19-3336; Rev 2; 6/10

可提供评估板

16μA I_Q、1.2A PWM 降压型DC-DC转换器

概述

MAX1556/MAX1556A/MAX1557是低工作电流(16μA)、固定频率的降压型调节器。这些转换器具有高效率、低静态工作电流、低压差等特性，降压转换时的最低(27μA)静态电流非常适于用1节锂离子电池或3节碱性/NiMH电池供电的便携式装置。MAX1556最高可提供1.2A电流，通过引脚可以选择1.8V、2.5V与3.3V输出，或可调输出。MAX1557最高可提供600mA电流，通过引脚可以选择1V、1.3V与1.5V输出，或可调输出。

MAX1556/MAX1556A/MAX1557包含一个低导通电阻的内置MOSFET开关和一个同步整流器，以最少的外围元件数据提供最佳的效率与降压转换性能。采用专有的拓扑结构，工作在高固定频率模式下，轻载与满载时都能提供优异的性能。1MHz PWM开关频率允许外部元件尺寸很小。这两种器件都具有可调的软启动，可以减小电池的瞬态负载变化。

MAX1556/MAX1556A/MAX1557提供微型10引脚TDFN (3mm x 3mm)封装。

应用

PDA与掌上电脑

蜂窝电话与智能电话

数码照相机与摄像机

便携式MP3与DVD播放器

手持式仪器

特性

- ◆ 高达97%的效率
- ◆ 1mA负载电流下提供95%的效率
- ◆ 16μA低静态电流
- ◆ 1MHz PWM开关
- ◆ 3.3μH小型电感
- ◆ 可选3.3V、2.5V、1.8V、1.5V、1.3V、1.2V、1.0V与可调输出
- ◆ 保证输出1.2A电流(MAX1556/MAX1556A)
- ◆ 电压定位优化负载瞬态响应
- ◆ 降压转换时具有27μA的低静态电流
- ◆ 0.1μA的低关断电流
- ◆ 不需要外部肖特基二极管
- ◆ 零过冲电流的模拟软启动
- ◆ 小型的10引脚3mm x 3mm TDFN封装

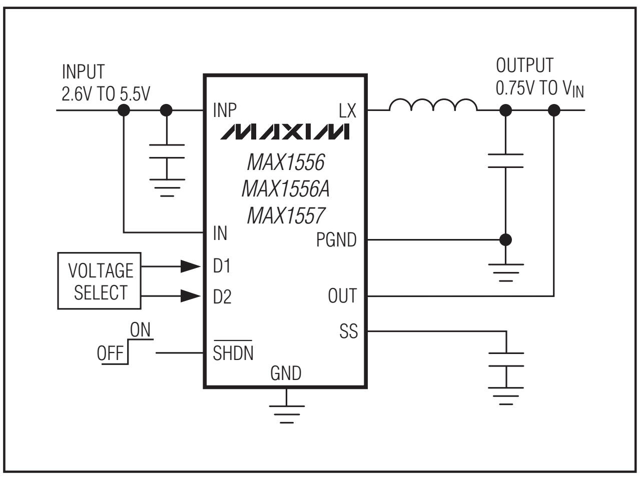
定购信息

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX1556ETB+	-40°C to +85°C	10 TDFN-EP*	ACQ
MAX1556AETB+	-40°C to +85°C	10 TDFN-EP*	AUJ
MAX1557ETB+	-40°C to +85°C	10 TDFN-EP*	ACR

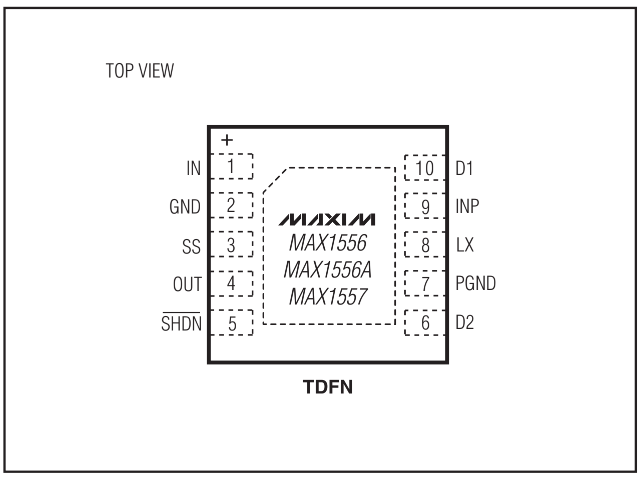
*EP = 裸焊盘。

+表示无铅(Pb)/符合RoHS标准的封装。

典型工作电路



引脚配置



本文是英文数据资料的译文，文中可能存在翻译上的不准确或错误。如需进一步确认，请在您的设计中参考英文资料。

有关价格、供货及订购信息，请联络Maxim亚洲销售中心：10800 852 1249 (北中国区)，10800 152 1249 (南中国区)，或访问Maxim的中文网站：china.maxim-ic.com。

ABSOLUTE MAXIMUM RATINGS

IN, INP, OUT, D2, $\overline{SHDN}$ to GND ....-0.3V to +6.0V
SS, D1 to GND ....-0.3V to (V_{IN} + 0.3V)
PGND to GND ....-0.3V to +0.3V
LX Current (Note 1)..±2.25A
Output Short-Circuit Duration....................................Continuous
Continuous Power Dissipation (T_A = +70°C)
10-Pin TDFN (derate 24.4mW/°C above +70°C) 1951mW

Operating Temperature Range ....-40°C to +85°C
Junction Temperature...+150°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C
Soldering Temperature (reflow) ....+260°C

Note 1: LX has internal clamp diodes to GND and IN. Applications that forward bias these diodes should take care not to exceed the IC's package power-dissipation limits.

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_{IN} = V_{INP} = $V_{\overline{SHDN}}$ = 3.6V, T_A = -40°C to +85°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage			2.6		5.5	V
Undervoltage-Lockout Threshold	V_{IN} rising and falling, 35mV hysteresis (typ)		2.20	2.35	2.55	V
Quiescent Supply Current	No switching, D1 = D2 = GND			16	25	µA
	Dropout			27	42	
Shutdown Supply Current	$\overline{SHDN}$ = GND	T_A = +25°C		0.1	1	µA
		T_A = +85°C		0.1		
Output Voltage Range			0.75		V_{IN}	V
Output Accuracy	T_A = 0°C to +85°C (Note 3)	No load	-0.25	+0.75	+1.75	%
		300mA load	-0.75	0	+0.75	
		600mA load	-1.5	-0.75	0	
		1200mA load, MAX1556	-2.75	-2.25	-1.25	
		1200mA load, MAX1556A		-2.25		
	T_A = -40°C to +85°C (Note 3)	No load	-0.75		+2.25	
		300mA load	-1.5		+1.5	
		600mA load	-2.25		+0.50	
		1200mA load, MAX1556	-4.0		-1.0	
Maximum Output Current	MAX1556/MAX1556A		1200			mA
	MAX1557		600			
OUT Bias Current	D1 = D2 = GND MAX1556/MAX1557	T_A = +25°C		0.01	0.1	µA
		T_A = +85°C		0.01		
	For preset output voltages			3	4.5	
FB Threshold Accuracy	D1 = D2 = GND, V_{OUT} = 0.75V at 300mA (typ), T_A = 0°C to +85°C MAX1556/MAX1557	No load	-0.50	+0.75	+1.75	%
		300mA load	-1.2	0	+1.2	
		600mA load	-1.75	-0.75	+0.25	
		1200mA load, MAX1556 only	-3.25	-2.25	-1.25	
	D1 = D2 = GND, V_{OUT} = 0.75V at 300mA (typ), T_A = -40°C to +85°C MAX1556/MAX1557	No load	-1.25		+2.25	
		300mA load	-1.75		+1.50	
		600mA load	-2.75		+0.25	
		1200mA load, MAX1556 only	-4.25		-1.00	

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = V_{INP} = $V_{\overline{SHDN}}$ = 3.6V, T_A = -40°C to +85°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 2)

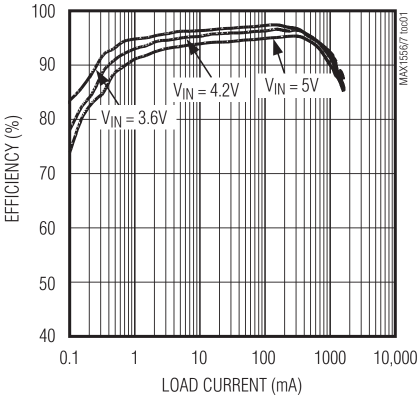
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Line Regulation	MAX1556, D1 = IN, D2 = GND; MAX1556A D1 = D2 = IN	V_{IN} = 2.6V to 3.6V		-0.37		%
		V_{IN} = 3.6V to 5.5V		0.33		
	MAX1557, D1 = IN, D2 = GND	V_{IN} = 2.6V to 3.6V		-0.1		
		V_{IN} = 3.6V to 5.5V		0.09		
p-Channel On-Resistance	MAX1556/MAX1556A	V_{IN} = 3.6V		0.19	0.35	Ω
		V_{IN} = 2.6V		0.23		
	MAX1557	V_{IN} = 3.6V		0.35	0.7	
		V_{IN} = 2.6V		0.42		
n-Channel On-Resistance	V_{IN} = 3.6V			0.27	0.48	Ω
	V_{IN} = 2.6V			0.33		
p-Channel Current-Limit Threshold	MAX1556/MAX1556A		1.5	1.8	2.1	A
	MAX1557		0.8	1.0	1.2	
n-Channel Zero Crossing Threshold			20	35	45	mA
RMS LX Output Current	MAX1556/MAX1556A				1.8	A_{RMS}
	MAX1557				1.0	
LX Leakage Current	V_{IN} = 5.5V, LX = GND or IN	T_A = +25°C		0.1	10	μA
		T_A = +85°C		0.1		
Maximum Duty Cycle			100			%
Minimum Duty Cycle					0	%
Internal Oscillator Frequency			0.9	1	1.1	MHz
SS Output Impedance	ΔV_{SS} / I_{SS} for I_{SS} = 2μA		130	200	300	kΩ
SS Discharge Resistance	$\overline{SHDN}$ = GND, 1mA sink current			90	200	Ω
Thermal-Shutdown Threshold				+160		°C
Thermal-Shutdown Hysteresis				15		°C
LOGIC INPUTS (D1, D2, $\overline{SHDN}$)						
Input-Voltage High	2.6V ≤ V_{IN} ≤ 5.5V		1.4			V
Input-Voltage Low					0.4	V
Input Leakage	T_A = +25°C			0.1	1	μA
	T_A = +85°C			0.1		

Note 2: All units are 100% production tested at T_A = +25°C. Limits over the operating range are guaranteed by design.
Note 3: For the MAX1556, 3.3V output accuracy is specified with a 4.2V input.

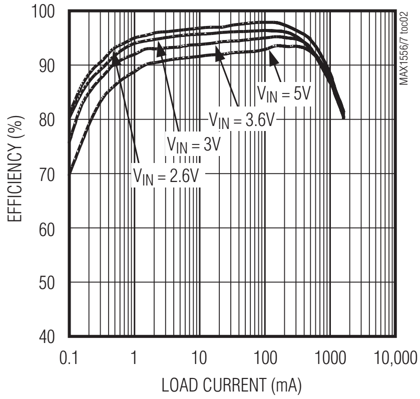
典型工作特性

(V_{IN} = V_{INP} = 3.6V, D1 = D2 = $\overline{SHDN}$ = IN, Circuits of Figures 2 and 3, T_A = +25°C, unless otherwise noted.)

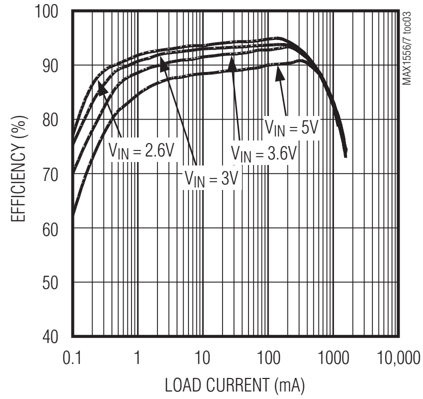
EFFICIENCY vs. LOAD CURRENT WITH 3.3V OUTPUT



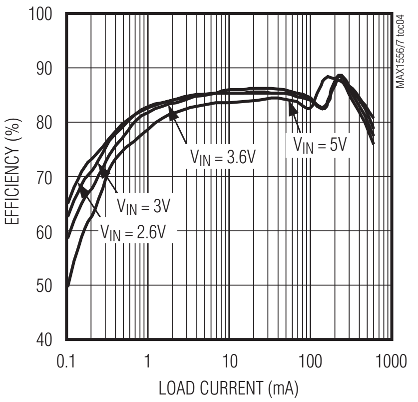
EFFICIENCY vs. LOAD CURRENT WITH 2.5V OUTPUT



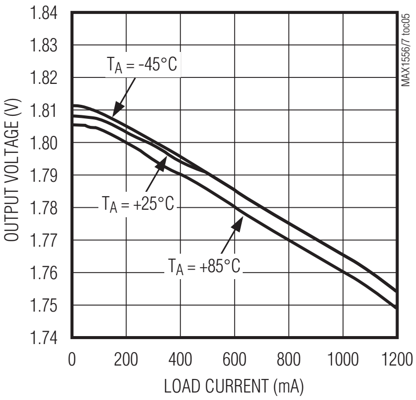
EFFICIENCY vs. LOAD CURRENT WITH 1.8V OUTPUT



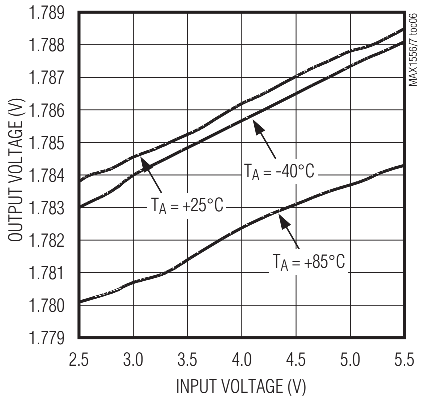
EFFICIENCY vs. LOAD CURRENT WITH 1.0V OUTPUT (MAX1557)



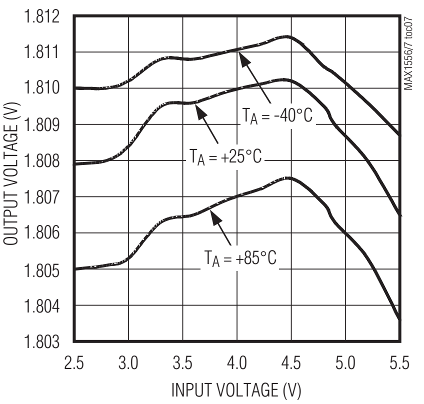
OUTPUT VOLTAGE vs. LOAD CURRENT



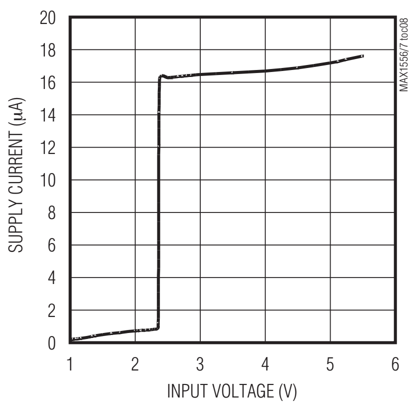
OUTPUT VOLTAGE vs. INPUT VOLTAGE WITH 600mA LOAD



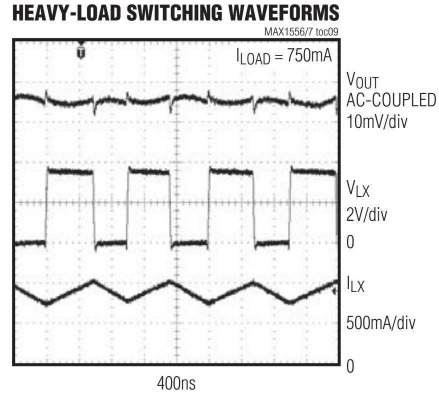
OUTPUT VOLTAGE vs. INPUT VOLTAGE WITH NO LOAD



SUPPLY CURRENT vs. INPUT VOLTAGE



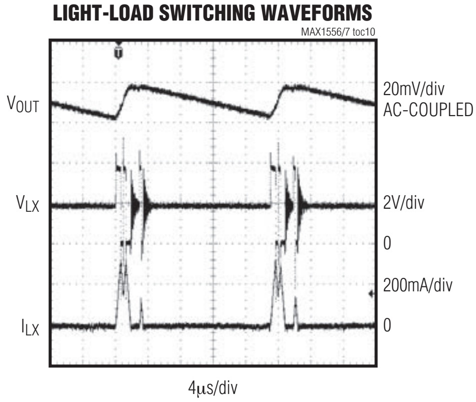
HEAVY-LOAD SWITCHING WAVEFORMS



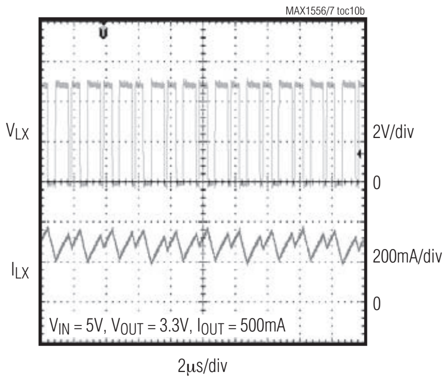
典型工作特性(续)

(V_{IN} = V_{INP} = 3.6V, D1 = D2 = $\overline{SHDN}$ = IN, Circuits of Figures 2 and 3, T_A = +25°C, unless otherwise noted.)

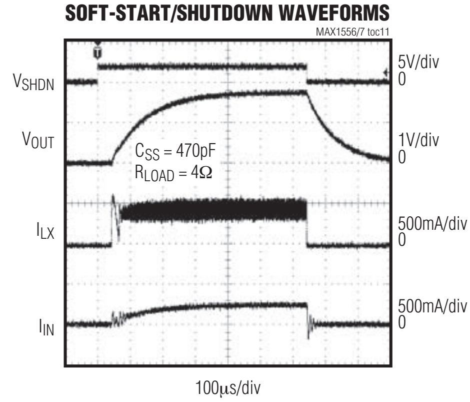
LIGHT-LOAD SWITCHING WAVEFORMS



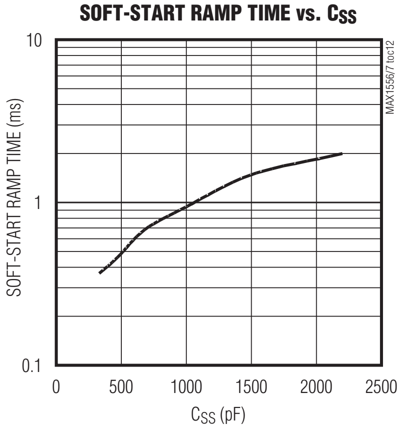
EXTERNAL FEEDBACK SWITCHING WAVEFORMS



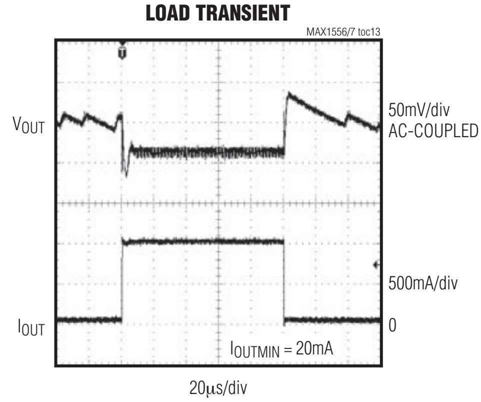
SOFT-START/SHUTDOWN WAVEFORMS



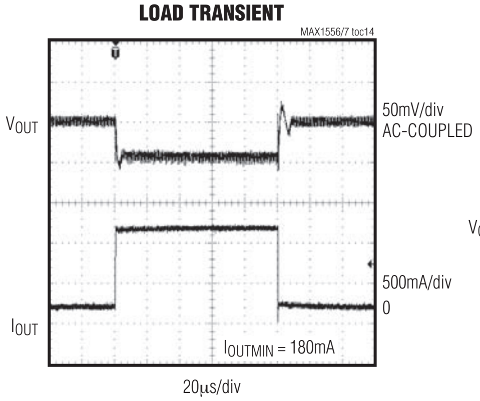
SOFT-START RAMP TIME vs. C_{SS}



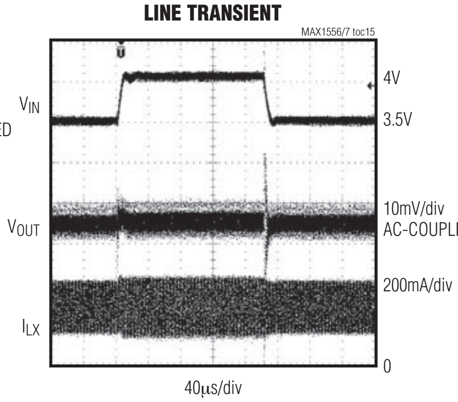
LOAD TRANSIENT



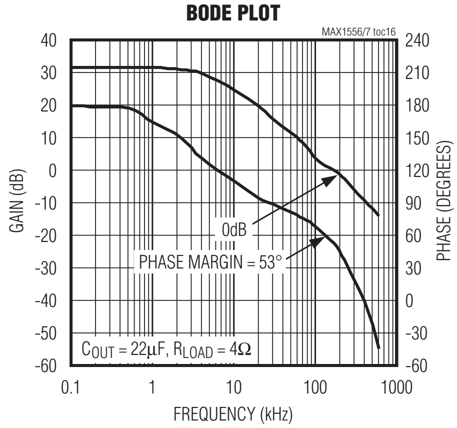
LOAD TRANSIENT



LINE TRANSIENT



BODE PLOT



引脚说明

引脚	名称	功能
1	IN	电源电压输入。接2.6V至5.5V电源。
2	GND	地。接PGND。
3	SS	软启动控制。在SS与GND之间连接一个1000pF的电容(C_{SS})消除启动时的输入电流过冲。C_{SS}在MAX1556/MAX1557的标准工作模式中是必需的。为了得到大于22μF的总输出电容，软启动时将C_{SS}值增大到C_{OUT} / 22,000。关断时，SS通过200Ω内部电阻对GND放电。
4	OUT	输出检测输入。接调节器输出端。D1与D2通过内部反馈电阻分压器控制输出所需电压。关断时内部反馈电阻分压器保持连接。
5	$\overline{SHDN}$	关断输入。将$\overline{SHDN}$置为低电平时使能低功耗关断模式。标准工作模式下置为高电平或连接到IN。
6	D2	输出电压选择输入。参见表1。
7	PGND	功率地。连接到GND。
8	LX	接电感。内部接功率MOSFET漏极。关断模式下为高阻状态。
9	INP	电源电压，大电流输入。接2.6V至5.5V电源。用一个10μF陶瓷电容旁路到PGND。
10	D1	输出电压选择输入。参见表1。
—	EP	裸焊盘。连接到地平面。EP可以帮助散热。焊接到电路板地平面，以增大散热能力。

表1. 输出电压选择真值表

D1	D2	MAX1556 V_{OUT}	MAX1556A V_{OUT}	MAX1557 V_{OUT}
0	0	Adjustable (V_{FB} = 0.75V) from 0.75V to V_{IN}	3.3V	Adjustable (V_{FB} = 0.75V) from 0.75V to V_{IN}
0	1	3.3V	1.5V	1.5V
1	0	2.5V	1.2V	1.3V
1	1	1.8V	2.5V	1.0V

0表示D_被置为低电平或连接到GND。
1表示D_被置为高电平或连接到IN。

详细说明

MAX1556/MAX1557同步降压转换器在0.75V至V_{IN}的输出电压下可保证提供1.2A/600mA电流。这些器件采用带内部补偿的1MHz PWM电流模式控制方案，可以使用微型外部元件并实现快速的瞬态响应。轻载时MAX1556/MAX1557自动切换到跳脉冲模式，保证低至16μA的静态电源电流。图2与图3给出了典型应用电路。

控制方案

PWM工作期间，转换器使用固定频率电流模式控制方案。电流模式PWM控制器的核心是开环、多路输入比较器，用来比较误差放大器电压反馈信号以及经过放大的电流检测信号与斜率补偿斜坡信号之和。每个时钟周期的开始，内部高端p沟道MOSFET导通，直到PWM比较器翻转。这段时间里，电感电流逐渐增大，为输出提供电流，并以电感磁场的形式存储能量。当p沟道MOSFET断开时，内部低端n沟道MOSFET导通。这样，在电流逐渐减小时电感释放存储的能量，为输出提供电流。当电感电流超过负载电流时，输出电容充电；当电感电流低于负载电流时，输出电容放电。过载时，电感电流超过电流限制后，高端MOSFET断开，低端MOSFET保持导通，直到下一个时钟周期。

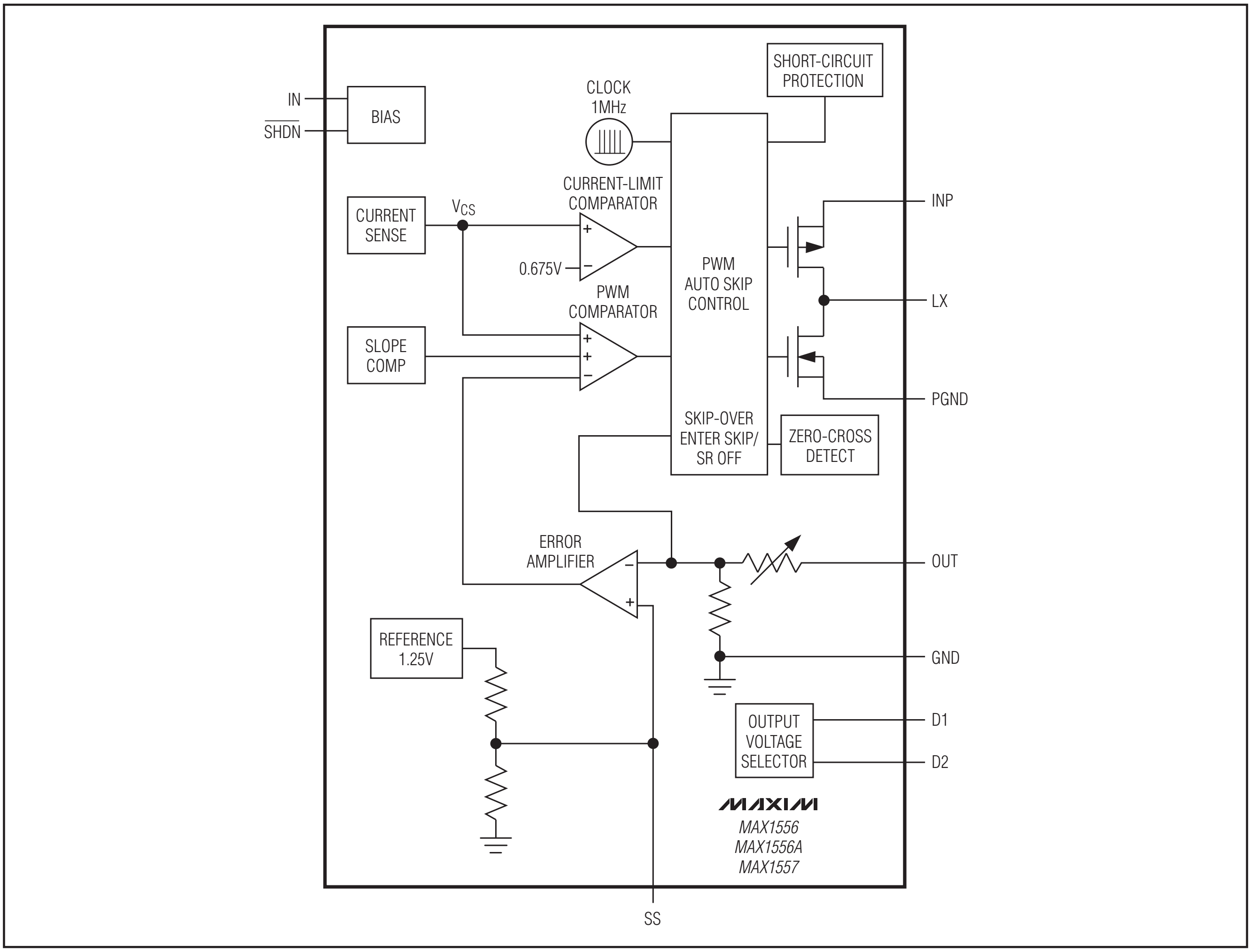


图1. 功能框图

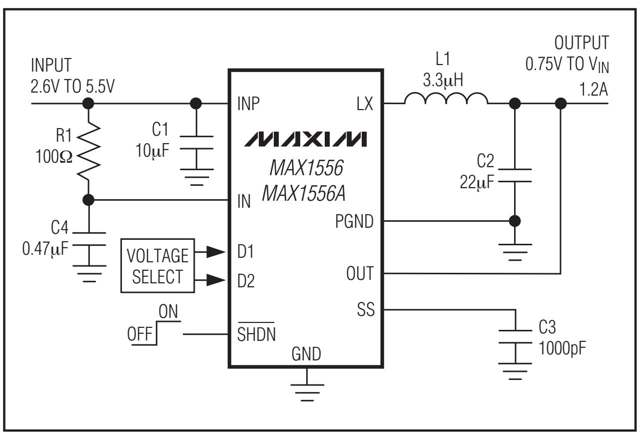


图2. MAX1556典型应用电路

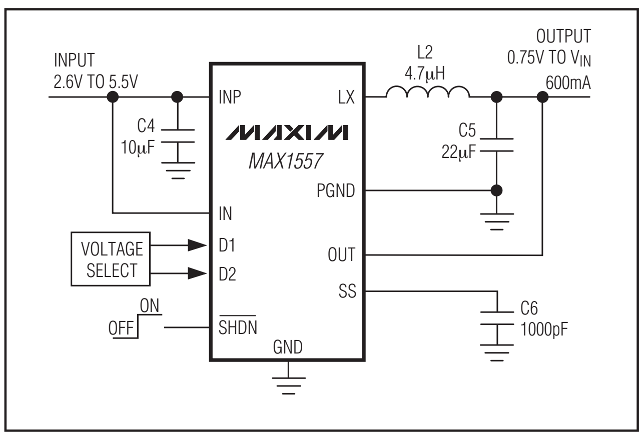


图3. MAX1557典型应用电路

负载电流下降时，转换器进入跳脉冲模式，该模式下PWM比较器被禁用。轻载时通过跳脉冲模式提高效率，该模式下，仅在需要驱动负载时工作。跳脉冲模式下静态电流典型值为16μA。参见*典型工作特性*中的Light-Load Switching Waveforms与Load Transient曲线图。

负载瞬态响应/电压定位

MAX1556/MAX1556A/MAX1557将负载调节与瞬态压降保持匹配。有时这被称作电压定位。用来获得该特性的负载线如图4和图5所示。移去负载时过冲最小，轻载向满载跳变瞬间压降最小。另外，MAX1556、MAX1556A与MAX1557使用宽带反馈回路，与使用传统积分反馈回路的调节器相比，可以得到对负载瞬变更快的响应(参见*典型工作特性*中的Load Transient)。

MAX1556/MAX1556A/MAX1557使用宽带控制回路与电压定位，降低响应负载瞬变时的过冲及下冲幅值与持续时间，实现高性能的负载瞬态响应。其它使用高增益控制回路的DC-DC转换器，通过外部补偿来保持严格的直流负载调节，但是在瞬变过程中仍允许5%或更大的电压跌落，并持续几百个微秒。例如，若该负载是运行在600MHz的CPU，则低电压持续100μs相当于60,000 CPU时钟周期。

MAX1556/MAX1556A/MAX1557的电压定位可实现最大2.25% (典型值)的负载调节电压变化，但是不会出现进一步的瞬态压降。所以在负载瞬变过程中，与其它具有更严格起始直流精度的调节器相比，能以更高效率提供给CPU额定电压。总的来说，与负载调节率为0.5%、但瞬变过程电压跌落为5%或更多的转换器相比，负载调节率为2.25%但无瞬变压降的转换器效果更好。负载瞬态变化只能用示波器观察到(参见*典型工作特性*)，用电压表读取直流负载调节无法显示电源对负载瞬变的响应。

降压/100%占空比工作

MAX1556/MAX1556A/MAX1557工作在100%占空比下，输入和输出电压差值可以很低。在该状态下，高端的p沟道MOSFET始终导通。这对3.3V输出的电池供电应用非常有用。在低至3V或更低的电压下，系统与负载还可以正常工作。当输入电池电压降至低于调节电压以下时，MAX1556/MAX1556A/MAX1557允许输出跟随输入电池电压。该状态下的静态电流小幅上升至27μA (典型值)，

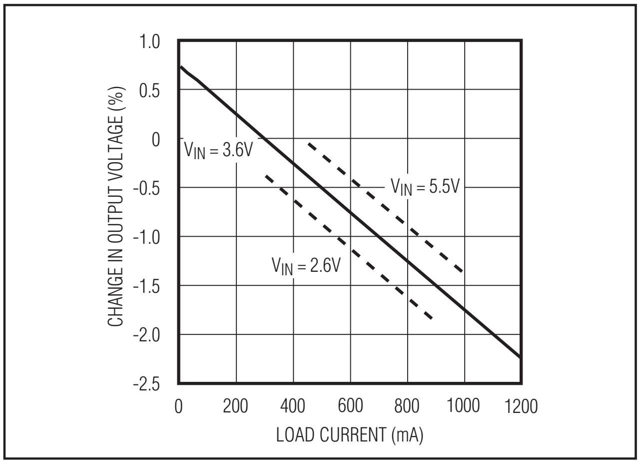


图4. MAX1556电压定位负载曲线

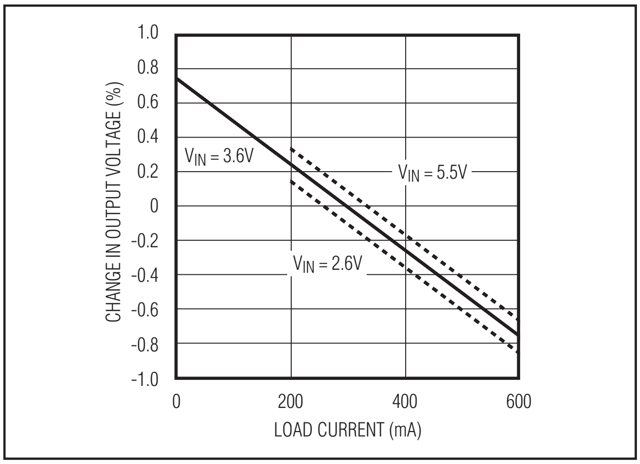


图5. MAX1557电压定位负载曲线

这有助于延长电池寿命。由于充分利用了整个电池范围，这样的降压/100%占空比工作可以延长电池工作时间。

维持调节作用所需的输入电压是输出电压与负载的函数。最小输入电压与输出电压之间的差值称为压差。压差是内部p沟道MOSFET导通电阻($R_{DS(ON)P}$)与电感电阻(DCR)的函数。

$$V_{DROPOUT} = I_{OUT} \times (R_{DS(ON)P} + DCR)$$

*Electrical Characteristics*中给出了$R_{DS(ON)P}$。表2列出了一些推荐电感的DCR。

表2. 电感选择

MANUFACTURER	PART	VALUE (μH)	DCR (mΩ)	I_{SAT} (mA)	SIZE (mm)	SHIELDED
Taiyo Yuden	LMNP04SB3R3N	3.3	36	1300	5 x 5 x 2.0	Yes
Taiyo Yuden	LMNP04SB4R7N	4.7	50	1200	5 x 5 x 2.0	Yes
TOKO	D52LC	3.5	73	1340	5 x 5 x 2.0	Yes
TOKO	D52LC	4.7	87	1140	5 x 5 x 2.0	Yes
Sumida	CDRH3D16	4.7	50	1200	3.8 x 3.8 x 1.8	Yes
TOKO	D412F	4.7	100*	1200*	4.8 x 4.8 x 1.2	Yes
Murata	LQH32CN	4.7	97	790	2.5 x 3.2 x 2.0	No
Sumitomo	CXL180	4.7	70*	1000*	3.0 x 3.2 x 1.7	No
Sumitomo	CXLD140	4.7	100*	800*	2.8 x 3.2 x 1.5	No

**根据数值相似的典型电感估计得到。*

软启动

MAX1556/MAX1556A/MAX1557使用软启动消除启动时的冲击电流，降低输入电源瞬变。软启动对于Li+与碱性电池等阻抗更高的输入电源特别有用。在SS与GND之间连接所需的软启动电容。对大多数应用，使用22μF输出电容，在SS与GND之间连接1000pF电容。若使用更大的输出电容，则利用以下公式计算软启动电容值：

$$C_{SS} = \frac{C_{OUT}}{22000}$$

软启动时，输出电压呈指数由0升至$V_{OUT(NOM)}$，时间常数等于C_{SS}乘以200kΩ (参见*典型工作特性*)。假定3倍的时间常数达到满输出电压，使用下面的公式计算软启动时间：

$$t_{SS} = 600 \times 10^3 \times C_{SS}$$

关断模式

将$\overline{SHDN}$接GND或逻辑低电平，使MAX1556/MAX1556A/MAX1557进入关断模式，并将电源电流降至0.1μA。在关断模式下，控制电路和内部p沟道、n沟道MOSFET断开，LX变为高阻状态。将$\overline{SHDN}$接IN或逻辑高电平，进入标准工作状态。

热关断

当MAX1556/MAX1556A/MAX1557结温超过+160°C时，IC进入热关断模式。在该模式下，内部p沟道开关与内部n沟道同步整流器关闭。当结温下降到低于+145°C，器件恢复标准工作状态。

应用信息

MAX1556/MAX1556A/MAX1557经过优化可以与小型外围元件一起使用。正确选择电感及输入与输出电容可以确保高效率、低纹波输出以及快速瞬态响应。

输出电压调节

MAX1556/MAX1556A/MAX1557提供1.0V、1.2V、1.3V、1.5V、1.8V、2.5V和3.3V预设输出电压以及可通过外部电阻调节的输出电压。应尽可能使用预设输出(由D1和D2设置)。如果采用外部电阻反馈，耦合至FB的噪声会导致LX脉冲交替出现过早截止，造成大小脉冲交替的电感电流波形。请参见*典型工作特性*部分中的External Feedback Switching Waveforms图。需要注意的是，外部反馈和大小交替脉冲波形不会影响环路稳定性，对于器件稳定或可靠地工作没有负面影响。

D1 = D2 = 0时选择可调节输出，使用外部电阻分压器设定输出电压(参见图6)。MAX1556/MAX1557定义了输入电源与负载调节斜率。负载调节可以针对预设输出也可

以针对可调输出，*Electrical Characteristics*表以及图4、图5进行了介绍。将修正系数代入反馈电阻方程，可以降低输入电源调节斜率的影响。

首先，计算修正系数k，将期望的输出电压代入以下公式：

$$k = 1.06 \times 10^{-2}V \times \left(\frac{V_{OUTPUT} - 0.75V}{3.6V}\right)$$

k代表反馈节点(OUT)工作点处的偏移。

选择较小的(≤ 35.7kΩ)反馈电阻R3，以保证稳定性，并求解R2：

$$\left(\frac{0.75V - k}{V_{OUTPUT}}\right) = \frac{R3}{(R3 + R2)}$$

电感选择

对MAX1557满负荷(600mA)应用，推荐使用饱和电流至少800mA的4.7µH电感。对1.2A满负荷的MAX1556/MAX1556A应用，使用饱和电流至少1.34A的3.3µH电感。对较低的满负载电流，可以降低电感电流额定值。为了获得最大效率，电感的电阻(DCR)应当尽可能低。请注意不同厂商与电感型号的磁芯材料不同，磁芯材料会影响效率。推荐的电感与厂商见表2。

电容选择

对绝大多数应用，推荐使用陶瓷输入与输出电容。为了在宽温度范围内获得最佳稳定性，应使用X5R或更好电介质的电容，因为这些电容具有小尺寸、低ESR与低温度系数的特点。

输出电容

为了保证较小的输出电压纹波，并保证调节回路的稳定性，需要连接输出电容C_{OUT}。C_{OUT}在开关频率上必须具有低阻抗。对于大多数应用，推荐使用22µF陶瓷输出电容。若使用更大的输出电容，建议并联一个小电容，以保证电容在开关频率上的低等效阻抗。

输入电容

由于降压转换器输入电流具有脉动特性，为了对输入电压滤波，并降低对其他电路的干扰，INP引脚需要接一个低ESR的输入电容。输入电容C_{INP}的阻抗在开关频率上应该很低。对大多数应用，INP处的电容推荐使用的最小值为10µF。为了实现更好的输入滤波，可以增大输入电容。

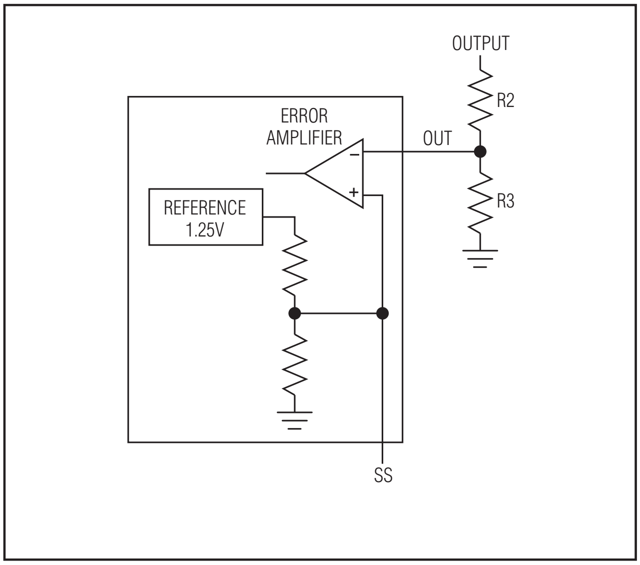


图6. 可调输出电压

IN输入滤波器

在所有MAX1557的应用中，直接连接INP与IN，并根据*输入电容*部分的说明旁路INP。IN引脚不需要额外的旁路电容。对于MAX1556和MAX1556A的应用，INP与IN之间的RC滤波器可以防止电源噪声进入IC。INP与IN之间接100Ω电阻，IN与GND之间接0.47µF电容。

软启动电容

为了使MAX1556/MAX1556A/MAX1557正常工作，需要软启动电容C_{SS}。*软启动*部分中讨论了C_{SS}的推荐值。不同软启动电容的软启动时间参见*典型工作特性*。

PCB布局与布线

对于快速开关波形与大电流通路，需要进行仔细的PCB布局。为加快设计提供了评估板(MAX1556EVKIT)。

进行电路板布局时，应减小IC、电感、输入电容与输出电容之间的走线长度。保持这些走线短、直接、并且宽。保持有噪声的走线，如LX节点走线，远离OUT。输入旁路电容应尽可能靠近IC。连接GND与裸焊盘，并在输出电容处将PGND与GND星形连接。输入与输出电容的地连接应尽可能互相靠近。

芯片信息

PROCESS: BiCMOS

封装信息

如需最近的封装外形信息和焊盘布局，请查询 **china.maxim-ic.com/packages**。请注意，封装编码中的"+"、"#"或"-"仅表示RoHS状态。封装图中可能包含不同的尾缀字符，但封装图只与封装有关，与RoHS状态无关。

封装类型	封装编码	外形编号	焊盘布局编号
10 TDFN	T1033-1	21-0137	90-0003

16μA I_Q、1.2A PWM 降压型DC-DC转换器

修订历史

修订号	修订日期	说明	修改页
0	7/04	最初版本。	—
1	3/08	增加了MAX1556A新型号。	1–12
2	6/10	增加了焊接温度信息、外部反馈开关波形的TOC图、关于使用外部反馈电阻时的噪声耦合的相关段落。	1, 2, 5, 6, 9, 10, 11

Maxim北京办事处

北京 8328信箱 邮政编码 100083

免费电话：800 810 0310

电话：010-6211 5199

传真：010-6211 5299

Maxim不对Maxim产品以外的任何电路使用负责，也不提供其专利许可。Maxim保留在任何时间、没有任何通报的前提下修改产品资料和规格的权利。

© 2010 Maxim Integrated Products

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

MAX1556, MAX1556A, MAX1557

16μA I_Q、1.2A PWM降压型DC-DC转换器

16μA静态电流、**1.2A**和**600mA**、降压型转换器，输出电流为**1mA**时效率高达**95%**

状况

状况：生产中。

概述

MAX1556/MAX1556A/MAX1557是低工作电流(16μA)、固定频率的降压型调节器。这些转换器具有高工作频率、低静态电流、低压差等特性，低静态电流(27μA)使其非常适合用于1节锂离子电池或3节碱性/NiMH电池供电的便携式装置。MAX1556最高可提供1.2A电流，通过引脚可以选择1.8V、2.5V与3.3V输出，或可调输出。MAX1557最高可提供600mA电流，通过引脚可以选择1V、1.3V与1.5V输出，或可调输出。

MAX1556/MAX1556A/MAX1557包含一个低导通电阻的内部MOSFET开关和一个同步整流器，以最少的外部元件数提供高效、低压差指标。采用专有的拓扑结构，在高固定频率工作模式下，保证轻载和满载时都能保持优异的性能。1MHz PWM开关频率使外部元件尺寸最小。这两种器件都具有可调节的软启动，可以减小电池的瞬态负载变化。

MAX1556/MAX1556A/MAX1557提供细小的10引脚TDFN (3mm x 3mm)封装。

现备有评估板：MAX1556EVKIT

数据资料

完整的数据资料

英文 下载 Rev. 2 (PDF, 280kB)
中文 下载 Rev. 2 (PDF, 900kB)

关键特性

- 最高97%的效率
- 1mA负载电流下95%的效率
- 16μA低静态电流
- 1MHz PWM开关
- 3.3μH小尺寸电感
- 可选择3.3V、2.5V、1.8V、1.5V、1.3V、1.2V、1.0V或可调输出
- 保证1.2A输出电流(MAX1556/MAX1556A)
- 电压配置优化负载瞬态响应
- 低压差下具有27μA的静态电流
- 0.1μA的低关断电流
- 不需要外部肖特基二极管
- 零过冲电流模拟软启动
- 小尺寸、10引脚、3mm x 3mm TDFN封装

应用/使用

- 蜂窝电话/智能电话
- 数码相机和便携式摄像机
- 手持式仪表
- PDA与掌上电脑
- 便携式MP3和DVD播放器

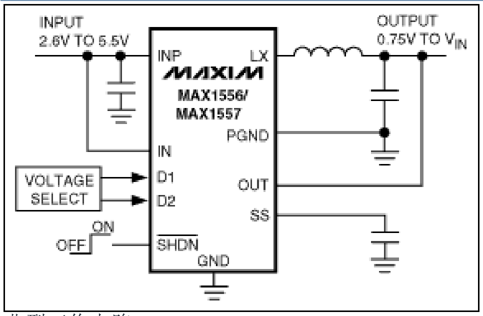
Key Specifications: Step-Down Switching Regulators

<table>
<tr><th rowspan="2">Part Number</th><th>V_{IN} (V)</th><th>V_{IN} (V)</th><th>V_{OUT} (V)</th><th>V_{OUT} (V)</th><th rowspan="2">Preset V_{OUT} (V)</th><th>Max. I_{OUT} (A)</th><th>Max. I_{OUT} (A)</th><th rowspan="2">Output Adjust. Method</th><th rowspan="2">DC-DC Outputs</th><th rowspan="2">Oper. Freq. (kHz)</th><th rowspan="2">Package/Pins</th><th>Smallest Available Pckg. (mm^2)</th><th>Price</th></tr>
<tr><th>min</th><th>max</th><th>min</th><th>max</th><th>≥</th><th>≤</th><th>max w/pins</th><th>See Notes</th></tr>
<tr><td>MAX1556</td><td rowspan="2">2.6</td><td rowspan="2">5.5</td><td rowspan="2">0.75</td><td rowspan="2">5.5</td><td>1.8
2.5
3.3</td><td>1.2</td><td>1.2</td><td rowspan="2">Preset
Resistor</td><td rowspan="2">1</td><td rowspan="2">1000</td><td>TDFN-EP/10</td><td rowspan="2">9.6</td><td>$1.55 @1k</td></tr>
<tr><td>MAX1557</td><td>1
1.3
1.5</td><td>0.6</td><td>0.6</td><td>TDFN-EP/10</td><td>$1.45 @1k</td></tr>
</table>

查看所有**Step-Down Switching Regulators (276)**

Pricing Notes:
This pricing is BUDGETARY, for comparing similar parts. Prices are in U.S. dollars and subject to change. Quantity pricing may vary substantially and international prices may differ due to local duties, taxes, fees, and exchange rates. For volume-specific prices and delivery, please see the price and availability page or contact an authorized distributor.

图表



典型工作电路

更多信息

顶标	MAX1556
顶标	MAX1556A
顶标	MAX1557
新品发布	[2004-08-27]

没有找到你需要的产品吗？

- 应用工程师帮助选型，下个工作日回复
- 参数搜索
- 应用帮助

概述
概述
关键特性
应用/使用
关键指标
图表
注释、注解

技术文档
数据资料
应用笔记
评估板
设计指南
可靠性报告
软件/模型

定购信息
价格与供货
样品
在线订购
封装信息
无铅信息

相关产品
类似功能器件
类似应用器件
评估板
类似型号器件
配合该器件使用的产品

参考文献： 19-3336 Rev. 2; 2010-06-29
本页最后一次更新：2010-06-29

联络我们：信息反馈、提出问题 • 对该网页的评价 • 发送本网页 • 隐私权政策 • 法律声明

© 2010 Maxim Integrated Products版权所有

19-3336; Rev 2; 6/10

EVALUATION KIT AVAILABLE

16µA I_Q, 1.2A PWM Step-Down DC-DC Converters

MAX1556/MAX1556A/MAX1557

General Description

The MAX1556/MAX1556A/MAX1557 are low-operating-current (16µA), fixed-frequency step-down regulators. High efficiency, low-quiescent operating current, low dropout, and minimal (27µA) quiescent current in dropout make these converters ideal for powering portable devices from 1-cell Li-ion or 3-cell alkaline/NiMH batteries. The MAX1556 delivers up to 1.2A; has pin-selectable 1.8V, 2.5V, and 3.3V outputs; and is also adjustable. The MAX1557 delivers up to 600mA; has pin-selectable 1V, 1.3V, and 1.5V outputs; and is also adjustable.

The MAX1556/MAX1556A/MAX1557 contain a low-on-resistance internal MOSFET switch and synchronous rectifier to maximize efficiency and dropout performance while minimizing external component count. A proprietary topology offers the benefits of a high fixed-frequency operation while still providing excellent efficiency at both light and full loads. A 1MHz PWM switching frequency keeps components small. Both devices also feature an adjustable soft-start to minimize battery transient loading.

The MAX1556/MAX1556A/MAX1557 are available in a tiny 10-pin TDFN (3mm x 3mm) package.

Applications

PDAs and Palmtop Computers

Cell Phones and Smart Phones

Digital Cameras and Camcorders

Portable MP3 and DVD Players

Hand-Held Instruments

Features

- ♦ **Up to 97% Efficiency**
- ♦ **95% Efficiency at 1mA Load Current**
- ♦ **Low 16µA Quiescent Current**
- ♦ **1MHz PWM Switching**
- ♦ **Tiny 3.3µH Inductor**
- ♦ **Selectable 3.3V, 2.5V, 1.8V, 1.5V, 1.3V, 1.2V, 1.0V, and Adjustable Output**
- ♦ **1.2A Guaranteed Output Current (MAX1556/MAX1556A)**
- ♦ **Voltage Positioning Optimizes Load-Transient Response**
- ♦ **Low 27µA Quiescent Current in Dropout**
- ♦ **Low 0.1µA Shutdown Current**
- ♦ **No External Schottky Diode Required**
- ♦ **Analog Soft-Start with Zero Overshoot Current**
- ♦ **Small, 10-Pin, 3mm x 3mm TDFN Package**

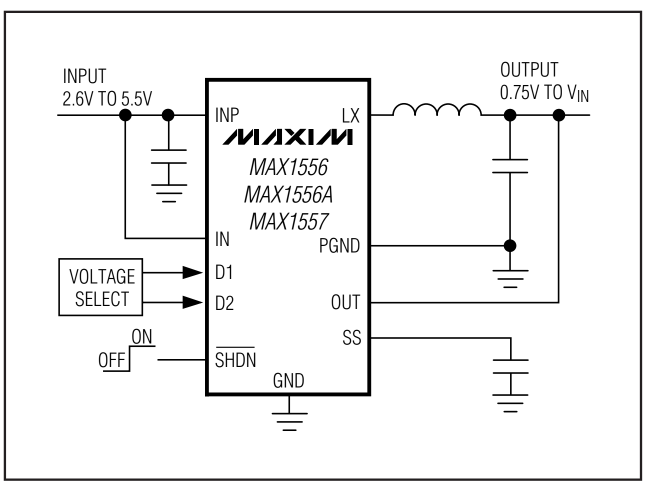
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX1556ETB+	-40°C to +85°C	10 TDFN-EP*	ACQ
MAX1556AETB+	-40°C to +85°C	10 TDFN-EP*	AUJ
MAX1557ETB+	-40°C to +85°C	10 TDFN-EP*	ACR

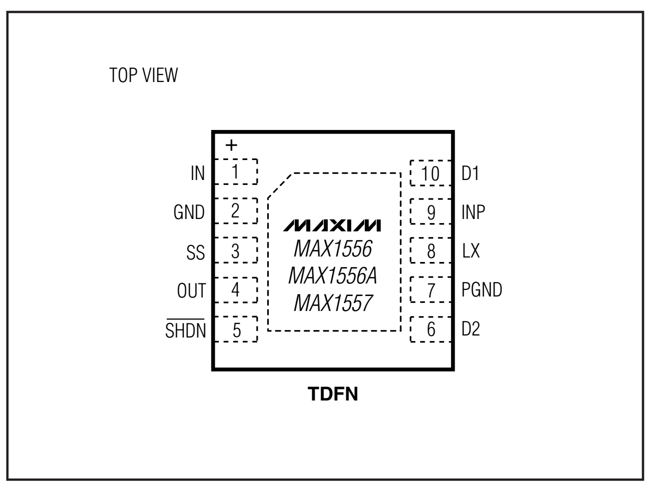
**EP = Exposed paddle.*

+Denotes a lead(Pb)-free/RoHS-compliant package.

Typical Operating Circuit



Pin Configuration



For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

16µA I_Q, 1.2A PWM DC-DC Step-Down Converters

ABSOLUTE MAXIMUM RATINGS

IN, INP, OUT, D2, $\overline{SHDN}$ to GND ....-0.3V to +6.0V
SS, D1 to GND ....-0.3V to (V_{IN} + 0.3V)
PGND to GND ....-0.3V to +0.3V
LX Current (Note 1)..±2.25A
Output Short-Circuit Duration....................................Continuous
Continuous Power Dissipation (T_A = +70°C)
10-Pin TDFN (derate 24.4mW/°C above +70°C) 1951mW

Operating Temperature Range ....-40°C to +85°C
Junction Temperature...+150°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C
Soldering Temperature (reflow) ....+260°C

Note 1: LX has internal clamp diodes to GND and IN. Applications that forward bias these diodes should take care not to exceed the IC's package power-dissipation limits.

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_{IN} = V_{INP} = $V_{\overline{SHDN}}$ = 3.6V, T_A = - 40°C to +85°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage			2.6		5.5	V
Undervoltage-Lockout Threshold	V_{IN} rising and falling, 35mV hysteresis (typ)		2.20	2.35	2.55	V
Quiescent Supply Current	No switching, D1 = D2 = GND			16	25	µA
	Dropout			27	42	
Shutdown Supply Current	$\overline{SHDN}$ = GND	T_A = +25°C		0.1	1	µA
		T_A = +85°C		0.1		
Output Voltage Range			0.75		V_{IN}	V
Output Accuracy	T_A = 0°C to +85°C (Note 2)	No load	-0.25	+0.75	+1.75	%
		300mA load	-0.75	0	+0.75	
		600mA load	-1.5	-0.75	0	
		1200mA load, MAX1556	-2.75	-2.25	-1.25	
		1200mA load, MAX1556A		-2.25		
	T_A = -40°C to +85°C (Note 2)	No load	-0.75		+2.25	
		300mA load	-1.5		+1.5	
		600mA load	-2.25		+0.50	
		1200mA load, MAX1556	-4.0		-1.0	
Maximum Output Current	MAX1556/MAX1556A		1200			mA
	MAX1557		600			
OUT Bias Current	D1 = D2 = GND MAX1556/MAX1557	T_A = +25°C		0.01	0.1	µA
		T_A = +85°C		0.01		
	For preset output voltages			3	4.5	
FB Threshold Accuracy	D1 = D2 = GND, V_{OUT} = 0.75V at 300mA (typ), T_A = 0°C to +85°C MAX1556/MAX1557	No load	-0.50	+0.75	+1.75	%
		300mA load	-1.2	0	+1.2	
		600mA load	-1.75	-0.75	+0.25	
		1200mA load, MAX1556 only	-3.25	-2.25	-1.25	
	D1 = D2 = GND, V_{OUT} = 0.75V at 300mA (typ), T_A = -40°C to +85°C MAX1556/MAX1557	No load	-1.25		+2.25	
		300mA load	-1.75		+1.50	
		600mA load	-2.75		+0.25	
		1200mA load, MAX1556 only	-4.25		-1.00	

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = V_{INP} = $V_{\overline{SHDN}}$ = 3.6V, T_A = - 40°C to +85°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 1)

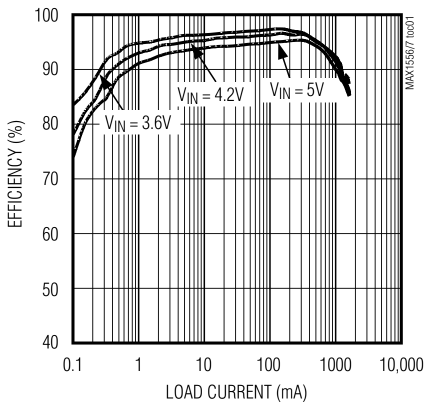
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Line Regulation	MAX1556, D1 = IN, D2 = GND; MAX1556A D1 = D2 = IN	V_{IN} = 2.6V to 3.6V		-0.37		%
		V_{IN} = 3.6V to 5.5V		0.33		
	MAX1557, D1 = IN, D2 = GND	V_{IN} = 2.6V to 3.6V		-0.1		
		V_{IN} = 3.6V to 5.5V		0.09		
p-Channel On-Resistance	MAX1556/MAX1556A	V_{IN} = 3.6V		0.19	0.35	Ω
		V_{IN} = 2.6V		0.23		
	MAX1557	V_{IN} = 3.6V		0.35	0.7	
		V_{IN} = 2.6V		0.42		
n-Channel On-Resistance	V_{IN} = 3.6V			0.27	0.48	Ω
	V_{IN} = 2.6V			0.33		
p-Channel Current-Limit Threshold	MAX1556/MAX1556A		1.5	1.8	2.1	A
	MAX1557		0.8	1.0	1.2	
n-Channel Zero Crossing Threshold			20	35	45	mA
RMS LX Output Current	MAX1556/MAX1556A				1.8	A_{RMS}
	MAX1557				1.0	
LX Leakage Current	V_{IN} = 5.5V, LX = GND or IN	T_A = +25°C		0.1	10	µA
		T_A = +85°C		0.1		
Maximum Duty Cycle			100			%
Minimum Duty Cycle					0	%
Internal Oscillator Frequency			0.9	1	1.1	MHz
SS Output Impedance	ΔV_{SS} / I_{SS} for I_{SS} = 2µA		130	200	300	kΩ
SS Discharge Resistance	$\overline{SHDN}$ = GND, 1mA sink current			90	200	Ω
Thermal-Shutdown Threshold				+160		°C
Thermal-Shutdown Hysteresis				15		°C
LOGIC INPUTS (D1, D2, $\overline{SHDN}$)						
Input-Voltage High	2.6V ≤ V_{IN} ≤ 5.5V		1.4			V
Input-Voltage Low					0.4	V
Input Leakage	T_A = +25°C			0.1	1	µA
	T_A = +85°C			0.1		

Note 1: All units are 100% production tested at T_A = +25°C. Limits over the operating range are guaranteed by design.
Note 2: For the MAX1556, 3.3V output accuracy is specified with a 4.2V input.

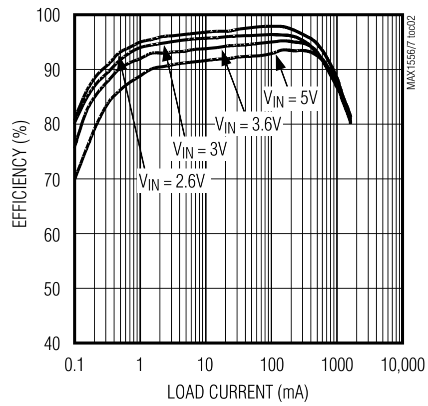
Typical Operating Characteristics

(V_{IN} = V_{INP} = 3.6V, D1 = D2 = $\overline{SHDN}$ = IN, Circuits of Figures 2 and 3, T_A = +25°C, unless otherwise noted.)

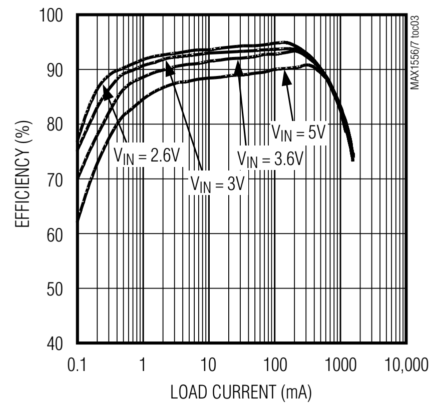
EFFICIENCY vs. LOAD CURRENT WITH 3.3V OUTPUT



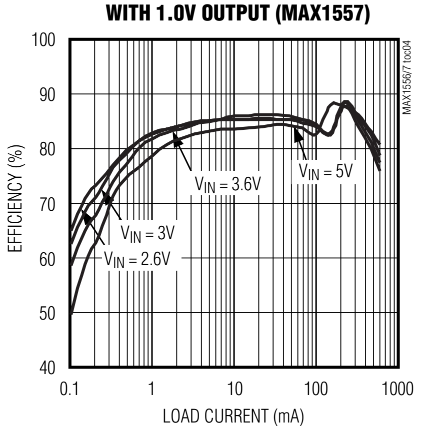
EFFICIENCY vs. LOAD CURRENT WITH 2.5V OUTPUT



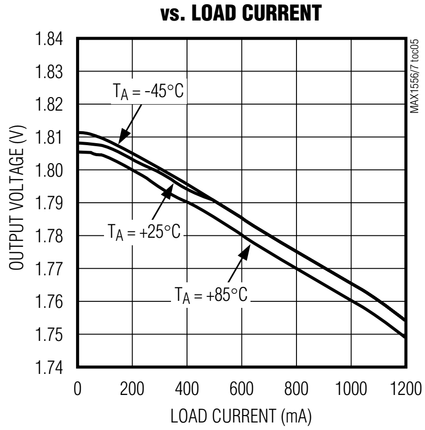
EFFICIENCY vs. LOAD CURRENT WITH 1.8V OUTPUT



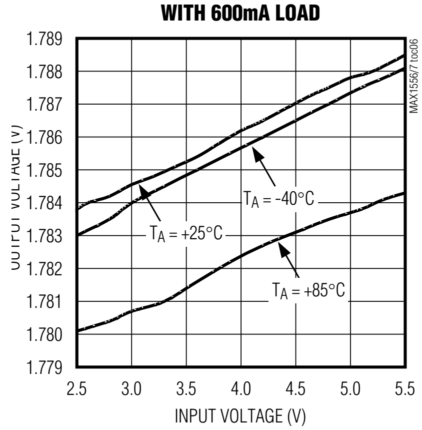
EFFICIENCY vs. LOAD CURRENT WITH 1.0V OUTPUT (MAX1557)



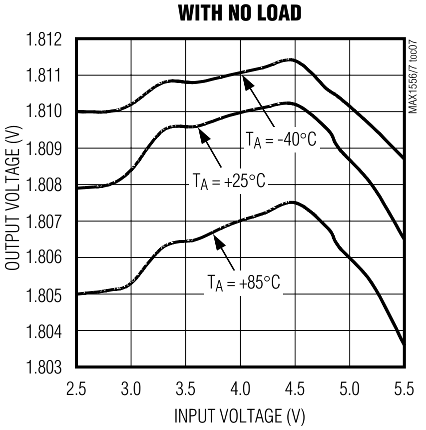
OUTPUT VOLTAGE vs. LOAD CURRENT



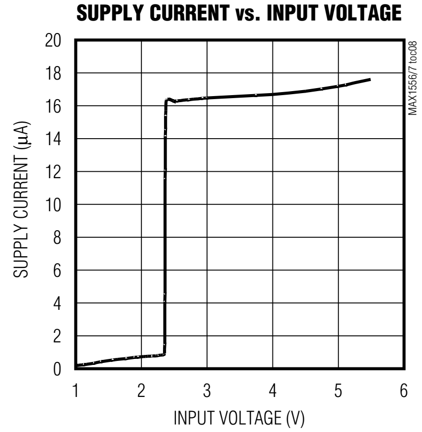
OUTPUT VOLTAGE vs. INPUT VOLTAGE WITH 600mA LOAD



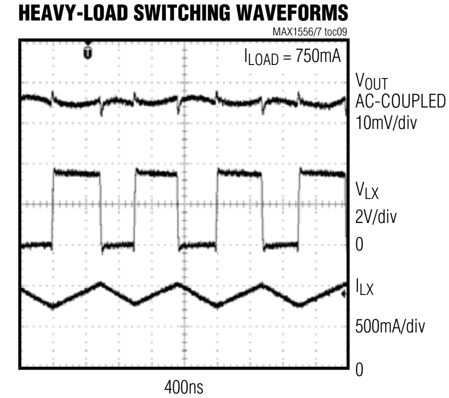
OUTPUT VOLTAGE vs. INPUT VOLTAGE WITH NO LOAD



SUPPLY CURRENT vs. INPUT VOLTAGE



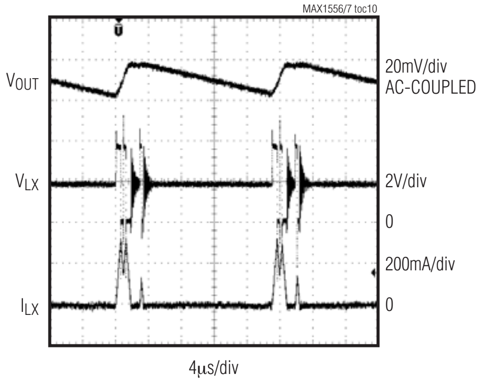
HEAVY-LOAD SWITCHING WAVEFORMS



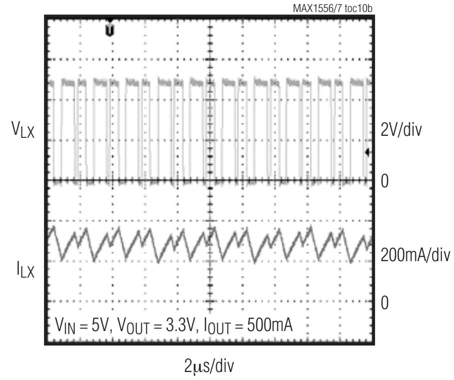
Typical Operating Characteristics (continued)

(V_{IN} = V_{INP} = 3.6V, D1 = D2 = $\overline{SHDN}$ = IN, Circuits of Figures 2 and 3, T_A = +25°C, unless otherwise noted.)

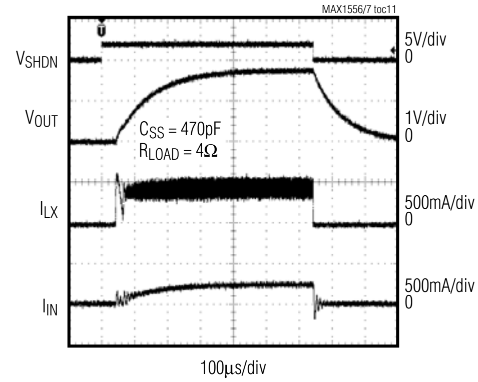
LIGHT-LOAD SWITCHING WAVEFORMS



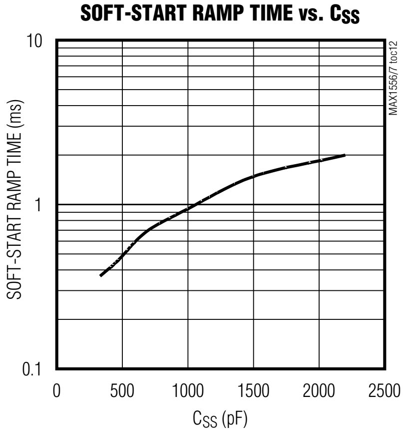
EXTERNAL FEEDBACK SWITCHING WAVEFORMS



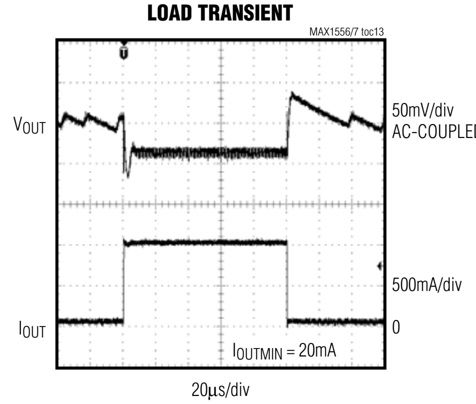
SOFT-START/SHUTDOWN WAVEFORMS



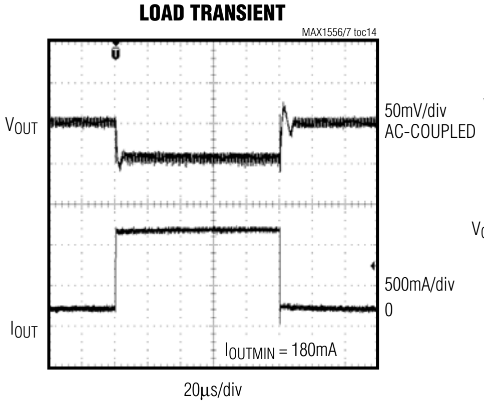
SOFT-START RAMP TIME vs. C_{SS}



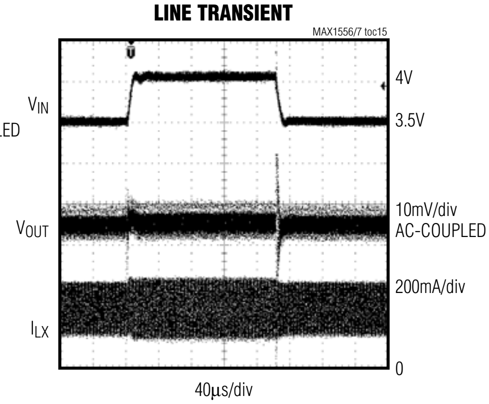
LOAD TRANSIENT



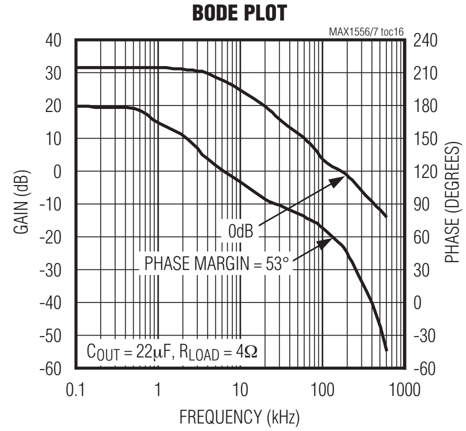
LOAD TRANSIENT



LINE TRANSIENT



BODE PLOT



16µA I_Q, 1.2A PWM DC-DC Step-Down Converters

Pin Description

PIN	NAME	FUNCTION
1	IN	Supply Voltage Input. Connect to a 2.6V to 5.5V source.
2	GND	Ground. Connect to PGND.
3	SS	Soft-Start Control. Connect a 1000pF capacitor (C_{SS}) from SS to GND to eliminate input-current overshoot during startup. C_{SS} is required for normal operation of the MAX1556/MAX1557. For greater than 22µF total output capacitance, increase C_{SS} to C_{OUT} / 22,000 for soft-start. SS is internally discharged through 200Ω to GND in shutdown.
4	OUT	Output Sense Input. Connect to the output of the regulator. D1 and D2 select the desired output voltage through an internal feedback resistor-divider. The internal feedback resistor-divider remains connected in shutdown.
5	$\overline{SHDN}$	Shutdown Input. Drive $\overline{SHDN}$ low to enable low-power shutdown mode. Drive high or connect to IN for normal operation.
6	D2	OUT Voltage-Select Input. See Table 1.
7	PGND	Power Ground. Connect to GND.
8	LX	Inductor Connection. Connected to the drains of the internal power MOSFETs. High impedance in shutdown mode.
9	INP	Supply Voltage, High-Current Input. Connect to a 2.6V to 5.5V source. Bypass with a 10µF ceramic capacitor to PGND.
10	D1	OUT Voltage-Select Input. See Table 1.
—	EP	Exposed Paddle. Connect to ground plane. EP also functions as a heatsink. Solder to circuit-board ground plane to maximize thermal dissipation.

Table 1. Output-Voltage-Select Truth Table

D1	D2	MAX1556 V_{OUT}	MAX1556A V_{OUT}	MAX1557 V_{OUT}
0	0	Adjustable (V_{FB} = 0.75) from 0.75V to V_{IN}	3.3V	Adjustable (V_{FB} = 0.75) from 0.75V to V_{IN}
0	1	3.3V	1.5V	1.5V
1	0	2.5V	1.2V	1.3V
1	1	1.8V	2.5V	1.0V

A zero represents D_ being driven low or connected to GND.
A 1 represents D_ being driven high or connected to IN.

Detailed Description

The MAX1556/MAX1557 synchronous step-down converters deliver a guaranteed 1.2A/600mA at output voltages from 0.75V to V_{IN}. They use a 1MHz PWM current-mode control scheme with internal compensation, allowing for tiny external components and a fast transient response. At light loads the MAX1556/MAX1557 automatically switch to pulse-skipping mode to keep the quiescent supply current as low as 16µA. Figures 2 and 3 show the typical application circuits.

Control Scheme

During PWM operation the converters use a fixed-frequency, current-mode control scheme. The heart of the current-mode PWM controller is an open-loop, multiple-input comparator that compares the error-amp voltage feedback signal against the sum of the amplified current-sense signal and the slope-compensation ramp. At the beginning of each clock cycle, the internal high-side p-channel MOSFET turns on until the PWM comparator trips. During this time the current in the inductor ramps up, sourcing current to the output and storing energy in the inductor's magnetic field. When the p-channel turns off, the internal low-side n-channel MOSFET turns on. Now the inductor releases the stored energy while the current ramps down, still providing current to the output. The output capacitor stores charge when the inductor current exceeds the load and discharges when the inductor current is lower than the load. Under overload conditions, when the inductor current exceeds the current limit, the high-side MOSFET is turned off and the low-side MOSFET remains on until the next clock cycle.

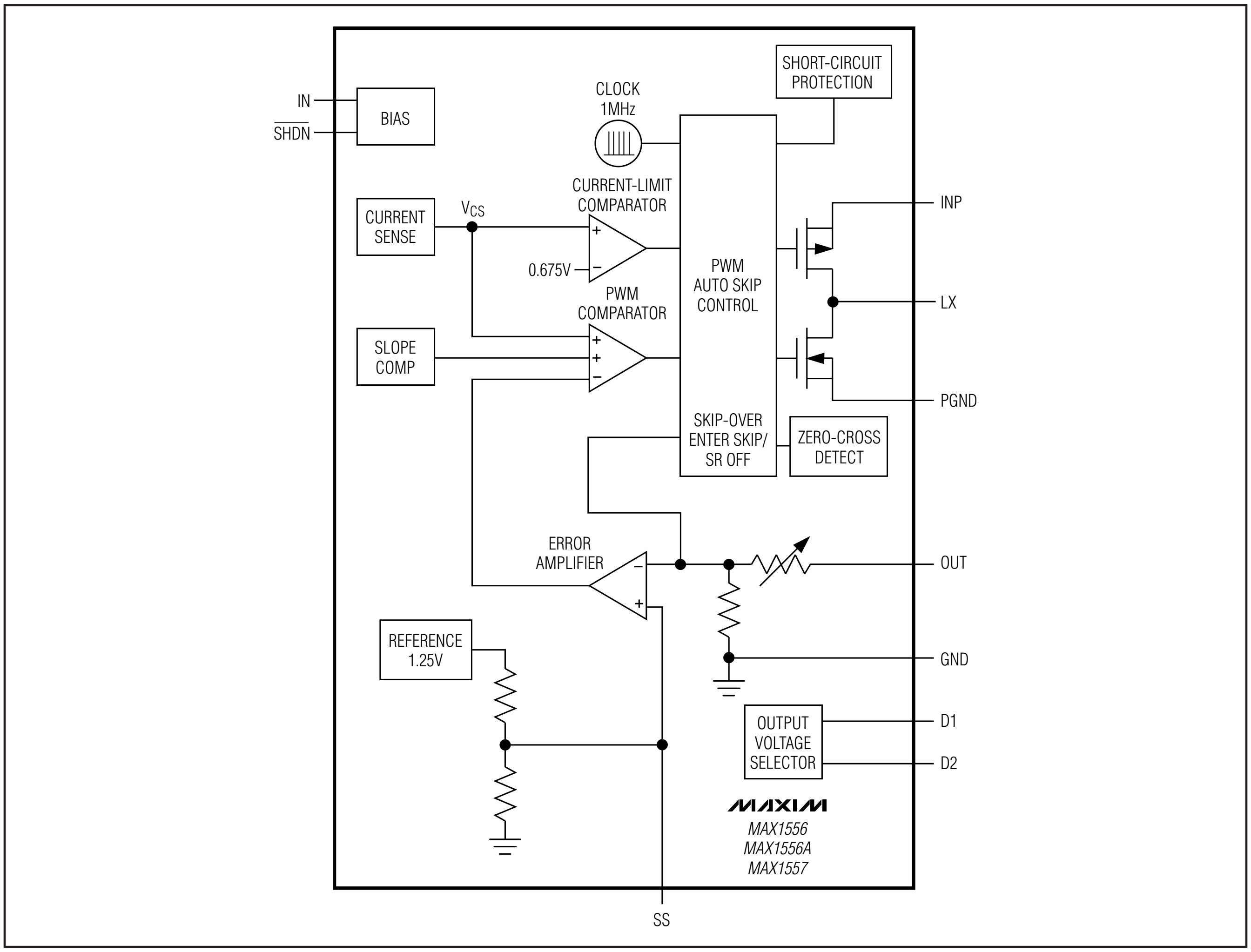


Figure 1. Functional Diagram

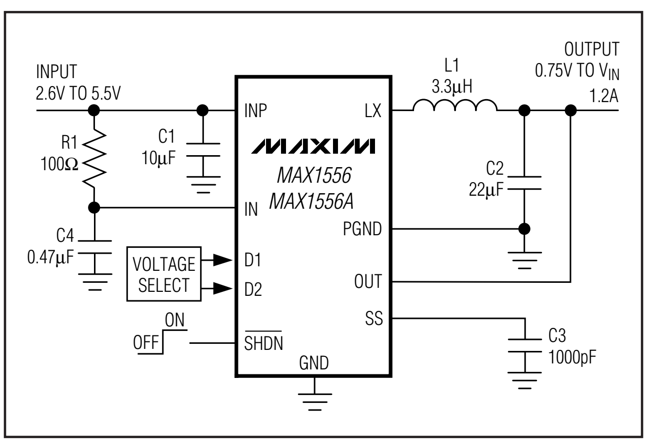


Figure 2. MAX1556 Typical Application Circuit

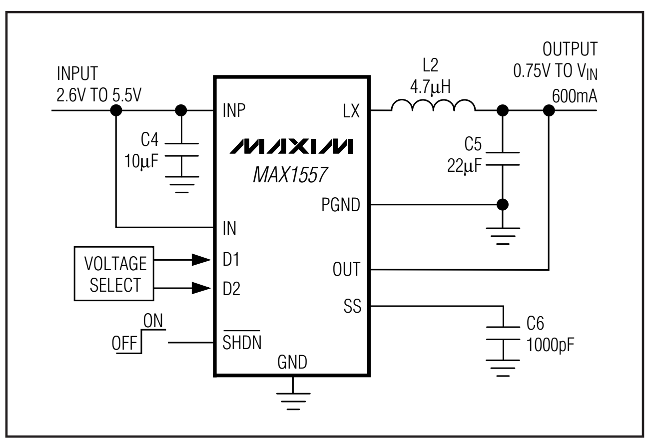


Figure 3. MAX1557 Typical Application Circuit

As the load current decreases, the converters enter a pulse-skip mode in which the PWM comparator is disabled. At light loads, efficency is enhanced by a pulse-skip mode in which switching occurs only as needed to service the load. Quiescent current in skip mode is typically 16µA. See the Light-Load Switching Waveforms and Load Transient graphs in the *Typical Operating Characteristics*.

Load-Transient Response/ Voltage Positioning

The MAX1556/MAX1556A/MAX1557 match the load regulation to the voltage droop seen during transients. This is sometimes called voltage positioning. The load line used to achieve this behavior is shown in Figures 4 and 5. There is minimal overshoot when the load is removed and minimal voltage drop during a transition from light load to full load. Additionally, the MAX1556, MAX1556A, and MAX1557 use a wide-bandwidth feedback loop to respond more quickly to a load transient than regulators using conventional integrating feedback loops (see Load Transient in the *Typical Operating Characteristics*).

The MAX1556/MAX1556A/MAX1557 use of a wide-band control loop and voltage positioning allows superior load-transient response by minimizing the amplitude and duration of overshoot and undershoot in response to load transients. Other DC-DC converters, with high gain- control loops, use external compensation to maintain tight DC load regulation but still allow large voltage droops of 5% or greater for several hundreds of microseconds during transients. For example, if the load is a CPU running at 600MHz, then a dip lasting 100µs corresponds to 60,000 CPU clock cycles.

Voltage positioning on the MAX1556/MAX1556A/MAX1557 allows up to 2.25% (typ) of load-regulation voltage shift but has no further transient droop. Thus, during load transients, the voltage delivered to the CPU remains within spec more effectively than with other regulators that might have tighter initial DC accuracy. In summary, a 2.25% load regulation with no transient droop is much better than a converter with 0.5% load regulation and 5% or more of voltage droop during load transients. Load-transient variation can be seen only with an oscilloscope (see the *Typical Operating Characteristics*), while DC load regulation read by a voltmeter does not show how the power supply reacts to load transients.

Dropout/100% Duty-Cycle Operation

The MAX1556/MAX1556A/MAX1557 function with a low input-to-output voltage difference by operating at 100% duty cycle. In this state, the high-side p-channel MOSFET is always on. This is particularly useful in battery-powered applications with a 3.3V output. The system and load might operate normally down to 3V or less. The MAX1556/MAX1556A/MAX1557 allow the output to follow the input battery voltage as it drops below the regulation voltage. The quiescent current in this state rises minimally to only 27µA (typ), which aids in extending battery life. This dropout/100% duty-cycle operation achieves long battery life by taking full advantage of the entire battery range.

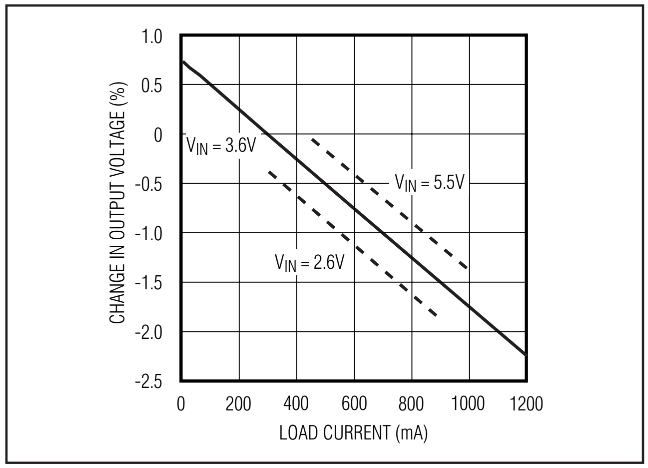


Figure 4. MAX1556 Voltage-Positioning Load Line

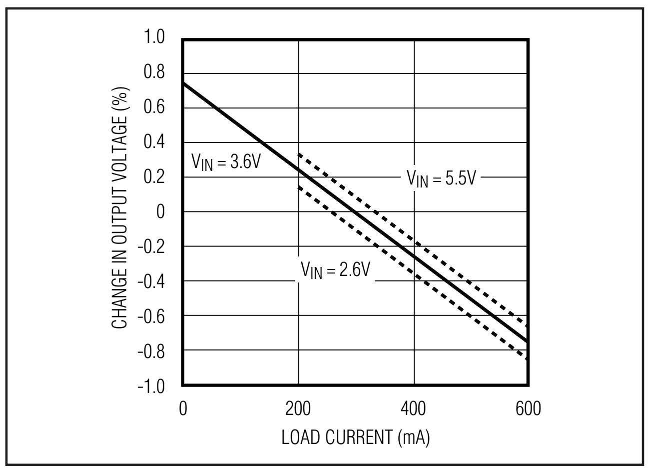


Figure 5. MAX1557 Voltage-Positioning Load Line

The input voltage required to maintain regulation is a function of the output voltage and the load. The difference between this minimum input voltage and the output voltage is called the dropout voltage. The dropout voltage is therefore a function of the on-resistance of the internal p-channel MOSFET ($R_{DS(ON)P}$) and the inductor resistance (DCR).

Table 2. Inductor Selection

MANUFACTURER	PART	VALUE (µH)	DCR (mΩ)	I_{SAT} (mA)	SIZE (mm)	SHIELDED
Taiyo Yuden	LMNP04SB3R3N	3.3	36	1300	5 x 5 x 2.0	Yes
Taiyo Yuden	LMNP04SB4R7N	4.7	50	1200	5 x 5 x 2.0	Yes
TOKO	D52LC	3.5	73	1340	5 x 5 x 2.0	Yes
TOKO	D52LC	4.7	87	1140	5 x 5 x 2.0	Yes
Sumida	CDRH3D16	4.7	50	1200	3.8 x 3.8 x 1.8	Yes
TOKO	D412F	4.7	100*	1200*	4.8 x 4.8 x 1.2	Yes
Murata	LQH32CN	4.7	97	790	2.5 x 3.2 x 2.0	No
Sumitomo	CXL180	4.7	70*	1000*	3.0 x 3.2 x 1.7	No
Sumitomo	CXLD140	4.7	100*	800*	2.8 x 3.2 x 1.5	No

**Estimated based upon similar-valued prototype inductors.*

$$V_{DROPOUT} = I_{OUT} \times (R_{DS(ON)P} + DCR)$$

$R_{DS(ON)P}$ is given in the *Electrical Characteristics*. DCR for a few recommended inductors is listed in Table 2.

Soft-Start

The MAX1556/MAX1556A/MAX1557 use soft-start to eliminate inrush current during startup, reducing transients at the input source. Soft-start is particularly useful for higher-impedance input sources such as Li+ and alkaline cells. Connect the required soft-start capacitor from SS to GND. For most applications using a 22µF output capacitor, connect a 1000pF capacitor from SS to GND. If a larger output capacitor is used, then use the following formula to find the value of the soft-start capacitor:

$$C_{SS} = \frac{C_{OUT}}{22000}$$

Soft-start is implemented by exponentially ramping up the output voltage from 0 to $V_{OUT(NOM)}$ with a time constant equal to C_{SS} times 200kΩ (see the *Typical Operating Characteristics*). Assuming three time constants to full output voltage, use the following formula to calculate the soft-start time:

$$t_{SS} = 600 \times 10^3 \times C_{SS}$$

Shutdown Mode

Connecting $\overline{SHDN}$ to GND or logic low places the MAX1556/MAX1556A/MAX1557 in shutdown mode and reduces supply current to 0.1µA. In shutdown, the control circuitry and the internal p-channel and n-channel MOSFETs turn off and LX becomes high impedance. Connect $\overline{SHDN}$ to IN or logic high for normal operation.

Thermal Shutdown

As soon as the junction temperature of the MAX1556/MAX1556A/MAX1557 exceeds +160°C, the ICs go into thermal shutdown. In this mode the internal p-channel switch and the internal n-channel synchronous rectifier are turned off. The device resumes normal operation when the junction temperature falls below +145°C.

Applications Information

The MAX1556/MAX1556A/MAX1557 are optimized for use with small external components. The correct selection of inductors and input and output capacitors ensures high efficiency, low output ripple, and fast transient response.

Adjusting the Output Voltage

The MAX1556/MAX1556A/MAX1557 offer preset output voltages of 1.0V, 1.2V, 1.3V, 1.5V, 1.8V, 2.5V, and 3.3V as well as an adjustable output using external resistors. Whenever possible, the preset outputs (set by D1 and D2) should be used. With external resistor feedback, noise coupling to FB can cause alternate LX pulse to terminate early resulting in an inductor current waveform with alternate large and small current pulses. See the *External Feedback Switching Waveforms* graph in *Typical Operating Characteristics* section). Note that external feedback and the alternating large-small pulse waveform do not impact loop stability and have no harmful effect on regulation or reliability.

The adjustable output is selected when D1 = D2 = 0 and an external resistor-divider is used to set the output voltage (see Figure 6). The MAX1556/MAX1557 have a defined line- and load-regulation slope. The load regulation is for both preset and adjustable outputs and is described in the *Electrical Characteristics* table and Figures 4 and 5. The impact of the line-regulation slope can be reduced by applying a correction factor to the feedback resistor equation.

First, calculate the correction factor, k, by plugging the desired output voltage into the following formula:

$$k = 1.06 \times 10^{-2} V \times \left(\frac{V_{OUTPUT} - 0.75V}{3.6V} \right)$$

k represents the shift in the operating point at the feedback node (OUT).

Select the lower feedback resistor, R3, to be ≤35.7kΩ to ensure stability and solve for R2:

$$\left(\frac{0.75V - k}{V_{OUTPUT}} \right) = \frac{R3}{(R3 + R2)}$$

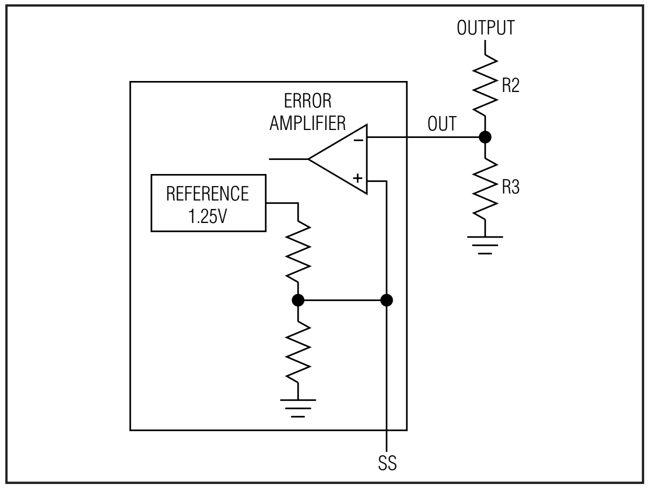


Figure 6. Adjustable Output Voltage

Inductor Selection

A 4.7µH inductor with a saturation current of at least 800mA is recommended for the MAX1557 full-load (600mA) application. For the MAX1556/MAX1556A application with 1.2A full load, use a 3.3µH inductor with at least 1.34A saturation current. For lower full-load currents the inductor current rating can be reduced. For maximum efficiency, the inductor's resistance (DCR) should be as low as possible. Please note that the core material differs among different manufacturers and inductor types and has an impact on the efficiency. See Table 2 for recommended inductors and manufacturers.

Capacitor Selection

Ceramic input and output capacitors are recommended for most applications. For best stability over a wide temperature range, use capacitors with an X5R or better dielectric due to their small size, low ESR, and low temperature coefficients.

Output Capacitor

The output capacitor C_{OUT} is required to keep the output voltage ripple small and to ensure regulation loop stability. C_{OUT} must have low impedance at the switching frequency. A 22µF ceramic output capacitor is recommended for most applications. If a larger output capacitor is used, then paralleling smaller capacitors is suggested to keep the effective impedance of the capacitor low at the switching frequency.

Input Capacitor

Due to the pulsating nature of the input current in a buck converter, a low-ESR input capacitor at INP is required for input voltage filtering and to minimize interference with other circuits. The impedance of the input capacitor C_{INP} should be kept very low at the switching frequency. A minimum value of 10µF is recommended at INP for most applications. The input capacitor can be increased for better input filtering.

IN Input Filter

In all MAX1557 applications, connect INP directly to IN and bypass INP as described in the *Input Capacitor* section. No additional bypass capacitor is required at IN. For applications using the MAX1556 and MAX1556A, an RC filter between INP and IN keeps power-supply noise from entering the IC. Connect a 100Ω resistor between INP and IN, and connect a 0.47µF capacitor from IN to GND.

Soft-Start Capacitor

The soft-start capacitor, C_{SS}, is required for proper operation of the MAX1556/MAX1556A/MAX1557. The recommended value of C_{SS} is discussed in the *Soft-Start* section. Soft-start times for various soft-start capacitors are shown in the *Typical Operating Characteristics*.

PCB Layout and Routing

Due to fast-switching waveforms and high-current paths, careful PCB layout is required. An evaluation kit (MAX1556EVKIT) is available to speed design.

When laying out a board, minimize trace lengths between the IC, the inductor, the input capacitor, and the output capacitor. Keep these traces short, direct, and wide. Keep noisy traces, such as the LX node trace, away from OUT. The input bypass capacitors should be placed as close as possible to the IC. Connect GND to the exposed paddle and star PGND and GND together at the output capacitor. The ground connections of the input and output capacitors should be as close together as possible.

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
10 TDFN	T1033-1	21-0137	90-0003

16µA IQ, 1.2A PWM DC-DC Step-Down Converters

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	7/04	Initial release	—
1	3/08	Adding MAX1556A as a new version	1–12
2	6/10	Added soldering temperature, added TOC for external feedback switching waveforms, and added paragraph discussing noise coupling when using external feedback resistors	1, 2, 5, 6, 9, 10, 11

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.

© 2010 Maxim Integrated Products

Maxim is a registered trademark of Maxim Integrated Products, Inc.