500-mA - Adjustable Boost Converter for Single or Dual Cell

DESCRIPTION

SiP12503 is a boost converter IC with adjustable output voltage for single or dual 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 six external components (an inductor, a diode,- two capacitors and two resistors) to construct a step-up converter. For best efficiency performance, it is designed to operate in PWM mode with 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 5.0 V, and adjustable output voltages from 2 V to 5 V. It also features low shutdown current of under 1 µA, over voltage protection, thermal shutdown protection, and antiring control to minimize EMI.

SiP12503 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.

FEATURES

- Voltage mode control with internal frequency compensation
- 0.85 V to 5.0 V input voltage range
- Adjustable output voltage range from 2.0 V to 5.0 V
- Low startup voltage: 0.65 V
- 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 µA)
- 85 % typical efficiency
- Internal power MOS switch: 0.2 Ω at 3.3 V output
- Antiringing switch to minimize EMI
- Shutdown input
- Thermal shutdown
- 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

TYPICAL APPLICATION CIRCUIT

SiP12503

Vishay Siliconix
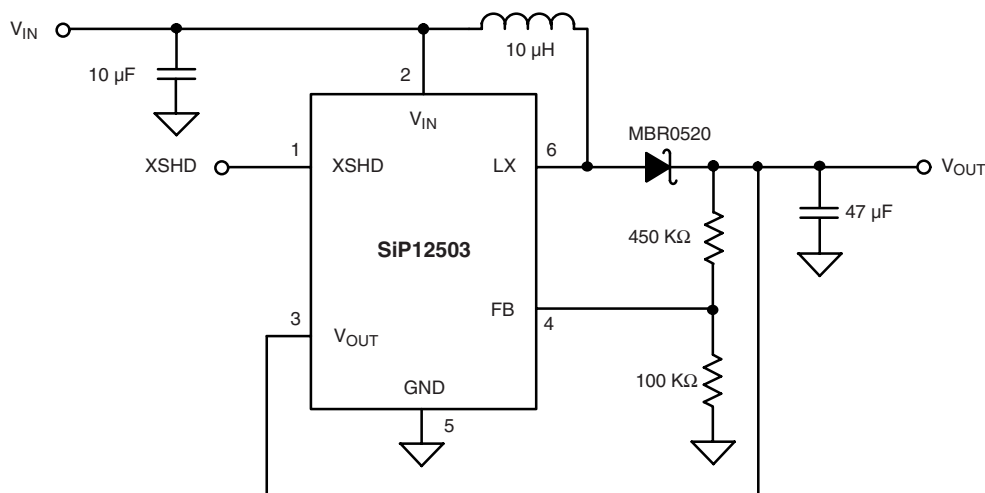
ABSOLUTE MAXIMUM RATINGS (all voltages referenced to GND = 0 V)

Parameter		Limit	Unit
Input Voltage, V_{IN}		- 0.3 to 6	
LX Voltage		- 0.3 to V_{OUT} + 0.5	
Output Voltage, V_{OUT}		- 0.3 to 6	V
XSHD Voltage		- 0.3 to V_{IN} + 0.5	
FB Voltage		- 0.3 to 6	
Maximum Junction Temperature		150	
Storage Temperature		- 55 to 150	°C
Operating Junction Temperature		125	
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)

| Parameter	Limit	Unit
Input Voltage, V_{IN}	0.85 to 5.0	
Output Voltage, V_{OUT}	2.0 to 5	
XSHD Voltage	0 to V_{IN}	V
LX Voltage	0 to V_{OUT} + 0.5	
FB Voltage	0 to 5 V_{OUT}	
Operating Temperature Range	- 40 to 85	°C

SPECIFICATIONS

Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 1.2 V, V_{OUT} = V_{nom}[e], T_A = 25 °C	Temp.[a]	Min.[b]	Typ.[c]	Max.[b]	Unit
Minimum Start-Up Voltage	V_{START}	I_{LOAD} = 1 mA	Full		0.65	0.85	
Minimum Operating Voltage[d]	V_{HOLD}	XSHD = V_{IN}			0.55		V
UVLO	V_{UVLO}	Rising V_{OUT}	Full		1.8	2	
UVLO Hysteresis	$V_{UVLOHYST}$		Full		0.100		
FB Voltage Accuracy	V_{FB}			- 1.5		+ 1.5	%
			- 25 to 85 °C	- 3.0		+ 3.0	
			Full	- 3.5		+ 3.5	
Feedback Input Current	I_{FB}	V_{FB} = 0.6 V			1		nA
Maximum PWM Duty Cycle	MAXDTY		Full	80	87		%
PWM Switching Frequency	f_{OSC}		Full	225	300	375	kHz

SPECIFICATIONS

Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 1.2 V, V_{OUT} = V_{nom}[e], T_A = 25 °C	Temp.[a]	Limits Min.[b]	Limits Typ.[c]	Limits Max.[b]	Unit
Supply Current 1	OUT	V_{OUT} = V_{nom} X 0.95			330	450	
Supply Current 2		V_{OUT} = V_{nom} + 0.5 V, V_{LX} > V_{IN}			134		
Supply Current 3		V_{OUT} = V_{nom} + 0.5 V, V_{LX} < V_{IN}			44		μA
Stand-By Current	I_{STB}	XSHD = 0 V, not including switch leakage	Full			1	
NMOS Switch Leakage	I_{LEAK}	LX = 5 V			1	2	
			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		
XSHD Input High Level	V_{XSHDH}	0.8 V ≤ V_{IN} ≤ 0.9 V	Full	0.55			
		0.9 V< V_{IN} ≤ 2 V	Full	0.8			V
		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 Hysteresis	T_{HYST}				20		

Notes:
a. Full = - 40 °C to 85 °C.
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum (- 40 °C 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 programmed output voltage.

PIN CONFIGURATION AND TRUTH TABLE

PowerPAK MLP33-6

Top View
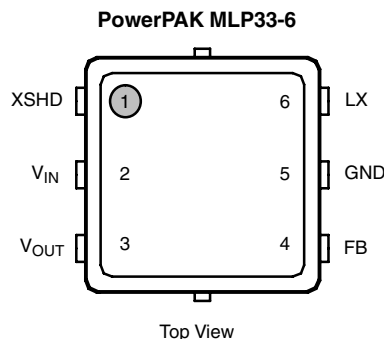
ORDERING INFORMATION

Part Number	Temperature Range	Marking
SiP12503DMP-T1-E3	- 40 °C to 85 °C	**2503**

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 IC-battery
4	FB	Output voltage feedback pin
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 battery input voltage. At start-up, SiP12503 is powered from the voltage at the V_{IN} pin. Once V_{OUT} exceeds V_{IN}, the SiP12503 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.

FB (Pin 4)

FB is the output voltage feedback pin via an external resistor divider. The feedback voltage is nominally 0.6 V.
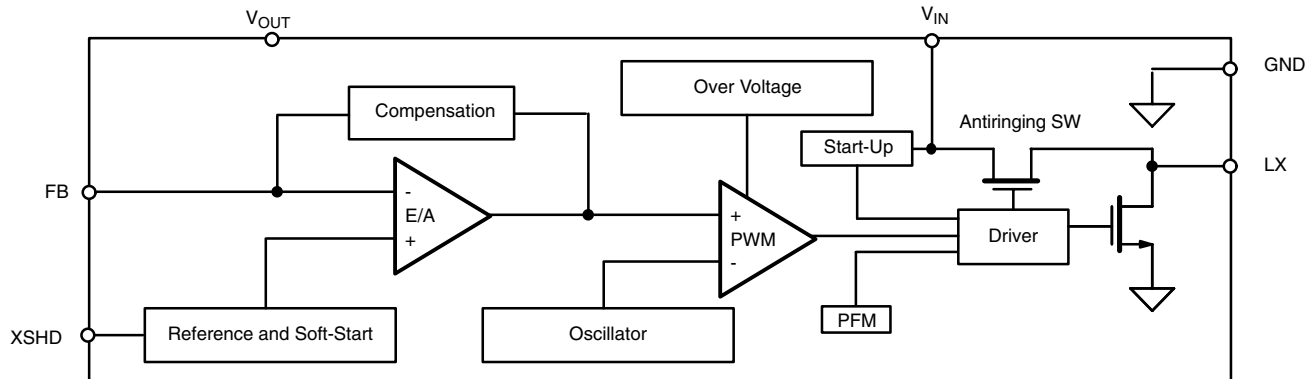
GND (Pin 5)

GND is the ground pin for signal and power ground.

LX (Pin 6)

LX 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 short from LX to V_{IN} to minimize EMI.

FUNCTIONAL BLOCK DIAGRAM

DETAILED OPERATION

SiP12503 is a 300 kHz boost converter IC, packaged in 6 pin MLP33 PowerPAK™ package. With start-up from input voltages as low as 0.65 V, this device features fixed frequency voltage mode PWM control with internal frequency compensation. With its low $R_{DS(on)}$ internal power MOSFET, this device maintains high efficiency over a wide range of load current. Under light load conditions, it switches to in PFM mode to maintain high efficiency. A FB pin is available to adjust the output voltage.

Low Voltage Start-Up

SiP12503 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 is 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 fails 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, then the device performs a new soft-start cycle, and 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} (capacitance on LX pin). When the IC is shutdown, this antiringing switch is also turned on.

APPLICATION INFORMATION

Setting the Adjustable Output Voltage

The SiP12503 regulated output can be adjusted from 1.8 V to 5.0 V via a resistor divider network from V_{OUT} to GND. R1 and R2 should be kept in the 50 kΩ to 100 kΩ range for low power consumption while maintaing adequate noise immunity. The value of R1 is calculated using the following formula:
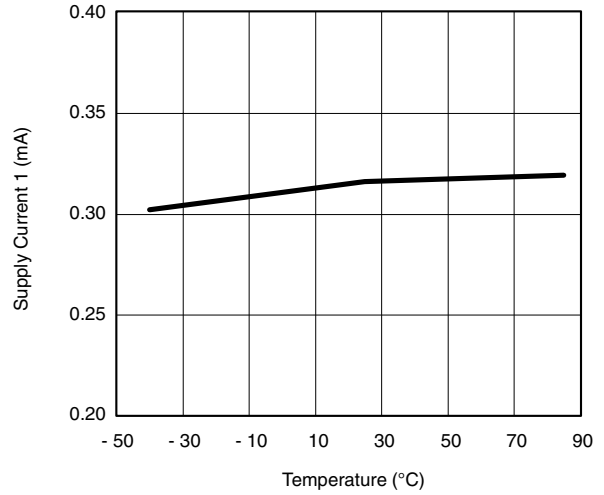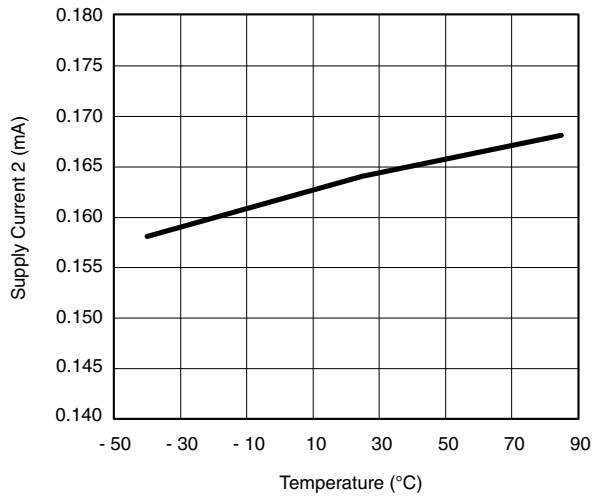
$$R1 = R2 * [(V_{OUT}/V_{FB}) - 1]$$

$$V_{FB} = 0.6 \text{ V}$$

SiP12503

Vishay Siliconix

TYPICAL CHARACTERISTICS
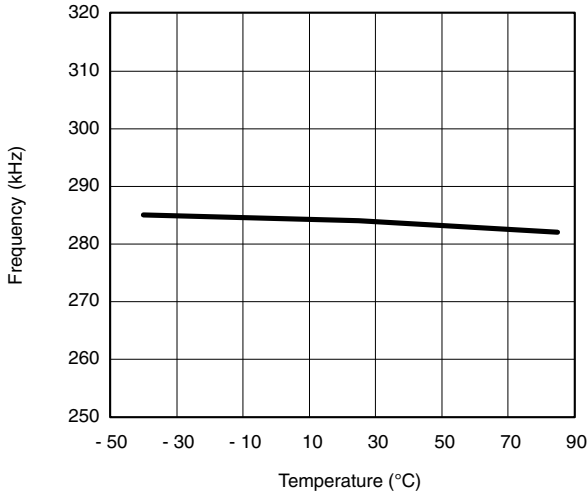
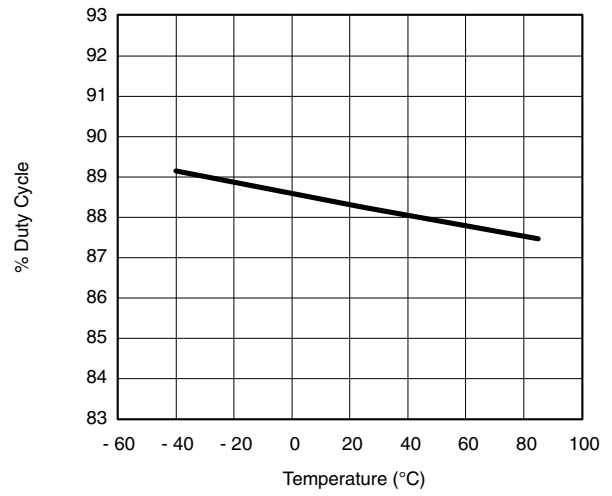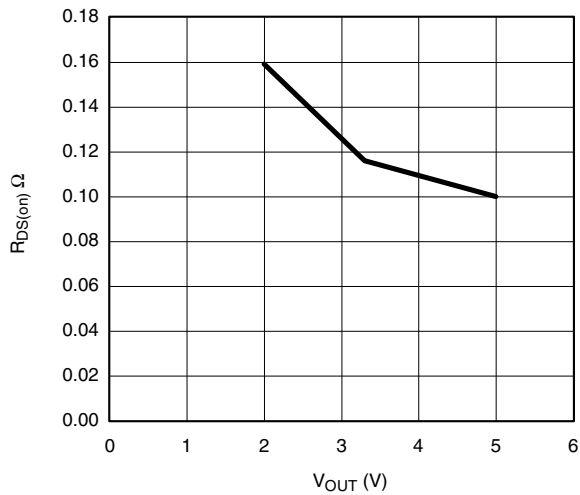

Frequency vs. Temperature
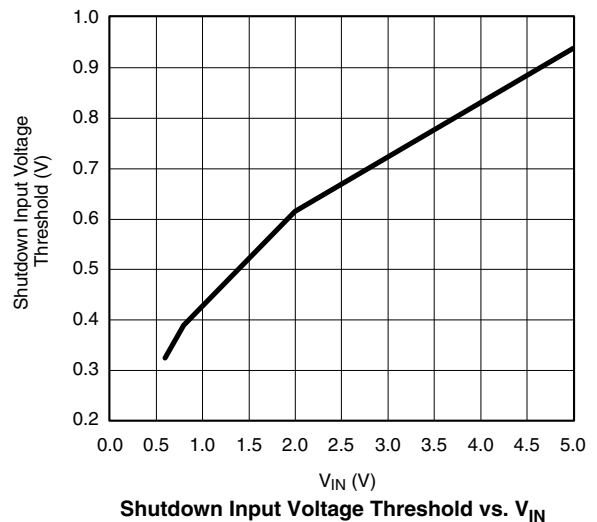

Supply Current 1 vs Temperature

Supply Current 2 vs. Temperature

Maximum PWM Duty Cycle vs. Temperature
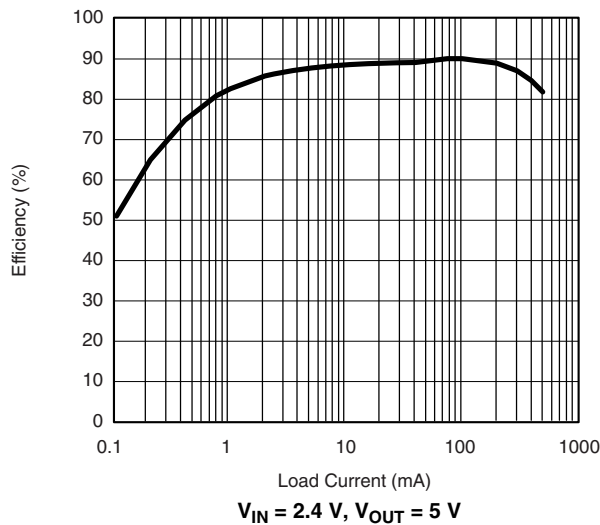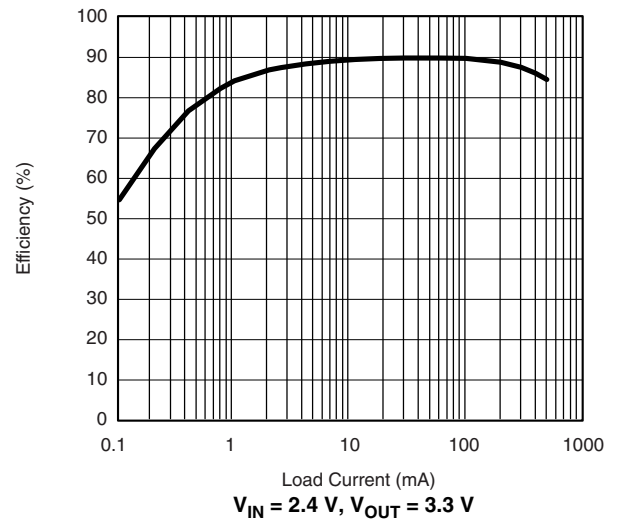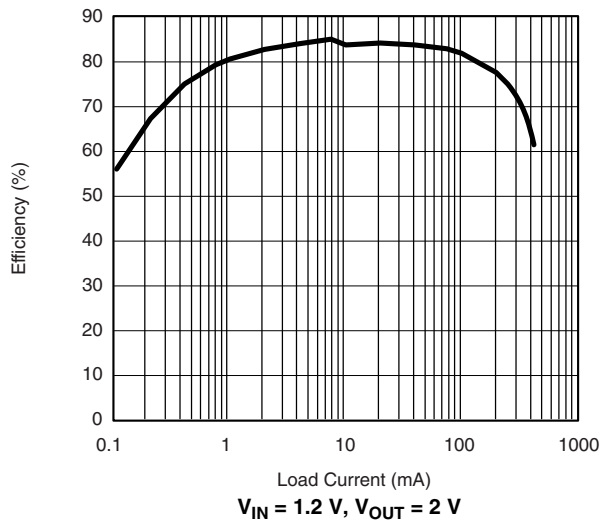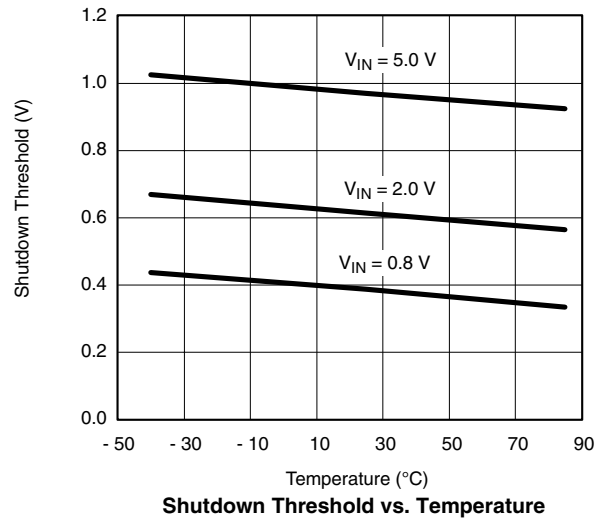

R$_{DS(on)}$ vs. Output Voltage

Shutdown Input Voltage Threshold vs. V$_{IN}$

TYPICAL CHARACTERISTICS

Feedback Voltage vs. Temperature

Shutdown Threshold vs. Temperature

V_IN = 1.2 V, V_OUT = 2 V

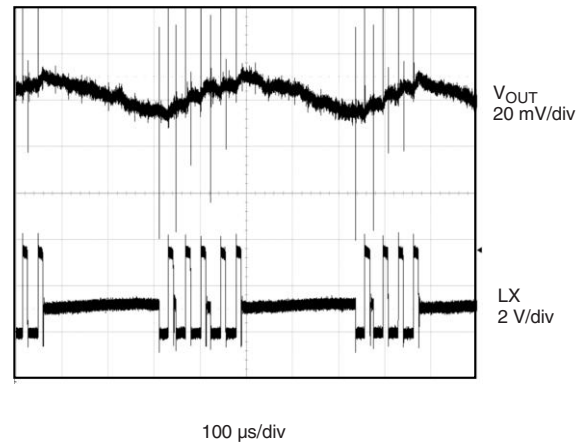**V_IN = 2.4 V, V_OUT = 3.3 V**

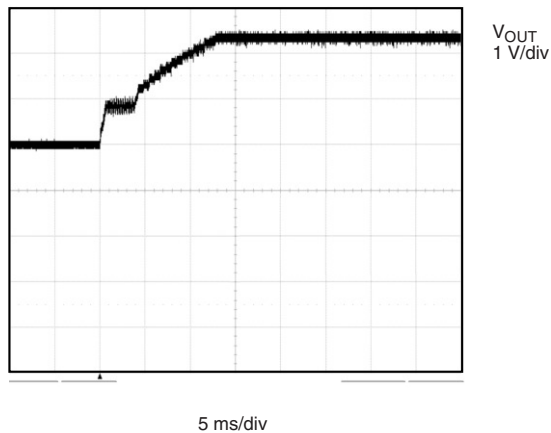**V_IN = 2.4 V, V_OUT = 5 V**
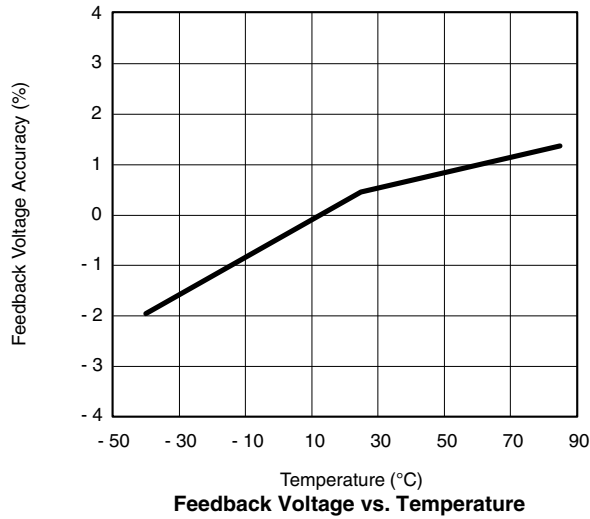
TYPICAL WAVEFORMS

1 µs/div
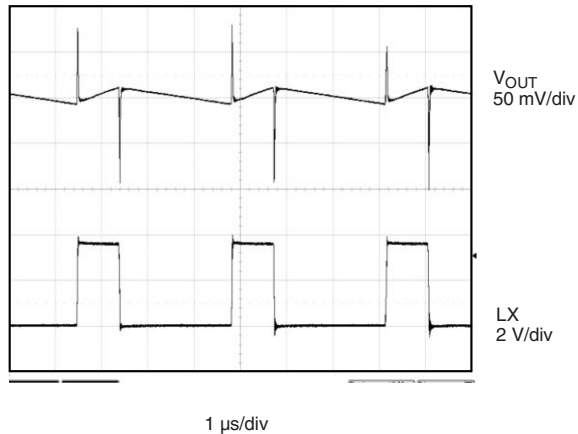
Typical Switching Waveform PWM Mode
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load Current = 150 mA,
L = 10 µH; C_{OUT} = 47 µF

100 µs/div

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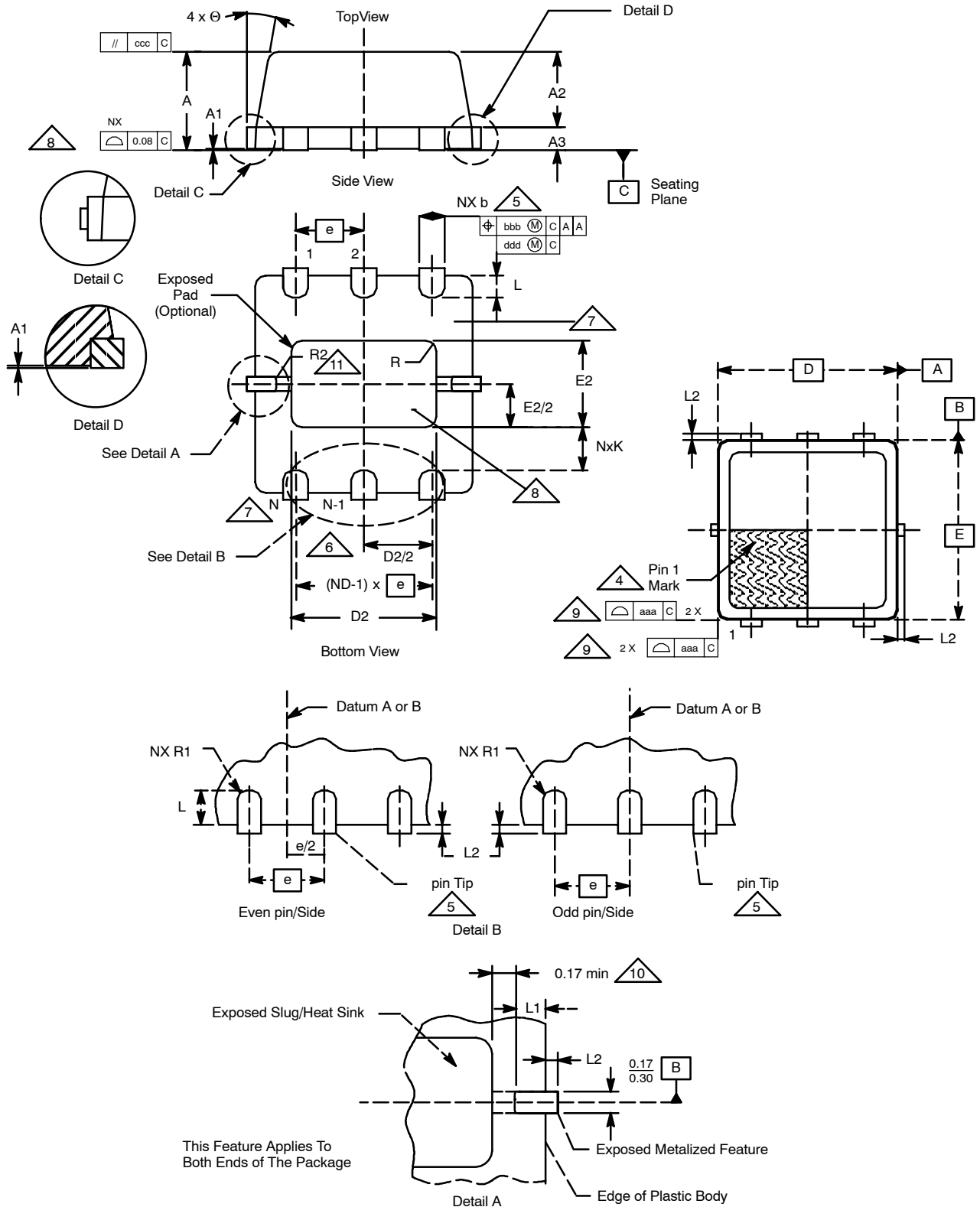L = 10 µH; C_{OUT} = 47 µF

5 ms/div
Soft Start
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load Current = 50 mA,
L = 10 µH; C_{OUT} = 47 µF

PowerPAK® MLP33-6, 8 and 10 (POWER IC ONLY)

PowerPAK® MLP33-6, 8, 10

N = 6 PITCH: 0.95 mm
N = 8 PITCH: 0.65 mm
N = 10 PITCH: 0.50 mm

Dim	MILLIMETERS*			INCHES				Notes
	Basic	Min	Nom	Max	Basic	Min	Nom	Max	
A	–	0.80	0.90	1.00	–	0.031	0.035	0.039	1, 2
A1	–	0.00	0.025	0.05	–	0.000	0.001	0.002	1, 2
A2	–	0.65	0.70	0.75	–	0.026	0.028	0.030	1, 2
A3	–	0.15	0.20	0.25	–	0.006	0.008	0.010	1, 2
aaa	–	–	0.10	–	–	–	0.004	–	1, 2
b-6	–	0.33	0.35	0.43	–	0.013	0.014	0.017	1, 2, 8
b-8	–	0.285	0.305	0.385	–	0.011	0.012	0.015	1, 2, 8
b-10	–	0.18	0.20	0.28	–	0.007	0.008	0.011	1, 2, 8
bbb	–	–	0.10	–	–	–	0.004	–	1, 2
ccc	–	–	0.10	–	–	–	0.004	–	1, 2
D	3.00	–	–	–	0.118	–	–	–	1, 2, 8
D2	–	1.92	2.02	2.12	–	0.076	0.080	0.083	1, 2, 8
ddd	–	–	0.05	–	–		0.002		1, 2
E	3.00	–	–	–	0.118	–	–	–	1, 2, 8
E2	–	1.10	1.20	1.30	–	0.043	0.047	0.051	1, 2, 8
e-6	–	–	0.95	–	–	–	0.037	–	1, 2
e-8	–	–	0.65	–	–	–	0.026	–	1, 2
e-10	–	–	0.50	–	–	–	0.020	–	1, 2
K	–	0.20	–	–	–	0.008	–	–	5, 11
L	–	0.20	0.29	0.45	–	0.008	0.011	0.018	1, 2, 8
L1-6	–	0.16	0.24	0.40	–	0.006	0.009	0.016	1, 2, 8
L1-8	–	0.16	0.24	0.40	–	0.006	0.009	0.016	1, 2, 8
L1-10	–	–	–	–	–	–	–	–	1, 2, 8
L2	–	–	–	0.125	–	–	–	0.005	5, 11
R Ref	–	–	0.15	–	–	–	0.006	–	1, 2, 8
R1 Ref-6	–	–	0.127	–	–	–	0.005	–	1, 2, 8
R1 Ref-8	–	–	0.15	–	–	–	0.006	–	1, 2, 8
R1 Ref-10	–	–	0.075	–	–	–	0.003	–	1, 2, 8
Θ	–	0°	10°	12°	–	0°	10°	12°	1, 2

* Use millimeters as the primary measurement.

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DWG: 5925

NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5M-1994.

2. All dimensions are in millimeters. All angels are in degrees.

3. N is the total number of pins.

4. The pin #1 identifier and pin numbering convention shall conform to JESD 95-1 SPP-012. Details of pin #1 identifier is located within the zone indicated. The pin #1 identifier is marked.

5. Dimension b applies to metallized pin and is measured between 0.15 mm and 0.20 mm from the pin tip.

6. ND refers to the maximum number of pins on the D side.

7. Depopulation of pins is allowed and will be called out on the individual variation.

8. Coplanarity applies to the exposed heat sink slug as well as the pins.

9. Profile tolerance (aaa) will be applicable only to the plastic body and not to the metallized features (such as the pin tips and tie bars.) Metallized features may protrude a maximum of L2 from the plastic body profile.

10. L1 max is not called out, the metallized feature will extend to the exposed pad. Thus, the 0.17-mm gap does not apply.

11. The corner will be sharp unless otherwise specified with radius dimensions.