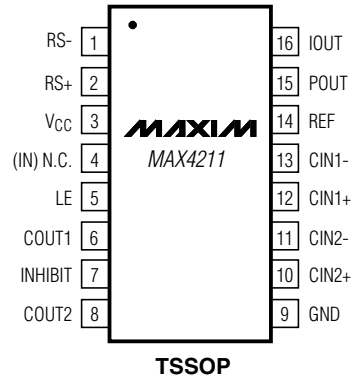
TOP VIEW



3mm x 3mm TDFN



4mm x 4mm THIN QFN



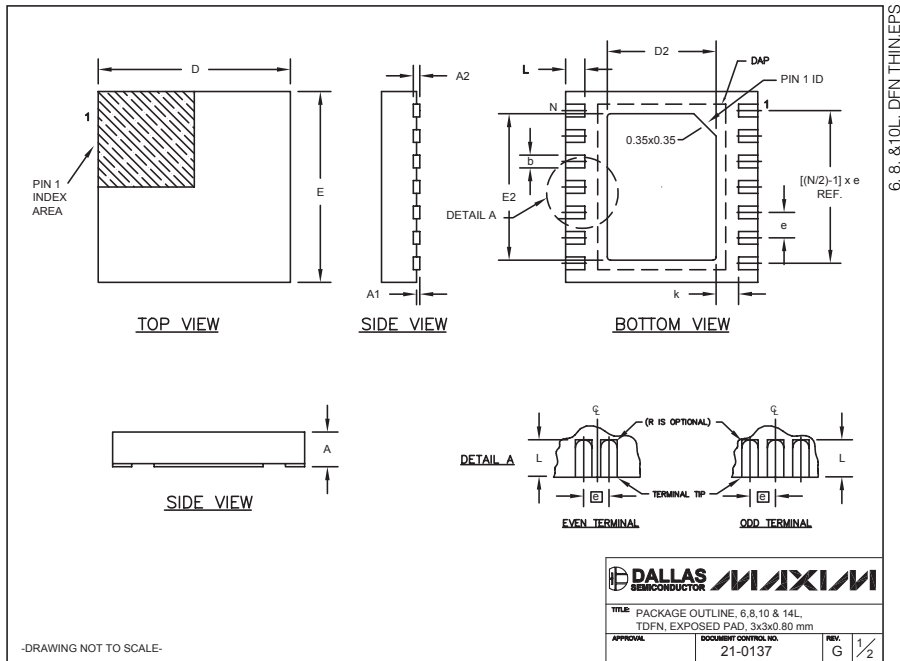
() ARE FOR MAX421_D/E/F.

高边功率、电流监视器

封装信息

(本数据资料提供的封装图可能不是最近的规格, 如需最近的封装外型信息, 请查询 www.maxim-ic.com.cn/packages。)

MAX4210/MAX4211



COMMON DIMENSIONS							
SYMBOL	MIN.	MAX.					
A	0.70	0.80					
D	2.90	3.10					
E	2.90	3.10					
A1	0.00	0.05					
L	0.20	0.40					
k	0.25 MIN.						
A2	0.20 REF.						

PACKAGE VARIATIONS								
PKG. CODE	N	D2	E2	e	JEDEC SPEC	b	[(N/2)-1] x e	DOWNBONDS ALLOWED
T633-1	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF	NO
T633-2	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF	NO
T833-1	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF	NO
T833-2	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF	NO
T833-3	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF	YES
T1033-1	10	1.50±0.10	2.30±0.10	0.50 BSC	MO229 / WEED-3	0.25±0.05	2.00 REF	NO
T1433-1	14	1.70±0.10	2.30±0.10	0.40 BSC	----	0.20±0.05	2.40 REF	YES
T1433-2	14	1.70±0.10	2.30±0.10	0.40 BSC	----	0.20±0.05	2.40 REF	NO

NOTES:
 1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
 2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
 3. WARPAGE SHALL NOT EXCEED 0.10 mm.
 4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
 5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
 6. "N" IS THE TOTAL NUMBER OF LEADS.
 7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 6, 8, 10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm
 APPROVAL: DOCUMENT CONTROL NO. 21-0137 REV. G 2/2

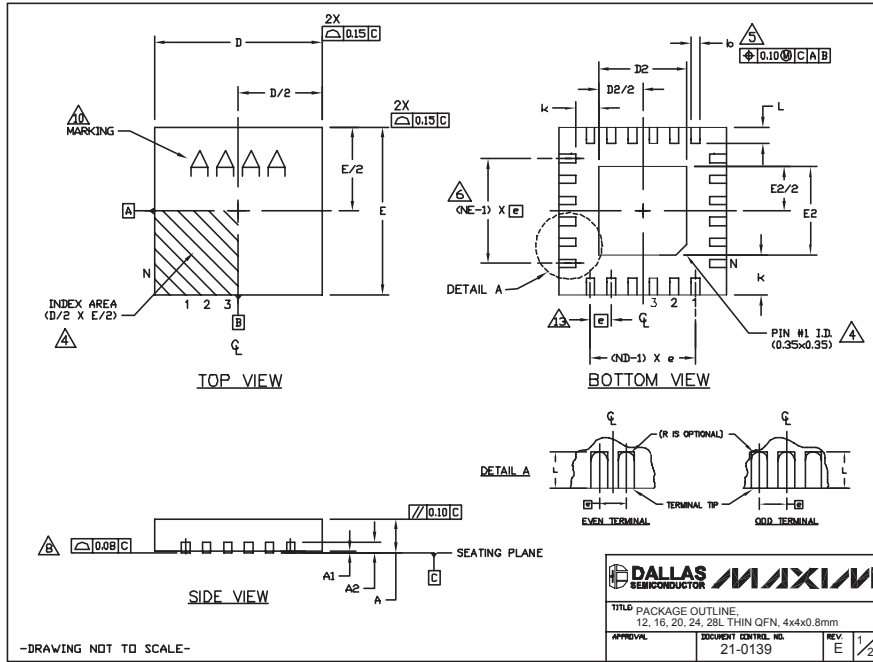
-DRAWING NOT TO SCALE-

注意: TDFN 裸露焊盘的尺寸-变更封装码: T633-1

高边功率、电流监视器

封装信息 (续)

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COMMON DIMENSIONS													EXPOSED PAD VARIATIONS				
PKG REF.	12L 4x4			16L 4x4			20L 4x4			24L 4x4			28L 4x4			DOWN BOND ALLOWED	
	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.	MIN.	NDM.	MAX.		
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	YES	
A1	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	NO	
A2	0.20 REF			0.20 REF			0.20 REF			0.20 REF			0.20 REF			YES	
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.18	0.23	0.30	0.15	0.20	0.25	NO	
D	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	YES	
E	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	NO	
e	0.80 BSC			0.65 BSC			0.50 BSC			0.50 BSC			0.40 BSC			YES	
k	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-	YES	
L	0.45	0.55	0.65	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50	0.30	0.40	0.50	NO	
N	12			16			20			24			28				
ND	3			4			5			6			7				
NE	3			4			5			6			7				
WGGC VGR	VGG8			VGGC			WGGD-1			WGGD-2			WGGE				

NOTES:

- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
- ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
- N IS THE TOTAL NUMBER OF TERMINALS.

THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.

DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TP.

ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.

DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.

COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

DRAWING CONFORMS TO JEDEC MO220, EXCEPT FOR T2444-3, T2444-4 AND T2844-1.

MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

COPLANARITY SHALL NOT EXCEED 0.08mm

WARPAGE SHALL NOT EXCEED 0.10mm

LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

14. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

DALLAS SEMICONDUCTOR MAXIM

TITLE PACKAGE OUTLINE:
12, 16, 20, 24, 28L THIN QFN, 4x4x0.8mm

APPROVAL DOCUMENT CONTROL NO. 21-0139 REV. E 2/2

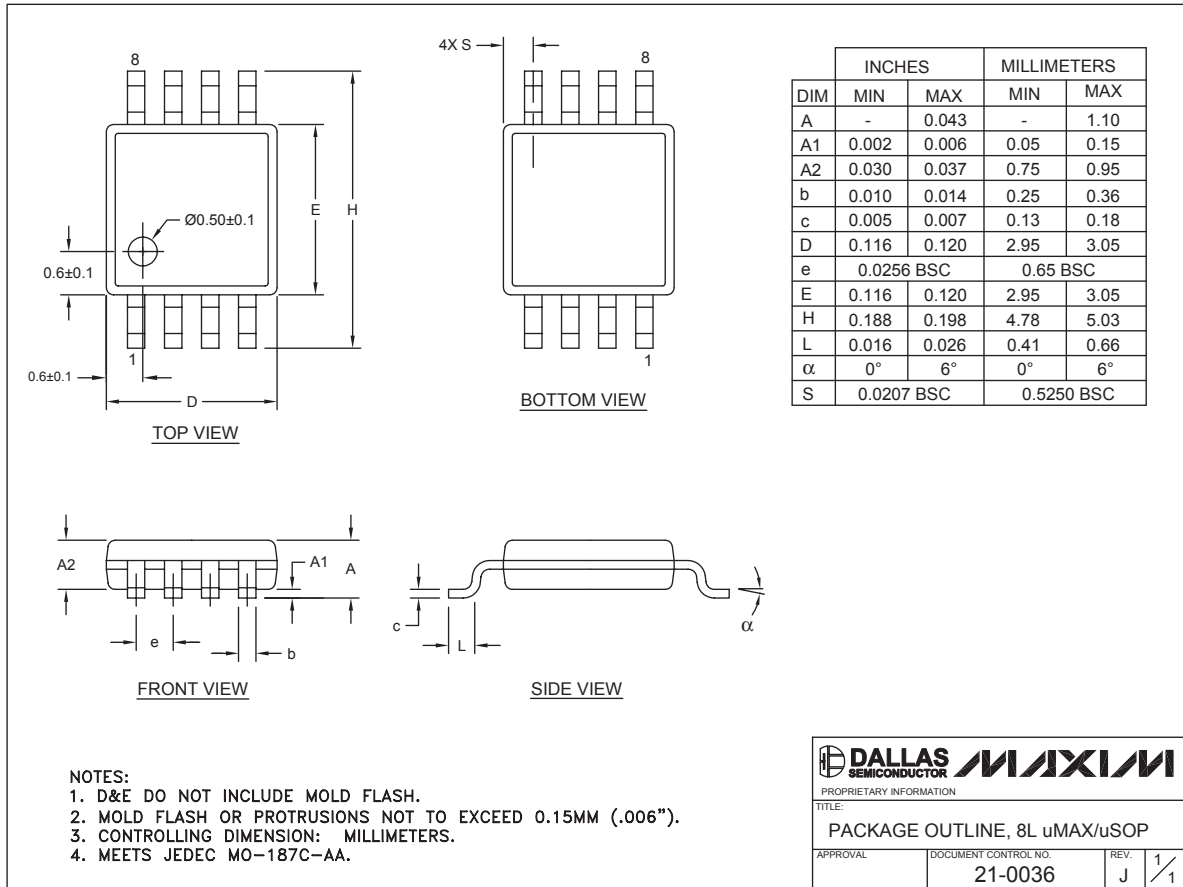
注意: 薄型QFN裸露焊盘的尺寸-变更封装码: T1644-4

高边功率、电流监视器

封装信息 (续)

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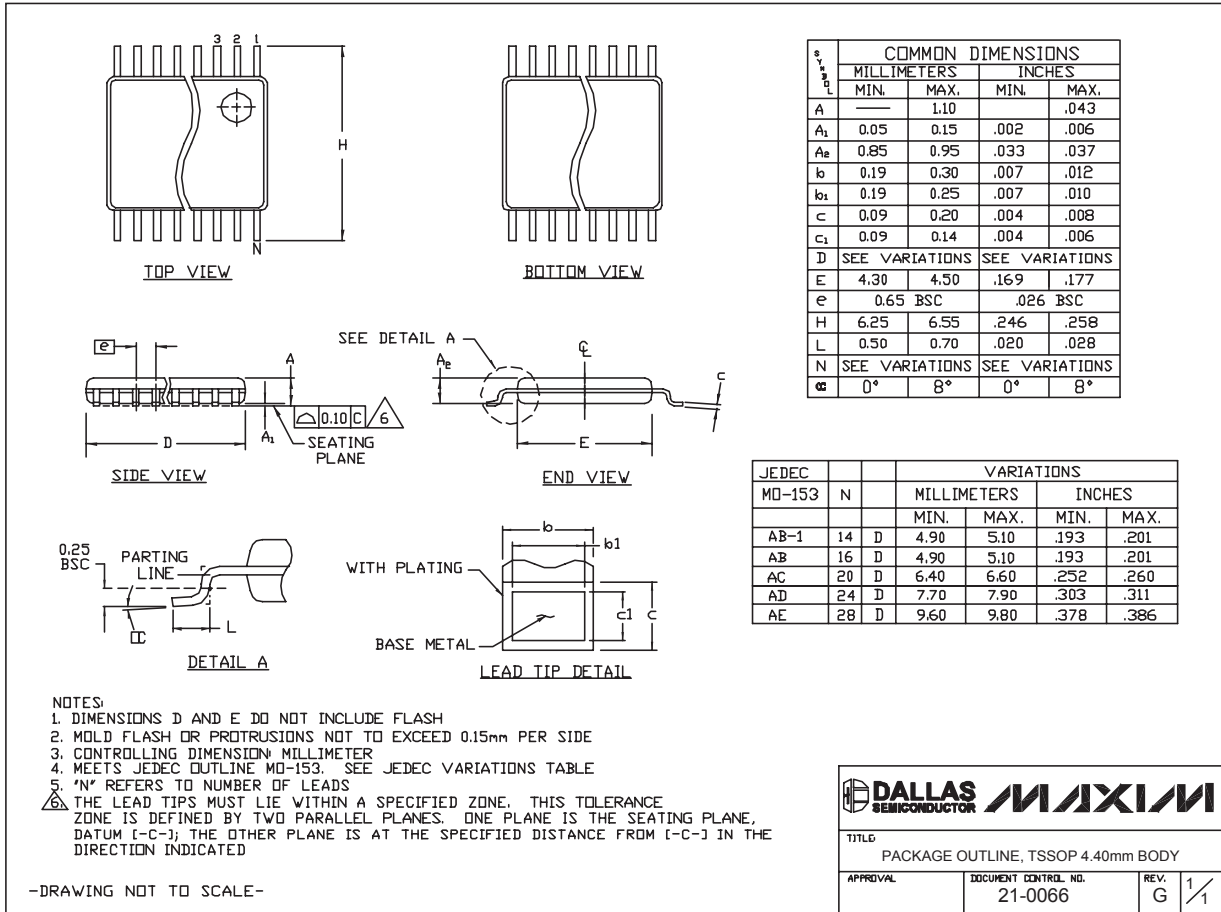
MAX4210/MAX4211



高边功率、电流监视器

封装信息 (续)

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