

## 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  $\mu$ A, over voltage protection, thermal shutdown protection, and antiringing 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  $^{\circ}$ C to 85  $^{\circ}$ C.

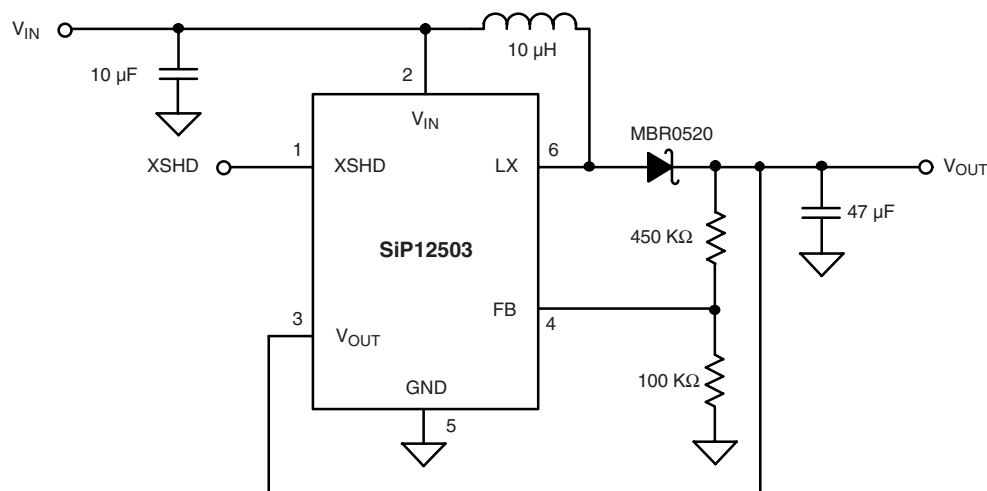
### FEATURES

- 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 ( $< 1 \mu$ A)
- 85 % typical efficiency
- Internal power MOS switch: 0.2  $\Omega$  at 3.3 V output
- Antiringing switch to minimize EMI
- Shutdown input
- Thermal shutdown
- Minimum external components
- PowerPAK<sup>®</sup> 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



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

Parameter	Limit	Unit
Input Voltage, $V_{IN}$	- 0.3 to 6	V
LX Voltage	- 0.3 to $V_{OUT} + 0.5$	
Output Voltage, $V_{OUT}$	- 0.3 to 6	
XSHD Voltage	- 0.3 to $V_{IN} + 0.5$	
FB Voltage	- 0.3 to 6	
Maximum Junction Temperature	150	°C
Storage Temperature	- 55 to 150	
Operating Junction Temperature	125	
Power Dissipation <sup>a</sup>	PowerPAK MLP33-6 ( $T_A = 70\text{ °C}$ ) <sup>a</sup>	mW
Thermal Resistance <sup>b</sup>	PowerPAK MLP33-6	°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	V
Output Voltage, $V_{OUT}$	2.0 to 5	
XSHD Voltage	0 to $V_{IN}$	
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 $V_{IN} = 1.2\text{ V}$ , $V_{OUT} = V_{nom}$ , $T_A = 25\text{ °C}$	Temp. <sup>a</sup>	Limits			Unit
				Min. <sup>b</sup>	Typ. <sup>c</sup>	Max. <sup>b</sup>	
Minimum Start-Up Voltage	$V_{START}$	$I_{LOAD} = 1\text{ mA}$	Full		0.65	0.85	V
Minimum Operating Voltage <sup>d</sup>	$V_{HOLD}$	$XSHD = V_{IN}$			0.55		
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	$I_{FB}$	$V_{FB} = 0.6\text{ V}$			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 $V_{IN} = 1.2\text{ V}$ , $V_{OUT} = V_{nom}^e$ , $T_A = 25\text{ }^{\circ}\text{C}$	Temp. <sup>a</sup>	Limits			Unit
				Min. <sup>b</sup>	Typ. <sup>c</sup>	Max. <sup>b</sup>	
Supply Current 1	OUT	$V_{OUT} = V_{nom} \times 0.95$			330	450	$\mu\text{A}$
Supply Current 2		$V_{OUT} = V_{nom} + 0.5\text{ V}$ , $V_{LX} > V_{IN}$			134		
Supply Current 3		$V_{OUT} = V_{nom} + 0.5\text{ V}$ , $V_{LX} < V_{IN}$			44		
Stand-By Current	$I_{STB}$	XSHD = 0 V, not including switch leakage	Full			1	
NMOS Switch Leakage	$I_{LEAK}$	$LX = 5\text{ V}$			1	2	$\mu\text{A}$
			Full			10	
NMOS Switch On Resistance	$R_{DS(on)}$	$V_{OUT} = 3.3\text{ V}$			0.2		$\Omega$
PWM to PFM Current Threshold	$I_{WTOF}$				3		mA
PFM to PWM Current Threshold	$I_{FTOF}$				22		
XSHD Input High Level	$V_{XSHDH}$	$0.8\text{ V} \leq V_{IN} \leq 0.9\text{ V}$	Full	0.55			V
		$0.9\text{ V} < V_{IN} \leq 2\text{ V}$	Full	0.8			
		$2\text{ V} < V_{IN} \leq 5\text{ V}$	Full	1.2			
XSHD Input Low Level	$V_{XSHDL}$		Full			0.2	
Softstart Time	$t_{START}$	$V_{IN} = 1.8\text{ V}$			1.6		ms
Over Voltage Threshold	$V_{OV}$				110		%
Over Voltage Hysteresis	$V_{OVHYST}$				10		
Thermal Shutdown	$T_{SHD}$				160		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis	$T_{HYST}$				20		

Notes:

a. Full = - 40  $^{\circ}\text{C}$  to 85  $^{\circ}\text{C}$ .

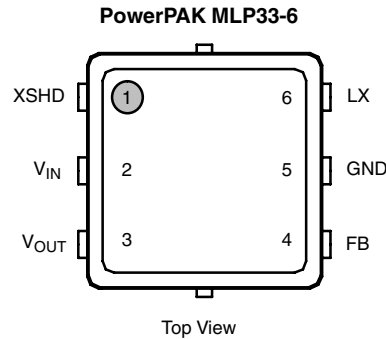
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum (- 40  $^{\circ}\text{C}$  to 85  $^{\circ}\text{C}$ ).

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.  $V_{nom}$  equals programmed output voltage.

PIN CONFIGURATION AND TRUTH TABLE



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 <sub>IN</sub>	Input voltage
3	V <sub>OUT</sub>	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<sub>IN</sub>. When XSHD is high, the IC is working in normal operation.

V<sub>IN</sub> (Pin 2)

V<sub>IN</sub> is the pin connected to battery input voltage. At start-up, SiP12503 is powered from the voltage at the V<sub>IN</sub> pin. Once V<sub>OUT</sub> exceeds V<sub>IN</sub>, the SiP12503 is powered from V<sub>OUT</sub>. This increases the drive to the gate of the internal power switch, to allow higher maximum output currents and higher converter efficiency.

V<sub>OUT</sub> (Pin 3)

V<sub>OUT</sub> 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.

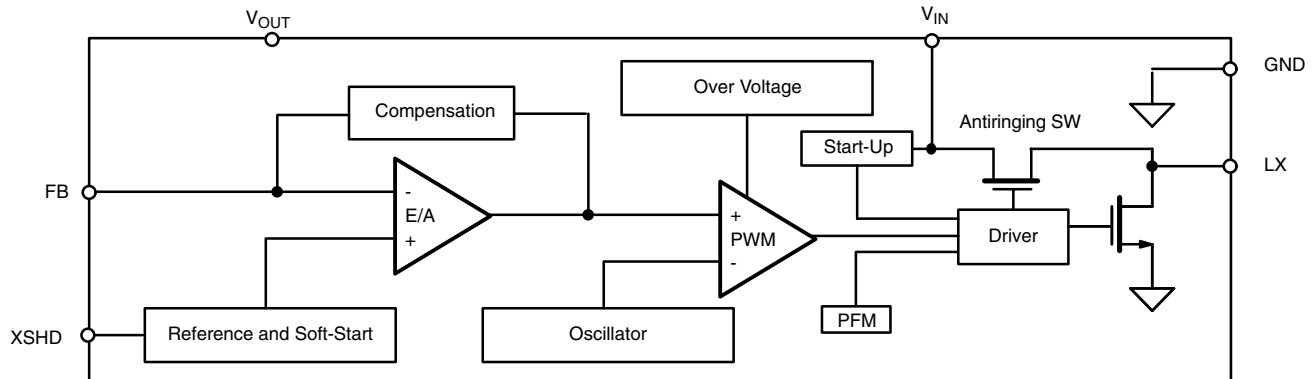
GND (Pin 5)

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<sub>IN</sub> 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 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, 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

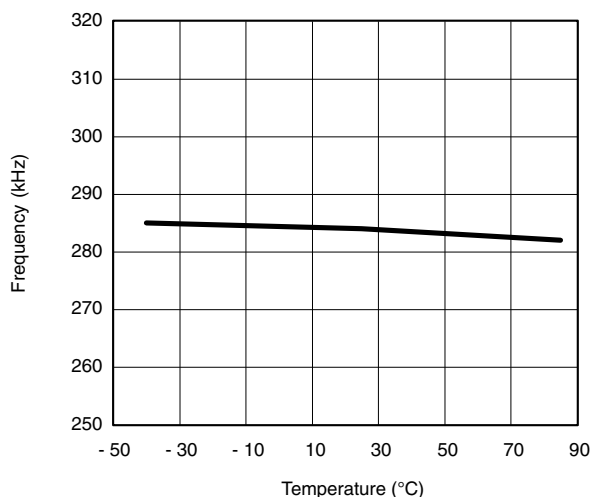
### Setting the Adjustable Output Voltage

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 maintaining adequate noise immunity. The value of R1 is calculated using the following formula:

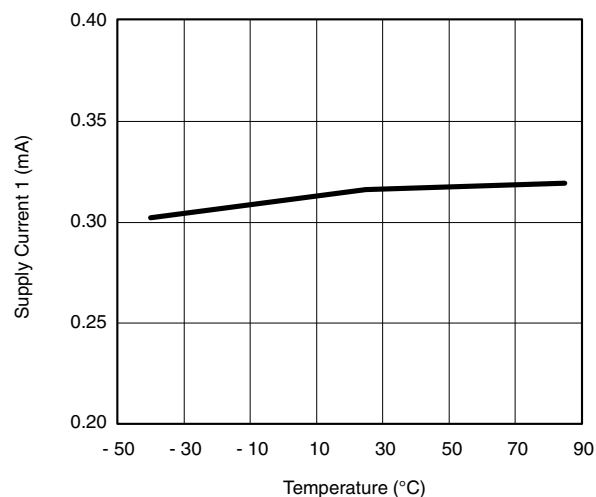
$$R1 = R2 * [(V_{OUT}/V_{FB}) - 1]$$

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

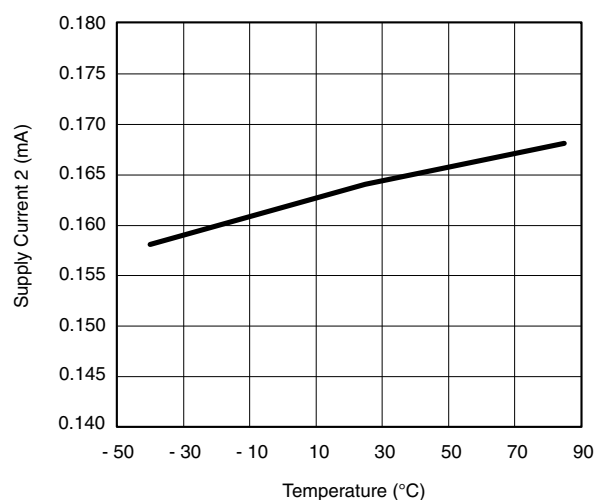
## TYPICAL CHARACTERISTICS



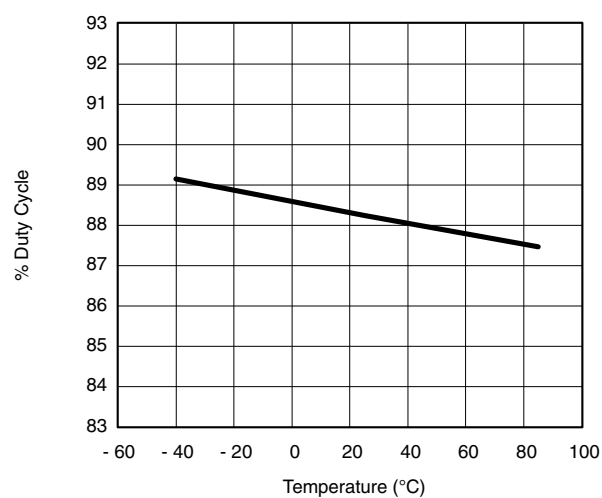
Frequency vs. Temperature



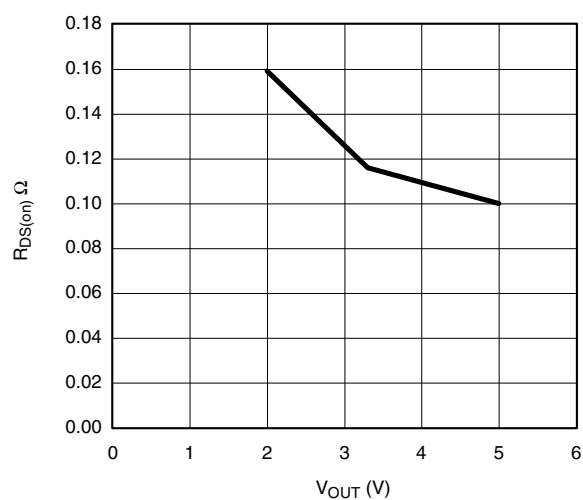
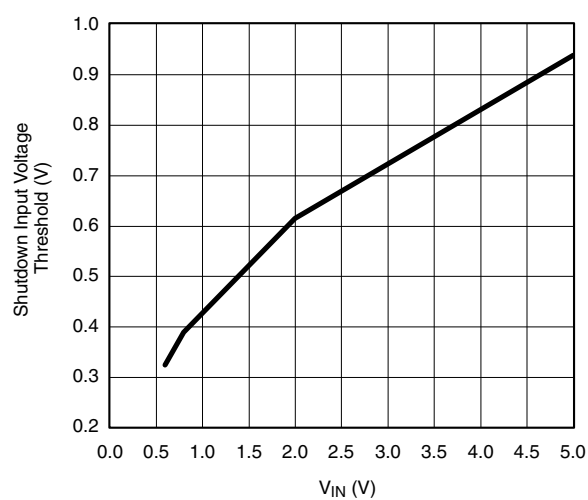
Supply Current 1 vs Temperature



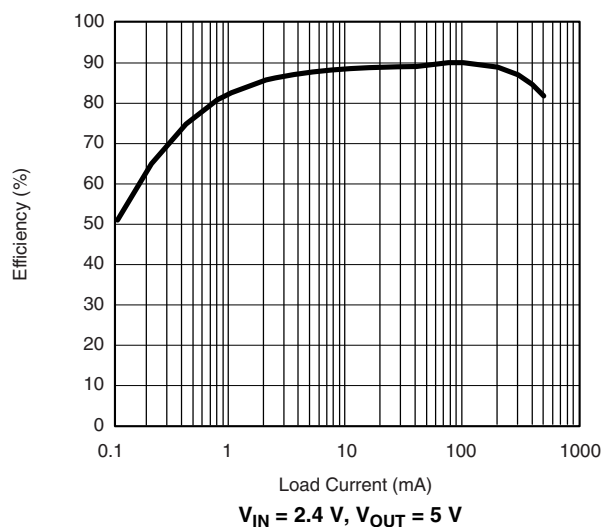
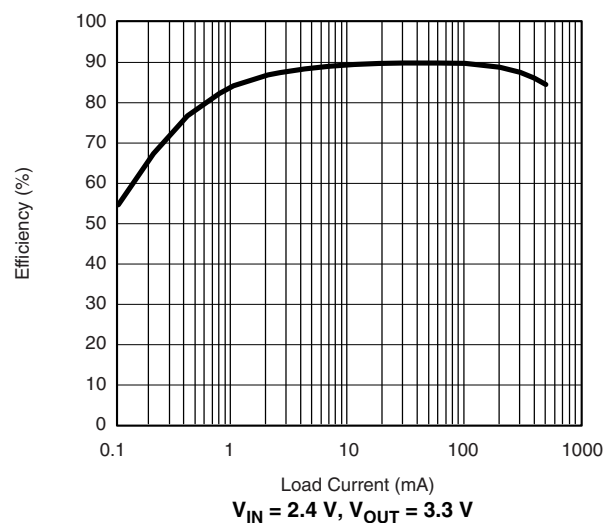
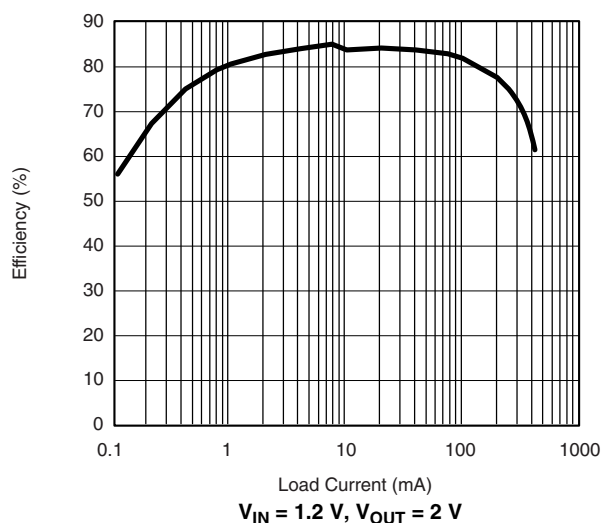
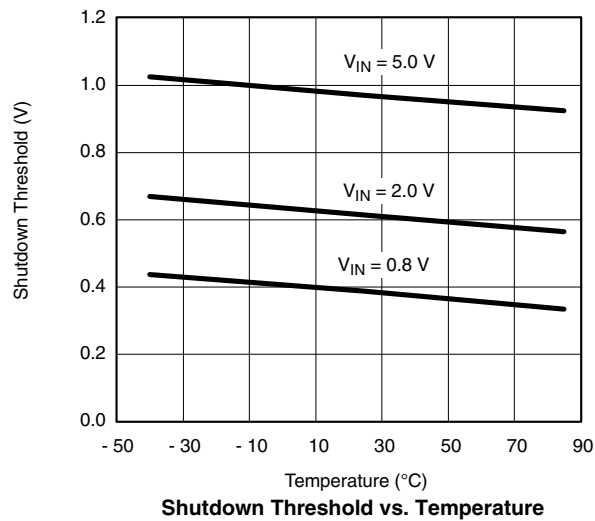
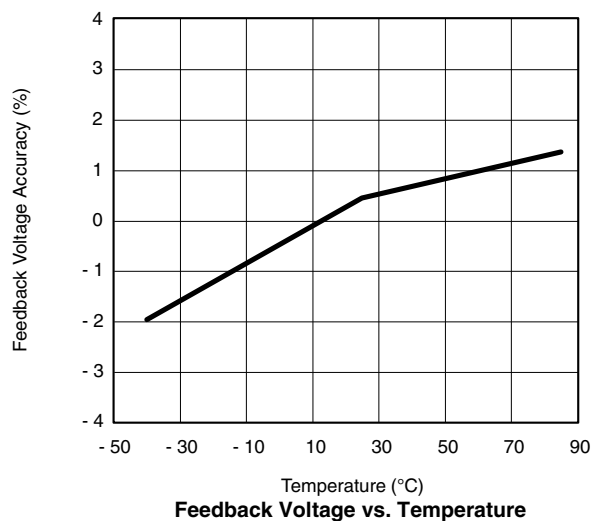
Supply Current 2 vs. Temperature



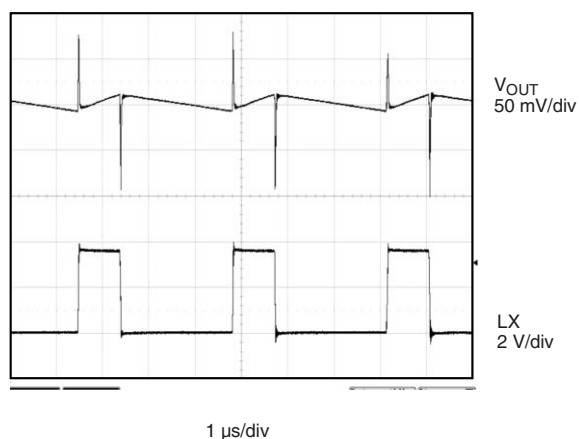
Maximum PWM Duty Cycle vs. Temperature

 $R_{DS(on)}$  vs. Output VoltageShutdown Input Voltage Threshold vs.  $V_{IN}$

## TYPICAL CHARACTERISTICS

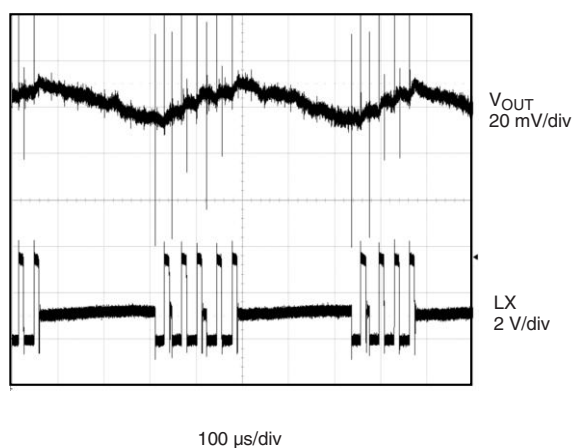


## TYPICAL WAVEFORMS



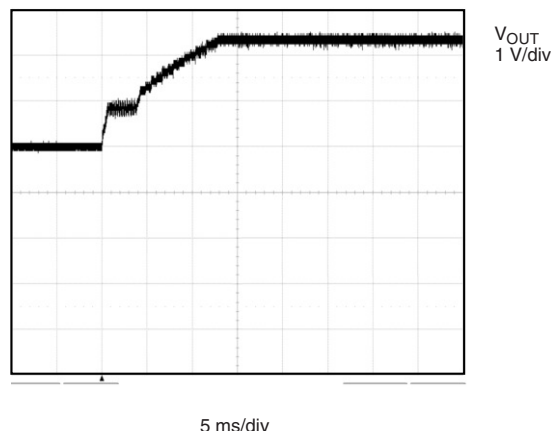
Typical Switching Waveform PWM Mode

$V_{IN} = 1.2$  V,  $V_{OUT} = 3.3$  V, Load Current = 150 mA,  
 $L = 10$   $\mu$ H;  $C_{OUT} = 47$   $\mu$ F



Typical Switching Waveform PFM Mode

$V_{IN} = 1.2$  V,  $V_{OUT} = 3.3$  V, Load Current = 10 mA,  
 $L = 10$   $\mu$ H;  $C_{OUT} = 47$   $\mu$ F

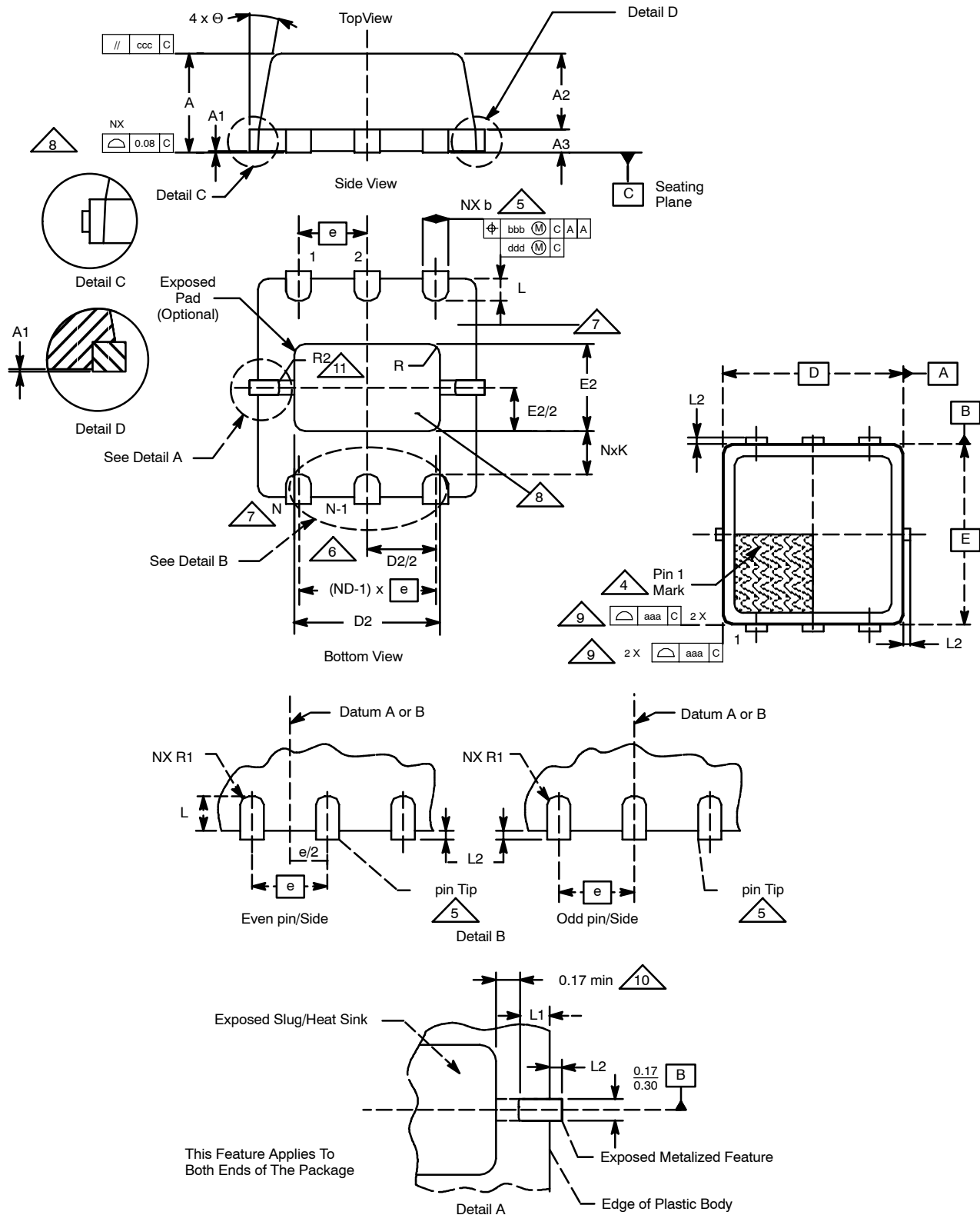


Soft Start

$V_{IN} = 1.2$  V,  $V_{OUT} = 3.3$  V, Load Current = 50 mA,  
 $L = 10$   $\mu$ H;  $C_{OUT} = 47$   $\mu$ F



### 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.

ECN: S-40082—Rev. A, 02-Feb-04  
 DWG: 5925

#### NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5M-1994.
2. All dimensions are in millimeters. All angles 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.



## Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and/or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.

## Material Category Policy

**Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.**

**Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.**

**Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.**

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

Vishay:

[SIP12503DMP-T1-E3](#)