500 mA – Fixed Output Boost Converter for Single or Dual Cell

FEATURES

- Voltage Mode Control with Internal Frequency Compensation
- 0.85 V to 5.0 V Input Voltage Range
- Fixed Output Voltage Options — 2.0 V, 3.3 V, and 5.0 V
- Other Voltages available upon request
- PWM Control with 300-kHz Fixed Switching Frequency
- PFM Control for Light Load
- Powered from the Output Voltage Supply
- Integrated UVLO and Soft-Start
- Logic Controlled Shutdown ($< 1\ \mu A$)
- 85 % Typical Efficiency
- Internal Power MOS Switch: 0.2 Ω at 3.3 V Output
- Antiringing Switch to Minimize EMI
- Power Good Output
- Shutdown Input
- Minimum External Components
- PowerPAK® MLP33-6 Package, (DFN–6, 3 x 3)
- Over Voltage Protection

APPLICATIONS

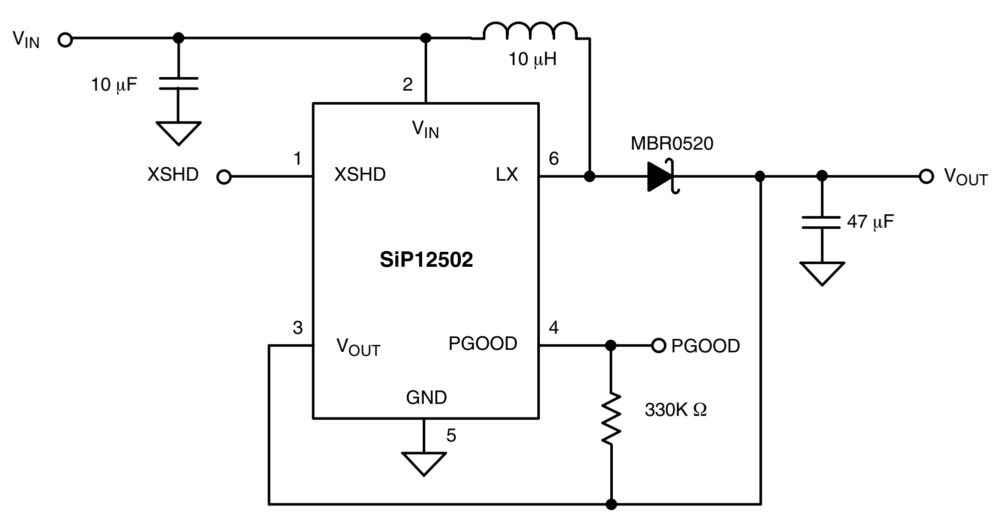
- Portable Applications
- Battery–powered Equipment
- Handheld Devices
- Digital Cameras
- Wireless handsets
- LCD and OLED Bias

DESCRIPTION

SiP12502 is a boost converter IC with fixed output voltage for single or double cell NiMH or Alkaline battery pack. Featuring with an internal low resistance power MOSFET, it is capable of starting up with a low battery voltage of 0.85 V. It only needs four external components (an inductor, a diode and two capacitors) to construct a step–up converter. For best efficiency performance, it is designed to operate in PWM mode with a 300-kHZ switching frequency under normal load and in PFM mode under light load. The voltage–mode control loop is internally compensated, simplifying converter design and reducing external parts count. It accepts input voltages from 0.85 V to 5 V, providing fixed output voltages of 2.0, 3.3, and 5.0 V. It also features low shutdown current of under 1-μA, over voltage protection, thermal shutdown protection, a power good output and antiringing control to minimize EMI.

SiP12502 is available in a lead (Pb)-free 6-pin, PowerPAK MLP33 package and is specified to operate over the industrial temperature range of – 40 °C to 85 °C.

TYPICAL APPLICATION CIRCUIT



ABSOLUTE MAXIMUM RATINGS (ALL VOLTAGES REFERENCED TO GND = 0 V)

Input Voltage, V_{IN} . . . . . . – 0.3 to 6 V
LX Voltage . . . . . . – 0.3 to V_{OUT} + 0.5 V
Output Voltage, V_{OUT} . . . . . . – 0.3 to 6 V
XSHD Voltage . . . . . . – 0.3 to V_{IN} + 0.5 V
PGOOD Voltage . . . . . . – 0.3 to 6 V
Maximum Junction Temperature . . . . . . 150 °C
Storage Temperature . . . . . . – 55 to 150 °C

Operating Junction Temperature . . . . . . 125 °C
Power Dissipation[a]
PowerPAK MLP33-6 (T_A = 70 °C)[a] . . . . . . 1100 mW
Thermal Resistance[b]
PowerPAK MLP33-6 . . . . . . 50 °C/W

Notes
a. Derate 20 mW/°C above 70 °C.
b. Device mounted with all leads soldered or welded to PC board.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING RANGE (ALL VOLTAGES REFERENCED TO GND = 0 V)

Input Voltage, V_{IN} . . . . . . 0.85 to 5.0 V
Output Voltage, V_{OUT} . . . . . . 2.0 to 5 V
XSHD Voltage . . . . . . 0 V to V_{IN}

LX Voltage . . . . . . 0 V to V_{OUT} + 0.5 V
PGOOD Voltage . . . . . . 0 V to 5 V
Operating Temperature Range . . . . . . – 40 to 85 °C

SPECIFICATIONS

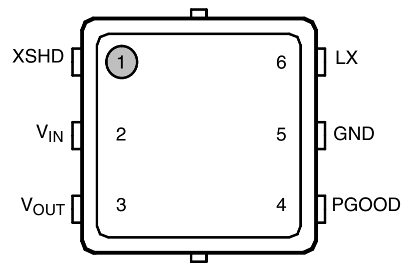
Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 1.2 V, V_{OUT} = Vnom[e], T_A = 25 °C	Temp[a]	Limits Min[b]	Typ[c]	Max[b]	Unit
Minimum Start-Up Voltage	V_{START}	I_{LOAD} = 1 mA	Full		0.65	0.85	V
Minimum Operating Voltage[d]	V_{HOLD}	XSHD = V_{IN}			0.55		
Output Voltage Accuracy	V_{OUT}			– 1.5		+ 1.5	%
			– 25 to 85 °C	– 3.0		+ 3.0	
			Full	– 3.5		+ 3.5	
UVLO	V_{UVLO}	Rising V_{OUT}	Full		1.8	2	V
UVLO Hysteresis	$V_{UVLOHYST}$		Full		0.100		
Maximum PWM Duty Cycle	MAXDTY		Full	80	87		%
PWM Switching Frequency	f_{OSC}		Full	225	300	375	kHz
Supply Current 1	I_{OUT1}	V_{OUT} = Vnom X 0.95	Full		330	620	µA
Supply Current 2	I_{OUT2}	V_{OUT} = 6 V, Vnom + 0.6 V, $V_{LX} > V_{IN}$			150		µA
Supply Current 3	I_{OUT3}	V_{OUT} = Vnom + 0.5 V, $V_{LX} < V_{IN}$			75		µA
Stand-By Current	I_{STB}	XSHD = 0 V, Not Including Switch Leakage	Full			1	µA
NMOS Switch Leakage	I_{LEAK}	LX = 5 V			1	2	µA
			Full			10	
NMOS Switch On Resistance	$r_{DS(on)}$	V_{OUT} = 3.3 V			0.2		Ω
PWM to PFM Current Threshold	I_{WTOF}				3		mA
PFM to PWM Current Threshold	I_{FTOF}				22		mA
XSHD Input High Level	V_{XSHDH}	0.8 V ≤ V_{IN} ≤ 0.9 V	Full	0.55			V
		0.9 V < V_{IN} ≤ 2 V	Full	0.8			
		2 V < V_{IN} ≤ 5 V	Full	1.2			
XSHD Input Low Level	V_{XSHDL}		Full			0.2	
Softstart Time	t_{START}	V_{IN} = 1.8 V			1.6		ms
Over Voltage Threshold	V_{OV}				110		%
Over Voltage Hysteresis	V_{OVHYST}				10		%
Thermal Shutdown	T_{SHD}				160		°C
Thermal Shutdown Hysteresus	T_{HYST}				20		°C

SPECIFICATIONS							
Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 1.2 V, V_{OUT} = Vnom[e], T_A = 25 °C	Temp[a]	Limits			Unit
				Min[b]	Typ[c]	Max[b]	
PGOOD Threshold	V_{PGOOD}			85	90	95	%
PGOOD Hysteresis	$V_{PGOODHYST}$				2		%
PGOOD Output Voltage Low	PG_{GOODL}	V_{OUT} = 3.3 V, I_{PGOOD} = 1 mA	FULL		0.15	0.2	V
PGOOD Output Leakage Current	PG_{GOOD}	V_{PGOOD} = 5 V	FULL		0.01	1	μA

Notes
a. Full = – 40 to 85 °C.
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum (– 40° to 85 °C).
c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
d. Minimum Operating Voltage is determined by the battery's capability to provide energy as it is deeply discharged.
e. Vnom equals Voltage Output for part selected.

PIN CONFIGURATION AND TRUTH TABLE

PowerPAK MLP33-6



Top View

ORDERING INFORMATION			
Part Number	**Voltage Output**	**Temperature Range**	**Marking**
SiP12502DMP–20–E3	2.0 V	– 40 to 85 °C	**502A**
SiP12502DMP–33–E3	3.3 V	– 40 to 85 °C	**502E**
SiP12502DMP–50–E3	5.0 V	– 40 to 85 °C	**502G**

* Other Voltages available upon request.

PIN DESCRIPTION		
Pin Number	**Name**	**Function**
1	XSDH	Logic Controlled Shutdown Input, XSHD = High: Normal Operation, XSHD = Low: Shutdown
2	V_{IN}	Input Voltage
3	V_{OUT}	Output of the Boost Converter and Power Source for the ICBattery
4	PGOOD	Power Good Comparator Output
5	GND	Signal and Power Ground
6	LX	Switch Pin

PIN FUNCTIONS

XSHD (Pin 1)

XSHD is a logic–level shutdown control pin. When XSHD is low, the IC's switching is disabled and an antiringing switch is connected between LX and V_{IN}. When XSHD is high, the IC is working in normal operation.

V_{IN} (Pin 2)

V_{IN} is the pin connected to the battery input voltage. At start–up, SIP12502 is powered from the voltage at the V_{IN} pin. Once V_{OUT} exceeds V_{IN}, the SIP12502 is powered from V_{OUT}. This increases the drive to the gate of the internal power switch, to allow higher maximum output currents and higher converter efficiency.

V_{OUT} (Pin 3)

V_{OUT} is the output of the boost converter and also the power source for the IC.

PGOOD (Pin 4)

PGOOD is the open–drain output pin of the power good comparator. It is low when V_{OUT} is 10 % lower than its regulation voltage. After the soft start is finished and V_{OUT} is higher than 90 % of its regulation voltage, PGOOD will go high. Its hysteresis is 2 %.

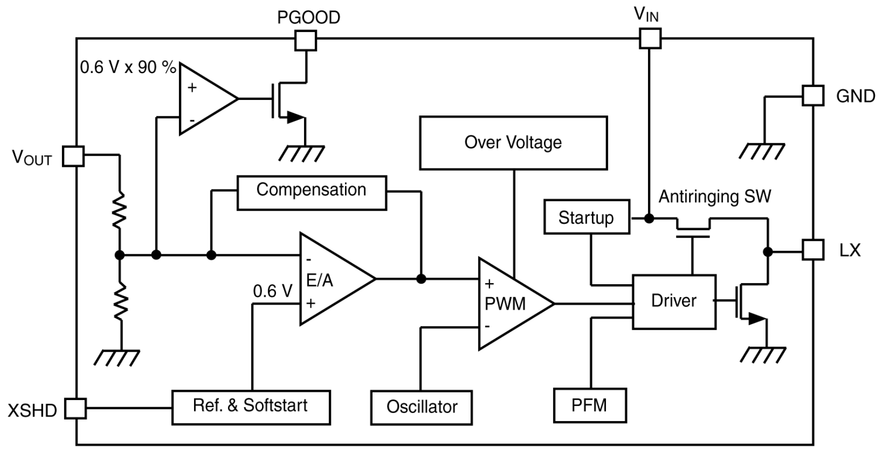
GND (Pin 5)

GND is the ground pin for signal and power ground.

LX (Pin 6)

LX is connects to the drain of the internal power MOSFET (boost switch). Externally, the LX pin should be connected to the boost inductor and Schottky diode. If the inductor current falls to zero, or XSHD is low, an internal antiringing switch is connected from LX to V_{IN} to minimize EMI.

FUNCTIONAL BLOCK DIAGRAM



DETAILED OPERATION

SiP12502 is a 300-kHz boost converter IC, packaged in 6-pin MLP33 PowerPAK^{TM} package. With start-up from input volta–ges as low as 0.65 V, this device features fixed frequency voltage mode PWM control with internal frequency com–pensation. With its low $r_{DS(on)}$ internal power MOSFET, this device maintains high efficiency over a wide range of load currents. Under light load conditions, it switches to PFM mode to maintain high efficiency. A power good signal is available to monitor the output voltage.

Low Voltage Start-Up

SiP12502 is designed to start-up at input voltage of typically 0.65 V. At start–up, V_{OUT} is lower than V_{IN} due to the voltage drop of the Schottky diode. Therefore, the device uses V_{IN} as the power source for its control logic and internal gate drive, until V_{OUT} exceeds V_{IN}. During the start–up interval, the boost switch's conduction interval during each cycle is determined by the time taken for the inductor current to reach internal current limit, followed by a fixed off time before the switch is allowed to turn on again. Once V_{OUT} exceeds V_{IN}, the device uses V_{OUT} as the IC's power source. When V_{OUT} exceeds 1.89 V, the device engages its built–in soft–start circuitry.

Soft-Start

During soft-start, the loop compensation guarantees the slow increase of output voltage, so that no large voltage overshoot or inrush current transients occur when the soft-start period ends.

PWM operation

After the soft-start interval is over, the device works in PWM operation with a fixed frequency of 300 kHz, with automatic switch–over to PFM operation during light load conditions.

PFM Operation

When operating into light loads, the SiP12502 automatically switches to PFM operation. This reduces gate charge losses in the boost switch, hence raising converter efficiency.

Over Voltage Protection

If the output voltage is above 10 % of the regulation voltage, the device will turn off the internal power MOSFET and wait until the output voltage falls below the regulation voltage, then the PWM operation is enabled again.

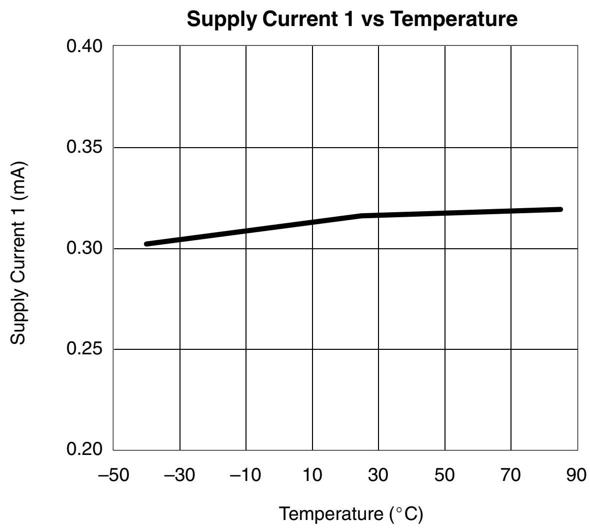
Thermal Shutdown Protection

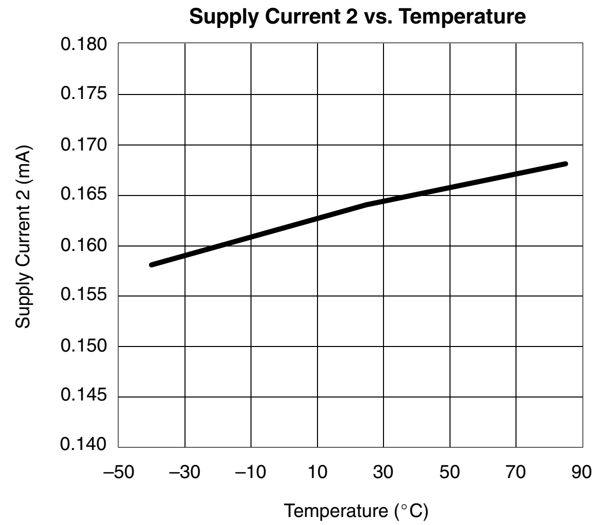
If the internal device temperature rises above 160 °C, the device will turn off the internal power MOSFET. Once the die temperature falls below 140 °C, the device performs a new soft–start cycle, the converter resumes normal operation.

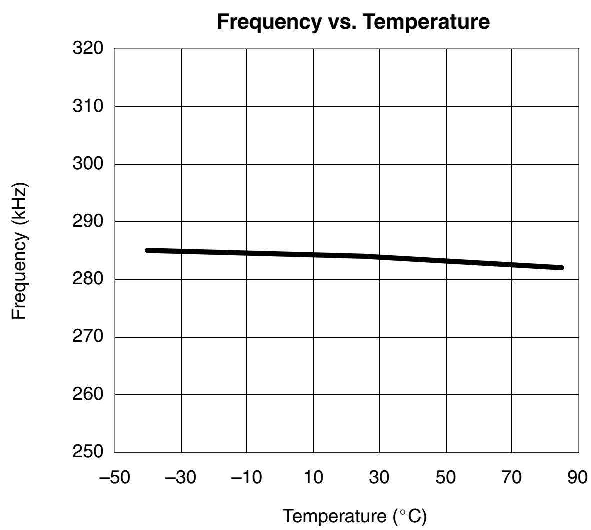
Antiringing Control

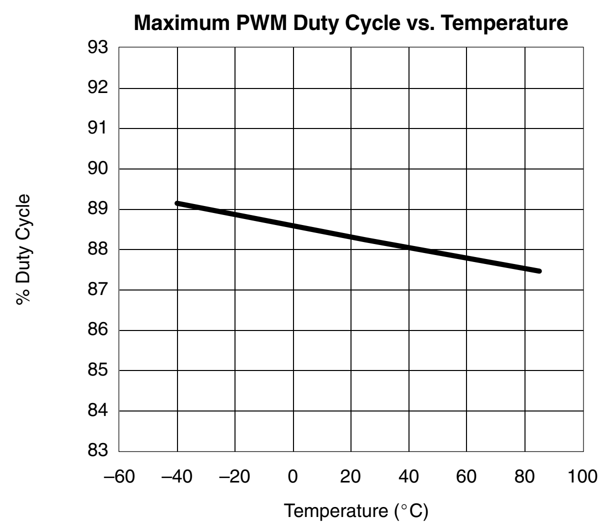
The antiringing control circuitry prevents high frequency ringing at the LX pin as the inductor current goes to zero by damping the resonant circuit formed by L and C_{LX} (capa–citance on LX pin). When the IC is shutdown, this antiringing switch is also turned on.

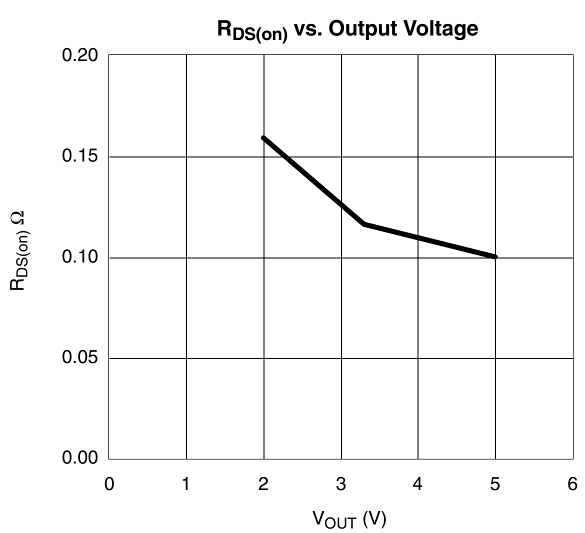
TYPICAL CHARACTERISTICS

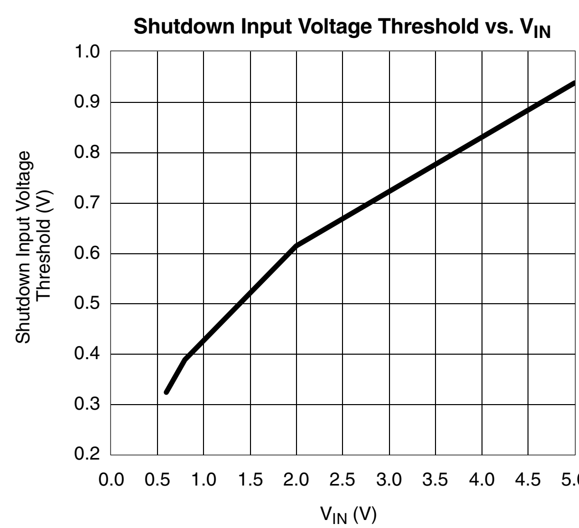






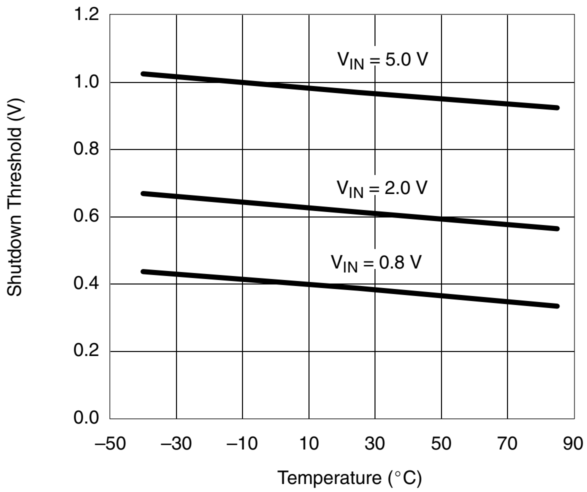




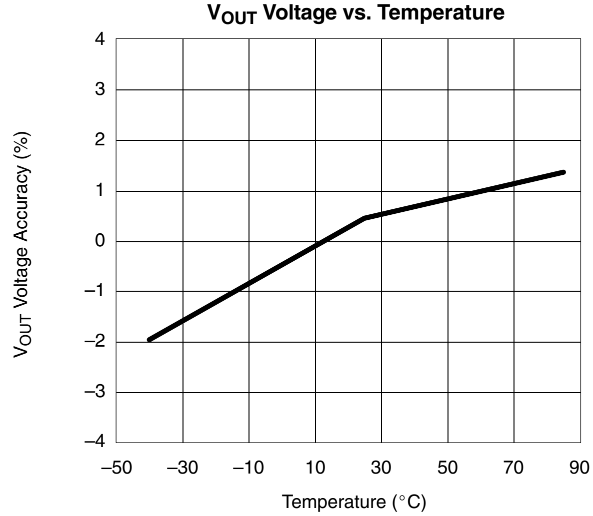


TYPICAL CHARACTERISTICS

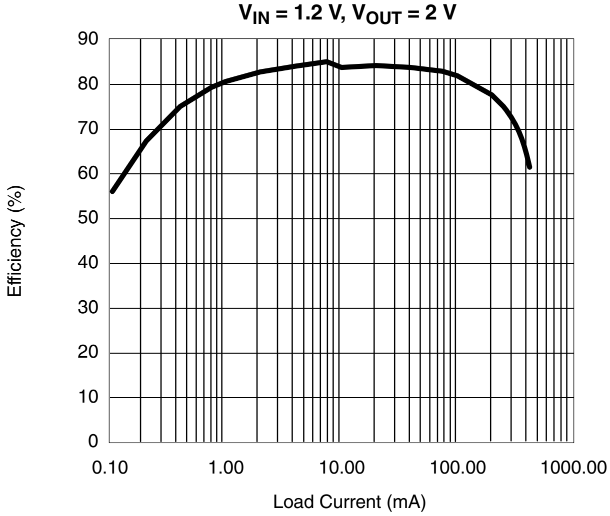
Shutdown Threshold vs. Temperature



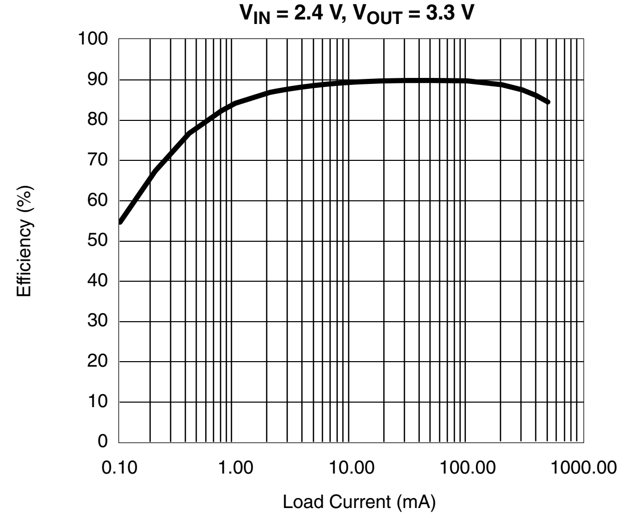
V_{OUT} Voltage vs. Temperature



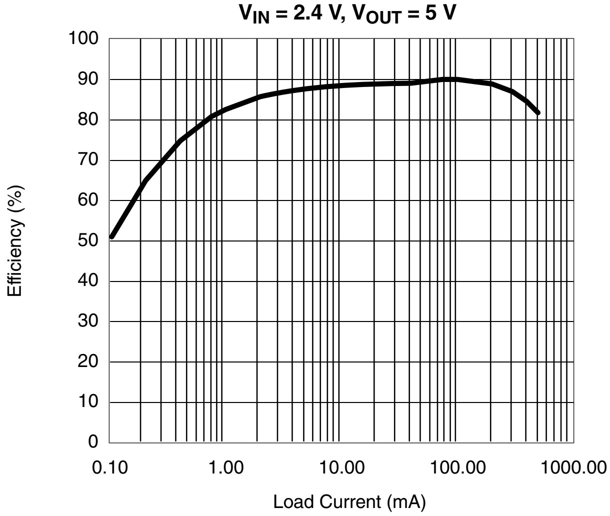
V_{IN} = 1.2 V, V_{OUT} = 2 V



V_{IN} = 2.4 V, V_{OUT} = 3.3 V



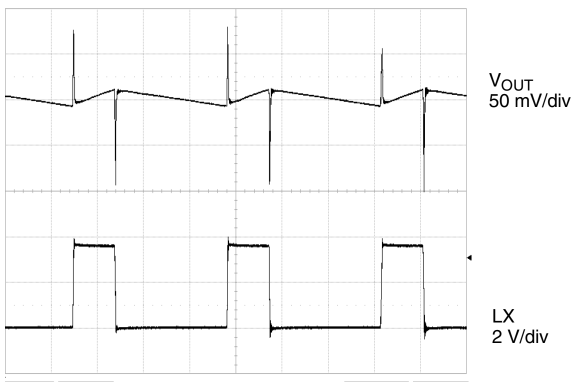
V_{IN} = 2.4 V, V_{OUT} = 5 V



TYPICAL WAVEFORMS

Typical Switching Waveform PWM Mode

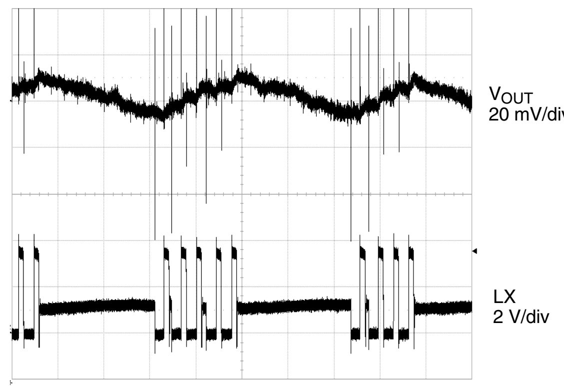
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load Current = 150 mA, L = 10 µH; C_{OUT} = 47 µF



1 µs/div

Typical Switching Waveform PFM Mode

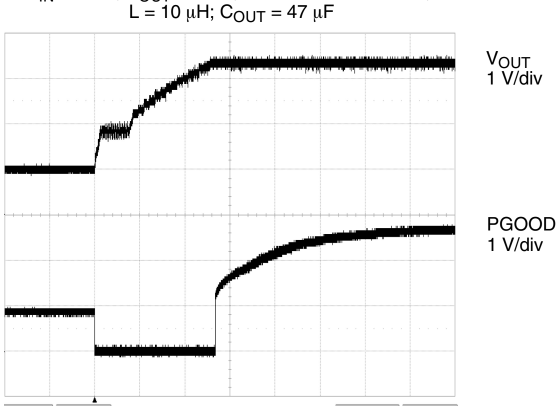
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load Current = 10 mA, L = 10 µH; C_{OUT} = 47 µF



100 µs/div

Soft Start and PGOOD

V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load Current = 50 mA, L = 10 µH; C_{OUT} = 47 µF



5 ms/div

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