LTM4600

10A High Efficiency DC/DC µModule

FEATURES

- **Complete Switch Mode Power Supply**
- **Wide Input Voltage Range: 4.5V to 20V**
- **10A DC, 14A Peak Output Current**
- **Parallel Two µModules™ for 20A Output Current**
- **0.6V to 5V Output Voltage**
- **1.5% Regulation**
- **Ultrafast Transient Response**
- **Current Mode Control**
- **Pb-Free (e^4) 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

DESCRIPTION

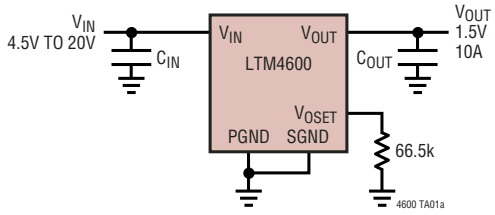
The LTM®4600 is a complete 10A, DC/DC step down power supply. Included in the package are the switching controller, power FETs, inductor, and all support components. Operating over an input voltage range of 4.5V to 20V, the LTM4600 supports an output voltage range of 0.6V to 5V, set by a single resistor. 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.

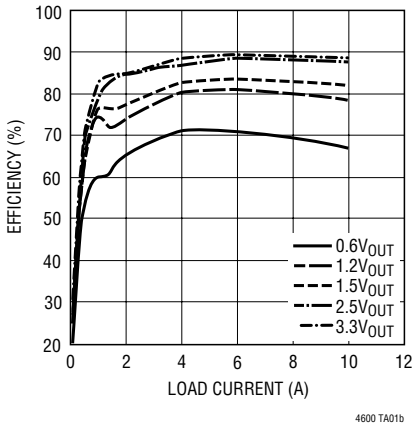
The LTM4600 is packaged in a thermally enhanced, compact (15mm × 15mm) and low profile (2.8mm) over-molded Land Grid Array (LGA) package suitable for automated assembly by standard surface mount equipment. The LTM4600 is Pb-free and RoHS certified.

TYPICAL APPLICATION

10A µModule Power Supply with 4.5V to 20V Input



Efficiency vs Load Current with $12V_{IN}$ (FCB = 0)

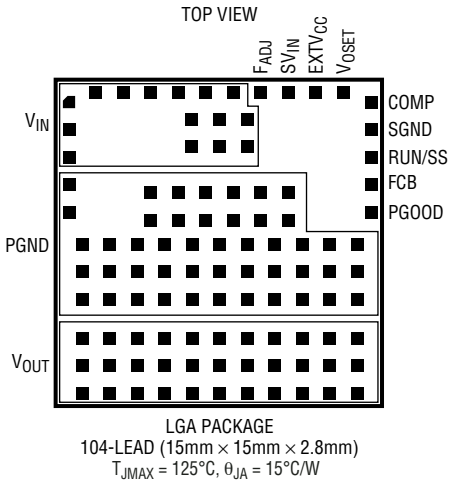


ABSOLUTE MAXIMUM RATINGS

(Note 1)

FCB, $EXTV_{CC}$, PGOOD, RUN/SS, V_{OUT}..... –0.3V to 6V
V_{IN}, SV_{IN}, F_{ADJ} ..... –0.3V to 20V
V_{OSET}, 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



ORDER PART NUMBER
LTM4600EV LTM4600IV
LGA PART MARKING
LTM4600EV LTM4600IV

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_A = 25°C, V_{IN} = 12V. External C_{IN} = 120µF, C_{OUT} = 200µF/Ceramic per typical application (front page) configuration.

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

ELECTRICAL CHARACTERISTICS

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

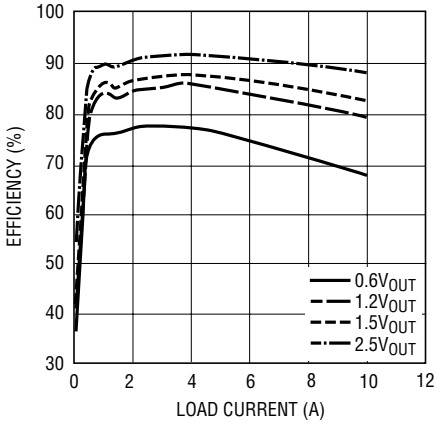
SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Output Specifications							
I_{OUTDC}	Output Continuous Current Range (See Output Current Derating Curves for Different V_{IN}, V_{OUT} and T_A)	V_{IN} = 12V, V_{OUT} = 1.5V		0		10	A
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation Accuracy I_{OUT} = 0A	V_{OUT} = 1.5V. FCB = 0V	 ●		 0.3		 %
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation Accuracy V_{IN} = 5V V_{IN} = 12V	V_{OUT} = 1.5V. FCB = 0V 0A to 10A	 ●		 	 ±1 ±1	 % %
$V_{OUT(AC)}$	Output Ripple Voltage V_{IN} = 12V, V_{OUT} = 1.5V, FCB = 0V V_{IN} = 5V, V_{OUT} = 1.5V, FCB = 0V	I_{OUT} = 0A	 ●		 15 20	 25	 mV_{P-P} mV_{P-P}
Fs	Output Ripple Voltage Frequency	FCB = 0V, I_{OUT} = 5A, V_{IN} = 12V, V_{OUT} = 1.5V			800		kHz
t_{START}	Turn-On Time V_{IN} = 12V V_{IN} = 5V	V_{OUT} = 1.5V, I_{OUT} = 10A			 0.5 0.7		 ms ms
ΔV_{OUTLS}	Voltage Drop for Dynamic Load Step V_{IN} = 12V, V_{OUT} = 1.5V	Load Step: 0A to 5A/µs C_{OUT} = 3 • 22µF 6.3V, 470µF 4V Pos Cap, See Table 2			36		mV
t_{SETTLE}	Settling Time for Dynamic Load Step V_{IN} = 12V	Load: 10% to 90% to 10% of Full Load			25		µs
I_{OUTPK}	Output Current Limit V_{IN} = 12V, V_{OUT} = 1.5V V_{IN} = 5V, V_{OUT} = 1.5V				 17 17		 A A
Control Stage							
V_{OSET}	Voltage at V_{OSET} Pin	I_{OUT} = 0A, V_{OUT} = 1.5V	●	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	$V_{RUN/SS}$ = 0V		–0.5	–1.2	–3	µA
$I_{RUN(D)/SS}$	Soft-Start Discharging Current	$V_{RUN/SS}$ = 4V		0.8	1.8	3	µA
$V_{IN} – SV_{IN}$		$EXTV_{CC}$ = 0, FCB = 0V			100		mV
I_{EXTVCC}	Current into $EXTV_{CC}$ Pin	FCB = 0V, V_{OUT} = 1.5V, I_{OUT} = 0A			16		mA
R_{FBHI}	Resistor Between V_{OUT} and FB Pins				100		kΩ
V_{FCB}	Forced Continuous Threshold			0.57	0.6	0.63	V
I_{FCB}	Forced Continuous Pin Current	V_{FCB} = 0.6V			–1	–2	µA
PGOOD Output							
ΔV_{OSETH}	PGOOD Upper Threshold	V_{OSET} Rising		7.5	10	12.5	%
ΔV_{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} = 5mA			0.15	0.4	V

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

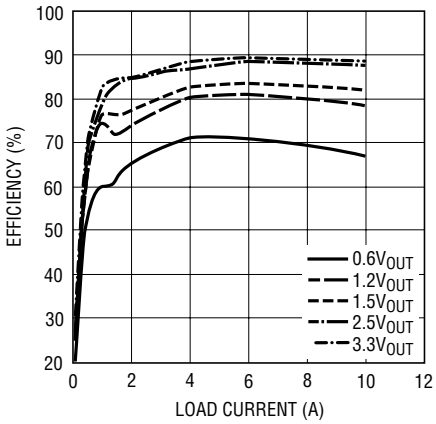
Note 2: The LTM4600E is guaranteed to meet performance specifications from 0°C to 85°C. Specifications over the –40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls. The LTM4600I is guaranteed and tested over the –40°C to 85°C temperature range.

TYPICAL PERFORMANCE CHARACTERISTICS

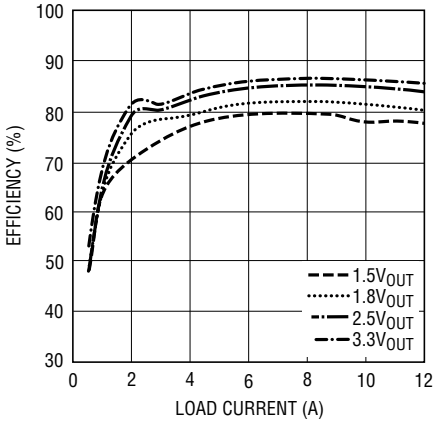
Efficiency vs Load Current with $5V_{IN}$ (FCB = 0)



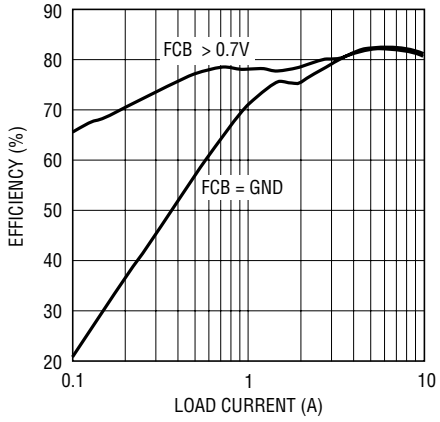
Efficiency vs Load Current with $12V_{IN}$ (FCB = 0)



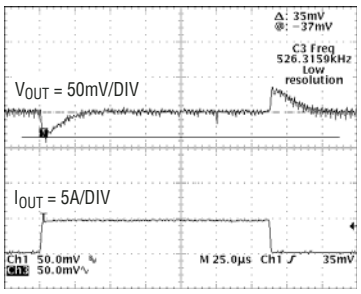
Efficiency vs Load Current with $18V_{IN}$ (FCB = 0)



Efficiency vs Load Current with Different FCB Settings

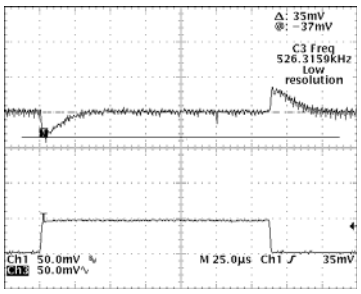


1.2V Transient Response (See Figure 17)



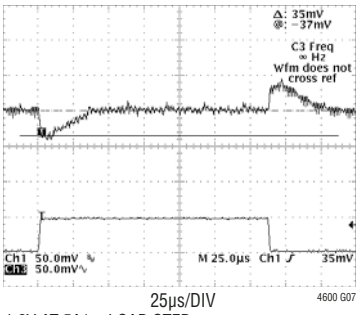
1.2V AT 5A/µs LOAD STEP
C_{OUT} = 3 • 22µF 6.3V CERAMICS
470µF 4V SANYO POS CAP
C3 = 100pF

1.5V Transient Response (See Figure 17)



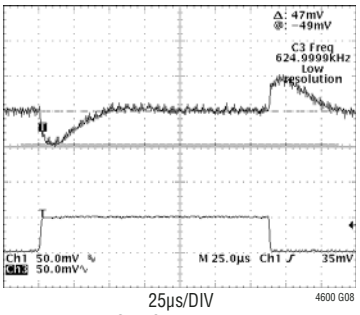
1.5V AT 5A/µs LOAD STEP
C_{OUT} = 3 • 22µF 6.3V CERAMICS
470µF 4V SANYO POS CAP
C3 = 100pF

1.8V Transient Response (See Figure 17)



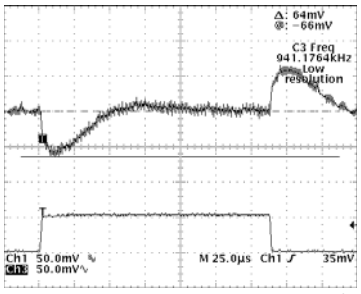
1.8V AT 5A/µs LOAD STEP
C_{OUT} = 3 • 22µF 6.3V CERAMICS
470µF 4V SANYO POS CAP
C3 = 100pF

2.5V Transient Response (See Figure 17)



2.5V AT 5A/µs LOAD STEP
C_{OUT} = 3 • 22µF 6.3V CERAMICS
470µF 4V SANYO POS CAP
C3 = 100pF

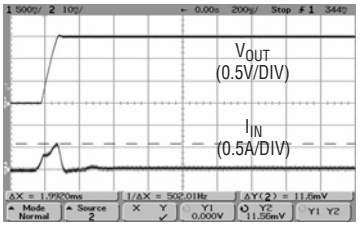
3.3V Transient Response (See Figure 17)



3.3V AT 5A/µs LOAD STEP
C_{OUT} = 3 • 22µF 6.3V CERAMICS
470µF 4V SANYO POS CAP
C3 = 100pF

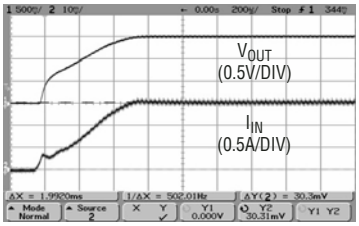
TYPICAL PERFORMANCE CHARACTERISTICS

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



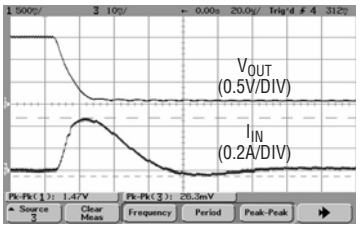
V_{IN} = 12V
V_{OUT} = 1.5V
C_{OUT} = 200µF
NO EXTERNAL SOFT-START CAPACITOR

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



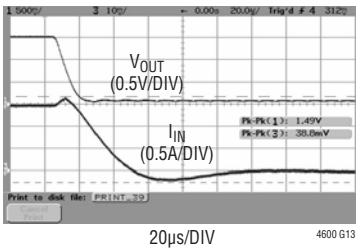
V_{IN} = 12V
V_{OUT} = 1.5V
C_{OUT} = 200µF
NO EXTERNAL SOFT-START CAPACITOR

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



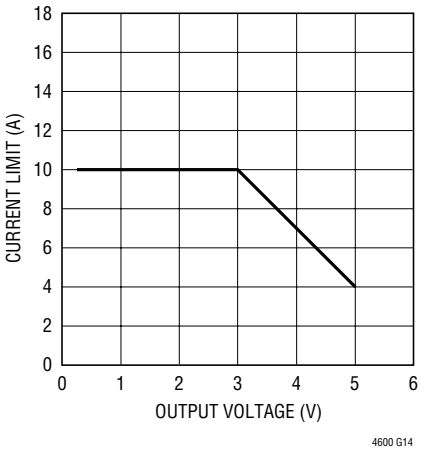
V_{IN} = 12V
V_{OUT} = 1.5V
C_{OUT} = 2× 200µF/X5R
NO EXTERNAL SOFT-START CAPACITOR

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

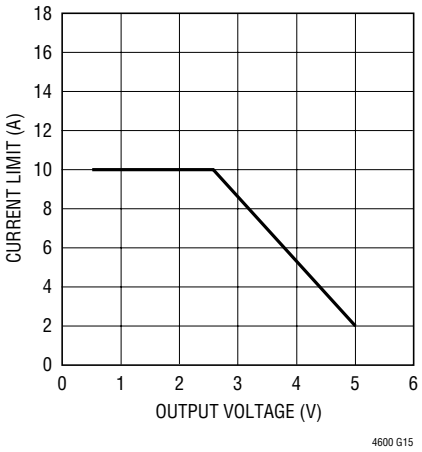


V_{IN} = 12V
V_{OUT} = 1.5V
C_{OUT} = 2× 200µF/X5R
NO EXTERNAL SOFT-START CAPACITOR

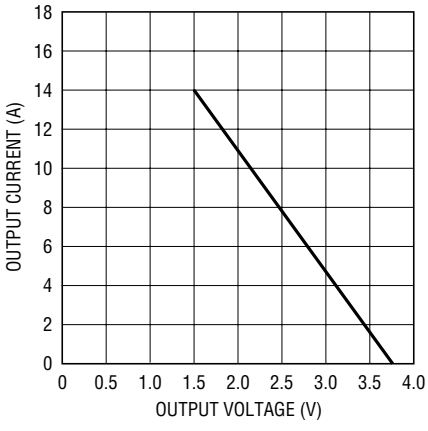
Current Limit with $12V_{IN}$



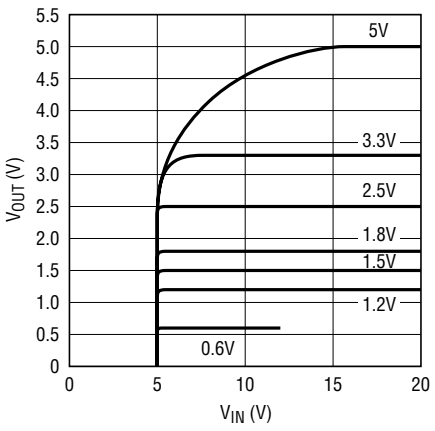
Current Limit with $9V_{IN}$



Current Limit with $5V_{IN}$



V_{IN} to V_{OUT} Stepdown Ratio



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.

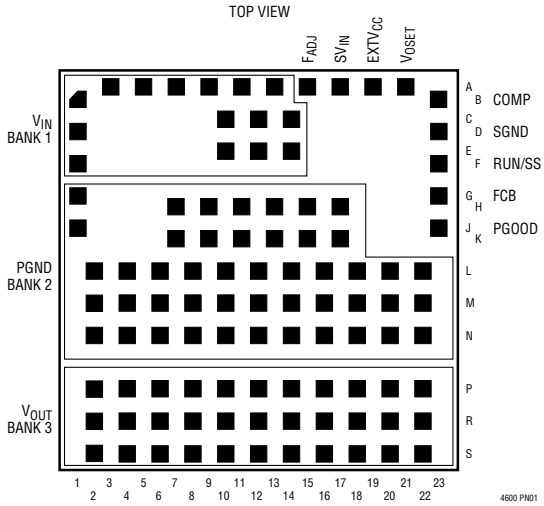
RUN/SS (Pin F23): Run and Soft-Start Control. Forcing this pin below 0.8V will shut down the power supply. Inside the power module, there is a 1000pF capacitor which provides approximately 0.7ms soft-start time with 200µF output capacitance. Additional soft-start time can be achieved by adding additional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



SIMPLIFIED BLOCK DIAGRAM

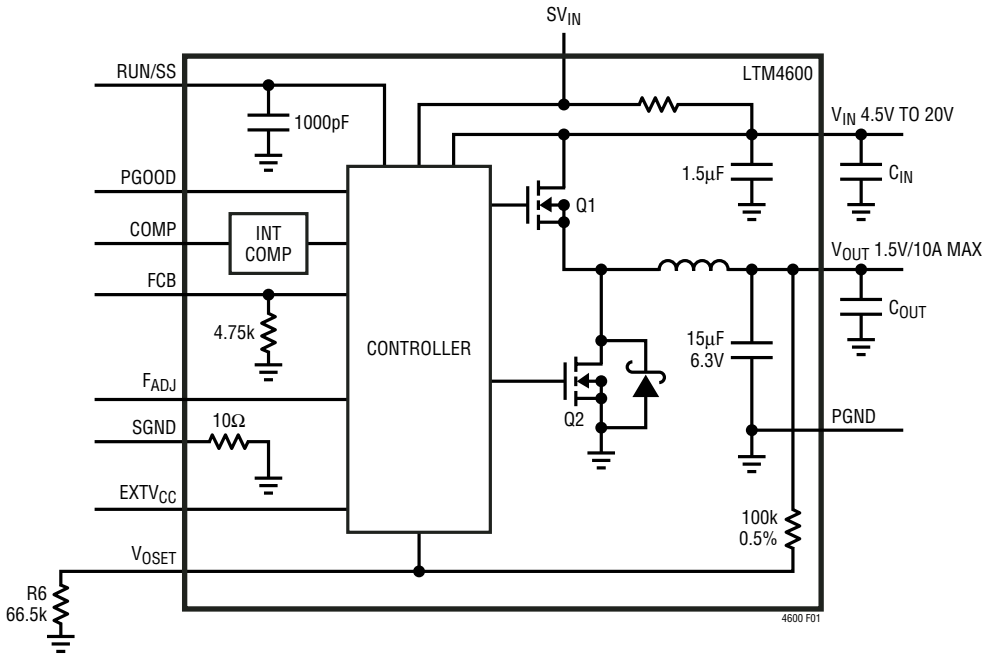


Figure 1. Simplified LTM4600 Block Diagram

DECOUPLING REQUIREMENTS

T_A = 25°C, V_{IN} = 12V. Use Figure 1 configuration.

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

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 ±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 1.2µA 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±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:

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

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

Table 1.

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

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

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

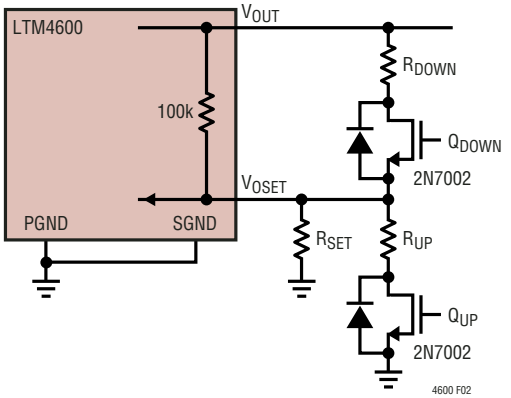


Figure 2.

Input Capacitors

The LTM4600 µModule 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:

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

In the above equation, η% is the estimated efficiency of the power module. C1 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, 10µF ceramic capacitors are recommended. This decoupling capacitor should be placed directly adjacent

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 200µF 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/µs 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 ≤ 30µA). Releasing the pin allows an internal 1.2µA 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:

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

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_{IN} to V_{OUT} Stepdown Ratios

There are restrictions in the maximum V_{IN} to V_{OUT} step down ratio that can be achieved for a given input voltage. These contraints are shown in the Typical Performance Characteristics curves labeled "V_{IN} to V_{OUT} 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_{OUT1} VENDORS	PART NUMBER	C_{OUT2} 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_{OUT} (V)	C_{IN} (CERAMIC)	C_{IN} (BULK)	C_{OUT1} (CERAMIC)	C_{OUT2} (BULK)	C_{COMP}	C3	V_{IN} (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

APPLICATIONS INFORMATION

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, shuting 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 depends upon the size of the output capacitance, output voltage and load current characteristic. A minimum external soft-start capacitor can be estimated from:

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

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

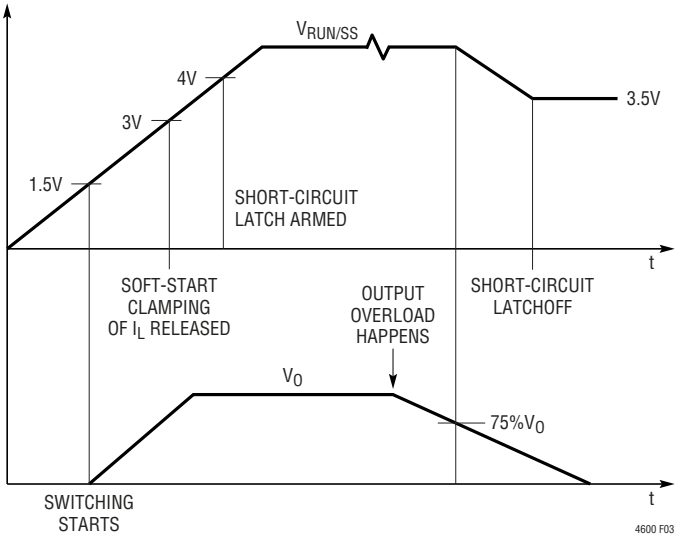


Figure 3. RUN/SS Pin Voltage During Startup and Short-Circuit Protection

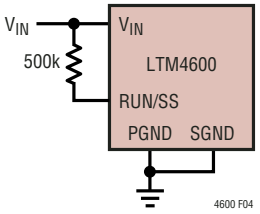


Figure 4. Defeat Short-Circuit Latchoff with a Pull-Up Resistor to V_{IN}

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 $\overline{ON}$ signal can also control the sequence of the output voltage.

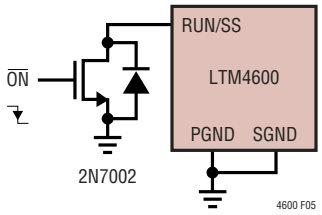


Figure 5. Enable Circuit with External Logic

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. Coincident, 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.

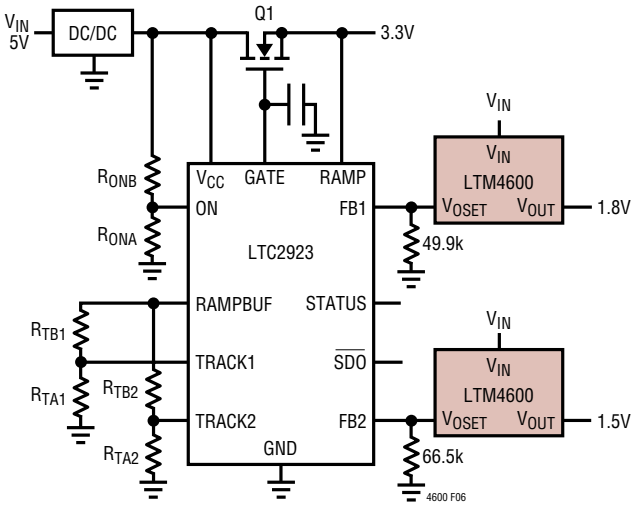


Figure 6. Output Voltage Tracking with the LTC2923 Controller

$EXTV_{CC}$ 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:

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

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 summaries 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.

APPLICATIONS INFORMATION

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 efficient 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:

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

where N is the number of LTM4600s in parallel.

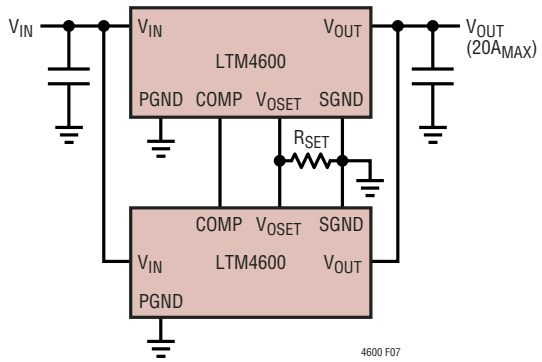


Figure 7. Parallel Two µModules with Load Sharing

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 θ_{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 θ_{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 θ_{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 θ_{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 θ_{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 θ_{JA}. Table 3 and 4 provide the approximate θ_{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

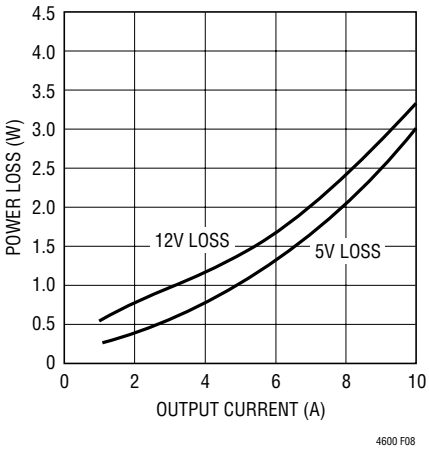


Figure 8. Power Loss vs Load Current

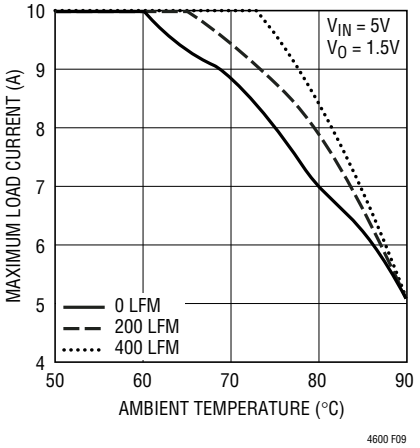


Figure 9. No Heatsink

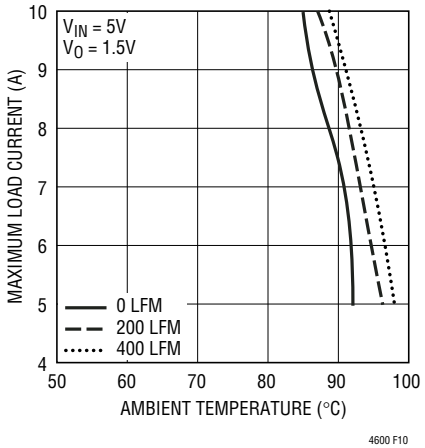


Figure 10. BGA Heatsink

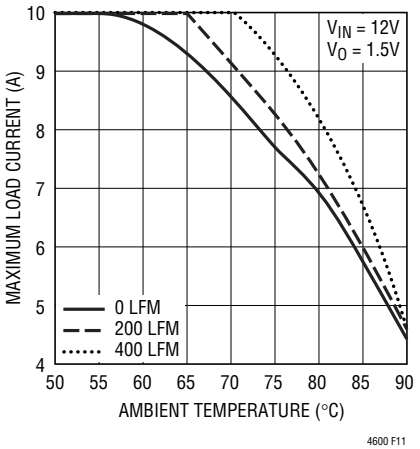


Figure 11. No Heatsink

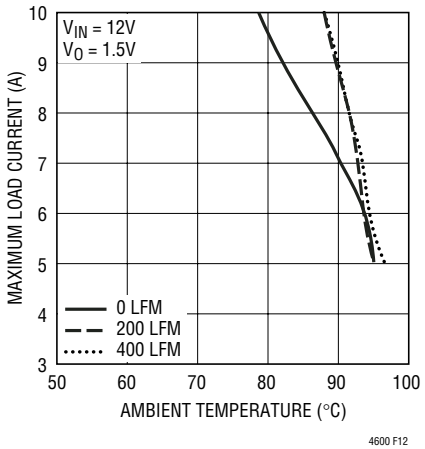


Figure 12. BGA Heatsink

APPLICATIONS INFORMATION

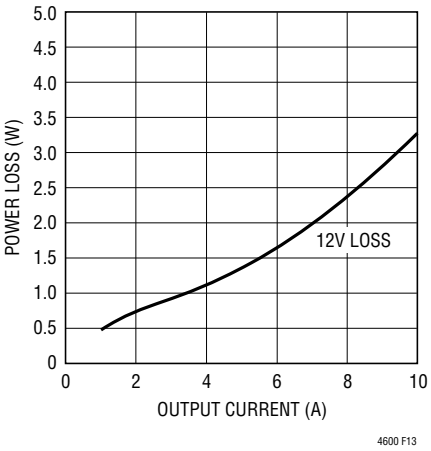


Figure 13. Power Loss vs Load Current

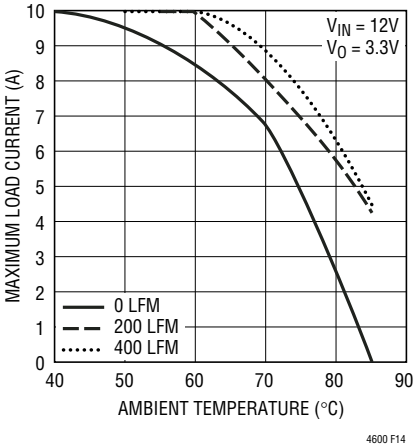


Figure 14. No Heatsink

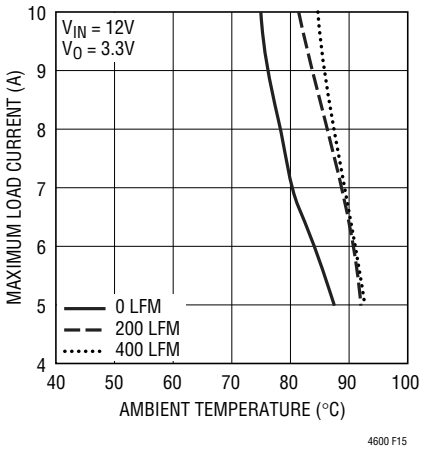


Figure 15. BGA Heatsink

APPLICATIONS INFORMATION

Table 3. 1.5V Output

DE-RATING CURVE	V_{IN} (V)	POWER LOSS CURVE	AIR FLOW (LFM)	HEATSINK*	θ_{JA} (°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_{IN} (V)	POWER LOSS CURVE	AIR FLOW (LFM)	HEATSINK*	θ_{JA} (°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

APPLICATIONS INFORMATION

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.

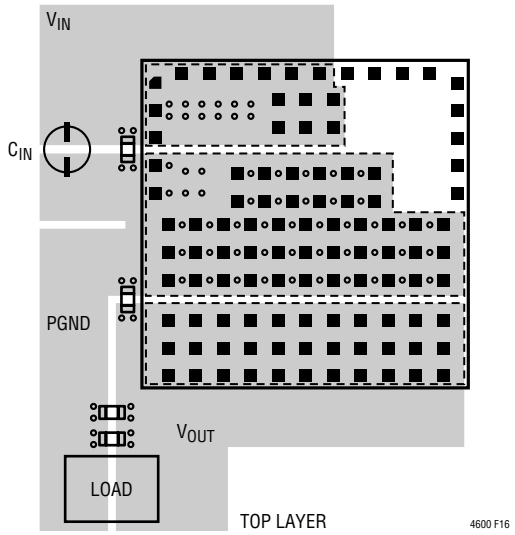


Figure 16. Recommended PCB Layout

TYPICAL APPLICATION

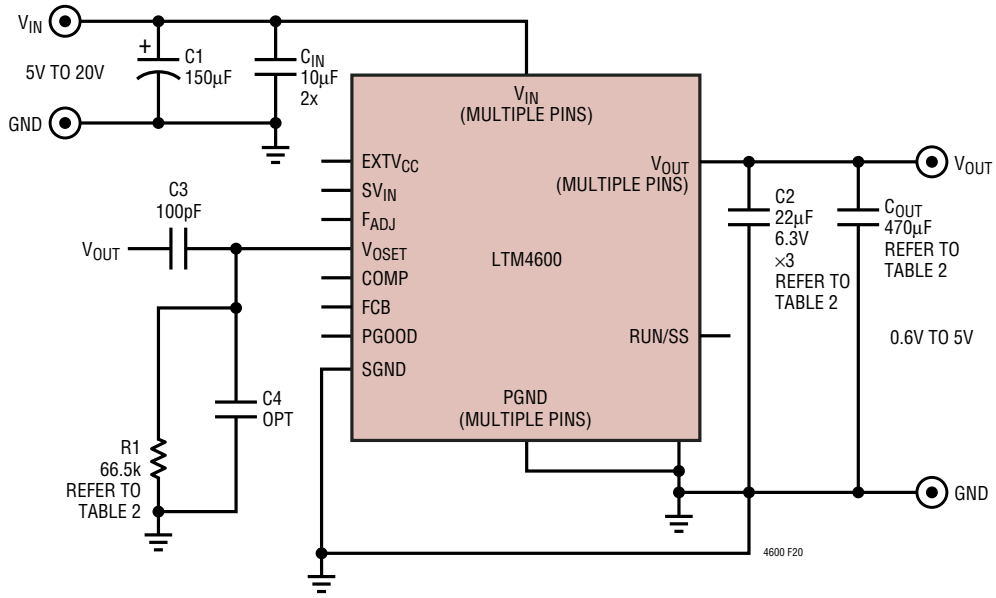
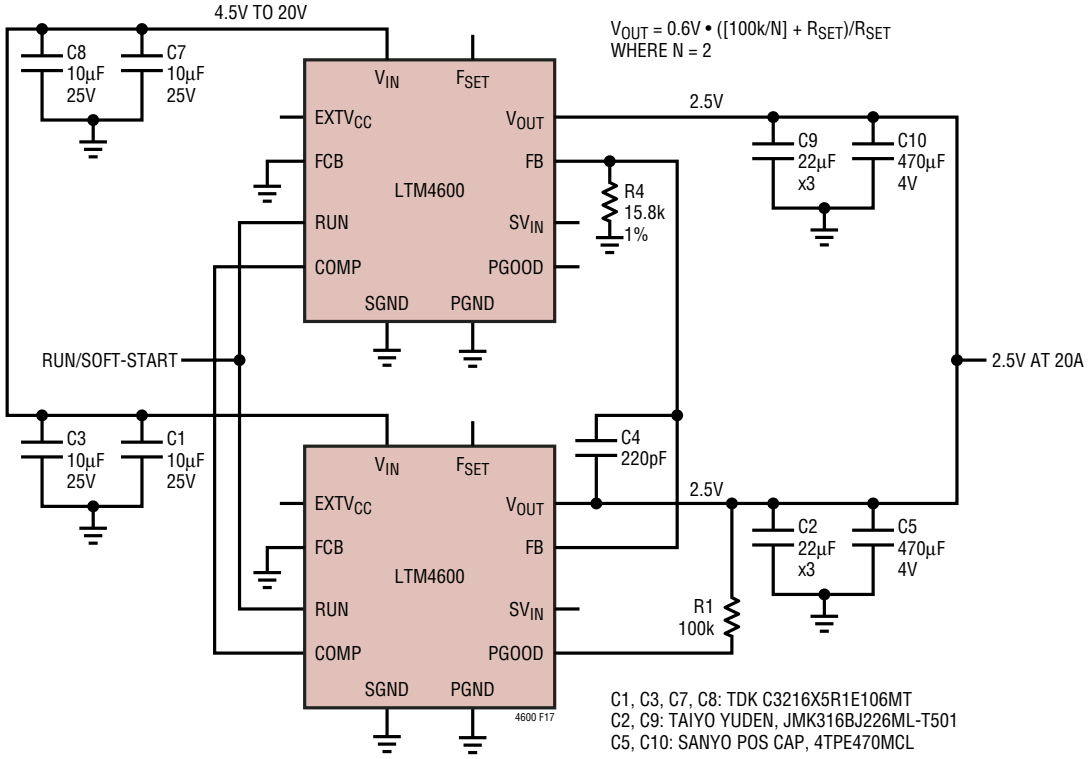


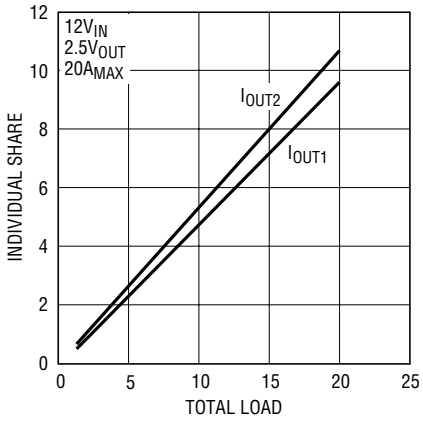
Figure 17. Typical Application, 5V to 20V Input, 0.6V to 5V Output, 10A Max

TYPICAL APPLICATION

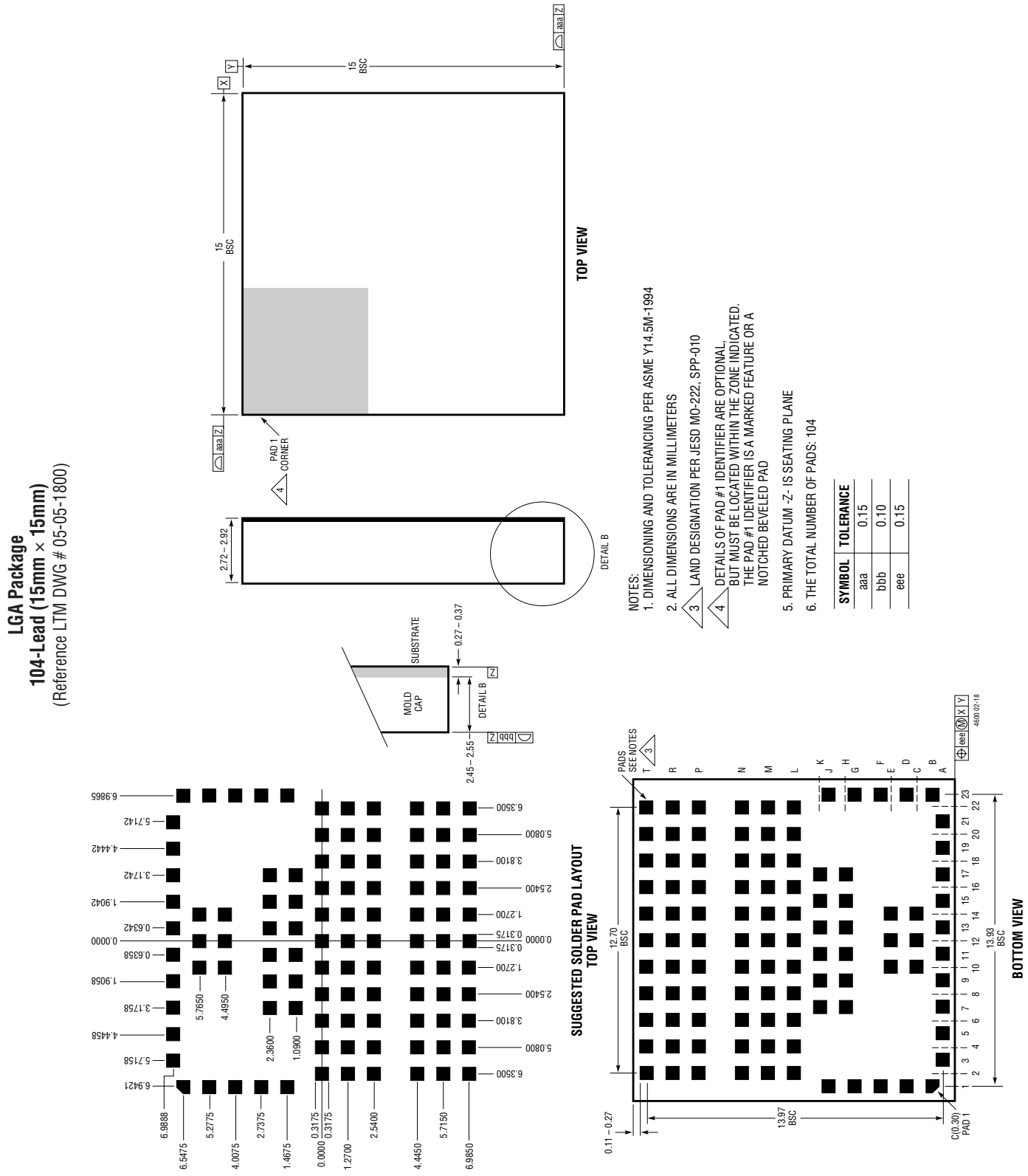
Parallel Operation and Load Sharing



Current Sharing Between Two LTM4600 Modules



PACKAGE DESCRIPTION



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_{IN}	C1 -	D1 V_{IN}	E1 -	F1 V_{IN}	G1 PGND	H1 -
A2 -	B2 -	C2 -	D2 -	E2 -	F2 -	G2 -	H2 -
A3 V_{IN}	B3 -	C3 -	D3 -	E3 -	F3 -	G3 -	H3 -
A4 -	B4 -	C4 -	D4 -	E4 -	F4 -	G4 -	H4 -
A5 V_{IN}	B5 -	C5 -	D5 -	E5 -	F5 -	G5 -	H5 -
A6 -	B6 -	C6 -	D6 -	E6 -	F6 -	G6 -	H6 -
A7 V_{IN}	B7 -	C7 -	D7 -	E7 -	F7 -	G7 -	H7 PGND
A8 -	B8 -	C8 -	D8 -	E8 -	F8 -	G8 -	H8 -
A9 V_{IN}	B9 -	C9 -	D9 -	E9 -	F9 -	G9 -	H9 PGND
A10 -	B10 -	C10 V_{IN}	D10 -	E10 V_{IN}	F10 -	G10 -	H10 -
A11 V_{IN}	B11 -	C11 -	D11 -	E11 -	F11 -	G11 -	H11 PGND
A12 -	B12 -	C12 V_{IN}	D12 -	E12 V_{IN}	F12 -	G12 -	H12 -
A13 V_{IN}	B13 -	C13 -	D13 -	E13 -	F13 -	G13 -	H13 PGND
A14 -	B14 -	C14 V_{IN}	D14 -	E14 V_{IN}	F14 -	G14 -	H14 -
A15 FADJ	B15 -	C15 -	D15 -	E15 -	F15 -	G15 -	H15 PGND
A16 -	B16 -	C16 -	D16 -	E16 -	F16 -	G16 -	H16 -
A17 SV_{IN}	B17 -	C17 -	D17 -	E17 -	F17 -	G17 -	H17 PGND
A18 -	B18 -	C18 -	D18 -	E18 -	F18 -	G18 -	H18 -
A19 $EXTV_{CC}$	B19 -	C19 -	D19 -	E19 -	F19 -	G19 -	H19 -
A20 -	B20 -	C20 -	D20 -	E20 -	F20 -	G20 -	H20 -
A21 V_{OSET}	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_{OUT}	R2 V_{OUT}	T2 V_{OUT}
J3 -	K3 -	L3 -	M3 -	N3 -	P3 -	R3 -	T3 -
J4 -	K4 -	L4 PGND	M4 PGND	N4 PGND	P4 V_{OUT}	R4 V_{OUT}	T4 V_{OUT}
J5 -	K5 -	L5 -	M5 -	N5 -	P5 -	R5 -	T5 -
J6 -	K6 -	L6 PGND	M6 PGND	N6 PGND	P6 V_{OUT}	R6 V_{OUT}	T6 V_{OUT}
J7 -	K7 PGND	L7 -	M7 -	N7 -	P7 -	R7 -	T7 -
J8 -	K8	L8 PGND	M8 PGND	N8 PGND	P8 V_{OUT}	R8 V_{OUT}	T8 V_{OUT}
J9 -	K9 PGND	L9 -	M9 -	N9 -	P9 -	R9 -	T9 -
J10 -	K10	L10 PGND	M10 PGND	N10 PGND	P10 V_{OUT}	R10 V_{OUT}	T10 V_{OUT}
J11 -	K11 PGND	L11 -	M11 -	N11 -	P11 -	R11 -	T11 -
J12 -	K12 -	L12 PGND	M12 PGND	N12 PGND	P12 V_{OUT}	R12 V_{OUT}	T12 V_{OUT}
J13 -	K13 PGND	L13 -	M13 -	N13 -	P13 -	R13 -	T13 -
J14 -	K14 -	L14 PGND	M14 PGND	N14 PGND	P14 V_{OUT}	R14 V_{OUT}	T14 V_{OUT}
J15 -	K15 PGND	L15 -	M15 -	N15 -	P15 -	R15 -	T15 -
J16 -	K16 -	L16 PGND	M16 PGND	N16 PGND	P16 V_{OUT}	R16 V_{OUT}	T16 V_{OUT}
J17 -	K17 PGND	L17 -	M17 -	N17 -	P17 -	R17 -	T17 -
J18 -	K18 -	L18 PGND	M18 PGND	N18 PGND	P18 V_{OUT}	R18 V_{OUT}	T18 V_{OUT}
J19 -	K19 -	L19 -	M19 -	N19 -	P19 -	R19 -	T19 -
J20 -	K20 -	L20 PGND	M20 PGND	N20 PGND	P20 V_{OUT}	R20 V_{OUT}	T20 V_{OUT}
J21 -	K21 -	L21 -	M21 -	N21 -	P21 -	R21 -	T21 -
J22 -	K22 -	L22 PGND	M22 PGND	N22 PGND	P22 V_{OUT}	R22 V_{OUT}	T22 V_{OUT}
J23 PGOOD	K23 -	L23 -	M23 -	N23 -	P23 -	R23 -	T23 -

PACKAGE DESCRIPTION

Pin Assignment Tables
(Arranged by Pin Number)

PIN	NAME
G1	PGND
H7	PGND
H9	PGND
H11	PGND
H13	PGND
H15	PGND
H17	PGND
J1	PGND
K7	PGND
K9	PGND
K11	PGND
K13	PGND
K15	PGND
K17	PGND
L2	PGND
L4	PGND
L6	PGND
L8	PGND
L10	PGND
L12	PGND
L14	PGND
L16	PGND
L18	PGND
L20	PGND
L22	PGND
M2	PGND
M4	PGND
M6	PGND
M8	PGND
M10	PGND
M12	PGND
M14	PGND
M16	PGND
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

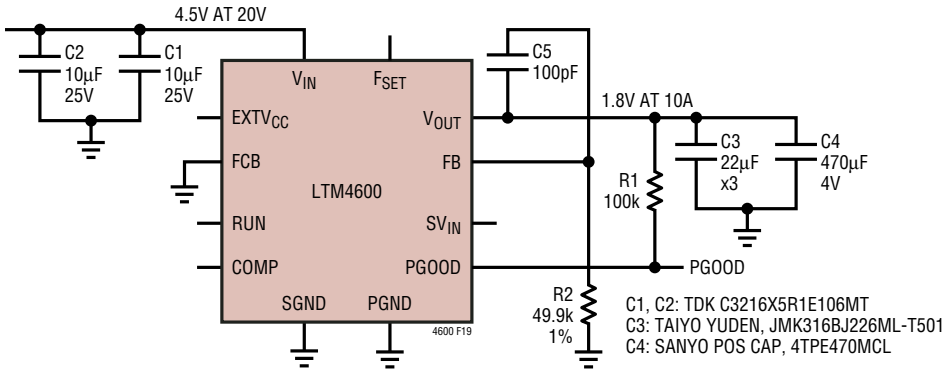
PIN	NAME
P2	V_{OUT}
P4	V_{OUT}
P6	V_{OUT}
P8	V_{OUT}
P10	V_{OUT}
P12	V_{OUT}
P14	V_{OUT}
P16	V_{OUT}
P18	V_{OUT}
P20	V_{OUT}
P22	V_{OUT}
R2	V_{OUT}
R4	V_{OUT}
R6	V_{OUT}
R8	V_{OUT}
R10	V_{OUT}
R12	V_{OUT}
R14	V_{OUT}
R16	V_{OUT}
R18	V_{OUT}
R20	V_{OUT}
R22	V_{OUT}
T2	V_{OUT}
T4	V_{OUT}
T6	V_{OUT}
T8	V_{OUT}
T10	V_{OUT}
T12	V_{OUT}
T14	V_{OUT}
T16	V_{OUT}
T18	V_{OUT}
T20	V_{OUT}
T22	V_{OUT}

PIN	NAME
A3	V_{IN}
A5	V_{IN}
A7	V_{IN}
A9	V_{IN}
A11	V_{IN}
A13	V_{IN}
B1	V_{IN}
C10	V_{IN}
C12	V_{IN}
C14	V_{IN}
D1	V_{IN}
E10	V_{IN}
E12	V_{IN}
E14	V_{IN}
F1	V_{IN}

PIN	NAME
A15	FADJ
A17	SV_{IN}
A19	$EXTV_{CC}$
A21	V_{OSET}
B23	COMP
D23	SGND
F23	RUN/SS
G23	FCB
J23	PGOOD

TYPICAL APPLICATION

1.8V, 10A Regulator



PRE-RELEASE