

LTM4600

10A High Efficiency  
DC/DC  $\mu$ Module

## FEATURES

- Complete Switch Mode Power Supply
- Wide Input Voltage Range: 4.5V to 20V
- 10A DC, 14A Peak Output Current
- Parallel Two  $\mu$ Modules™ for 20A Output Current
- 0.6V to 5V Output Voltage
- 1.5% Regulation
- Ultrafast Transient Response
- Current Mode Control
- Pb-Free (e<sup>4</sup>) RoHS Compliant Package
- Up to 92% Efficiency
- Programmable Soft-Start
- Output Overvoltage Protection
- Optional Short-Circuit Shutdown Timer
- Small Footprint, Low Profile (15mm × 15mm × 2.8mm) Surface Mount LGA Package

## APPLICATIONS

- Telecom and Networking Equipment
- Servers
- Industrial Equipment
- Point of Load Regulation
- Other General Purpose Step Down DC/DC

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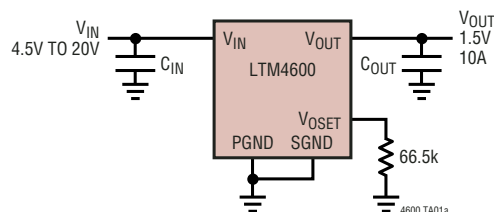
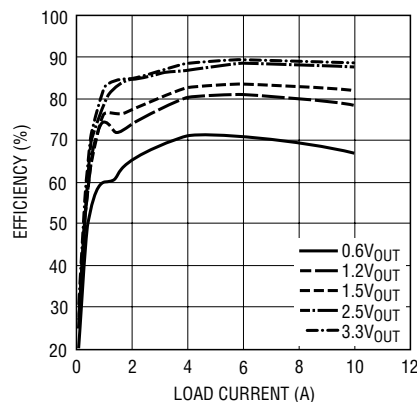
## DESCRIPTION

The LTM<sup>®</sup>4600 is a complete 10A, DC/DC step down power supply. Included in the package are the switching controller, power FETs, inductor, and all support components. Operating over an input voltage range of 4.5V to 20V, the LTM4600 supports an output voltage range of 0.6V to 5V, set by a single resistor. This high efficiency design delivers 10A continuous current (14A peak), needing no heat sinks or airflow to meet power specifications. Only bulk input and output capacitors are needed to finish the design.

The low profile package (2.8mm) enables utilization of unused space on the bottom of PC boards for high density point of load regulation. High switching frequency and an adaptive on-time current mode architecture enables a very fast transient response to line and load changes without sacrificing stability. Fault protection features include integrated overvoltage and short circuit protection with a defeatable shutdown timer. A built-in soft-start timer is adjustable with a small capacitor.

The LTM4600 is packaged in a thermally enhanced, compact (15mm × 15mm) and low profile (2.8mm) over-molded Land Grid Array (LGA) package suitable for automated assembly by standard surface mount equipment. The LTM4600 is Pb-free and RoHS certified.

## TYPICAL APPLICATION

10A  $\mu$ Module Power Supply with 4.5V to 20V InputEfficiency vs Load Current  
with 12V<sub>IN</sub> (FCB = 0)

4600 TA01b

4600p

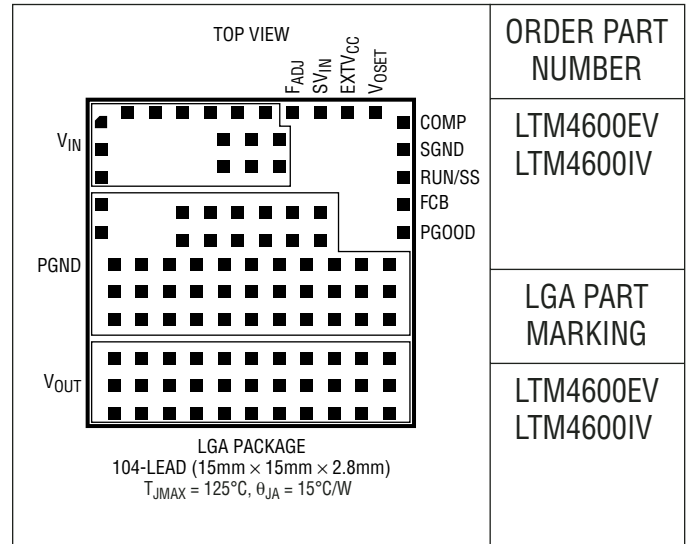
## LTM4600

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

FCB, EXTV <sub>CC</sub> , PGOOD, RUN/SS, V <sub>OUT</sub> .....	-0.3V to 6V
V <sub>IN</sub> , SV <sub>IN</sub> , F <sub>ADJ</sub> .....	-0.3V to 20V
V <sub>OSET</sub> , COMP .....	-0.3V to 2.7V
Operating Temperature Range (Note 2) ...	-40°C to 85°C
Junction Temperature .....	125°C
Storage Temperature Range.....	-65°C to 150°C

## PACKAGE/ORDER INFORMATION



Consult LTC Marketing for parts specified with wider operating temperature ranges.

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the -40°C to 85°C temperature range, otherwise specifications are at T<sub>A</sub> = 25°C, V<sub>IN</sub> = 12V. External C<sub>IN</sub> = 120μF, C<sub>OUT</sub> = 200μF/Ceramic per typical application (front page) configuration.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>IN(DC)</sub>	Input DC Voltage		● 4.5		20	V
V <sub>OUT(DC)</sub>	Output Voltage V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.5V, I <sub>OUT</sub> = 0A V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.5V, I <sub>OUT</sub> = 0A V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 1.5V, I <sub>OUT</sub> = 0A	FCB = 0	● 1.478	1.50	1.522	V
<b>Input Specifications</b>						
V <sub>IN(UVLO)</sub>	Under Voltage Lockout Threshold	I <sub>OUT</sub> = 0A		3.4	4	V
I <sub>INRUSH(VIN)</sub>	Input Inrush Current at Startup V <sub>IN</sub> = 5V V <sub>IN</sub> = 12V	I <sub>OUT</sub> = 0A, V <sub>OUT</sub> = 1.5V, FCB = 0		0.6 0.7		A A
I <sub>Q(VIN)</sub>	Input Supply Bias Current V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.5V, FCB = 5V V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.5V, FCB = 0V V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 1.5V, FCB = 5V V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 1.5V, FCB = 0V Shutdown, RUN = 0, V <sub>IN</sub> = 12V	I <sub>OUT</sub> = 0A, EXTV <sub>CC</sub> Open		1.2 42 1.0 52 15		mA mA mA mA μA
I <sub>S(VIN)</sub>	Input Supply Current V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 1.5V, I <sub>OUT</sub> = 10A V <sub>IN</sub> = 12V, V <sub>OUT</sub> = 3.3V, I <sub>OUT</sub> = 10A V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 1.5V, I <sub>OUT</sub> = 10A			1.52 3.13 3.64		A A A

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  temperature range, otherwise specifications are at  $T_A = 25^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$ . Per typical application (front page) configuration.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>Output Specifications</b>							
$I_{OUTDC}$	Output Continuous Current Range (See Output Current Derating Curves for Different $V_{IN}$ , $V_{OUT}$ and $T_A$ )	$V_{IN} = 12\text{V}$ , $V_{OUT} = 1.5\text{V}$	0		10	A	
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation Accuracy $I_{OUT} = 0\text{A}$	$V_{OUT} = 1.5\text{V}$ . FCB = 0V	●	0.3		%	
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation Accuracy $V_{IN} = 5\text{V}$ $V_{IN} = 12\text{V}$	$V_{OUT} = 1.5\text{V}$ . FCB = 0V 0A to 10A	●		$\pm 1$ $\pm 1$	% %	
$V_{OUT(AC)}$	Output Ripple Voltage $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.5\text{V}$ , FCB = 0V $V_{IN} = 5\text{V}$ , $V_{OUT} = 1.5\text{V}$ , FCB = 0V	$I_{OUT} = 0\text{A}$	●	15 20	25	mV <sub>P-P</sub> mV <sub>P-P</sub>	
$F_s$	Output Ripple Voltage Frequency	FCB = 0V, $I_{OUT} = 5\text{A}$ , $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.5\text{V}$		800		kHz	
$t_{START}$	Turn-On Time $V_{IN} = 12\text{V}$ $V_{IN} = 5\text{V}$	$V_{OUT} = 1.5\text{V}$ , $I_{OUT} = 10\text{A}$		0.5 0.7		ms ms	
$\Delta V_{OUTLS}$	Voltage Drop for Dynamic Load Step $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.5\text{V}$	Load Step: 0A to 5A/ $\mu\text{s}$ $C_{OUT} = 3 \cdot 22\mu\text{F}$ 6.3V, 470 $\mu\text{F}$ 4V Pos Cap, See Table 2		36		mV	
$t_{SETTLE}$	Settling Time for Dynamic Load Step $V_{IN} = 12\text{V}$	Load: 10% to 90% to 10% of Full Load		25		$\mu\text{s}$	
$I_{OUTPK}$	Output Current Limit $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.5\text{V}$ $V_{IN} = 5\text{V}$ , $V_{OUT} = 1.5\text{V}$			17 17		A A	
<b>Control Stage</b>							
$V_{OSET}$	Voltage at $V_{OSET}$ Pin	$I_{OUT} = 0\text{A}$ , $V_{OUT} = 1.5\text{V}$	●	0.594	0.6	0.606	V
$V_{RUN/SS}$	RUN ON/OFF Threshold			0.8	1.5	2	V
$I_{RUN(C)/SS}$	Soft-Start Charging Current	$V_{RUN/SS} = 0\text{V}$		-0.5	-1.2	-3	$\mu\text{A}$
$I_{RUN(D)/SS}$	Soft-Start Discharging Current	$V_{RUN/SS} = 4\text{V}$		0.8	1.8	3	$\mu\text{A}$
$V_{IN} - SV_{IN}$		EXTV <sub>CC</sub> = 0, FCB = 0V			100		mV
$I_{EXTVCC}$	Current into EXTV <sub>CC</sub> Pin	FCB = 0V, $V_{OUT} = 1.5\text{V}$ , $I_{OUT} = 0\text{A}$			16		mA
$R_{FBHI}$	Resistor Between $V_{OUT}$ and FB Pins				100		k $\Omega$
$V_{FCB}$	Forced Continuous Threshold			0.57	0.6	0.63	V
$I_{FCB}$	Forced Continuous Pin Current	$V_{FCB} = 0.6\text{V}$			-1	-2	$\mu\text{A}$
<b>PGOOD Output</b>							
$\Delta V_{OSETH}$	PGOOD Upper Threshold	$V_{OSET}$ Rising		7.5	10	12.5	%
$\Delta V_{OSETL}$	PGOOD Lower Threshold	$V_{OSET}$ Falling		-7.5	-10	-12.5	%
$\Delta V_{OSET(HYS)}$	PGOOD Hysteresis	$V_{OSET}$ Returning			1	2.5	%
$V_{PGL}$	PGOOD Low Voltage	$I_{PGOOD} = 5\text{mA}$			0.15	0.4	V

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

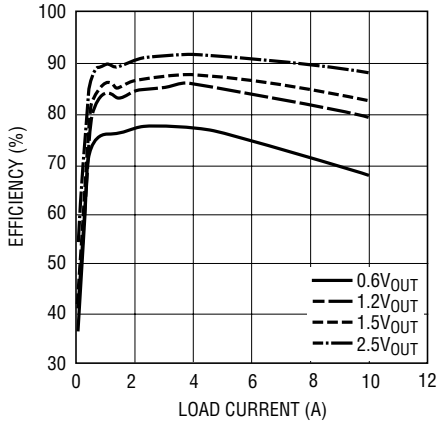
**Note 2:** The LTM4600E is guaranteed to meet performance specifications from  $0^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . Specifications over the  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  operating

temperature range are assured by design, characterization and correlation with statistical process controls. The LTM4600I is guaranteed and tested over the  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  temperature range.

# LTM4600

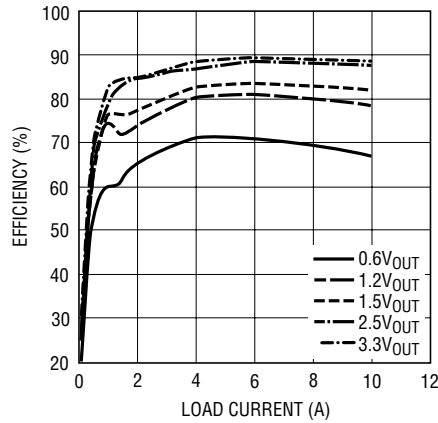
## TYPICAL PERFORMANCE CHARACTERISTICS

**Efficiency vs Load Current with 5V<sub>IN</sub> (FCB = 0)**



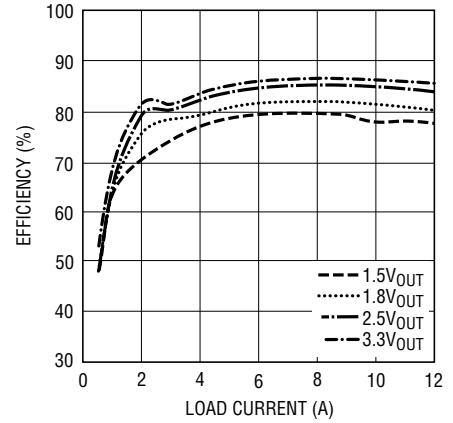
4600 G01

**Efficiency vs Load Current with 12V<sub>IN</sub> (FCB = 0)**



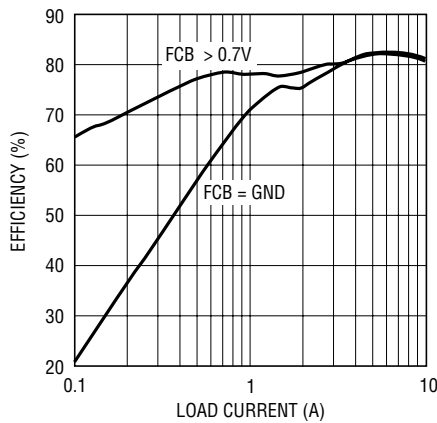
4600 G02

**Efficiency vs Load Current with 18V<sub>IN</sub> (FCB = 0)**



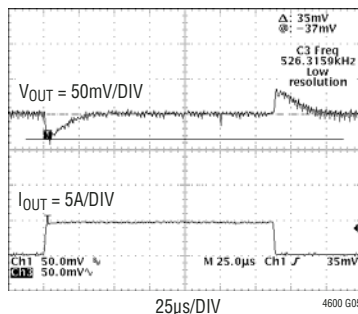
4600 G03

**Efficiency vs Load Current with Different FCB Settings**



4600 G04

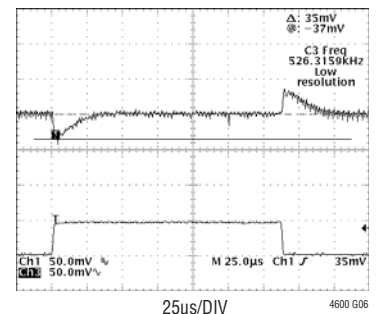
**1.2V Transient Response (See Figure 17)**



4600 G05

25µs/DIV  
1.2V AT 5A/µs LOAD STEP  
C<sub>OUT</sub> = 3 • 22µF 6.3V CERAMICS  
470µF 4V SANYO POS CAP  
C<sub>3</sub> = 100pF

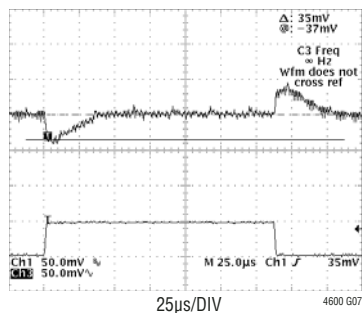
**1.5V Transient Response (See Figure 17)**



4600 G06

25µs/DIV  
1.5V AT 5A/µs LOAD STEP  
C<sub>OUT</sub> = 3 • 22µF 6.3V CERAMICS  
470µF 4V SANYO POS CAP  
C<sub>3</sub> = 100pF

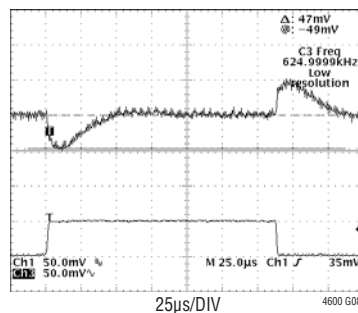
**1.8V Transient Response (See Figure 17)**



4600 G07

25µs/DIV  
1.8V AT 5A/µs LOAD STEP  
C<sub>OUT</sub> = 3 • 22µF 6.3V CERAMICS  
470µF 4V SANYO POS CAP  
C<sub>3</sub> = 100pF

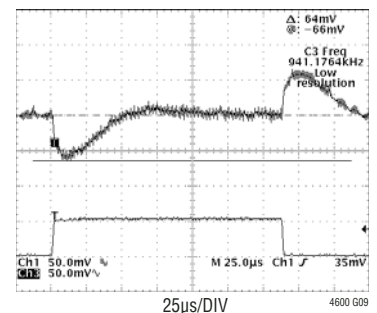
**2.5V Transient Response (See Figure 17)**



4600 G08

25µs/DIV  
2.5V AT 5A/µs LOAD STEP  
C<sub>OUT</sub> = 3 • 22µF 6.3V CERAMICS  
470µF 4V SANYO POS CAP  
C<sub>3</sub> = 100pF

**3.3V Transient Response (See Figure 17)**



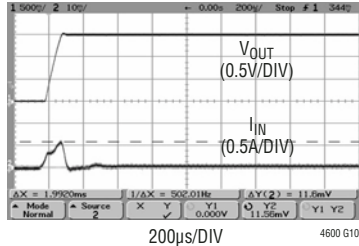
4600 G09

25µs/DIV  
3.3V AT 5A/µs LOAD STEP  
C<sub>OUT</sub> = 3 • 22µF 6.3V CERAMICS  
470µF 4V SANYO POS CAP  
C<sub>3</sub> = 100pF

4600p

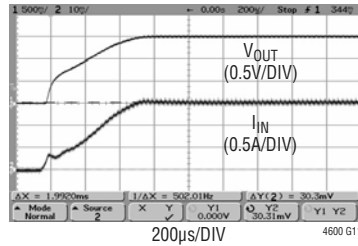
# TYPICAL PERFORMANCE CHARACTERISTICS

**Start-Up,  $I_{OUT} = 0A$   
(See Figure 17)**



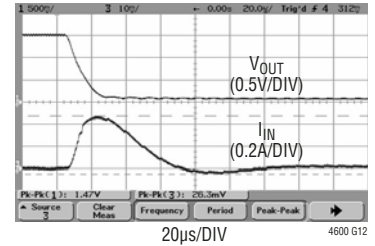
$V_{IN} = 12V$   
 $V_{OUT} = 1.5V$   
 $C_{OUT} = 200\mu F$   
 NO EXTERNAL SOFT-START CAPACITOR

**Start-Up,  $I_{OUT} = 10A$   
(Resistive Load) (See Figure 17)**



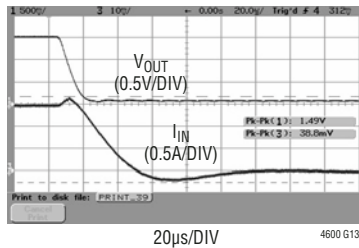
$V_{IN} = 12V$   
 $V_{OUT} = 1.5V$   
 $C_{OUT} = 200\mu F$   
 NO EXTERNAL SOFT-START CAPACITOR

**Short-Circuit Protection,  
 $I_{OUT} = 0A$  (See Figure 17)**



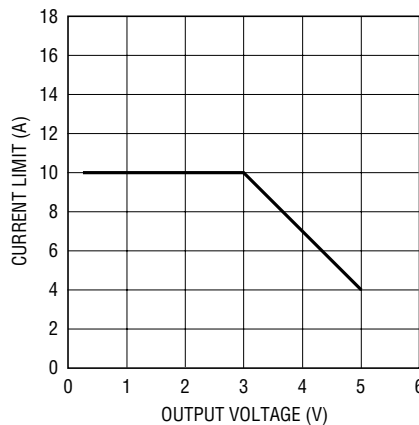
$V_{IN} = 12V$   
 $V_{OUT} = 1.5V$   
 $C_{OUT} = 2 \times 200\mu F / X5R$   
 NO EXTERNAL SOFT-START CAPACITOR

**Short-Circuit Protection,  
 $I_{OUT} = 10A$  (See Figure 17)**



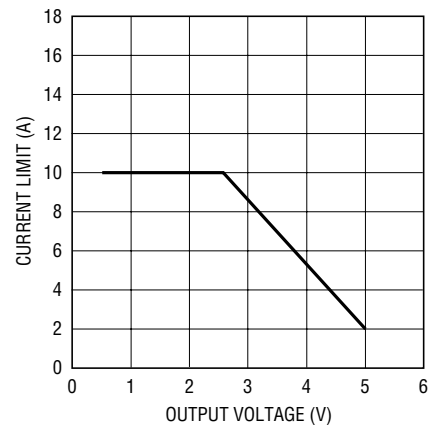
$V_{IN} = 12V$   
 $V_{OUT} = 1.5V$   
 $C_{OUT} = 2 \times 200\mu F / X5R$   
 NO EXTERNAL SOFT-START CAPACITOR

**Current Limit with  $12V_{IN}$**



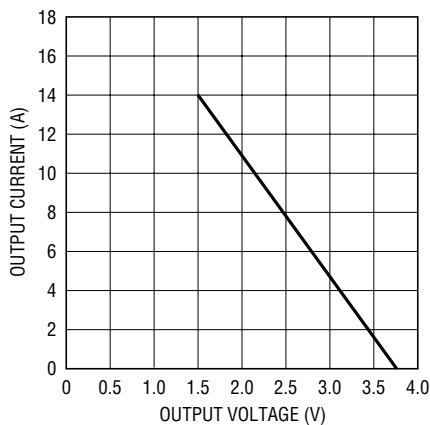
4600 G14

**Current Limit with  $9V_{IN}$**



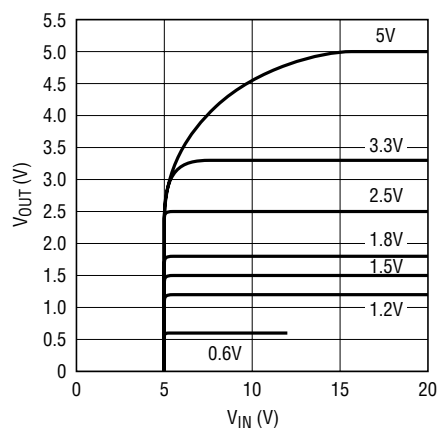
4600 G15

**Current Limit with  $5V_{IN}$**



4600 G16

**$V_{IN}$  to  $V_{OUT}$  Stepdown Ratio**



4600 G17

## LTM4600

## PIN FUNCTIONS (See Package Description for Pin Assignment)

**$V_{IN}$  (Bank 1):** Power Input Pins. Apply input voltage between these pins and GND pins. Recommend placing input decoupling capacitance directly between  $V_{IN}$  pins and GND pins.

**$F_{ADJ}$  (Pin A15):** An internal resistor from  $V_{IN}$  to this pin sets the one-shot timer current, thereby setting the switching frequency.

**$SV_{IN}$  (Pin A17):** Supply Pin for Internal PWM Controller. Leave this pin open or add additional decoupling capacitance.

**$EXTV_{CC}$  (Pin A19):** External 5V supply pin for controller. If left open, the internal 5V linear regulator will power the controller and MOSFET drivers. For high input voltage applications, connecting this pin to an external 5V will reduce the power loss in the power module. The  $EXTV_{CC}$  voltage should never be higher than  $V_{IN}$ .

**$V_{OSET}$  (Pin A21):** The Negative Input of The Error Amplifier. Internally, this pin is connected to  $V_{OUT}$  with a 100k precision resistor. Different output voltages can be programmed with additional resistors between the  $V_{OSET}$  and SGND pins.

**COMP (Pin B23):** Current Control Threshold and Error Amplifier Compensation Point. The current comparator threshold increases with this control voltage. The voltage ranges from 0V to 2.4V with 0.8V corresponding to zero sense voltage (zero current).

**SGND (Pin D23):** Signal Ground Pin. All small-signal

components should connect to this ground, which in turn connects to PGND at one point.

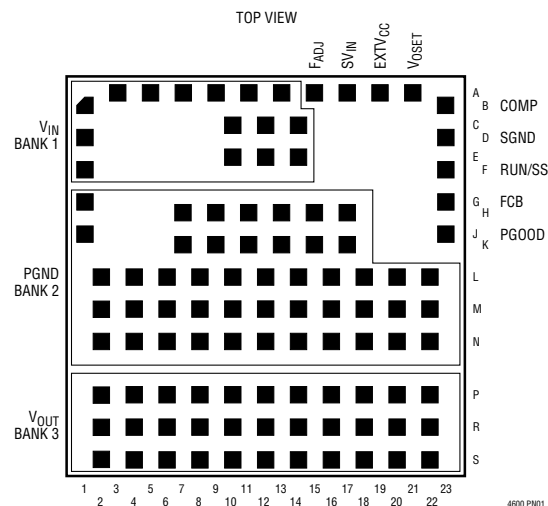
**RUN/SS (Pin F23):** Run and Soft-Start Control. Forcing this pin below 0.8V will shut down the power supply. Inside the power module, there is a 1000pF capacitor which provides approximately 0.7ms soft-start time with 200 $\mu$ F output capacitance. Additional soft-start time can be achieved by adding additional capacitance between the RUN/SS and SGND pins. The internal short-circuit lathoff can be disabled by adding a resistor between this pin and the  $V_{IN}$  pin. This resistor must supply a minimum 5 $\mu$ A pull up current.

**FCB (Pin G23):** Forced Continuous Input. Grounding this pin enables forced continuous mode operation regardless of load conditions. Tying this pin above 0.63V enables discontinuous conduction mode to achieve high efficiency operation at light loads. There is an internal 4.75K resistor between the FCB and SGND pins.

**PGOOD (Pin J23):** Output Voltage Power Good Indicator. When the output voltage is within 10% of the nominal voltage, the PWRGD is open drain output. Otherwise, this pin is pulled to ground.

**PGND (Bank 2):** Power ground pins for both input and output returns.

**$V_{OUT}$  (Bank 3):** Power Output Pins. Apply output load between these pins and GND pins. Recommend placing High Frequency output decoupling capacitance directly between these pins and GND pins.



4600p

## SIMPLIFIED BLOCK DIAGRAM

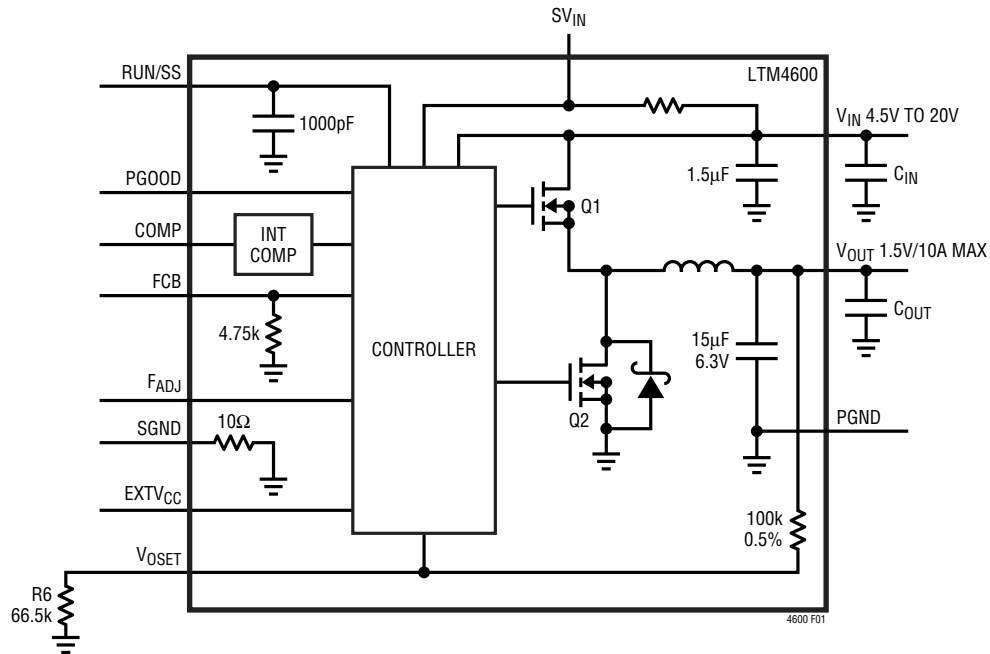


Figure 1. Simplified LTM4600 Block Diagram

DECOUPLING REQUIREMENTS  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 12\text{V}$ . Use Figure 1 configuration.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$C_{IN}$	External Input Capacitor Requirement ( $V_{IN} = 4.5\text{V to }15\text{V}$ , $V_{OUT} = 1.5\text{V}$ )	$I_{OUT} = 10\text{A}$	20			$\mu\text{F}$
$C_{OUT}$	External Output Capacitor Requirement ( $V_{IN} = 4.5\text{V to }15\text{V}$ , $V_{OUT} = 1.5\text{V}$ )	$I_{OUT} = 10\text{A}$ , Refer to Table 2 in the Applications Information Section	100	200		$\mu\text{F}$



# LTM4600

## OPERATION

### μModule Description

The LTM4600 is a standalone non-isolated synchronous switching DC/DC power supply. It can deliver up to 10A of DC output current with only bulk external input and output capacitors. This module provides a precisely regulated output voltage programmable via one external resistor from  $0.6V_{DC}$  to  $5.0V_{DC}$ , not to exceed 80% of the input voltage. The input voltage range is 4.5V to 20V. A simplified block diagram is shown in Figure 1 and the typical application schematic is shown in Figure 17.

The LTM4600 contains an integrated LTC constant on-time current-mode regulator, ultra-low  $R_{DS(ON)}$  FETs with fast switching speed and integrated Schottky diode. The typical switching frequency is 800kHz at full load. With current mode control and internal feedback loop compensation, the LTM4600 module has sufficient stability margins and good transient performance under a wide range of operating conditions and with a wide range of output capacitors, even all ceramic output capacitors.

Current mode control provides cycle-by-cycle fast current limit. In addition, foldback current limiting is provided in an over-current condition while  $V_{FB}$  drops. Also, the LTM4600 has defeatable short circuit latch off. Internal overvoltage and undervoltage comparators pull the open-drain PGOOD output low if the output feedback voltage exits a

$\pm 10\%$  window around the regulation point. Furthermore, in an overvoltage condition, internal top FET Q1 is turned off and bottom FET Q2 is turned on and held on until the overvoltage condition clears.

Pulling the RUN/SS pin low forces the controller into its shutdown state, turning off both Q1 and Q2. Releasing the pin allows an internal  $1.2\mu A$  current source to charge up the softstart capacitor. When this voltage reaches 1.5V, the controller turns on and begins switching.

At low load current the module works in continuous current mode by default to achieve minimum output voltage ripple. It can be programmed to operate in discontinuous current mode for improved light load efficiency when the FCB pin is pulled up above 0.8V and no higher than 5V. The FCB pin has a 4.25k resistor to ground, so a resistor to  $V_{IN}$  can set the voltage on the FCB pin.

When  $EXTV_{CC}$  pin is grounded, an integrated 5V linear regulator powers the controller and MOSFET gate drivers. If a minimum 4.7V external bias supply is applied on the  $EXTV_{CC}$  pin, the internal regulator is turned off, and an internal switch connects  $EXTV_{CC}$  to the gate driver voltage. This eliminates the linear regulator power loss with high input voltage, reducing the thermal stress on the controller. The maximum voltage on  $EXTV_{CC}$  pin is 6V. The  $EXTV_{CC}$  voltage should never be higher than the  $V_{IN}$  voltage. Also  $EXTV_{CC}$  must be sequenced after  $V_{IN}$ .



## APPLICATIONS INFORMATION

The typical LTM4600 application circuit is shown in Figure 20. External component selection is primarily determined by the maximum load current and output voltage.

### Output Voltage Programming and Margining

The PWM controller of the LTM4600 has an internal  $0.6V \pm 1\%$  reference voltage. As shown in the block diagram, a  $100k/0.5\%$  internal feedback resistor connects  $V_{OUT}$  and FB pins. Adding a resistor  $R_{SET}$  from  $V_{OSET}$  pin to SGND pin programs the output voltage:

$$V_O = 0.6V \cdot \frac{100k + R_{SET}}{R_{SET}}$$

Table 1 shows the standard values of  $1\%$   $R_{SET}$  resistor for typical output voltages:

Table 1.

$R_{SET}$ (k $\Omega$ )	Open	100	66.5	49.9	43.2	31.6	22.1	13.7
$V_O$ (V)	0.6	1.2	1.5	1.8	2	2.5	3.3	5

Voltage margining is the dynamic adjustment of the output voltage to its worst case operating range in production testing to stress the load circuitry, verify control/protection functionality of the board and improve the system reliability. Figure 2 shows how to implement margining function with the LTM4600. In addition to the feedback resistor  $R_{SET}$ , several external components are added. Turn off both transistor  $Q_{UP}$  and  $Q_{DOWN}$  to disable the margining. When  $Q_{UP}$  is on and  $Q_{DOWN}$  is off, the output voltage is margined up. The output voltage is margined

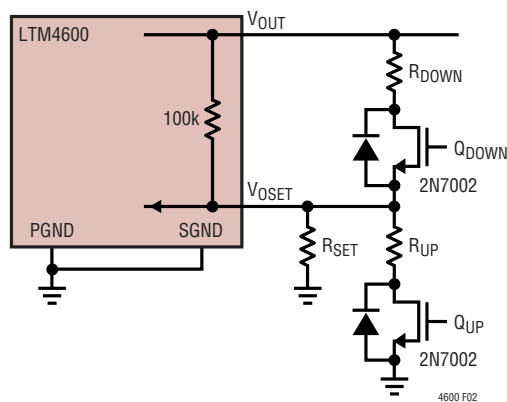


Figure 2.

down when  $Q_{DOWN}$  is on and  $Q_{UP}$  is off. If the output voltage  $V_O$  needs to be margined up/down by  $\pm M\%$ , the resistor values of  $R_{UP}$  and  $R_{DOWN}$  can be calculated from the following equations:

$$\frac{(R_{SET} \parallel R_{UP}) \cdot V_O \cdot (1 + M\%)}{(R_{SET} \parallel R_{UP}) + 100k\Omega} = 0.6V$$

$$\frac{R_{SET} \cdot V_O \cdot (1 - M\%)}{R_{SET} + (100k\Omega \parallel R_{DOWN})} = 0.6V$$

### Input Capacitors

The LTM4600  $\mu$ Module should be connected to a low ac-impedance AC source. High frequency, low ESR input capacitors are required to be placed adjacent to the module. In Figure 20, the bulk input capacitor  $C_{IN}$  is selected for its ability to handle the large RMS current into the converter. For a buck converter, the switching duty-cycle can be estimated as:

$$D = \frac{V_O}{V_{IN}}$$

Without considering the inductor current ripple, the RMS current of the input capacitor can be estimated as:

$$I_{CIN(RMS)} = \frac{I_{O(MAX)}}{\eta\%} \cdot \sqrt{D \cdot (1 - D)}$$

In the above equation,  $\eta\%$  is the estimated efficiency of the power module.  $C_1$  can be a switcher-rated electrolytic aluminum capacitor, OS-CON capacitor or high volume ceramic capacitors. Note the capacitor ripple current ratings are often based on only 2000 hours of life. This makes it advisable to properly derate the input capacitor, or choose a capacitor rated at a higher temperature than required. Always contact the capacitor manufacturer for derating requirements.

In Figure 16, the input capacitors are used as high frequency input decoupling capacitors. In a typical 10A output application, 1-2 pieces of very low ESR X5R or X7R,  $10\mu F$  ceramic capacitors are recommended. This decoupling capacitor should be placed directly adjacent

# LTM4600

## APPLICATIONS INFORMATION

the module input pins in the PCB layout to minimize the trace inductance and high frequency AC noise.

### Output Capacitors

The LTM4600 is designed for low output voltage ripple. The bulk output capacitors  $C_{OUT}$  is chosen with low enough effective series resistance (ESR) to meet the output voltage ripple and transient requirements.  $C_{OUT}$  can be low ESR tantalum capacitor, low ESR polymer capacitor or ceramic capacitor. The typical capacitance is 200 $\mu$ F if all ceramic output capacitors are used. The internally optimized loop compensation provides sufficient stability margin for all ceramic capacitors applications. Additional output filtering may be required by the system designer, if further reduction of output ripple or dynamic transient spike is required. Refer to Table 2 for an output capacitance matrix for each output voltage Droop, peak to peak deviation and recovery time during a 5A/ $\mu$ s transient with a specific output capacitance.

### Fault Conditions: Current Limit and Over current Foldback

The LTM4600 has a current mode controller, which inherently limits the cycle-by-cycle inductor current not only in steady state operation, but also in transient.

To further limit current in the event of an over load condition, the LTM4600 provides foldback current limiting. If the output voltage falls by more than 50%, then the maximum output current is progressively lowered to about one sixth of its full current limit value.

### Soft-Start and Latchoff with the RUN/SS pin

The RUN/SS pin provides a means to shut down the LTM4600 as well as a timer for soft-start and over-current latchoff. Pulling the RUN/SS pin below 0.8V puts the LTM4600 into a low quiescent current shutdown ( $I_Q \leq 30\mu$ A). Releasing the pin allows an internal 1.2 $\mu$ A current source to charge up the timing capacitor CSS. Inside LTM4600, there is an internal 1000pF capacitor from RUN/SS pin to ground. If RUN/SS pin has an external capacitor CSS\_EXT to ground, the delay before starting is about:

$$t_{DELAY} = \frac{1.5V}{1.2\mu A} \cdot (C_{SS\_EXT} + 1000pF)$$

When the voltage on RUN/SS pin reaches 1.5V, the LTM4600 internal switches are operating with a clamping of the maximum output inductor current limited by the RUN/SS pin total soft-start capacitance. As the RUN/SS pin voltage rises to 3V, the soft-start clamping of the inductor current is released.

### V<sub>IN</sub> to V<sub>OUT</sub> Stepdown Ratios

There are restrictions in the maximum V<sub>IN</sub> to V<sub>OUT</sub> step down ratio that can be achieved for a given input voltage. These constraints are shown in the Typical Performance Characteristics curves labeled "V<sub>IN</sub> to V<sub>OUT</sub> Stepdown Ratio". Note that additional thermal de-rating may apply. See the Thermal Considerations and Output Current De-Rating sections of this data sheet.

## APPLICATIONS INFORMATION

Table 2. Output Voltage Response Verses Component Matrix

### TYPICAL MEASURED VALUES

C <sub>OUT1</sub> VENDORS	PART NUMBER	C <sub>OUT2</sub> VENDORS	PART NUMBER
TDK	C4532X5R0J107MZ (100UF, 6.3V)	SANYO POS CAP	6TPE330MIL (330μF, 6.3V)
TAIYO YUDEN	JMK432BJ107MU-T (100μF, 6.3V)	SANYO POS CAP	2R5TPE470M9 (470μF, 2.5V)
TAIYO YUDEN	JMK316BJ226ML-T501 (22μF, 6.3V)	SANYO POS CAP	4TPE470MCL (470μF, 4V)

V <sub>OUT</sub> (V)	C <sub>IN</sub> (CERAMIC)	C <sub>IN</sub> (BULK)	C <sub>OUT1</sub> (CERAMIC)	C <sub>OUT2</sub> (BULK)	C <sub>COMP</sub>	C3	V <sub>IN</sub> (V)	DROOP (mV)	PEAK TO PEAK (mV)	RECOVERY TIME (μs)	LOAD STEP (A/μs)
1.2	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	12	35	68	25	5
1.2	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	5	35	68	25	5
1.5	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	12	36	75	25	5
1.5	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	5	36	75	25	5
1.8	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	12	40	81	30	5
1.8	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	5	40	81	30	5
2.5	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	12	51	102	30	5
2.5	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	5	57	116	30	5
3.3	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	12	64	129	35	5
3.3	2 × 10μF 25V	150μF 35V	3 × 22μF 6.3V	470μF 4V	NONE	100pF	7	82	166	35	5
1.2	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	12	35	70	20	5
1.2	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	5	35	70	20	5
1.5	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	12	37	79	20	5
1.5	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	5	37	79	20	5
1.8	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	12	44	85	20	5
1.8	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 2.5V	NONE	100pF	5	44	88	20	5
2.5	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 4V	NONE	100pF	12	48	103	30	5
2.5	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 4V	NONE	100pF	5	48	103	30	5
3.3	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 4V	NONE	100pF	12	52	106	30	5
3.3	2 × 10μF 25V	150μF 35V	1 × 100μF 6.3V	470μF 4V	NONE	100pF	7	66	132	30	5
1.2	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	12	40	80	20	5
1.2	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	5	40	80	20	5
1.5	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	12	44	89	20	5
1.5	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	5	44	84	20	5
1.8	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	12	44	91	20	5
1.8	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	5	46	91	20	5
2.5	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	12	56	113	30	5
2.5	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	5	56	113	30	5
3.3	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	12	64	126	30	5
3.3	2 × 10μF 25V	150μF 35V	2 × 100μF 6.3V	330μF 6.3V	NONE	100pF	7	64	126	30	5
1.2	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	12	49	98	20	5
1.2	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	5	49	98	20	5
1.5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	12	54	108	20	5
1.5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	5	61	118	20	5
1.8	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	12	62	125	20	5
1.8	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	5	62	128	20	5
2.5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	12	70	159	25	5
2.5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	5	60	115	25	5
3.3	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	12	76	144	25	5
3.3	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	7	100	200	25	5
5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	15	188	375	25	5
5	2 × 10μF 25V	150μF 35V	4 × 100μF 6.3V	NONE	NONE	100pF	20	159	320	25	5

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After the controller has been started and given adequate time to charge up the output capacitor, CSS is used as a short-circuit timer. After the RUN/SS pin charges above 4V, if the output voltage falls below 75% of its regulated value, then a short-circuit fault is assumed. A 1.8μA current then begins discharging CSS. If the fault condition persists until the RUN/SS pin drops to 3.5V, then the controller turns off both power MOSFETs, shutting down the converter permanently. The RUN/SS pin must be actively pulled down to ground in order to restart operation.

The over-current protection timer requires the soft-start timing capacitor CSS be made large enough to guarantee that the output is in regulation by the time CSS has reached the 4V threshold. In general, this will depend upon the size of the output capacitance, output voltage and load current characteristic. A minimum external soft-start capacitor can be estimated from:

$$C_{SS\_EXT} + 1000pF > C_{OUT} \cdot V_{OUT} (10^{-3} [F / V_s])$$

Generally 0.1μF is more than sufficient.

Since the load current is already limited by the current mode control and current foldback circuitry during a shortcircuit, over-current latching operation is NOT always needed or desired, especially the output has large amount of capacitance or the load draw huge current during start up. The latching feature can be overridden by a pull-up current greater than 5μA but less than 80μA to the RUN/SS pin. The additional current prevents the discharge of CSS during a fault and also shortens the soft-start period. Using a resistor from RUN/SS pin to  $V_{IN}$  is a simple solution

to defeat latching. Any pull-up network must be able to maintain RUN/SS above 4V maximum latching threshold and overcome the 4μA maximum discharge current. Figure 3 shows a conceptual drawing of  $V_{RUN/SS}$  during startup and short circuit.

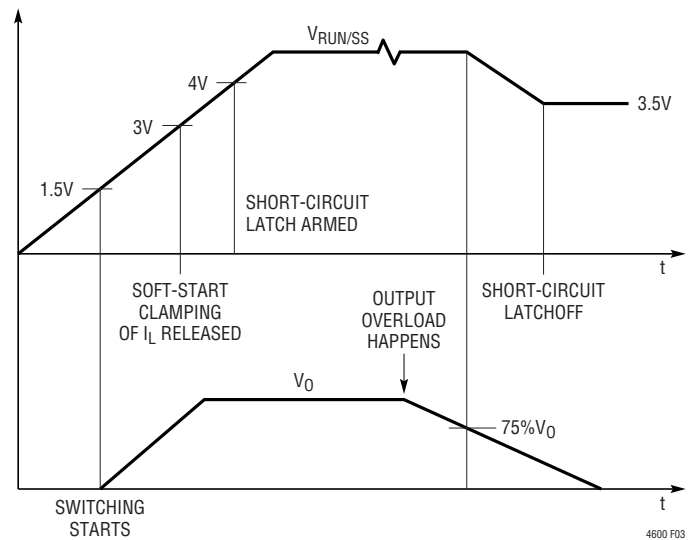


Figure 3. RUN/SS Pin Voltage During Startup and Short-Circuit Protection

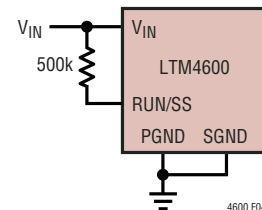


Figure 4. Defeat Short-Circuit Latching with a Pull-Up Resistor to  $V_{IN}$

## APPLICATIONS INFORMATION

### Enable

The RUN/SS pin can be driven from logic as shown in Figure 5. This function allows the LTM4600 to be turned on or off remotely. The ON signal can also control the sequence of the output voltage.

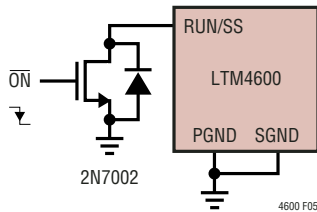


Figure 5. Enable Circuit with External Logic

### Output Voltage Tracking

For the applications that require output voltage tracking, several LTM4600 modules can be programmed by the power supply tracking controller such as the LTC2923. Figure 6 shows a typical schematic with LTC2923. Coin-

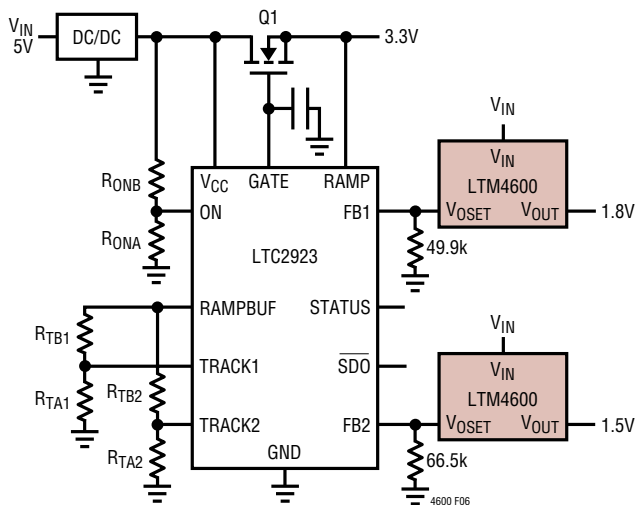


Figure 6. Output Voltage Tracking with the LTC2923 Controller

cident, ratiometric and offset tracking for  $V_O$  rising and falling can be implemented with different sets of resistor values. See the LTC2923 data sheet for more details.

### EXTV<sub>CC</sub> Connection

An internal low dropout regulator produces an internal 5V supply that powers the control circuitry and FET drivers. Therefore, if the system does not have a 5V power rail, the LTM4600 can be directly powered by  $V_{IN}$ . The gate driver current through LDO is about 18mA. The internal LDO power dissipation can be calculated as:

$$P_{LDO\_LOSS} = 18\text{mA} \cdot (V_{IN} - 5\text{V})$$

The LTM4600 also provides an external gate driver voltage pin  $EXTV_{CC}$ . If there is a 5V rail in the system, it is recommended to connect  $EXTV_{CC}$  pin to the external 5V rail. Whenever the  $EXTV_{CC}$  pin is above 4.7V, the internal 5V LDO is shut off and an internal 50mA P-channel switch connects the  $EXTV_{CC}$  to internal 5V. Internal 5V is supplied from  $EXTV_{CC}$  until this pin drops below 4.5V. Do not apply more than 6V to the  $EXTV_{CC}$  pin and ensure that  $EXTV_{CC} < V_{IN}$ . The following list summarizes the possible connections for  $EXTV_{CC}$ :

1.  $EXTV_{CC}$  grounded. Internal 5V LDO is always powered from the internal 5V regulator.
2.  $EXTV_{CC}$  connected to an external supply. Internal LDO is shut off. A high efficiency supply compatible with the MOSFET gate drive requirements (typically 5V) can improve overall efficiency. With this connection, it is always required that the  $EXTV_{CC}$  voltage can not be higher than  $V_{IN}$  pin voltage.

### Discontinuous Operation and FCB Pin

The FCB pin determines whether the internal bottom MOSFET remains on when the inductor current reverses. There is an internal 4.75k pulling down resistor connecting this pin to ground. The default light load operation mode is forced continuous (PWM) current mode. This mode provides minimum output voltage ripple.

# LTM4600

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In the application where the light load efficiency is important, tying the FCB pin above 0.6V threshold enables discontinuous operation where the bottom MOSFET turns off when inductor current reverses. Therefore, the conduction loss is minimized and light load efficiency is improved. The penalty is that the controller may skip cycle and the output voltage ripple increases at light load.

### Paralleling Operation with Load Sharing

Two or more LTM4600 modules can be paralleled to provide higher than 10A output current. Figure 7 shows the necessary interconnection between two paralleled modules. The OPTI-LOOP™ current mode control ensures good current sharing among modules to balance the thermal stress. The new feedback equation for two or more LTM4600s in parallel is:

$$V_{OUT} = 0.6V \cdot \frac{100k}{N} + R_{SET}$$

where N is the number of LTM4600s in parallel.

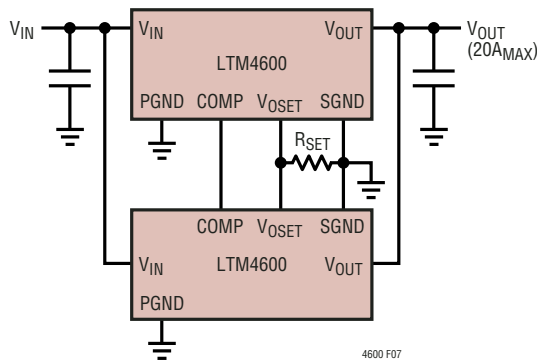


Figure 7. Parallel Two  $\mu$ Modules with Load Sharing

OPTI-LOOP is a trademark of Linear Technology Corporation.

### Thermal Considerations and Output Current Derating

The power loss curves in Figures 8 and 13 can be used in coordination with the load current de-rating curves in Figures 9 to 12 and Figures 14 to 15 for calculating an approximate  $\theta_{JA}$  for the module. Each of the load current de-rating curves will lower the maximum load current as a function of the increased ambient temperature to keep the maximum junction temperature of the power module at 100°C maximum. This 100°C maximum is to allow for an increased rise of about 15°C to 20°C inside the module. This will maintain the maximum operating temperature to below 125°C. Each of the de-rating curves and the power loss curve that corresponds to the correct output voltage can be used to solve for the approximate  $\theta_{JA}$  of the condition. Each Figure has three curves that are taken at three different air flow conditions. For example in Figure 9, the 10A load current can be achieved up to 60°C ambient temperature with no air flow. If this 60°C is subtracted from the maximum module temperature of 100°C, then 40°C is the maximum temperature rise. Now Figure 8 records the power loss for this 5V to 1.5V at the 10A output. If we take the 40°C rise and divided it by the 3 watts of loss, then we get an approximate  $\theta_{JA}$  of 13.5°C/W with no heatsink. If we take the next air flow curve in Figure 9 at 200LFM of air flow, then the maximum ambient temperature allowed at 10A load current is 65°C. This calculates to a 35°C rise, and an approximate  $\theta_{JA}$  of 11.6°C/W with no heatsink. In the next air flow curve at 400LFM in Figure 9, the maximum ambient temperature allowed at 10A load current is 73°C. This calculates to a 27°C rise, and an approximate  $\theta_{JA}$  of 9°C/W with no heatsink. Each of the de-rating curves in Figures 9 to 12 or Figures 14 to 15 can be used with the appropriate power loss curve in either figure 8 or figure 13 to derive an approximate  $\theta_{JA}$ . Table 3 and 4 provide the approximate  $\theta_{JA}$  for Figures 9 to 12, and Figures 14 to 15. A complete explanation of the thermal characteristics is provided in the thermal application note for the LTM4600.



# APPLICATIONS INFORMATION

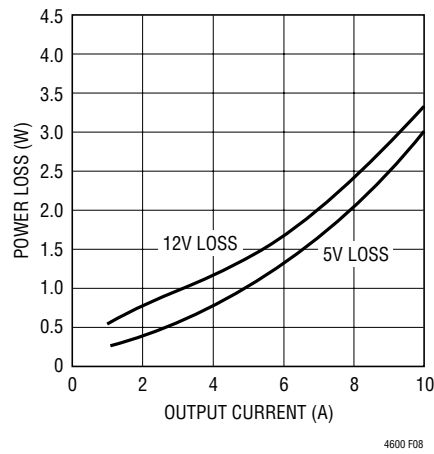


Figure 8. Power Loss vs Load Current

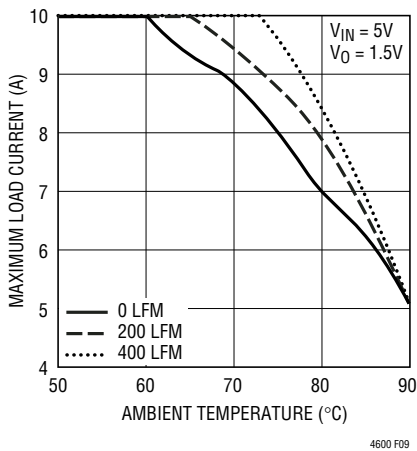


Figure 9. No Heatsink

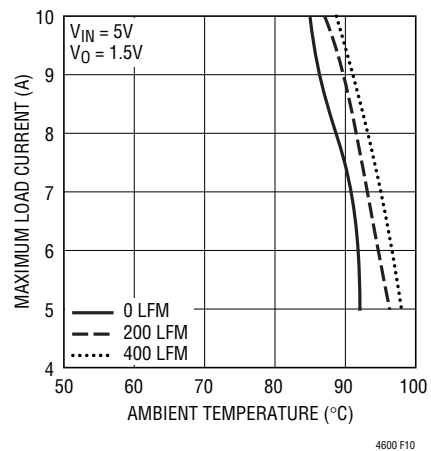


Figure 10. BGA Heatsink

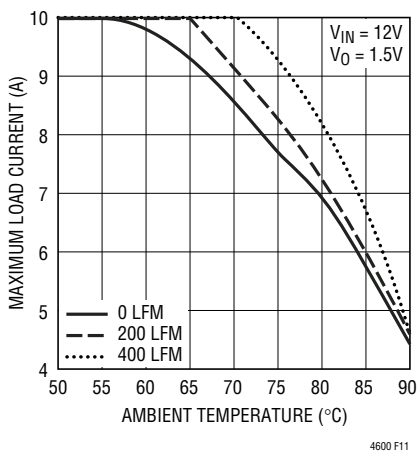


Figure 11. No Heatsink

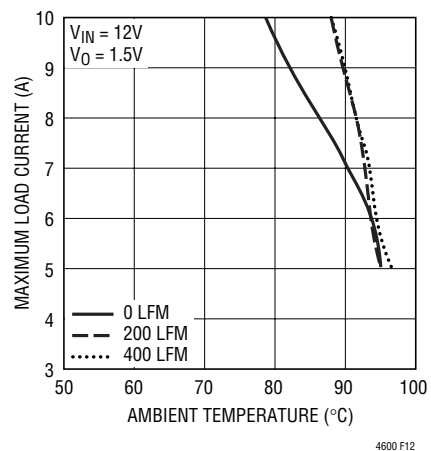


Figure 12. BGA Heatsink



# LTM4600

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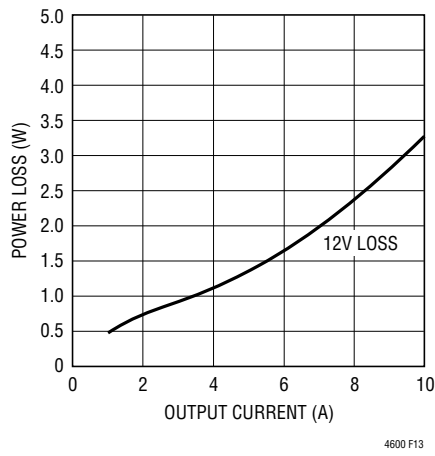


Figure 13. Power Loss vs Load Current

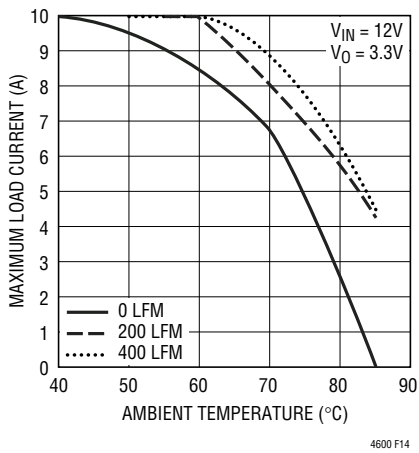


Figure 14. No Heatsink

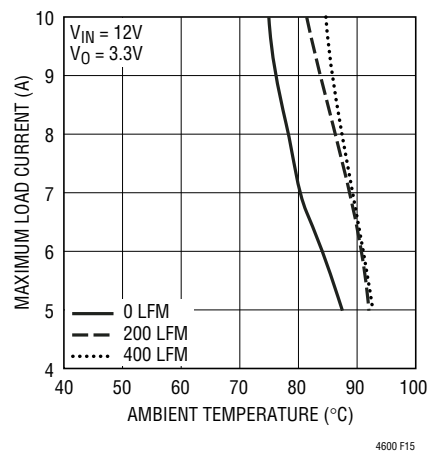


Figure 15. BGA Heatsink

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**Table 3. 1.5V Output**

DE-RATING CURVE	V <sub>IN</sub> (V)	POWER LOSS CURVE	AIR FLOW (LFM)	HEATSINK*	θ <sub>JA</sub> (°C/W)
Figures 9, 11	5, 12	Figure 8	0	None	13.5
Figures 9, 11	5, 12	Figure 8	200	None	11
Figures 9, 11	5, 12	Figure 8	400	None	9
Figures 10, 12	5, 12	Figure 8	0	BGA Heatsink	9.5
Figures 10, 12	5, 12	Figure 8	200	BGA Heatsink	6.25
Figures 10, 12	5, 12	Figure 8	400	BGA Heatsink	4.5

**Table 4. 3.3V Output**

DE-RATING CURVE	V <sub>IN</sub> (V)	POWER LOSS CURVE	AIR FLOW (LFM)	HEATSINK*	θ <sub>JA</sub> (°C/W)
Figure 14	12	Figure 8	0	None	13.5
Figure 14	12	Figure 8	200	None	11.6
Figure 14	12	Figure 8	400	None	10.4
Figure 15	12	Figure 8	0	BGA Heatsink	9.5
Figure 15	12	Figure 8	200	BGA Heatsink	6
Figure 15	12	Figure 8	400	BGA Heatsink	4.77

\*Heatsink manufacturer: Wakefield Engineering #CIS20069

# LTM4600

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### Safety Considerations

The LTM4600 modules do not provide isolation from  $V_{IN}$  to  $V_{OUT}$ . There is no internal fuse. If required, a slow blow fuse with a rating twice the maximum input current should be provided to protect each unit from catastrophic failure.

### Layout Checklist/Example

The high integration of the LTM4600 makes the PCB board layout very simple and easy. However, to optimize its electrical and thermal performance, some layout considerations are still necessary.

- Use large PCB copper areas for high current path, including  $V_{IN}$ , PGND and  $V_{OUT}$ . It helps to minimize the PCB conduction loss and thermal stress
- Place high frequency ceramic input and output capacitors next to the  $V_{IN}$ , PGND and  $V_{OUT}$  pins to minimize high frequency noise
- Place a dedicated power ground layer underneath the unit
- To minimize the via conduction loss and reduce module thermal stress, use multiple vias for interconnection between top layer and other power layers

- Do not put via directly on pad
- Use a separated SGND ground copper area for components connected to signal pins. Connect the SGND to PGND underneath the unit

Figure 16 gives a good example of the recommended layout.

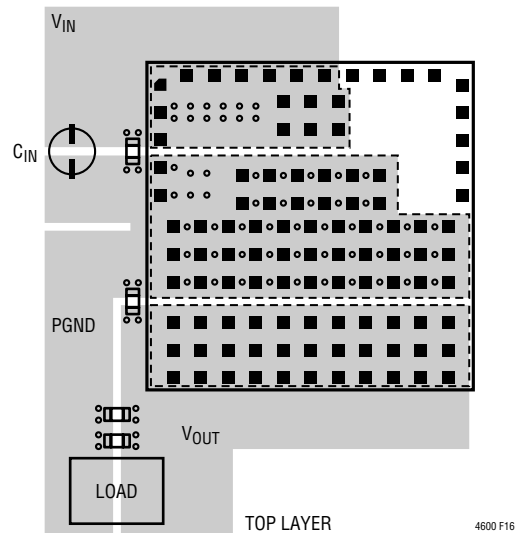


Figure 16. Recommended PCB Layout

# TYPICAL APPLICATION

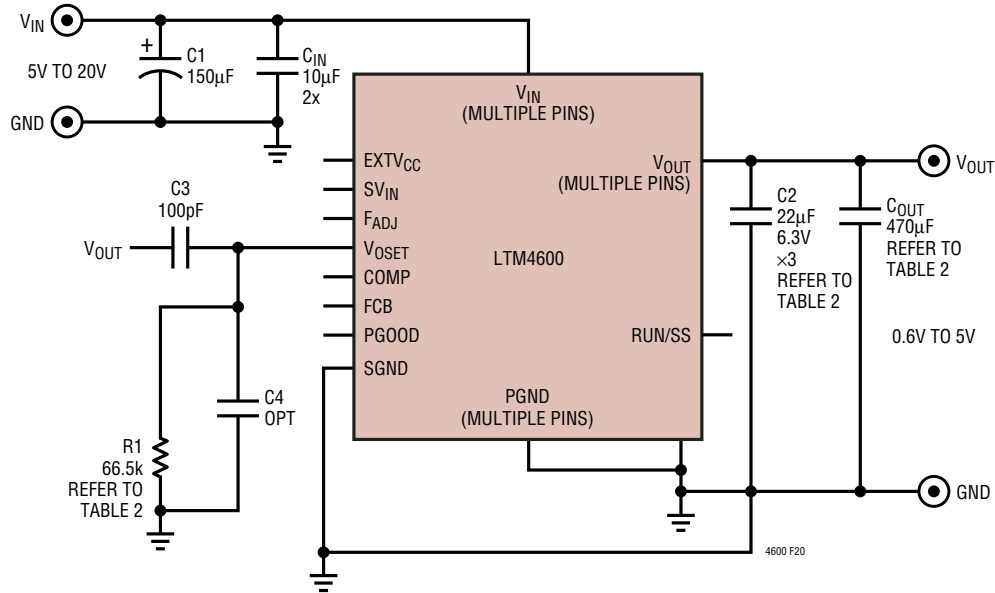
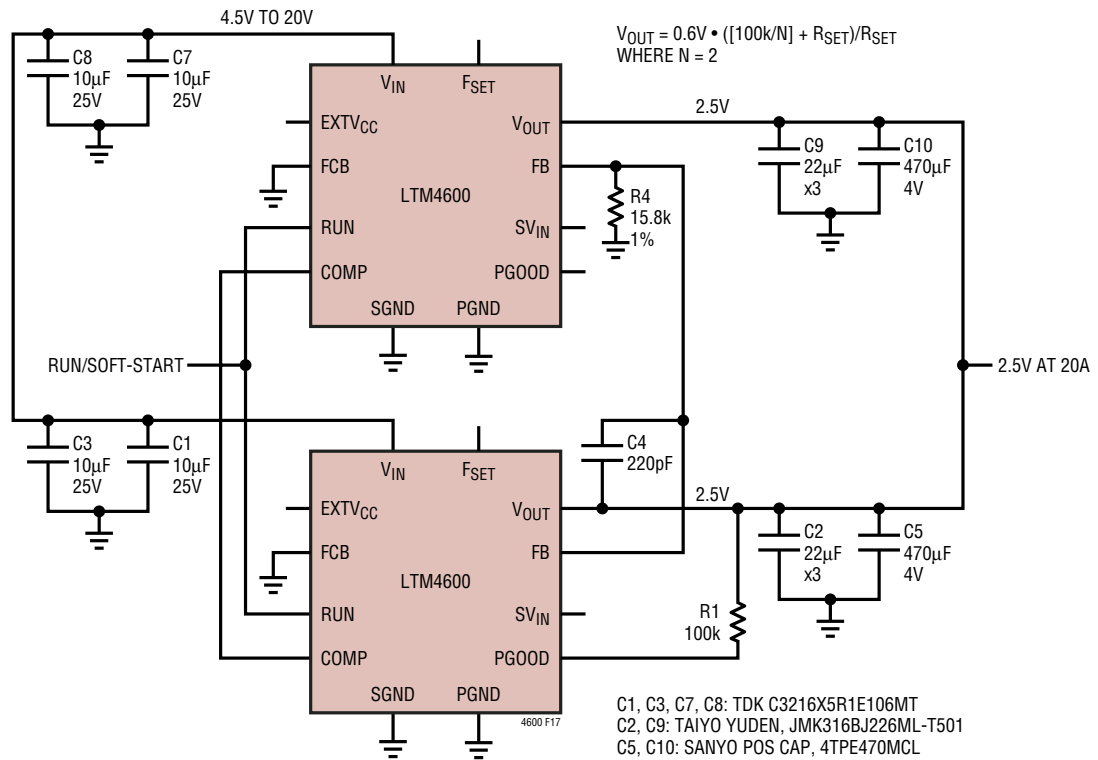


Figure 17. Typical Application, 5V to 20V Input, 0.6V to 5V Output, 10A Max

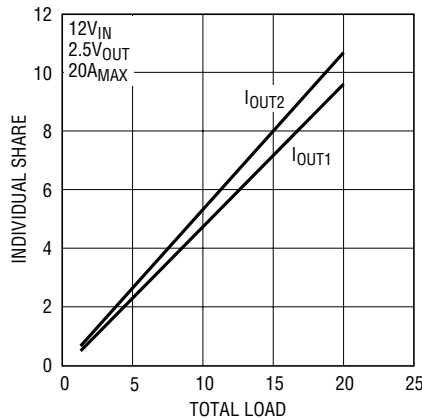
# LTM4600

## TYPICAL APPLICATION

### Parallel Operation and Load Sharing



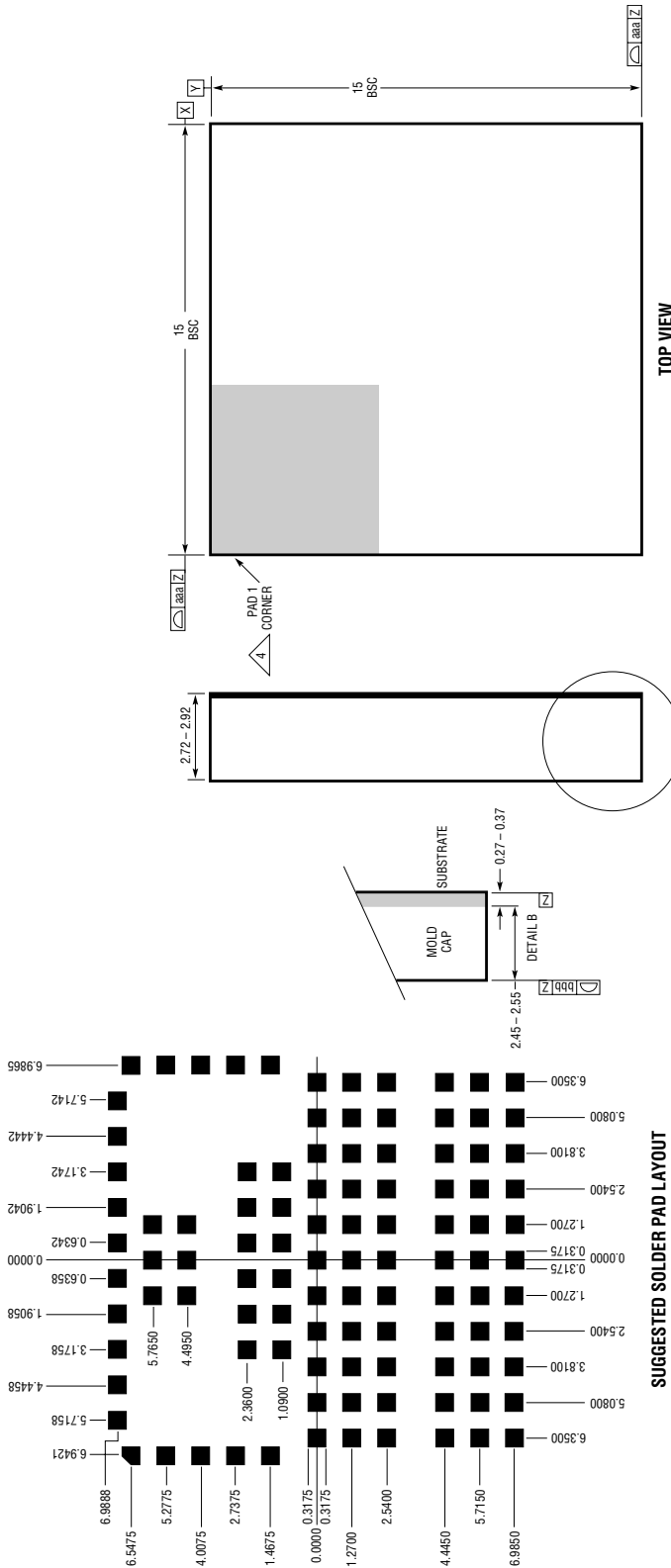
Current Sharing Between Two LTM4600 Modules



4600 F18

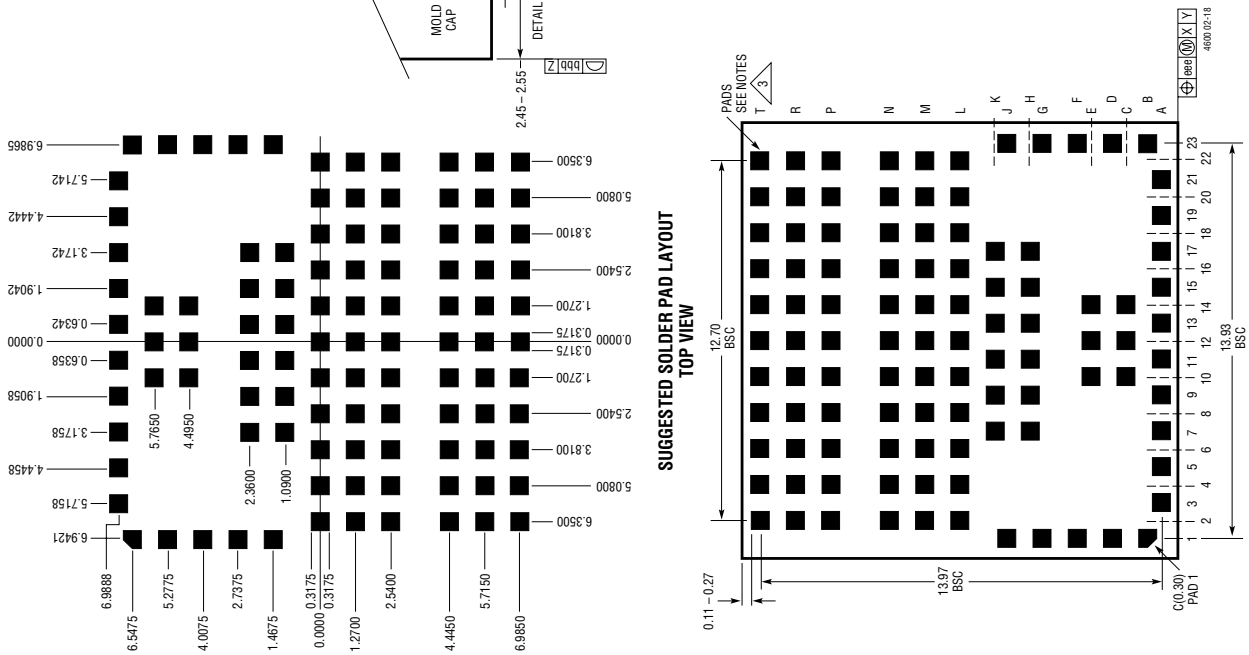
# PACKAGE DESCRIPTION

**LGA Package**  
**104-Lead (15mm x 15mm)**  
 (Reference LTM DWG # 05-05-1800)



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
  2. ALL DIMENSIONS ARE IN MILLIMETERS
  3. LAND DESIGNATION PER JEDEC MO-222, SPP-010
  4. DETAILS OF PAD #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE PAD #1 IDENTIFIER IS A MARKED FEATURE OR A NOTCHED BEVELED PAD
  5. PRIMARY DATUM -Z- IS SEATING PLANE
  6. THE TOTAL NUMBER OF PADS: 104

SYMBOL	TOLERANCE
aaa	0.15
bbb	0.10
eee	0.15



## LTM4600

## PACKAGE DESCRIPTION

Pin Assignment Tables  
(Arranged by Pin Number)

PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME
A1 -	B1 V <sub>IN</sub>	C1 -	D1 V <sub>IN</sub>	E1 -	F1 V <sub>IN</sub>	G1 PGND	H1 -
A2 -	B2 -	C2 -	D2 -	E2 -	F2 -	G2 -	H2 -
A3 V <sub>IN</sub>	B3 -	C3 -	D3 -	E3 -	F3 -	G3 -	H3 -
A4 -	B4 -	C4 -	D4 -	E4 -	F4 -	G4 -	H4 -
A5 V <sub>IN</sub>	B5 -	C5 -	D5 -	E5 -	F5 -	G5 -	H5 -
A6 -	B6 -	C6 -	D6 -	E6 -	F6 -	G6 -	H6 -
A7 V <sub>IN</sub>	B7 -	C7 -	D7 -	E7 -	F7 -	G7 -	H7 PGND
A8 -	B8 -	C8 -	D8 -	E8 -	F8 -	G8 -	H8 -
A9 V <sub>IN</sub>	B9 -	C9 -	D9 -	E9 -	F9 -	G9 -	H9 PGND
A10 -	B10 -	C10 V <sub>IN</sub>	D10 -	E10 V <sub>IN</sub>	F10 -	G10 -	H10 -
A11 V <sub>IN</sub>	B11 -	C11 -	D11 -	E11 -	F11 -	G11 -	H11 PGND
A12 -	B12 -	C12 V <sub>IN</sub>	D12 -	E12 V <sub>IN</sub>	F12 -	G12 -	H12 -
A13 V <sub>IN</sub>	B13 -	C13 -	D13 -	E13 -	F13 -	G13 -	H13 PGND
A14 -	B14 -	C14 V <sub>IN</sub>	D14 -	E14 V <sub>IN</sub>	F14 -	G14 -	H14 -
A15 FADJ	B15 -	C15 -	D15 -	E15 -	F15 -	G15 -	H15 PGND
A16 -	B16 -	C16 -	D16 -	E16 -	F16 -	G16 -	H16 -
A17 SV <sub>IN</sub>	B17 -	C17 -	D17 -	E17 -	F17 -	G17 -	H17 PGND
A18 -	B18 -	C18 -	D18 -	E18 -	F18 -	G18 -	H18 -
A19 EXTV <sub>CC</sub>	B19 -	C19 -	D19 -	E19 -	F19 -	G19 -	H19 -
A20 -	B20 -	C20 -	D20 -	E20 -	F20 -	G20 -	H20 -
A21 V <sub>OSET</sub>	B21 -	C21 -	D21 -	E21 -	F21 -	G21 -	H21 -
A22 -	B22 -	C22 -	D22 -	E22 -	F22 -	G22 -	H22 -
A23 -	B23 COMP	C23 -	D23 SGND	E23 -	F23 RUN/SS	G23 FCB	H23 -

PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME	PIN NAME
J1 PGND	K1 -	L1 -	M1 -	N1 -	P1 -	R1 -	T1 -
J2 -	K2 -	L2 PGND	M2 PGND	N2 PGND	P2 V <sub>OUT</sub>	R2 V <sub>OUT</sub>	T2 V <sub>OUT</sub>
J3 -	K3 -	L3 -	M3 -	N3 -	P3 -	R3 -	T3 -
J4 -	K4 -	L4 PGND	M4 PGND	N4 PGND	P4 V <sub>OUT</sub>	R4 V <sub>OUT</sub>	T4 V <sub>OUT</sub>
J5 -	K5 -	L5 -	M5 -	N5 -	P5 -	R5 -	T5 -
J6 -	K6 -	L6 PGND	M6 PGND	N6 PGND	P6 V <sub>OUT</sub>	R6 V <sub>OUT</sub>	T6 V <sub>OUT</sub>
J7 -	K7 PGND	L7 -	M7 -	N7 -	P7 -	R7 -	T7 -
J8 -	K8 -	L8 PGND	M8 PGND	N8 PGND	P8 V <sub>OUT</sub>	R8 V <sub>OUT</sub>	T8 V <sub>OUT</sub>
J9 -	K9 PGND	L9 -	M9 -	N9 -	P9 -	R9 -	T9 -
J10 -	K10 -	L10 PGND	M10 PGND	N10 PGND	P10 V <sub>OUT</sub>	R10 V <sub>OUT</sub>	T10 V <sub>OUT</sub>
J11 -	K11 PGND	L11 -	M11 -	N11 -	P11 -	R11 -	T11 -
J12 -	K12 -	L12 PGND	M12 PGND	N12 PGND	P12 V <sub>OUT</sub>	R12 V <sub>OUT</sub>	T12 V <sub>OUT</sub>
J13 -	K13 PGND	L13 -	M13 -	N13 -	P13 -	R13 -	T13 -
J14 -	K14 -	L14 PGND	M14 PGND	N14 PGND	P14 V <sub>OUT</sub>	R14 V <sub>OUT</sub>	T14 V <sub>OUT</sub>
J15 -	K15 PGND	L15 -	M15 -	N15 -	P15 -	R15 -	T15 -
J16 -	K16 -	L16 PGND	M16 PGND	N16 PGND	P16 V <sub>OUT</sub>	R16 V <sub>OUT</sub>	T16 V <sub>OUT</sub>
J17 -	K17 PGND	L17 -	M17 -	N17 -	P17 -	R17 -	T17 -
J18 -	K18 -	L18 PGND	M18 PGND	N18 PGND	P18 V <sub>OUT</sub>	R18 V <sub>OUT</sub>	T18 V <sub>OUT</sub>
J19 -	K19 -	L19 -	M19 -	N19 -	P19 -	R19 -	T19 -
J20 -	K20 -	L20 PGND	M20 PGND	N20 PGND	P20 V <sub>OUT</sub>	R20 V <sub>OUT</sub>	T20 V <sub>OUT</sub>
J21 -	K21 -	L21 -	M21 -	N21 -	P21 -	R21 -	T21 -
J22 -	K22 -	L22 PGND	M22 PGND	N22 PGND	P22 V <sub>OUT</sub>	R22 V <sub>OUT</sub>	T22 V <sub>OUT</sub>
J23 PGOOD	K23 -	L23 -	M23 -	N23 -	P23 -	R23 -	T23 -



## PACKAGE DESCRIPTION

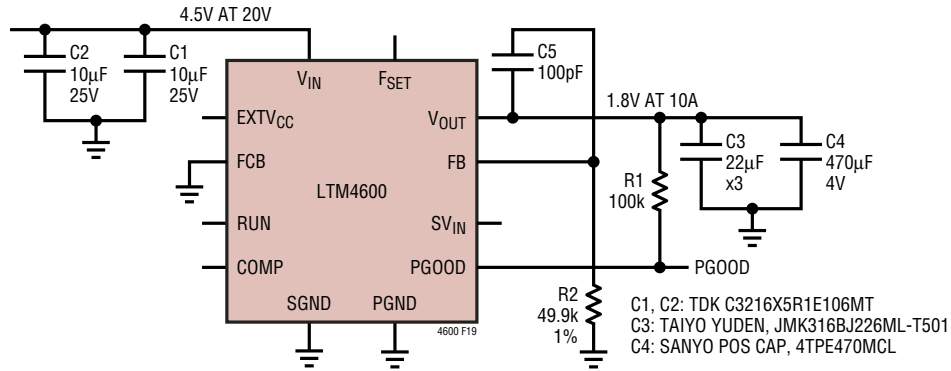
Pin Assignment Tables  
(Arranged by Pin Number)

PIN NAME		PIN NAME		PIN NAME		PIN NAME	
G1	PGND	P2	V <sub>OUT</sub>	A3	V <sub>IN</sub>	A15	FADJ
H7	PGND	P4	V <sub>OUT</sub>	A5	V <sub>IN</sub>	A17	SV <sub>IN</sub>
H9	PGND	P6	V <sub>OUT</sub>	A7	V <sub>IN</sub>	A19	EXTV <sub>CC</sub>
H11	PGND	P8	V <sub>OUT</sub>	A9	V <sub>IN</sub>	A21	V <sub>OSET</sub>
H13	PGND	P10	V <sub>OUT</sub>	A11	V <sub>IN</sub>	B23	COMP
H15	PGND	P12	V <sub>OUT</sub>	A13	V <sub>IN</sub>	D23	SGND
H17	PGND	P14	V <sub>OUT</sub>	B1	V <sub>IN</sub>	F23	RUN/SS
J1	PGND	P16	V <sub>OUT</sub>	C10	V <sub>IN</sub>	G23	FCB
K7	PGND	P18	V <sub>OUT</sub>	C12	V <sub>IN</sub>	J23	PGOOD
K9	PGND	P20	V <sub>OUT</sub>	C14	V <sub>IN</sub>		
K11	PGND	P22	V <sub>OUT</sub>	D1	V <sub>IN</sub>		
K13	PGND	R2	V <sub>OUT</sub>	E10	V <sub>IN</sub>		
K15	PGND	R4	V <sub>OUT</sub>	E12	V <sub>IN</sub>		
K17	PGND	R6	V <sub>OUT</sub>	E14	V <sub>IN</sub>		
L2	PGND	R8	V <sub>OUT</sub>	F1	V <sub>IN</sub>		
L4	PGND	R10	V <sub>OUT</sub>				
L6	PGND	R12	V <sub>OUT</sub>				
L8	PGND	R14	V <sub>OUT</sub>				
L10	PGND	R16	V <sub>OUT</sub>				
L12	PGND	R18	V <sub>OUT</sub>				
L14	PGND	R20	V <sub>OUT</sub>				
L16	PGND	R22	V <sub>OUT</sub>				
L18	PGND	T2	V <sub>OUT</sub>				
L20	PGND	T4	V <sub>OUT</sub>				
L22	PGND	T6	V <sub>OUT</sub>				
M2	PGND	T8	V <sub>OUT</sub>				
M4	PGND	T10	V <sub>OUT</sub>				
M6	PGND	T12	V <sub>OUT</sub>				
M8	PGND	T14	V <sub>OUT</sub>				
M10	PGND	T16	V <sub>OUT</sub>				
M12	PGND	T18	V <sub>OUT</sub>				
M14	PGND	T20	V <sub>OUT</sub>				
M16	PGND	T22	V <sub>OUT</sub>				
M18	PGND						
M20	PGND						
M22	PGND						
N2	PGND						
N4	PGND						
N6	PGND						
N8	PGND						
N10	PGND						
N12	PGND						
N14	PGND						
N16	PGND						
N18	PGND						
N20	PGND						
N22	PGND						

# LTM4600

## TYPICAL APPLICATION

### 1.8V, 10A Regulator



**PRE-RELEASE**

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