SC4509

Highly Integrated Step-Up Converter for White LED Applications in MLPD-W8-2x2

Description

The SC4509 is a highly integrated step-up DC/DC converter targeted for white LED backlighting applications. It is designed to drive up to five LEDs with a wide input voltage range of 2.7 to 10 volts. Designed for 20V output voltage, the SC4509 operates with a constant 1.2MHz PWM frequency. To optimize efficiency, the feedback voltage is set to only 199mV, minimizing the power loss in the current setting resistor. The product requires only four external components (CIN, COUT, L and R_{SET}), making it ideal for applications that require low cost and minimal PCB area.

The SC4509 offers current limit and over-voltage protection (OVP) to safeguard the device under extreme operating conditions. If the LEDs become disconnected or fail in an open state condition, OVP circuitry will be activated to shut down the device. The EN/SS pin allows the device to be placed in power-down mode, disabling the control circuitry to reduce input current.

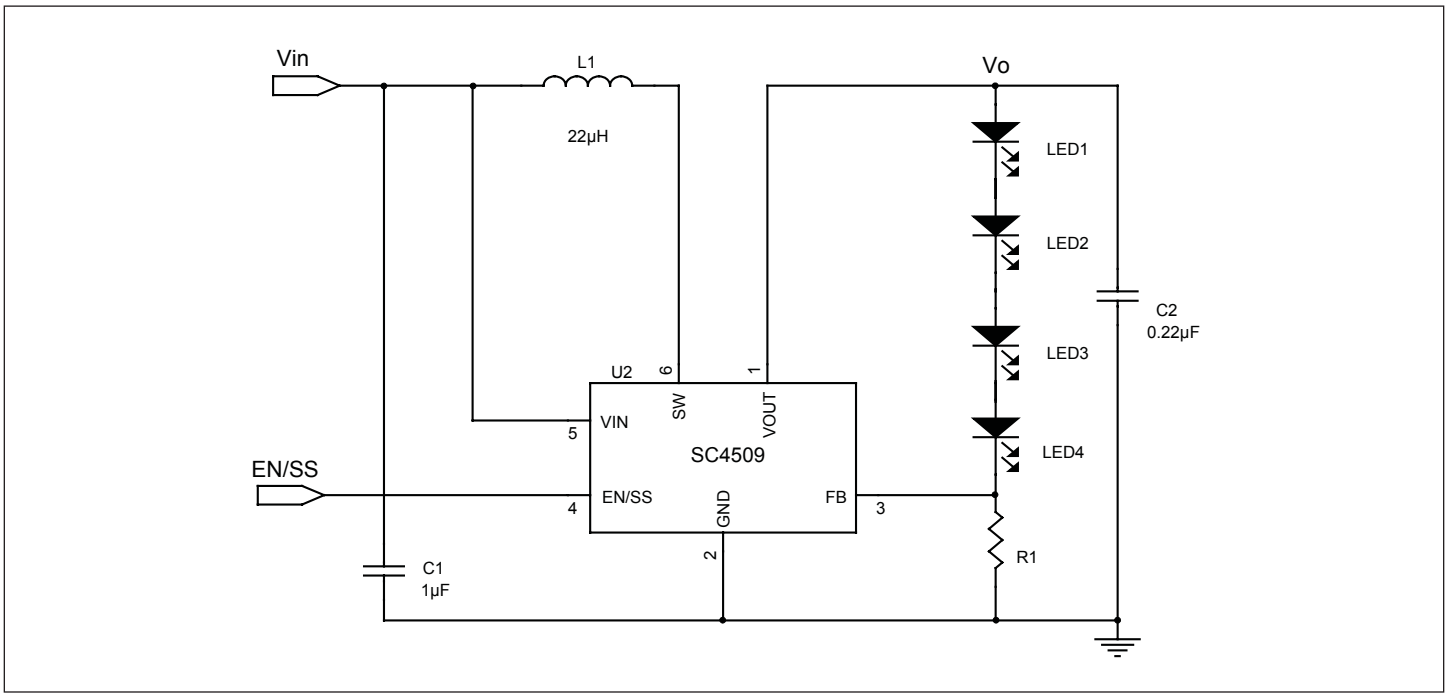
Features

- V_{IN} range: 2.7V — 10V
- Integrated Schottky diode
- 81% efficiency
- Requires only 4 external components
- Up to 20V of output voltage
- 30mA maximum LED current
- Open LED protection (OVP)
- 1.2MHz PWM switching frequency
- Low feedback voltage (200mV typical)
- Wide range of PWM dimming
- Drives up to 5 LEDs
- 500mA switch current limit
- 220nF output capacitor
- Available in 2mm x 2mm x 0.75mm MLPD-W8 and SOT23-6 packages
- Packages are fully WEEE and RoHS compliant

Applications

- Digital Video Cameras
- White LED Backlight Driver
- OLED Display Driver
- Portable Media Players
- GPS Receivers
- Cellular Phones
- PDAs and Handheld Computers

Typical Application Circuit



Absolute Maximum Rating

Exceeding the specifications below may result in permanent damage to the device, or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not implied. Exposure to Absolute Maximum rated conditions for extended periods of time may affect device reliability.

Parameter		Symbol	Maximum	Units
Input Supply Voltage		V_{IN}	-0.3 to 20	V
SW Voltage		V_{SW}	-0.3 to 30	V
Maximum Output Voltage		V_{OUT}	30	V
Feedback Voltage		V_{FB}	-0.3 to 20	V
EN/SS Voltage		$V_{EN/SS}$	-0.3 to V_{IN} + 0.3	V
Maximum Junction Temperature		T_J	125	°C
Storage Temperature Range		T_{STG}	-65 to +150	°C
Thermal Impedance Junction to Ambient(1)	MLPD-W8	θ_{JA}	78	C/W
	SOT23-6		165	
Lead Temperature (Soldering), 10s (SOT23-6 package only)		T_{LEAD}	300	°C
Peak IR Flow Temperature, (10-40sec)		T_{PKG}	260	°C
ESD Rating (Human Body Model)(2)		V_{ESD}	2	kV

Note:
1) Calculated from package in still air, mounted to 3"x 4.5", 4 layer FR4 PCB with thermal vias under the exposed pad per JESD51 standards.
2) Tested in accordance to JEDEC standard JESD22-A114B.

Electrical Characteristics

Unless specified: V_{IN} = $V_{EN/SS}$ = 3.6V; C_{IN} = 1µF; C_{OUT} = 0.22µF; L = 22µH; unless otherwise noted, T_A = +25°C for Typ, -40ºC to 85°C for Min and Max.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage	V_{IN}		2.7		10	V
Quiescent Current	I_Q	No switching		2.6	3.3	mA
Feedback Voltage	V_{FB}		182	199	216	mV
Feedback Pin Bias Current	I_{QFB}			35	100	nA
Switching Frequency	f_{OSC}	T_A=25 °C	1.0	1.2	1.4	MHz
Maximum Output Voltage	V_{OUT}		20			V
Switch Saturation Voltage	V_{CESAT}	I_{SW} = 85mA; T_A=25 °C		160	300	mV
Maximum Duty Cycle	D_{MAX}	V_{FB} = GND	90			%
Switch Current Limit	I_{cl}	I_{LOAD} = 0; T_A=25 °C	300	500	700	mA
Switch Leakage Current	I_{LKG}	V_{SW} = 5V; V_{OUT} = Open		0.01	5.0	µA
Shutdown Current	I_{SHD}	$V_{EN/SS}$ = GND; V_{IN} = 3V; V_{OUT} = Open		3	5	µA
PWM Dimming Frequency(1)	f_{DIM}			1	10	kHz
EN/SS Threshold Low	V_{IL}				50	mV
EN/SS Threshold High	V_{IH}		1.8			V

© 2007 Semtech Corp.

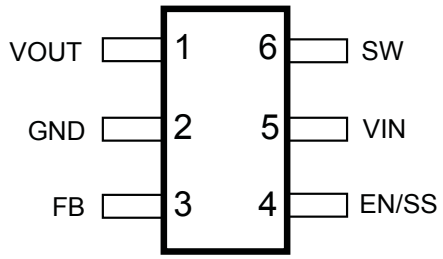
Electrical Characteristics (Cont.)

Unless specified: V_{IN} = $V_{EN/SS}$ = 3.6V; C_{IN} = 1µF; C_{OUT} = 0.22µF; L = 22µH; unless otherwise noted, T_A = +25°C for Typ, -40ºC to 85°C for Min and Max.

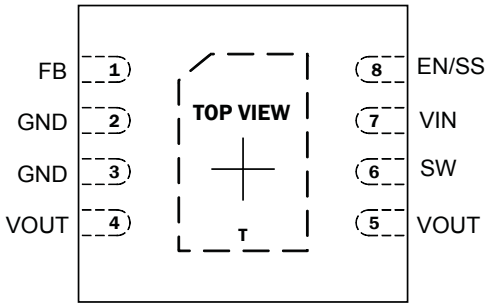
Parameter	Symbol	Conditions	Min	Typ	Max	Units
EN/SS Input Low Current	I_{IL}	$V_{EN/SS}$ = GND			1.0	µA
EN/SS Input High Current	I_{IH}			60	100	µA
Output Over-Voltage Protection	OVP		25	30		V
Schottky Forward Drop	V_{f_sch}	I_D = 150mA		0.7		V
Schottky Leakage Current	I_{f_sch}	V_{OUT} = 25V; V_{SW} = GND		1.0	4.0	µA

Note:
1. Guaranteed by design.

Pin Configuration



6-pin - SOT23



8-pin - MLPD 2X2

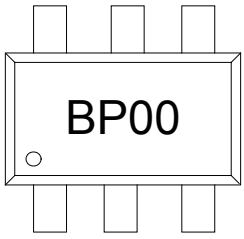
Ordering Information

Part Numbers	Package
SC4509SKTRT(1)(2)	SOT23-6
SC4509WLTRT(1)(2)	MLPD-W8 2mmx2mmx0.75mm
SC4509EVB(3)	Evaluation Board

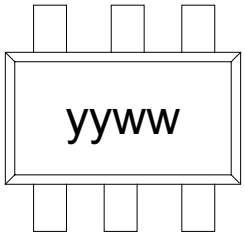
Notes:
(1) Only available in tape and reel packaging. A reel contains 3000 devices.
(2) Lead-free package. This product is fully WEEE and RoHS compliant.
(3) Specify package preference when ordering.

Marking Information

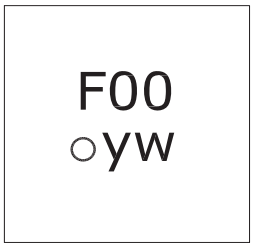
TOP MARK



BOTTOM MARK



Marking for SOT23, 6 Lead Package:
yyww = Datecode (Example: 0652)



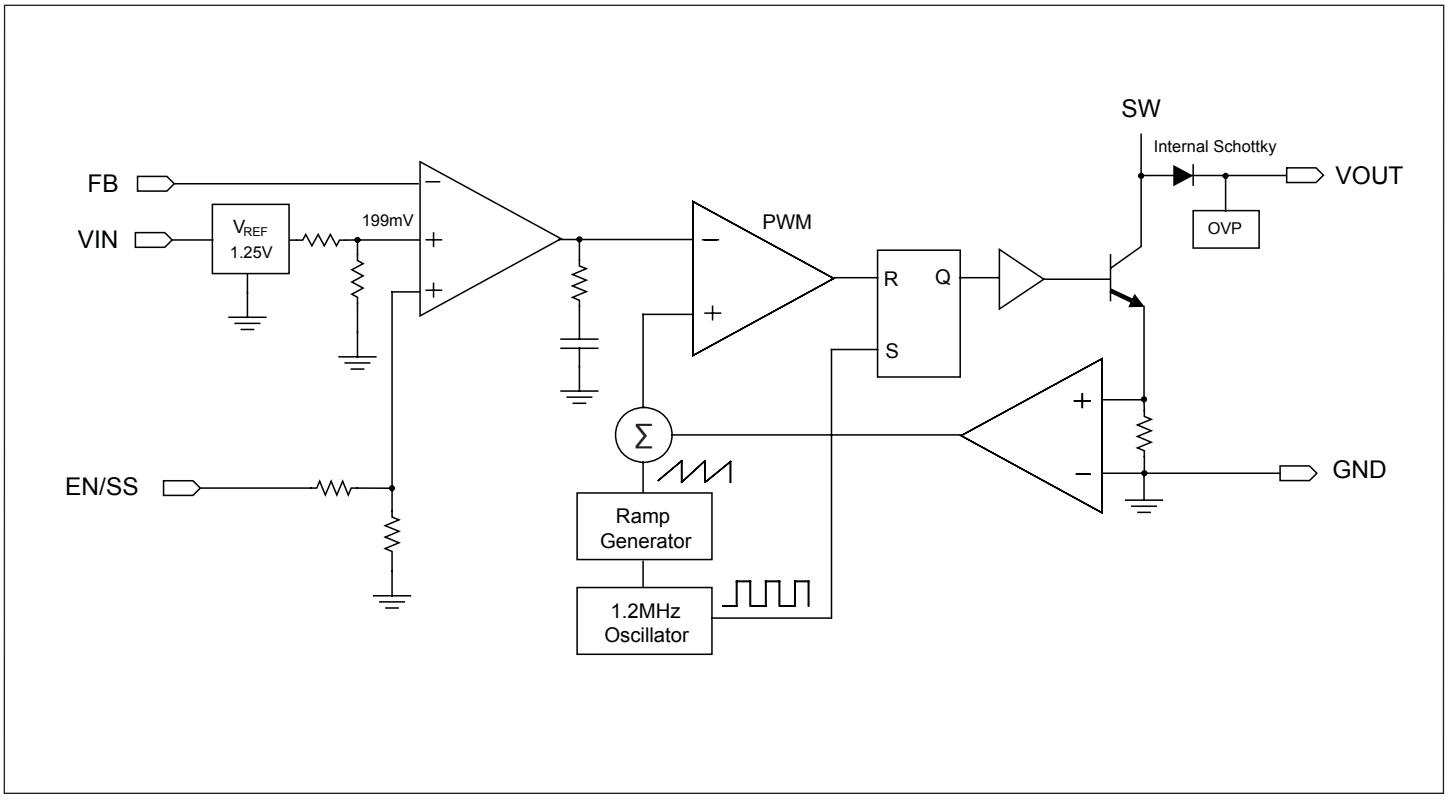
TOP MARK	
CHAR	ROWS
3/3	2

Marking for the 2 x 2mm MLPD-W 8 Lead package:
nnn = Part Number (Example: F00) - Reference Part No. Code for small MLP
yw = Datecode (Reference Package Marking Design Guide lines, Appendix A)

Pin Descriptions

SOT23	MLPD 2X2	Pin Name	Function
1	4, 5	VOUT	Cathode side of the Schottky output voltage. Connect a 0.22µF capacitor from this pin to ground.
2	2,3	GND	Ground connection
3	1	FB	Feedback input pin. Connect a resistor from this pin to GND to program the LED current.
4	8	EN/SS	Enable pin. When connected to logic high, the converter is enabled. When connected to logic low, the converter is disabled. The LED brightness can be controlled by applying a PWM signal to this pin.
5	7	VIN	Input voltage pin. Connect a 1µF capacitor from this pin to GND.
6	6	SW	Switching pin - collector of the internal switch.
N/A	T		Exposed pad (bottom); connect to GND directly beneath package.

Block Diagram



Theory of Operation

The SC4509 is a constant frequency PWM step-up regulator IC designed to operate with an input voltage range from 2.7V to 10V.

A maximum output voltage of 20V allows for up to five LEDs to be connected in series, providing even illumination by passing the same output current through each LED.

Designed for a low 199mV, the feedback voltage has a direct effect on the converter efficiency. Because the voltage drop across the feedback resistor does not contribute to the output power (LED brightness), the lower the feedback voltage, the higher the efficiency. A 1.2MHz oscillator frequency saves board space by reducing external component sizes, making the SC4509 ideal for battery-operated products.

The SC4509 can be configured as a voltage regulated boost converter or as a current-regulating boost converter for driving white LEDs. The device is designed to be stable without additional external components in both cases.

Over-Voltage Protection (OVP)

To prevent the output voltage from exceeding the maximum switch voltage rating (30V), an over-voltage protection circuit is integrated. As soon as the output voltage exceeds the OVP threshold, the converter stops switching and the output voltage starts to drop. When the output voltage drops back below the OVP threshold, the converter resumes operation. This sequence will repeat for as long as is necessary.

Enable and PWM Dimming

The SC4509 provides the EN/SS pin to serve multiple functions. Its main function is as an enable pin (active high). It also can be used to control LED brightness when a PWM signal (up to 10kHz) of varying duty cycle is applied. A third function acts as a soft-start control. Soft start can be implemented by ramping the voltage applied to the pin at startup or by slowly increasing the PMW duty cycle.

Applications Information

Programming the LED Current

Please refer to the Typical Application Circuit on page 1. The LED current is programmed by connecting a resistor (R1) between the FB pin and GND. The LED current in mA is given by the following equation:

$$I_{LED} = 199/R1$$

where R1 value is in Ohms.

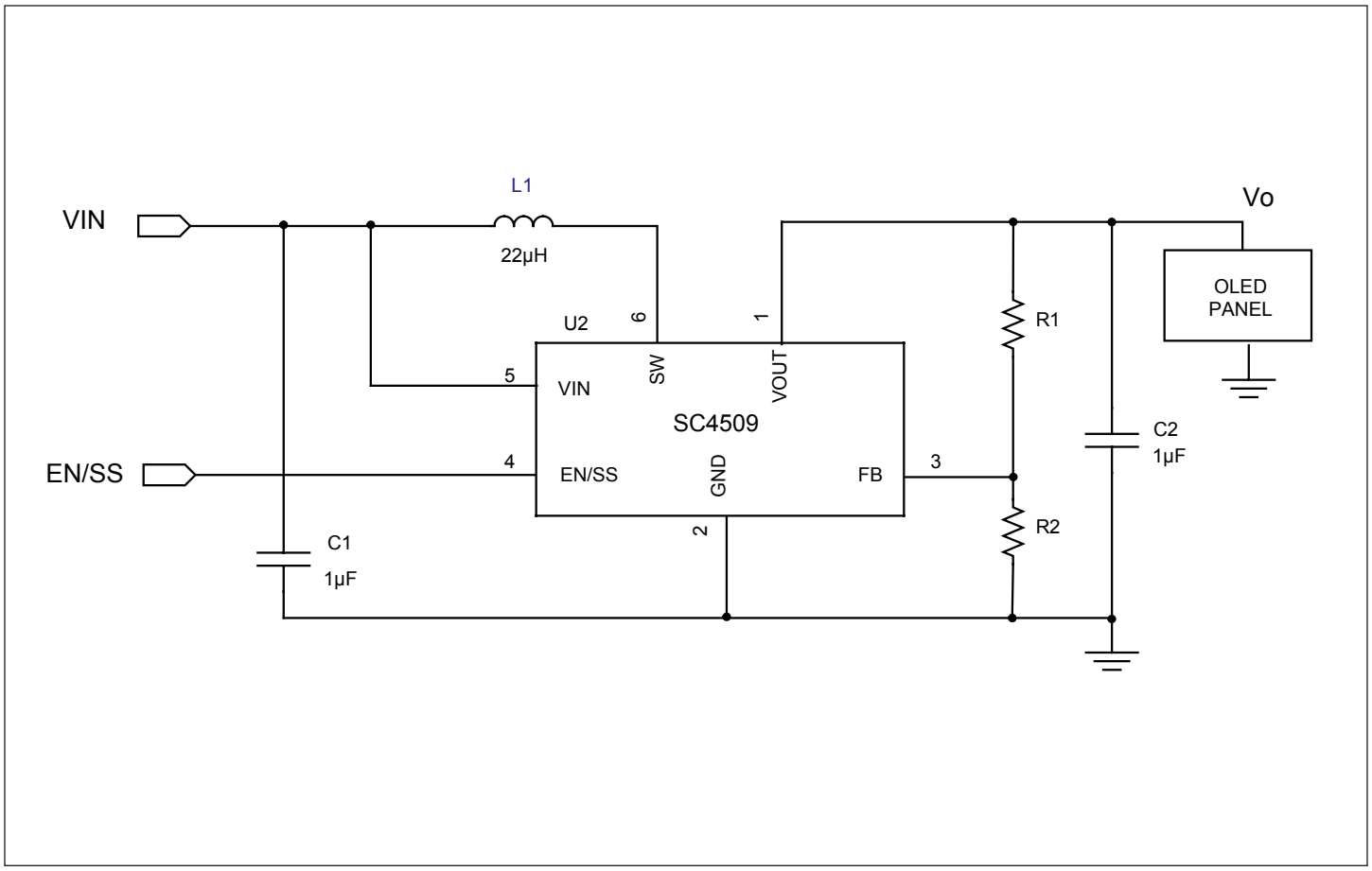
Setting the Output Voltage

The non-inverting input of the internal error amplifier is tied to a 199mV voltage reference. A simple voltage divider (R1 at the top and R2 at the bottom) sets the converter output voltage. Please refer to the Application Circuit for OLED Panels on the next page. The voltage feedback gain h = 0.199/Vo is related to the divider resistors value as

$$h = \frac{R2}{R1+R2}$$

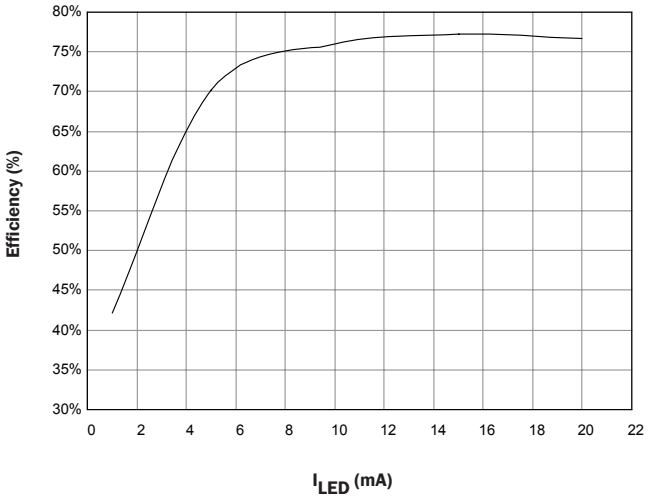
Once either R1 or R2 is chosen, the other can be calculated for the desired output voltage Vo. Since the number of standard resistance values is limited, the calculated resistance may not be available as a standard value resistor. As a result, there will be a set error in the converter output voltage. This non-random error is caused by the feedback voltage divider ratio. It cannot be corrected by the feedback loop.

Application Circuit for OLED Panels

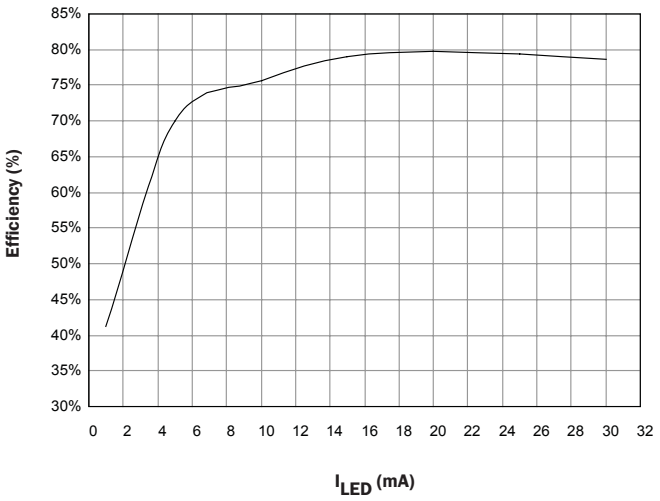


Typical Characteristics

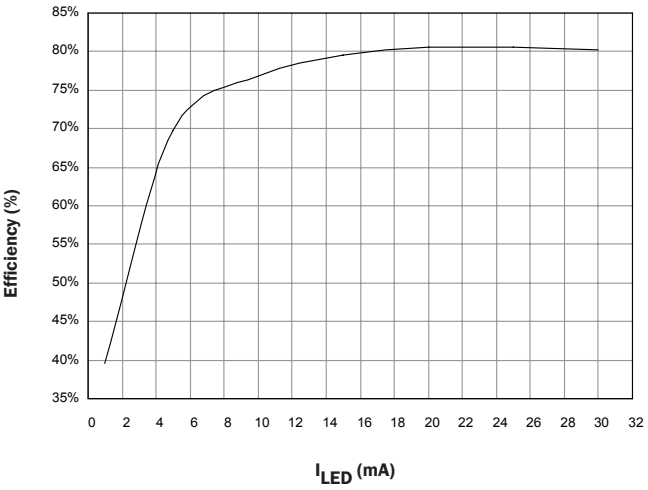
Efficiency vs. LED Current
V_{IN} = 2.7V, V_{OUT} = 16V, (4 LED)



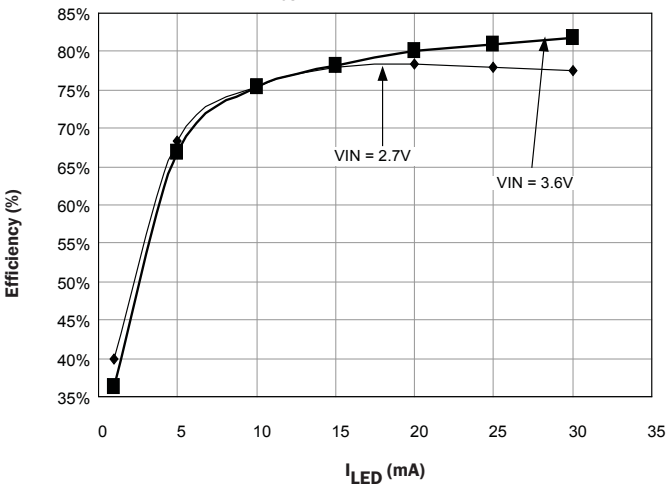
Efficiency vs. LED Current
V_{IN} = 3.3V, V_{OUT} = 16V, (4 LED)



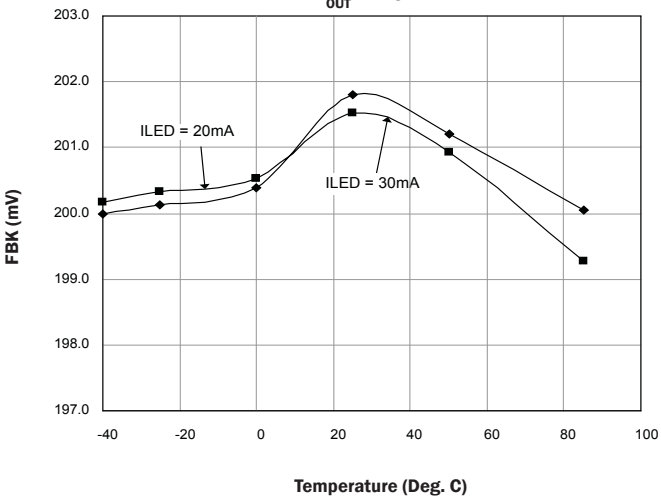
Efficiency vs. LED Current
V_{IN} = 3.6V, V_{OUT} = 16V, (4 LED)



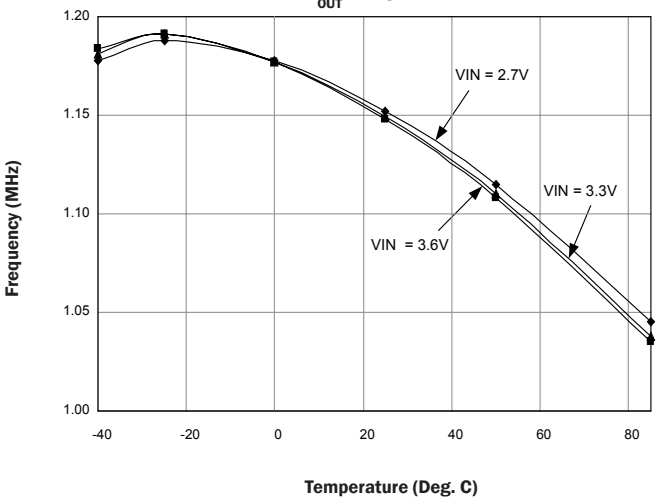
Efficiency vs. LED Current vs. Input Voltage
V_{OUT} = 12V, (3 LED)



Feedback Voltage vs. Temperature vs. LED Current,
V_{OUT} = 16V



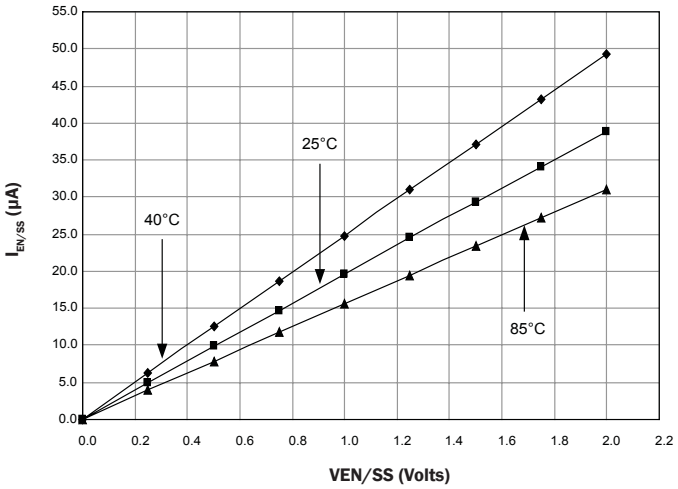
Frequency vs. Temperature vs. Input Voltage,
V_{OUT} = 16V



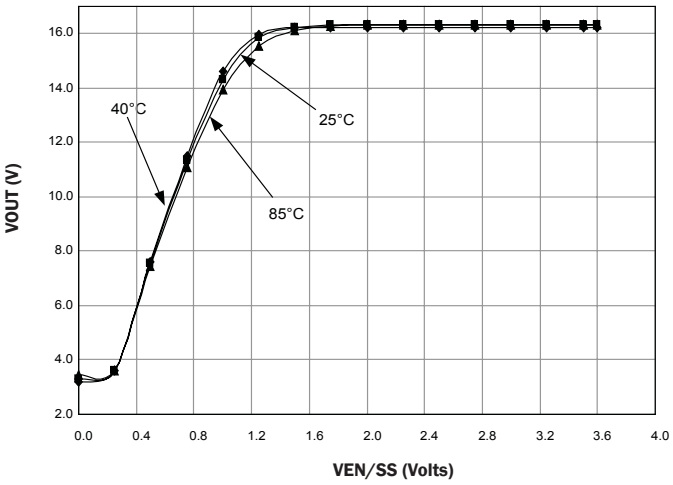
© 2007 Semtech Corp.

Typical Characteristics (Cont.)

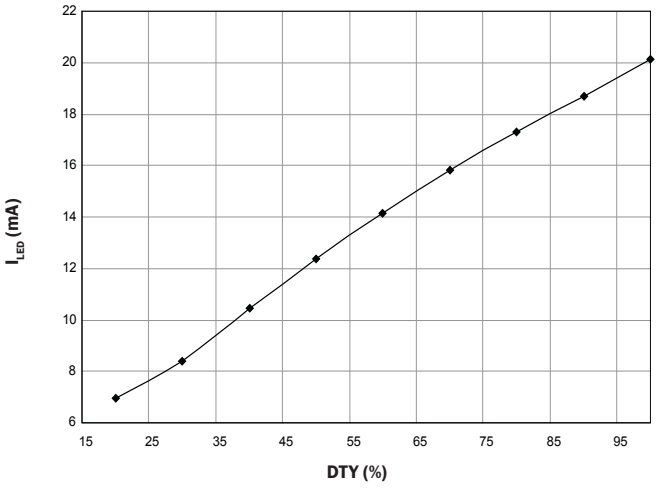
EN/SS Input Current vs. EN/SS Voltage vs. Temperature, V_{IN} = 3.6V; V_{OUT} = 16V



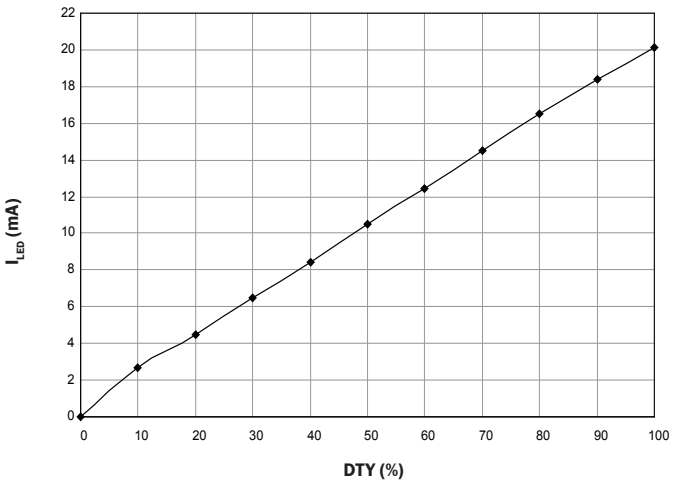
Output Voltage vs. EN/SS Voltage vs. Temperature, V_{IN} = 3.6V; V_{OUT} = 16V



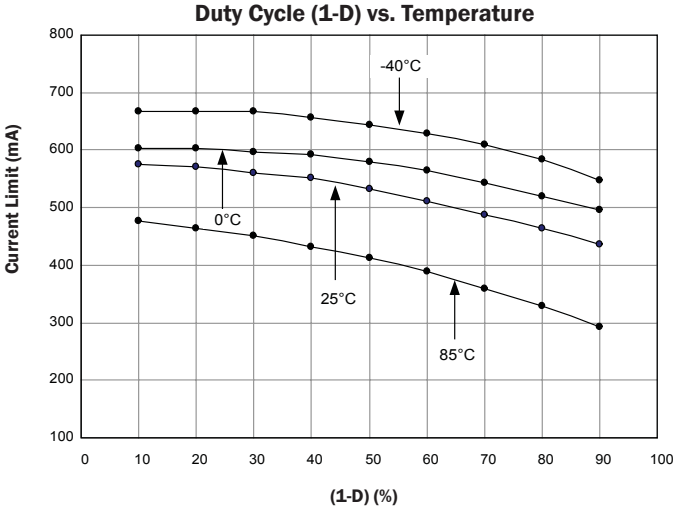
LED Current vs. PWM Dimming Duty Cycle V_{IN} = 3.6V; V_{OUT} = 16V; FPWM = 10kHz



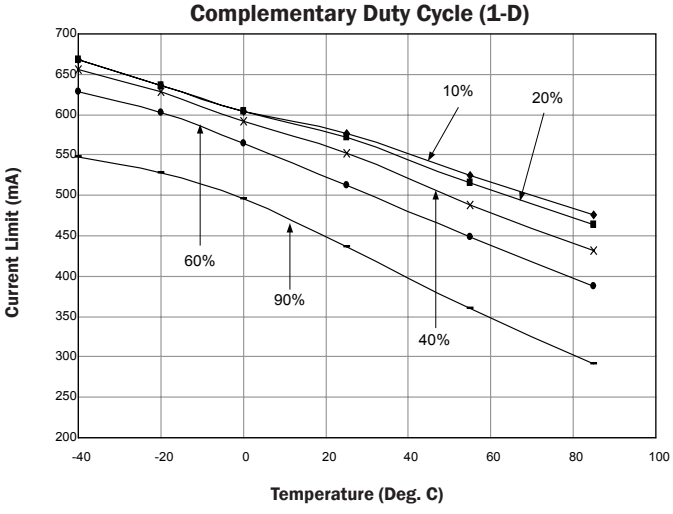
LED Current vs. PWM Dimming Duty Cycle V_{IN} = 3.6V; V_{OUT} = 16V; FPWM = 1kHz



Switch Current Limit vs. Complementary Duty Cycle (1-D) vs. Temperature

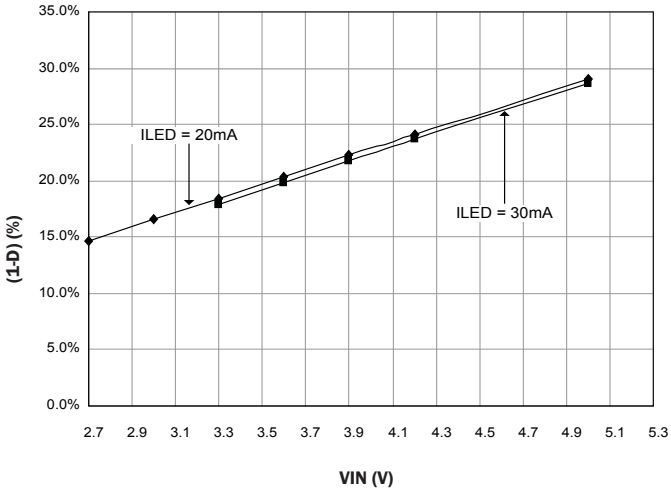


Switch Current Limit vs. Temperature vs. Complementary Duty Cycle (1-D)

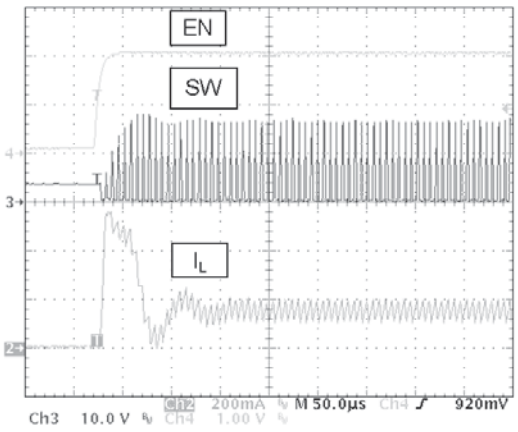


Typical Characteristics (Cont.)

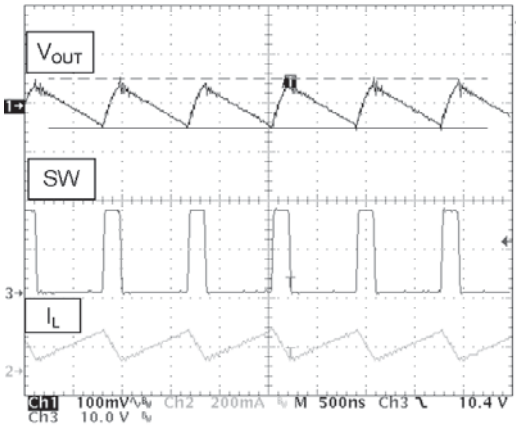
Switch Complementary Duty Cycle vs. Input Voltage vs. LED Current, V_{OUT} = 16V, (4 LED)



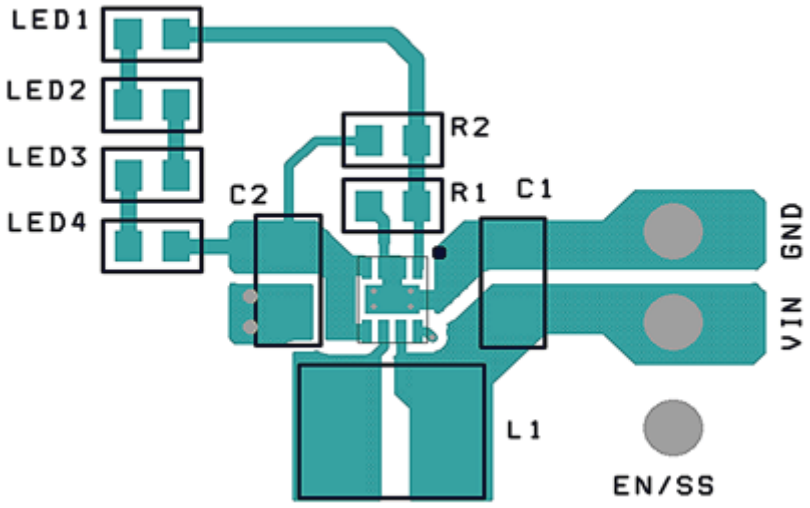
Startup Current
V_{IN} = 3.6V; I_{LED} = 30mA; V_{OUT} = 16V (4 LEDs)



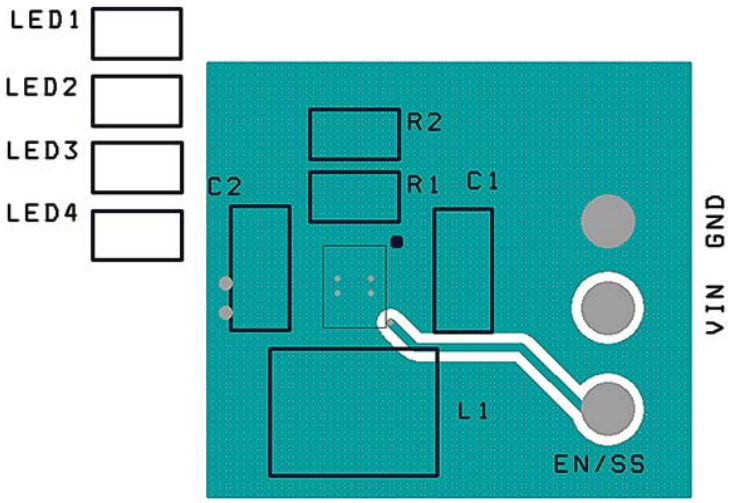
Switching Waveform
V_{IN} = 3.6V; I_{LED} = 20mA; V_{OUT} = 16V (4 LEDs)



Layout Example

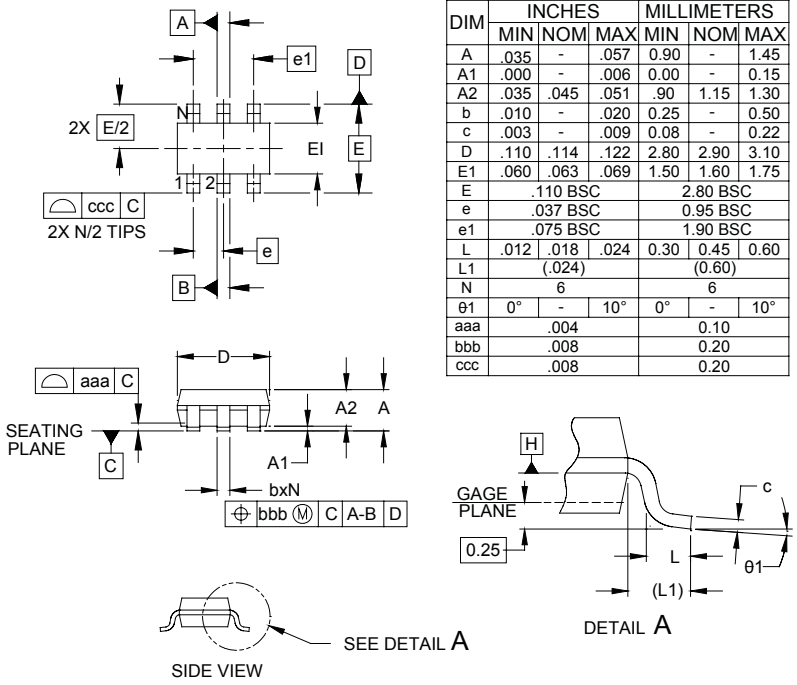


Top Layer



Bottom Layer

Outline Drawing - SOT23-6

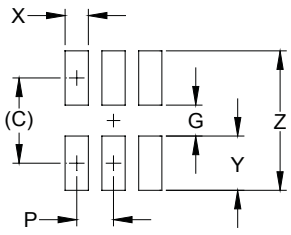


DIM	DIMENSIONS					
	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	.035	-	.057	0.90	-	1.45
A1	.000	-	.006	0.00	-	0.15
A2	.035	.045	.051	.90	1.15	1.30
b	.010	-	.020	0.25	-	0.50
c	.003	-	.009	0.08	-	0.22
D	.110	.114	.122	2.80	2.90	3.10
E1	.060	.063	.069	1.50	1.60	1.75
E	.110 BSC			2.80 BSC		
e	.037 BSC			0.95 BSC		
e1	.075 BSC			1.90 BSC		
L	.012	.018	.024	0.30	0.45	0.60
L1	(.024)			(0.60)		
N	6			6		
θ1	0°	-	10°	0°	-	10°
aaa	.004			0.10		
bbb	.008			0.20		
ccc	.008			0.20		

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-
3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

Land Pattern - SOT23-6

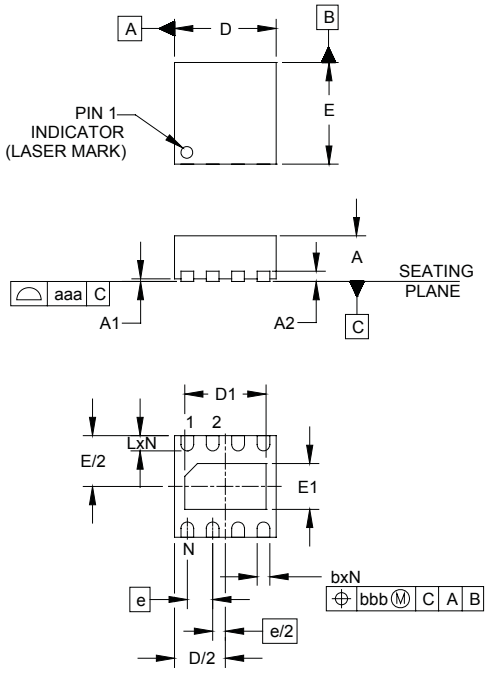


DIM	DIMENSIONS	
	INCHES	MILLIMETERS
C	(.098)	(2.50)
G	.055	1.40
P	.037	0.95
X	.024	0.60
Y	.043	1.10
Z	.141	3.60

NOTES:

1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

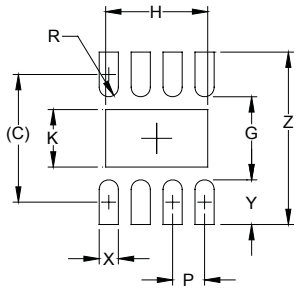
Outline Drawing - MLPD-W8 2x2



DIM	DIMENSIONS					
	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	.028	.030	.031	0.70	0.75	0.80
A1	.000	.001	.002	0.00	0.02	0.05
A2		(.008)			(0.20)	
b	.007	.010	.012	0.18	0.25	0.30
D	.075	.079	.083	1.90	2.00	2.10
D1	.059	.063	.067	1.50	1.60	1.70
E	.075	.079	.083	1.90	2.00	2.10
E1	.031	.035	.039	0.80	0.90	1.00
e		.020 BSC			0.50 BSC	
L	.008	.012	.016	0.20	0.30	0.40
N		8			8	
aaa		.003			0.08	
bbb		.003			0.08	

NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

Land Pattern - MLPD-W8 2x2



DIM	DIMENSIONS	
	INCHES	MILLIMETERS
C	(.079)	(2.00)
G	.051	1.30
H	.063	1.60
K	.035	0.90
P	.020	0.50
R	.006	0.15
X	.012	0.30
Y	.028	0.70
Z	.106	2.70

NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
3. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.

Contact Information

Semtech Corporation
Power Management Products Division
200 Flynn Road, Camarillo, CA 93012
Phone: (805) 498-2111 Fax: (805) 498-3804

www.semtech.com