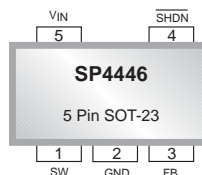# Sipex

SP4446

High Output Voltage Boost Regulator
LCD Bias Regulator

FEATURES

■ High Output Voltage: Up to 30V
■ High Efficiency
■ Low Quiescent Current: ~20uA
■ Miniature Package: (5-lead SOT-23)
■ Single Battery Cell Operation
■ Programmable Output Voltage
■ 1Ω Switch (150mV at 150mA)

APPLICATIONS

■ LCD Bias
■ Tuner Pin Voltage
■ White LED Driver
■ High Voltage Bias

■ Digital Cameras
■ Cell Phone
■ Battery Backup
■ Handheld Computers

V_{IN} 5		$\overline{SHDN}$ 4
	SP4446	
	5 Pin SOT-23	
1 SW	2 GND	3 FB

Now Available in Lead Free Packaging

DESCRIPTION

The SP4446 is a micro power Boost Regualtor in a 5-lead SOT-23 package. It is a current limited, fixed off-time regulator configured for use in boost mode applications. The operating voltage can be less than 3V and is capable of generating voltages as high as 30 Volts.

The SP4446 is to be supplied in a SOT-23-5 and permits the construction of complete regulators that occupy < 0.2 square inches of board space.

TYPICAL APPLICATION SCHEMATIC
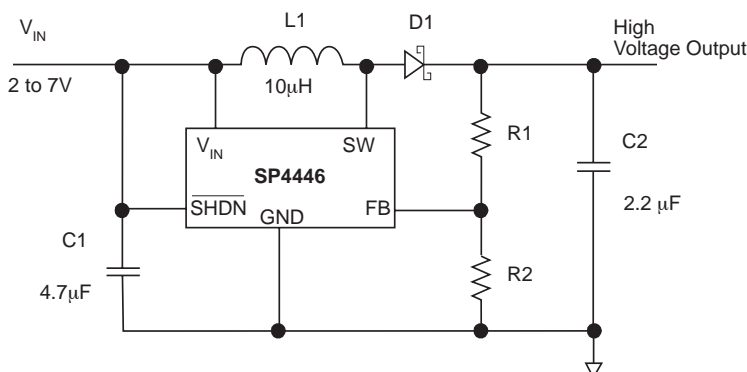
ABSOLUTE MAXIMUM RATINGS

V_{IN} 15V
SW Voltage .... -0.4 to 34V
FB Voltage 2.5V
All other pins .... -0.3 to V_{CC} + 0.3V
Current into FB .... ±1mA
T_J Max .... 125°C
Operating Temperature Range .... -40°C to 85°C
Peak Output Current < 10us SW 500mA
Storage Temperature .... -65°C to +150°C
Power Dissipation. 200mW

Lead Temperature (Soldering, 10 sec) .... 300°C
ESD Rating .... 2kV HBM

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

ELECTRICAL CHARACTERISTICS

Specifications are at V_{IN} = 3.3V, V_{SHDN} = V_{IN}, T_A = 25°C, ♦ denotes the specifications which apply over the full operating temperature range, unless otherwise specified.

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS		CONDITIONS
Input voltage	V_{IN}	1.0		8.0	V		Switch Current Limit = 150mA
Supply Current	I_Q		20	30	µA	♦	No Switching
			0.01	1	µA		$\overline{SHDN}$ = 0.0V
Reference Voltage	V_{FB}	1.17	1.22	1.27	V	♦	
FB Hysteresis	HYST		8		mV		
V_{FB} Input Bias Current	I_{FB}		15	80	nA	♦	V_{FB} = 1.22V
Line Regulation	$\Delta V_o/\Delta V_I$		0.04		%/V		1.2 ≤ V_{IN} ≤ 8V
Switch Off Time	T_{OFF}		300		nS		V_{FB} > 1V
			1200		nS		V_{FB} < 0.3V
Switch Saturation Voltage	V_{CESAT}		50		mV	♦	I_{SW} = 50mA
			150		mV		I_{SW} = 150mA
Switch Current Limit	I_{LIM}	100	150	200	mA	♦	
$\overline{SHDN}$ Bias Current	$I_{\overline{SHDN}}$		5	12	µA	♦	V_{SHDN} = 5V
$\overline{SHDN}$ High Threshold (on)	V_{IH}	0.9			V		
$\overline{SHDN}$ Low Threshold (off)	V_{IL}			0.25	V		
Switch Leakage Current	I_{SWLK}		2	5	µA	♦	Switch Off, V_{SW} = 5V

PIN DESCRIPTION

PIN NUMBER	PIN NAME	DESCRIPTION
1	SW	Switch input to the internal power switch.
2	GND	Ground
3	FB	Feedback
4	$\overline{SHDN}$	Shutdown. Pull high (on) to enable. Pull low (off) for shutdown.
5	V_{IN}	Input Voltage. Bypass this pin with a capacitor as close to the device as possible.
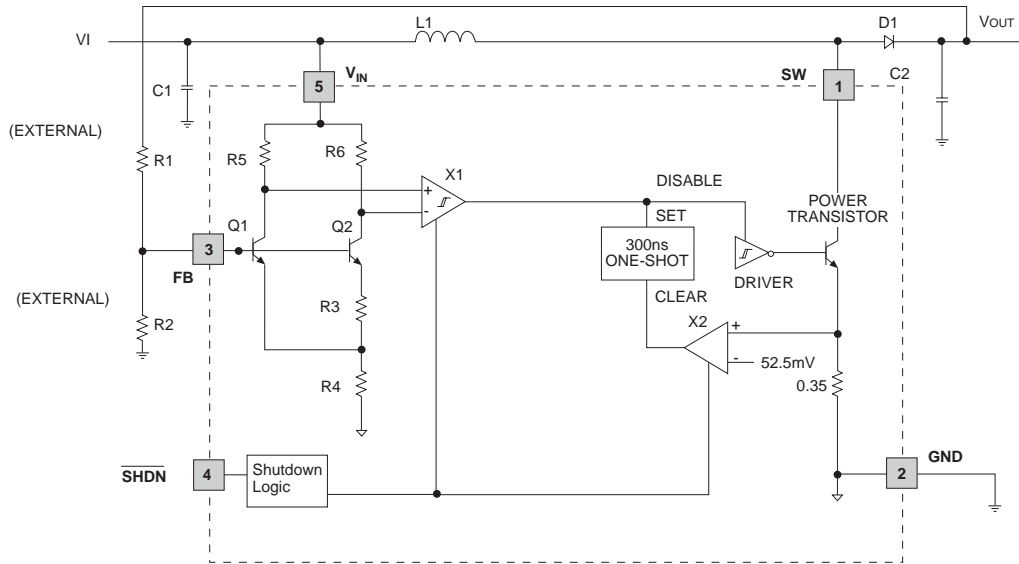
General Overview:

Operation can be best understood by referring to the above block diagram. Q1 and Q2 along with R3 and R4 form a band gap reference. The input to this circuit completes a feedback path from the high voltage output through a voltage divider, and is used as the regulation control input. When the voltage at the FB pin is slightly above 1.22V, comparator X1 disables most of the internal circuitry. Current is then provided by capacitor C2, which slowly discharges until the voltage at the FB pin drops below the lower hysteresis point of X1, about 6mV. X1 then enables the internal circuitry, turns on chip power, and the current in the inductor begins to ramp up. When the current through the driver transistor reaches about 150mA, comparator X2 clears the latch, which turns off the driver transistor for a preset 0.3μs. At the instant of shutoff, inductor current is diverted to the output through diode D1. During this 0.3μs time limit, inductor current decreases while its energy charges C2.

At the end of the 0.3μs time period, the driver transistor is again allowed to turn on which ramps the current back up to the 150mA level. Comparator X2 clears the latch, its output turns off the driver transistor, and this allows delivery of inductor L1's stored kinetic energy to C2. This switching action continues until the output capacitor voltage is charged to the point where FB is at band gap (1.22V). When this condition is reached, X1 turns off the internal circuitry and the cycle repeats. The SP4446 contains circuitry to provide protection during startup and while in short-circuit conditions. When FB pin voltage is less than approximately 300mV, the switch off time is increased to about 1.2μs and the current limit is reduced to about 70% of its normal value. While in this mode, the average inductor current is reduced and helps minimize power dissipation in the SP4446, the external inductor and diode.

Inductor Selection

For SP4446, the internal switch will be turned off only after the inductor current reaches the typical DC current limit (I_{LIM}=150mA). However, there is typically a propagation delay of 200nS between the time when the current limit is reached and when the switch is actually turned off. During this 200nS delay, the peak inductor current will increase, exceeding the current limit by a small amount. The peak inductor current can be estimated by:

$$I_{PK} = I_{LIM} + \frac{V_{IN(MAX)}}{L} \bullet 200nS$$

The larger the input voltage and the lower the inductor value, the greater the peak current.

In selecting an inductor, the saturation current specified for the inductor needs to be greater than the SP4446 peak current to avoid saturating the inductor, which would result in a loss of efficiency and could damage the inductor. Choosing an inductor with low DCR decreases power losses and increase efficiency.

Refer to Table 1 for some suggested low ESR inductors.

MANUF.	PART NUMBER	DCR (Ω)	Current Rating (mA)
MURATA 770-436-1300	LQH32CN100K21 (10µH)	0.44	300
MURATA 770-436-1300	LQH32CN220K21 (22µH)	0.71	250
TDK 847-803-6100	NLFC453232T-100K (10µH)	0.273	250
TDK 847-803-6100	NLC453232T-100K (22µH)	0.9	370

Table 1. Suggested Low ESR inductors

Diode Selection

A schottky diode with a low forward drop and fast switching speed is ideally used here to achieve high efficiency. In selecting a Schottky diode, the current rating of the schottky diode should be larger than the peak inductor current. Moreover, the reverse breakdown voltage of the Schottky diode should be larger than the output voltage.

Capacitor Selection

Ceramic capacitors are recommended for their inherently low ESR, which will help produce low peak to peak output ripple, and reduce high frequency spikes.

For the typical application, a 4.7µF input capacitor and a 2.2µF output capacitor are sufficient. The input and output ripple could be further reduced by increasing the value of the input and output capacitors. Place all the capacitors as close to the SP4446 as possible for layout. For use as a voltage source, to reduce the output ripple, a small feedforward capacitor (47pF) across the top feedback resistor can be used to provide sufficient overdrive for the error comparator, thus reduce the output ripple.

Refer to Table 2 for some suggested low ESR capacitors.

MANUF.	PART NUMBER	CAP/ VOLTAGE	SIZE/ TYPE
MURATA 770-436-1300	GRM32RR71E 225KC01B	2.2µF/25V	1210/X5R
MURATA 770-436-1300	GRM31CR61A 475KA01B	4.7µF/10V	1206/X5R
TDK 847-803-6100	C3225X7R1E 225M	2.2µF/25V	1206/X7R
TDK 847-803-6100	C3216X5R1A 475K	4.7µF/10V	1206/X5R

Table 2. Suggested Low ESR Capacitor

Output Voltage Program

In order for the SP4446 to be programmed as a voltage source, the SP4446 requires 2 feedback resistors R_1 & R_2 to control the output voltage, as shown in Figure 1.
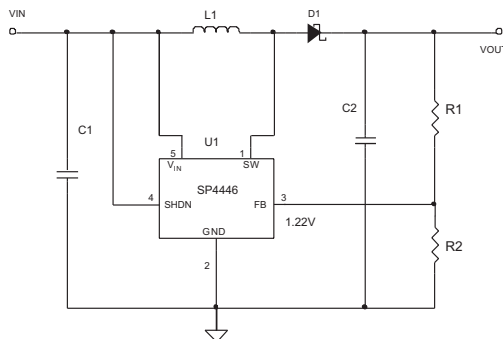

Figure 1. Using SP4446 as Voltage Source

The formula and table for the resistor selection are shown below:

$$R_1 = \left(\frac{V_{OUT}}{1.22} - 1\right) \cdot R_2$$

V_{OUT} (V)	R_1 (Ω)	R_2 (Ω)
12	1M	113K
15	1M	88.7K
18	1M	73.2K
20	1M	64.9K
30	1M	42.2K

Table 3. Divider Resistor Selection

Layout Considerations

Both the input capacitor and the output capacitor should be placed as close as possible to the IC. This can reduce the copper trace resistance which directly effects the input and output ripple. The feedback resistor network should be kept close to the FB pin to minimize copper trace connections that can inject noise into the system. The ground connection for the feedback resistor network should connect directly to the GND pin or to an analog ground plane that is tied directly to the GND pin. The inductor and the Schottky diode should be placed as close as possible to the switch pin to minimize the noise coupling to the other circuits, especially the feedback network.

PIN Diode Driver

The SP4446 can be used as PIN diode driver as shown in Figure. 2.
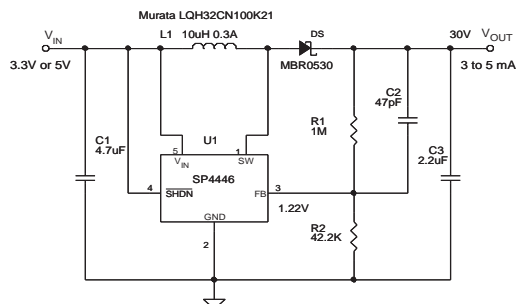
Fig. 2. Pin Diode Driver

Two Resistors (R_1=1MΩ, R_2=42.2KΩ) are used to program the output voltage to be 30V. When input voltage is 3.3V or 5V, it can supply a maximum current of 3mA and 5mA to the load.

Load Disconnect in Shutdown

When SP4446 is shut down, the load is still connected to the input. In applications that require output isolation during shutdown, an external PNP transistor (for example MMBT2907A) can be added as shown in Figure 3.
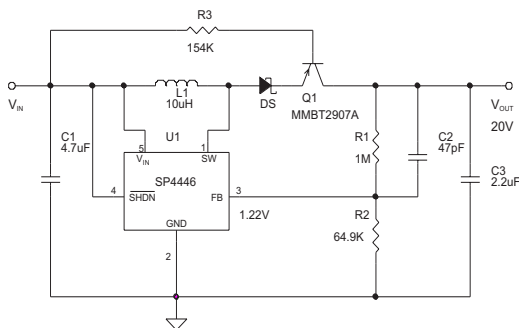
Fig. 3. Load Disconnect in Shutdown

When the SP4446 is active, the voltage set at the emitter of the transistor exceeds the input voltage, forcing the transistor into the saturation region. When the SP4446 is shut down, the input voltage exceeds the emitter voltage, thus the transistor becomes inactive and provides high-impedance isolation between the input and load. Efficiency will be slightly sacrificed because of the saturation voltage and base current of the PNP transistor.

Refer to the typical application circuit, $T_{AMB} = 25°C$, unless otherwise specified.
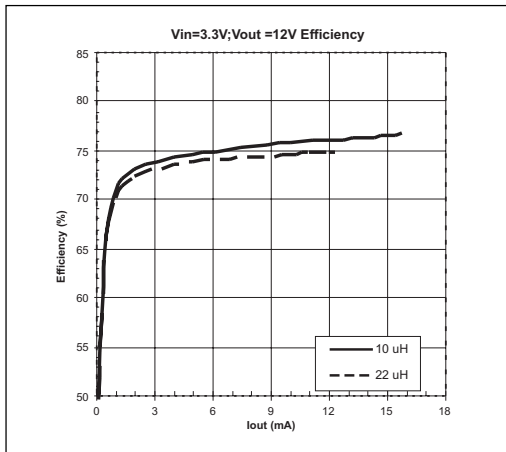
Figure 4. 12V Output Efficiency (V_{IN}=3.3V)

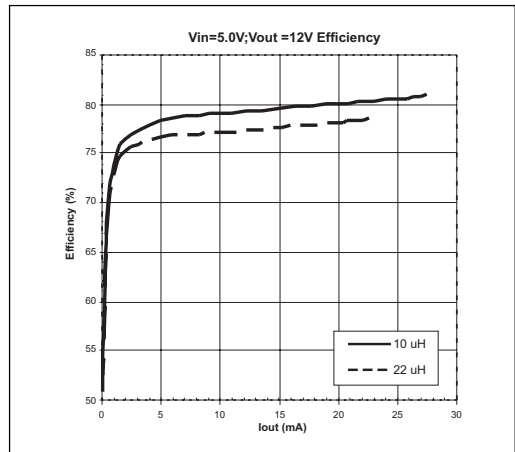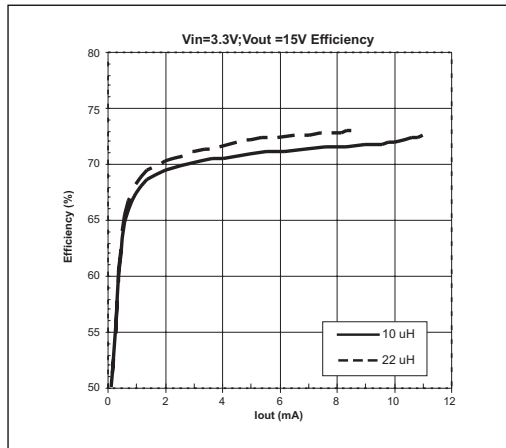**Figure 5. 12V Output Efficiency (V_{IN}=5V)**
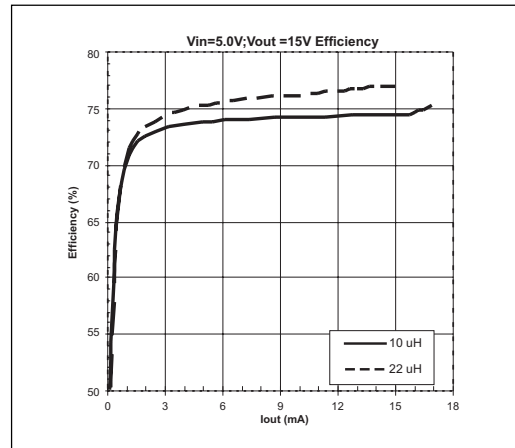
Figure 6. 15V Output Efficiency (V_{IN}=3.3V)
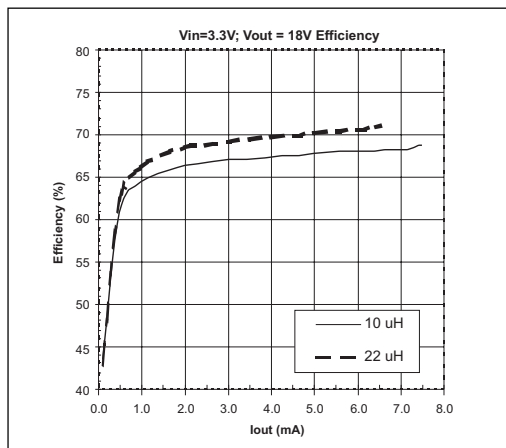
Figure 7. 15V Output Efficiency (V_{IN}=5V)

Figure 8. 18V Output Efficiency (V_{IN}=3.3V)

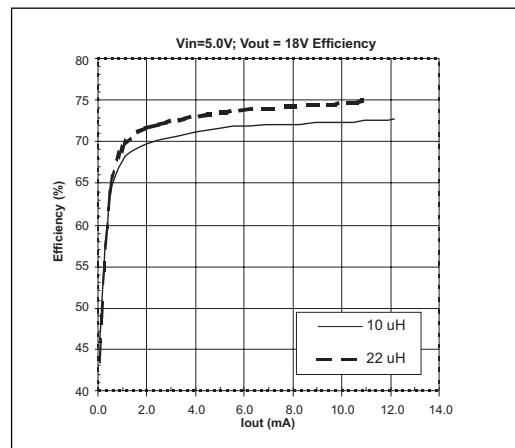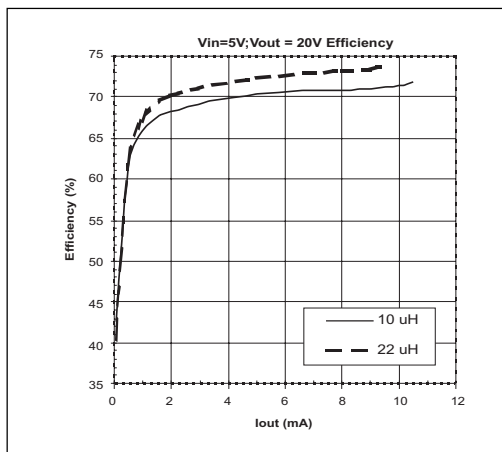**Figure 9. 18V Output Efficiency (V_{IN}=5V)**

Refer to the typical application circuit, $T_{AMB} = 25°C$, unless otherwise specified.
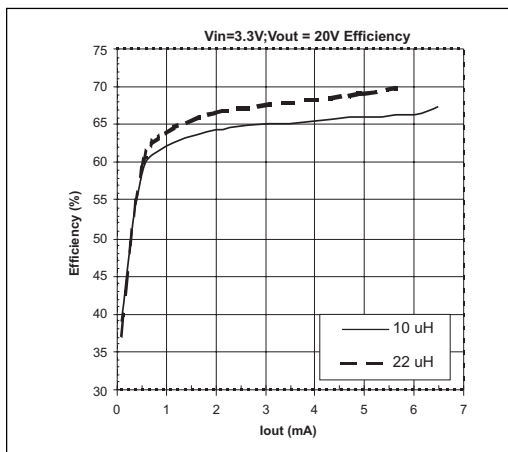
Figure 10. 20V Output Efficiency (V_{IN}=3.3V)

Figure 11. 20V Output Efficiency (V_{IN}=5V)
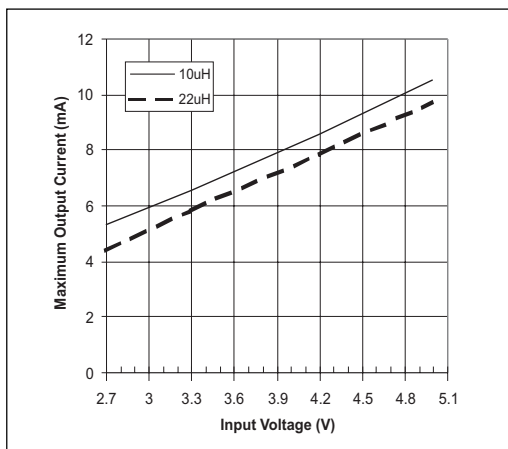
Figure 12. Maximum Output Current vs. V_{IN} (V_{OUT}=20V)
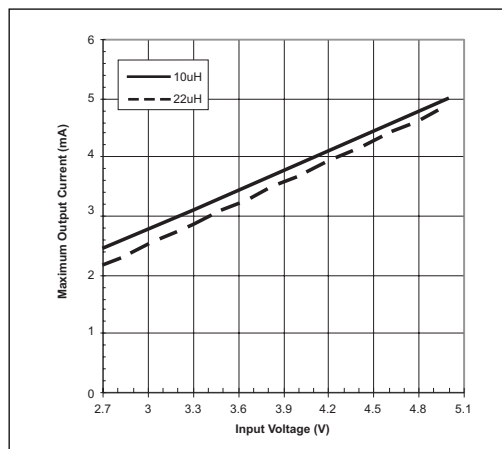
Figure 13. Maximum Output Current vs. V_{IN} (V_{OUT}=30V)
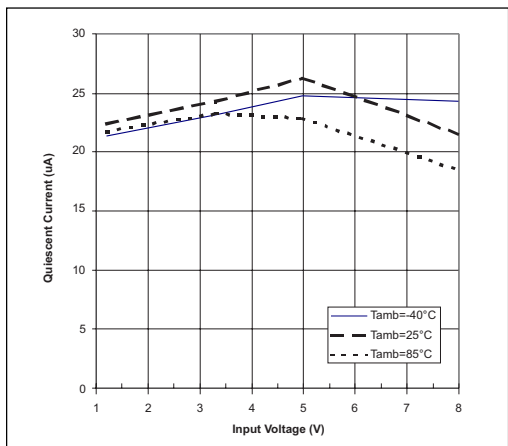
Figure 14. Quiescent Current I_Q vs. V_{IN}
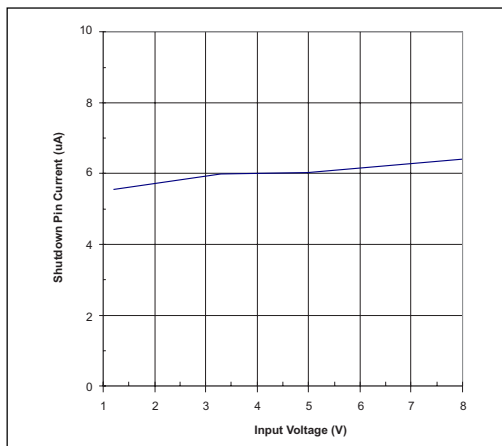
Figure 15. Shutdown Pin Current vs. V_{IN}

Refer to the typical application circuit, $T_{AMB} = 25°C$, unless otherwise specified.
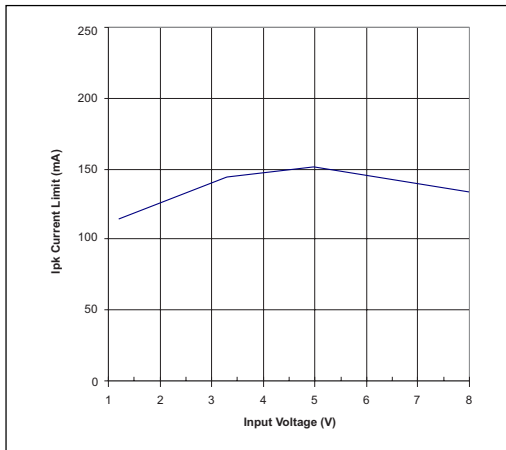
Figure 16. I_{PK} Current Limit vs. V_{IN}
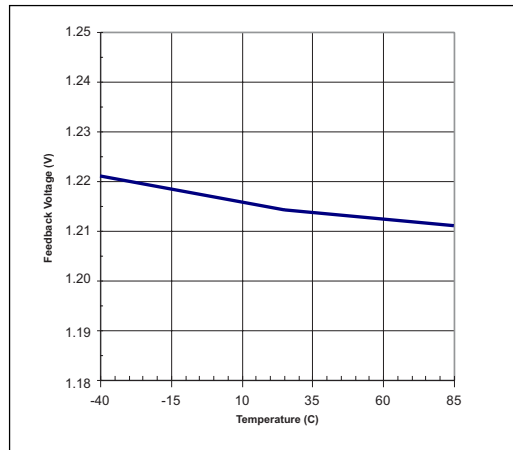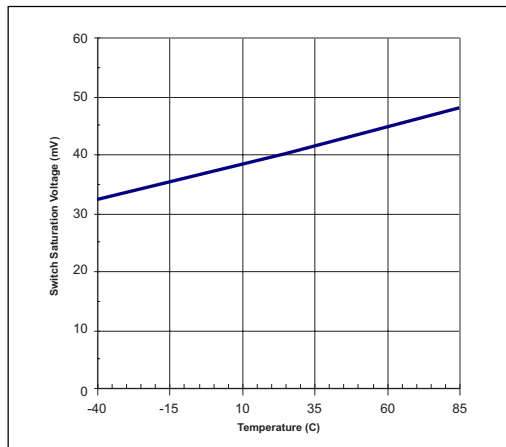

Figure 17. Feedback Voltage vs. Temperature

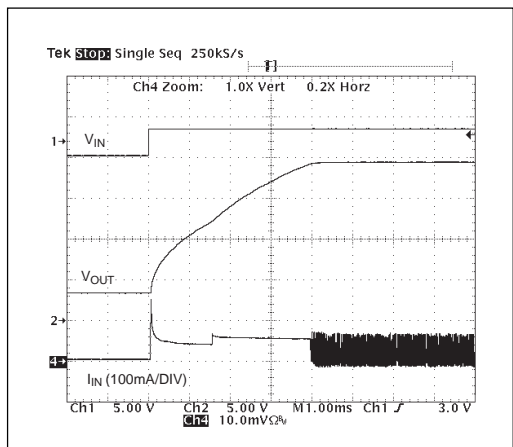*Figure 18. Switch Saturation Voltage V_{CESAT} vs. Temperature (I_{SW}=50mA)*

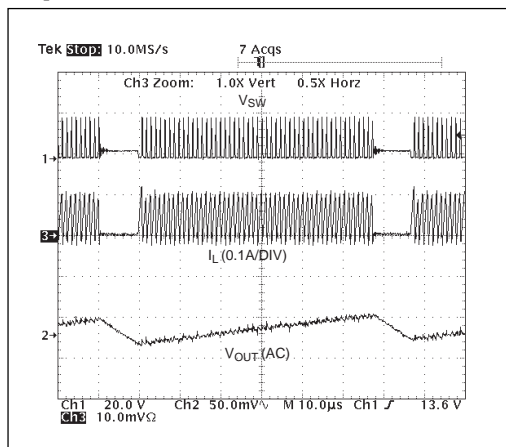*Figure 19. Startup Waveform (V_{IN}=3.3V, V_{OUT}=20V, I_{OUT}=2mA)*

Figure 20. Typical Switching Waveforms (V_{IN}=3.3V, V_{OUT}=20V, I_{OUT}=5mA)
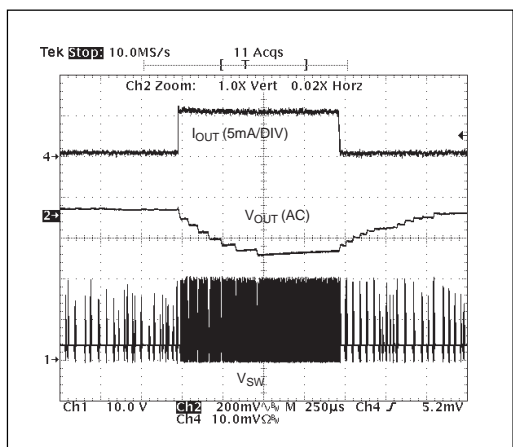
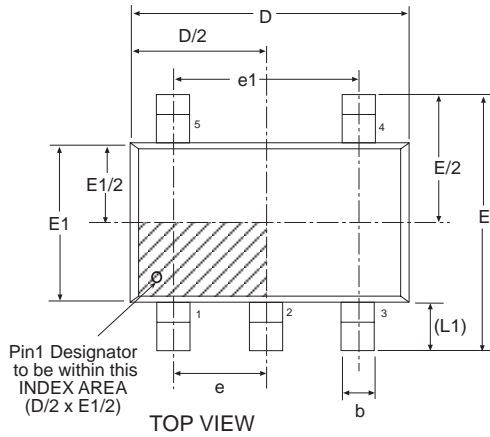*Figure 21. Load Step Transient (V_{IN}=3.3V, V_{OUT}=20V, I_O=100μA~5mA)*

SIDE VIEW

TOP VIEW

Pin1 Designator
to be within this
INDEX AREA
(D/2 x E1/2)

Seating
Plane

FRONT VIEW

Gauge Plane

Seating
Plane

SYMBOL	Dimensions in Millimeters: Controlling Dimension			Dimensions in Inches Conversion Factor: 1 Inch = 25.40 mm		
	MIN	NOM	MAX	MIN	NOM	MAX
A	-	-	1.45	-	-	0.057
A1	0.00	-	0.15	0.000	-	0.006
A2	0.90	1.15	1.30	0.036	0.045	0.051
c	0.08	-	0.22	0.004	-	0.009
D	2.90 BSC			0.115 BSC		
E	2.80 BSC			0.111 BSC		
E1	1.60 BSC			0.063 BSC		
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.60 REF			0.024 REF		
L2	0.25 BSC			0.010 BSC		
R	0.10	-	-	0.004	-	-
R1	0.10	-	0.25	0.004	-	0.010
Ø	0º	4º	8º	0º	4º	8º
ø1	5º	10º	15º	5º	10º	15º
b	0.30	-	0.50	0.012	-	0.020
e	0.95 BSC			0.038 BSC		
e1	1.90 BSC			0.075 BSC		

5 Pin SOT-23   JEDEC MO-178   Variation AA

SIPEX Pkg Signoff Date/Rev: JL Oct3-05 / Rev A

Part Number	Operating Temperature Range	Package Type
SP4446EK	-40°C to +85°C	5 Pin SOT-23
SP4446EK/TR	-40°C to +85°C	5 Pin SOT-23

Available in lead free packaging. To order add "-L" suffix to part number.

Example: SP4446EK/TR = standard; SP4446EK-L/TR = lead free

/TR = Tape and Reel

Pack quantity is 2,500 for SOT-23.

Sipex
Corporation

ANALOG EXCELLENCE

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