

## Boost Controller For Double AA Cell or Li-Ion Battery For White LED Application

### DESCRIPTION

SiP12401 is a boost controller IC for double cell NiMH or Alkaline battery and Li Ion battery, which can drive white LEDs connected in series to provide backlight in hand-held devices. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminating the need for ballast resistors. For best efficiency performance, the SiP12401 is designed to operate in PWM mode with 600 kHz switching. The voltage-mode PWM design is internally compensated, reducing the external parts count. It accepts input voltages from 1.8 V to 5.0 V. The LED current can be adjusted externally for its brightness control. SiP12401 features low shutdown current of under 1  $\mu$ A.

SiP12401 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
- 1.8 V to 5.0 V Input Voltage Range
- PWM Control with 600 kHz Fixed Switching Frequency
- Analog Control of LED Intensity
- Regulated Output Current
- Integrated UVLO and Soft-Start
- Logic Controlled Shutdown ( $< 1 \mu$ A)
- High Efficiency: Typical 80 %
- PowerPAK<sup>®</sup> MLP33-6 Package

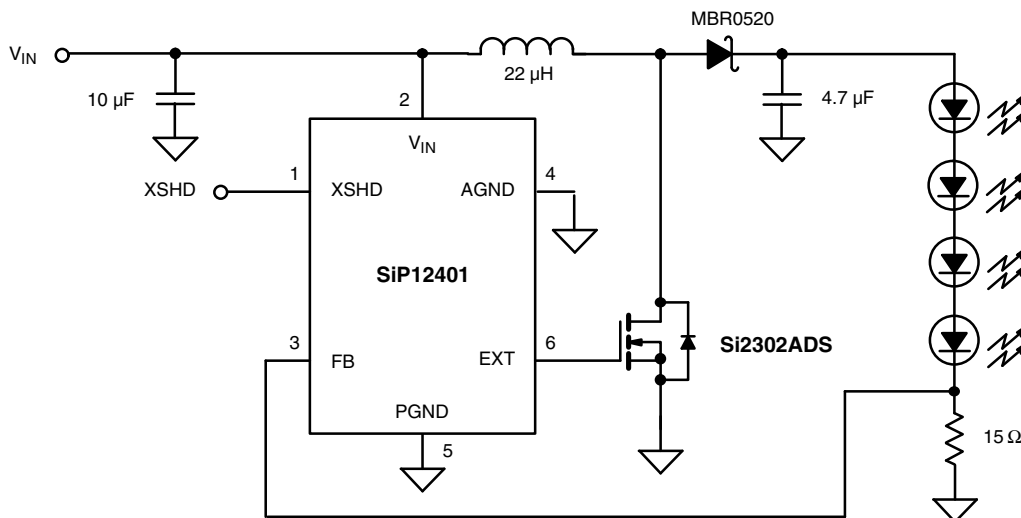


**RoHS**  
COMPLIANT

### APPLICATIONS

- White LED Backlighting
- LCD Bias Supplies
- Handheld Devices
- Digital Cameras
- Portable Applications

### TYPICAL APPLICATION CIRCUIT



| <b>ABSOLUTE MAXIMUM RATINGS</b> (all voltages referenced to GND = 0 V) |  |      |      |
|--|--|------|------|
| Parameter  | Limit  | Unit |      |
| Input Voltage, $V_{IN}$  | - 0.3 to 6   | V    |      |
| EXT Voltage  | - 0.3 to $V_{IN} + 0.5$                                |      |      |
| XSHD Voltage   | - 0.3 to $V_{IN} + 0.5$                                |      |      |
| FB Voltage   | - 0.3 to $V_{IN} + 0.5$                                |      |      |
| 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> | 1100 | mW   |
| Thermal Resistance <sup>b</sup>  | 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.

| <b>RECOMMENDED OPERATING RANGE</b> (all voltages referenced to GND = 0 V) |                      |      |
|---|----------------------|------|
| Parameter   | Limit                | Unit |
| Input Voltage, $V_{IN}$   | 1.8 to 5             | V    |
| XSHD, EXT Voltage   | 0 V to $V_{IN}$      |      |
| LX Voltage  | 0 to $V_{OUT} + 0.5$ |      |
| FB Voltage  | 0 to 5               |      |
| Operating Temperature Range   | - 40 to 85           | °C   |

| <b>SPECIFICATIONS<sup>a</sup></b> |                |  |                   |                  |                  |                  |      |
|-----------------------------------|----------------|--|-------------------|------------------|------------------|------------------|------|
| Parameter                         | Symbol         | Test Conditions Unless Specified<br>$V_{IN} = 3\text{ V}$ , $T_A = 25\text{ °C}$ | Temp <sup>a</sup> | Limits           |                  |                  | Unit |
|                                   |                |  |                   | Min <sup>b</sup> | Typ <sup>c</sup> | Max <sup>b</sup> |      |
| Input Voltage                     | $V_{IN}$       |  | Full              | 1.8              |                  | 5                | V    |
| UVLO                              | $V_{UVLO}$     |  | Full              |                  | 1.65             | 1.77             |      |
| UVLO Hysteresis                   | $V_{UVLOHYST}$ |  |                   |                  | 0.1              |                  |      |
| Feedback Voltage                  | $V_{FB}$       |  |                   | 0.291            | 0.3              | 0.309            |      |
|                                   |                |  | Full              | 0.282            |                  | 0.318            |      |
| Feedback Input Current            | $I_{FB}$       | $V_{FB} = 0.3\text{ V}$  |                   |                  | 1                |                  | nA   |
| Maximum PWM Duty Cycle            | MAXDTY         |  |                   | 77               | 85               |                  | %    |
| PWM Switching Frequency           | $f_{OSC}$      |  | Full              | 425              | 600              | 775              | kHz  |
| Quiescent Current                 | $I_Q$          | $V_{FB} = 0.4\text{ V}$  |                   |                  | 200              | 300              | μA   |
| Stand-By Current                  | $I_{STB}$      | XSHD = 0 V   | Full              |                  |                  | 1                |      |
| XSHD Input High Level             | $V_{XSHDH}$    |  | Full              | 1.2              |                  |                  | V    |
| XSHD Input Low Level              | $V_{XSHDL}$    |  | Full              |                  |                  | 0.2              |      |
| EXT High On Resistance            | $R_{EXTH}$     | $I_{EXT} = 10\text{ mA}$   |                   |                  | 35               |                  | Ω    |
| EXT Low On Resistance             | $R_{EXTL}$     |  |                   |                  | 30               |                  |      |

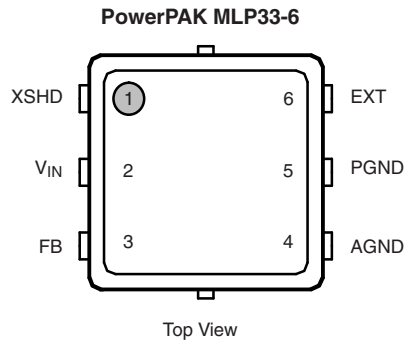
Notes:

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.

**PIN CONFIGURATION AND TRUTH TABLE**



| <b>ORDERING INFORMATION</b> |                   |         |
|-----------------------------|-------------------|---------|
| Part Number                 | Temperature Range | Marking |
| SiP12401DMP-T1-E3           | - 40 to 85 °C     | 2401    |

| <b>PIN DESCRIPTION</b> |                 |  |
|------------------------|-----------------|--|
| Pin Number             | Name            | Function   |
| 1                      | XSDH            | Logic Controlled Shutdown Input, XSHD = High: Normal Operation, XSHD = Low: Shutdown |
| 2                      | V <sub>IN</sub> | Battery Input Voltage  |
| 3                      | FB              | Output Voltage Feedback Pin  |
| 4                      | AGND            | Signal Ground  |
| 5                      | PGND            | Power Ground   |
| 6                      | EXT             | Drive Pin for External Power MOS   |

**PIN FUNCTIONS**

**XSHD (Pin 1)**

XSHD is the logic controlled shutdown input pin. When XSHD is low, the IC is shutdown and its quiescent current is less than 1  $\mu$ A. 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. The IC gets its power supply from V<sub>IN</sub>.

**FB (Pin 3)**

FB is the feedback pin of the output voltage via resistor divider. FB is about 0.3 V and its difference from 0.3 V reference voltage is amplified by the error amplifier.

**AGND (Pin 4)**

AGND is the pin for ground of controlling circuit.

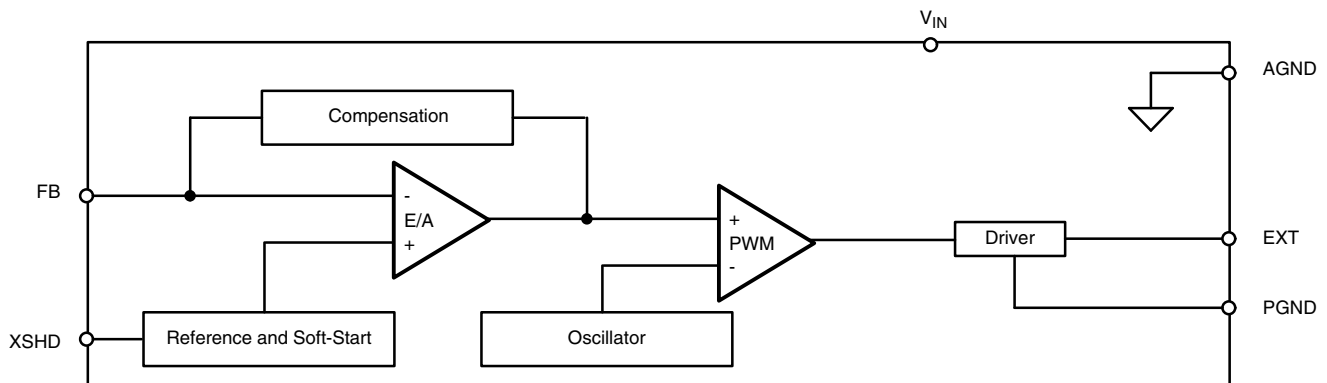
**PGND (Pin 5)**

PGND is the pin for ground of the internal power MOS driver.

**EXT (Pin 6)**

EXT is the output pin of internal driver. It's connected to the gate of external power MOSFET.

## FUNCTIONAL BLOCK DIAGRAM



## DETAILED OPERATION

SiP12401 is a 600 kHz boost controller IC, packaged in 6-pin MLP33, for white LED applications. It features fixed frequency voltage mode PWM control with internal frequency compensation. With the low  $r_{DS(on)}$  external power MOSFET, this device maintains high efficiency over a wide range of load current.

### Soft-Start

During soft-start, the loop compensation guarantees the slow increase of the output voltage and inrush current, so that no large voltage overshoot and inrush current occur when the soft-start is ended.

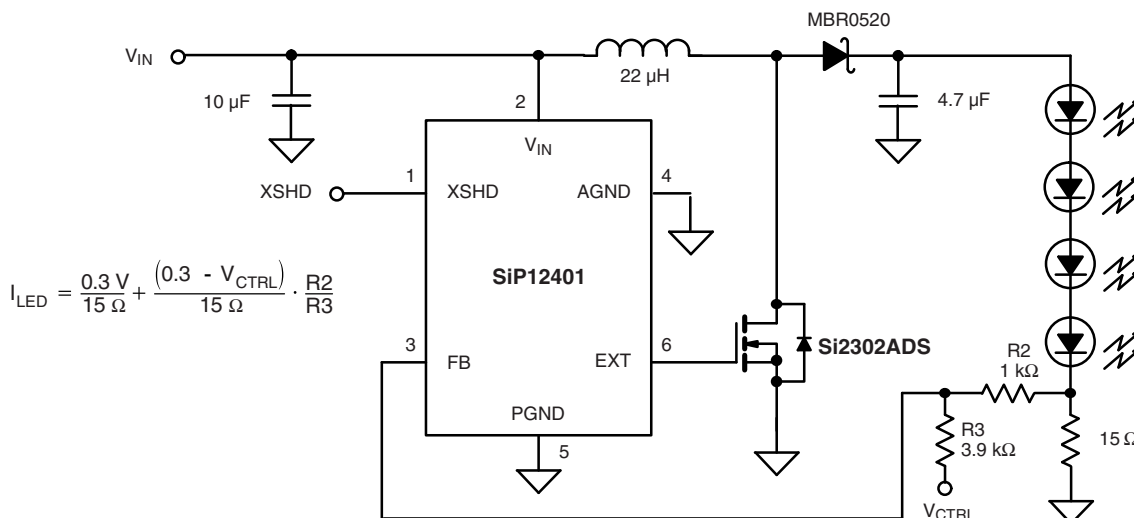
### PWM operation

After soft-start, the device is working in PWM operation with a fixed frequency of 600 kHz.

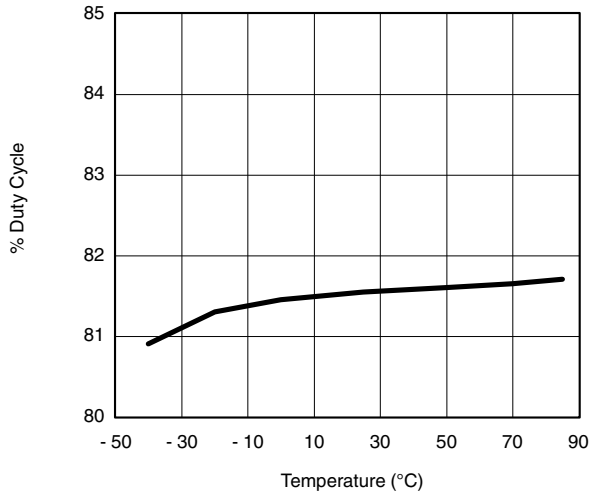
## APPLICATION INFORMATION

### White LED Brightness Control

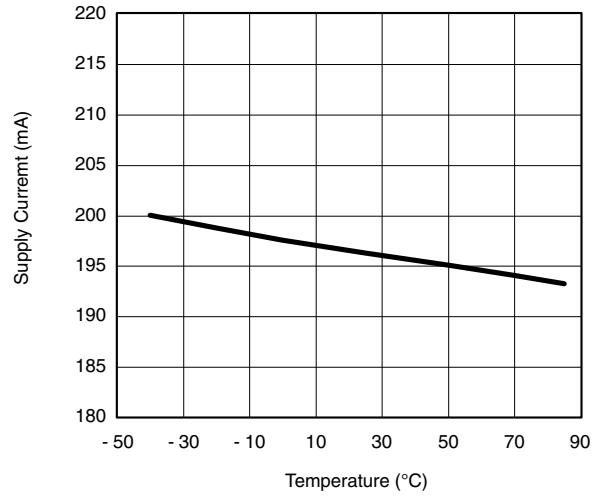
The current of white LED can be adjusted by PWM signal on the XSHD pin or by a variable dc voltage to control its brightness, (see Figure 1.) As control voltage  $V_{CTRL}$  increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from  $V_{CTRL}$  much smaller than LED current and much larger than the FB pin bias current.



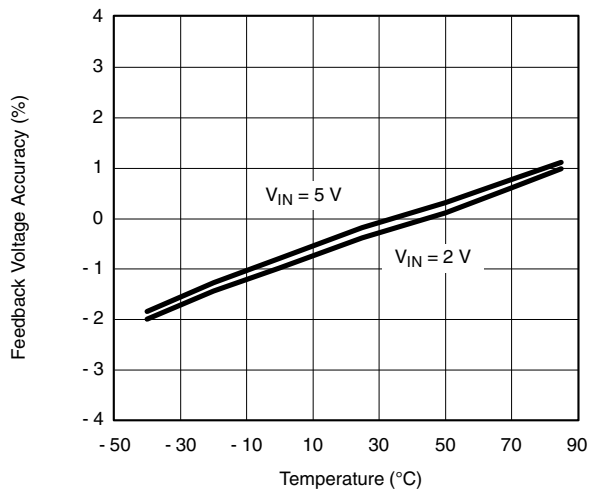
**TYPICAL CHARACTERISTICS**



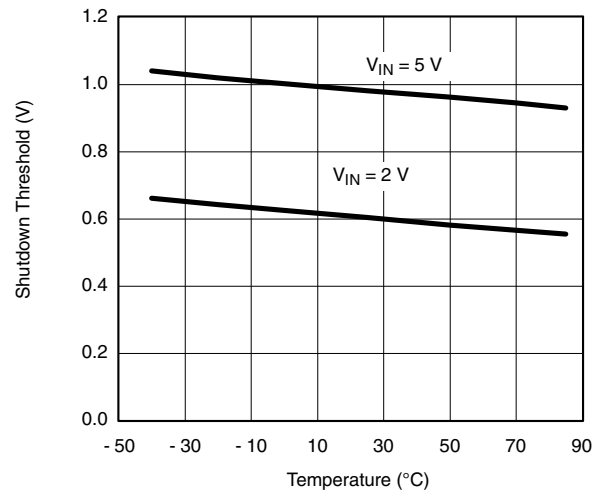
**Maximum PWM Duty Cycle vs. Temperature**



**Supply Current vs. Temperature**

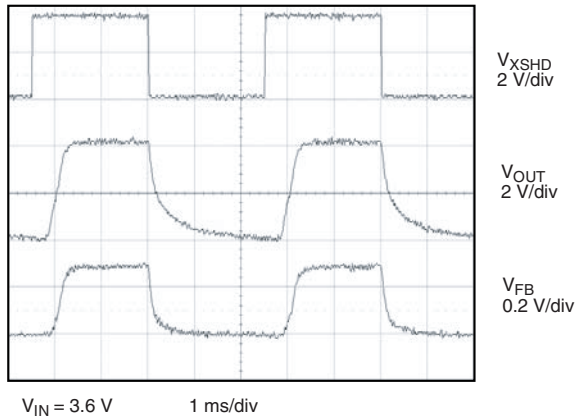


**Feedback Voltage Accuracy vs. Temperature**

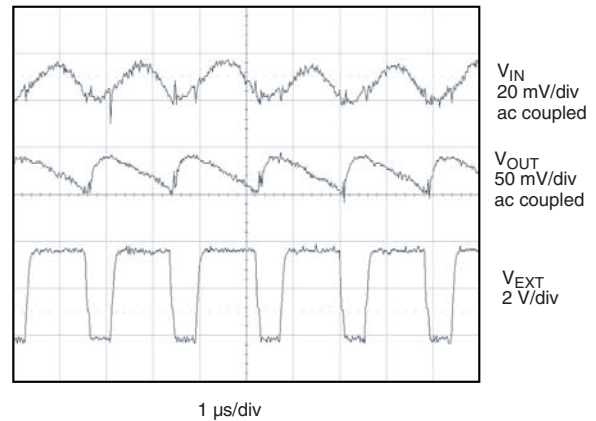


**Shutdown Threshold vs. Temperature**

## TYPICAL WAVEFORMS

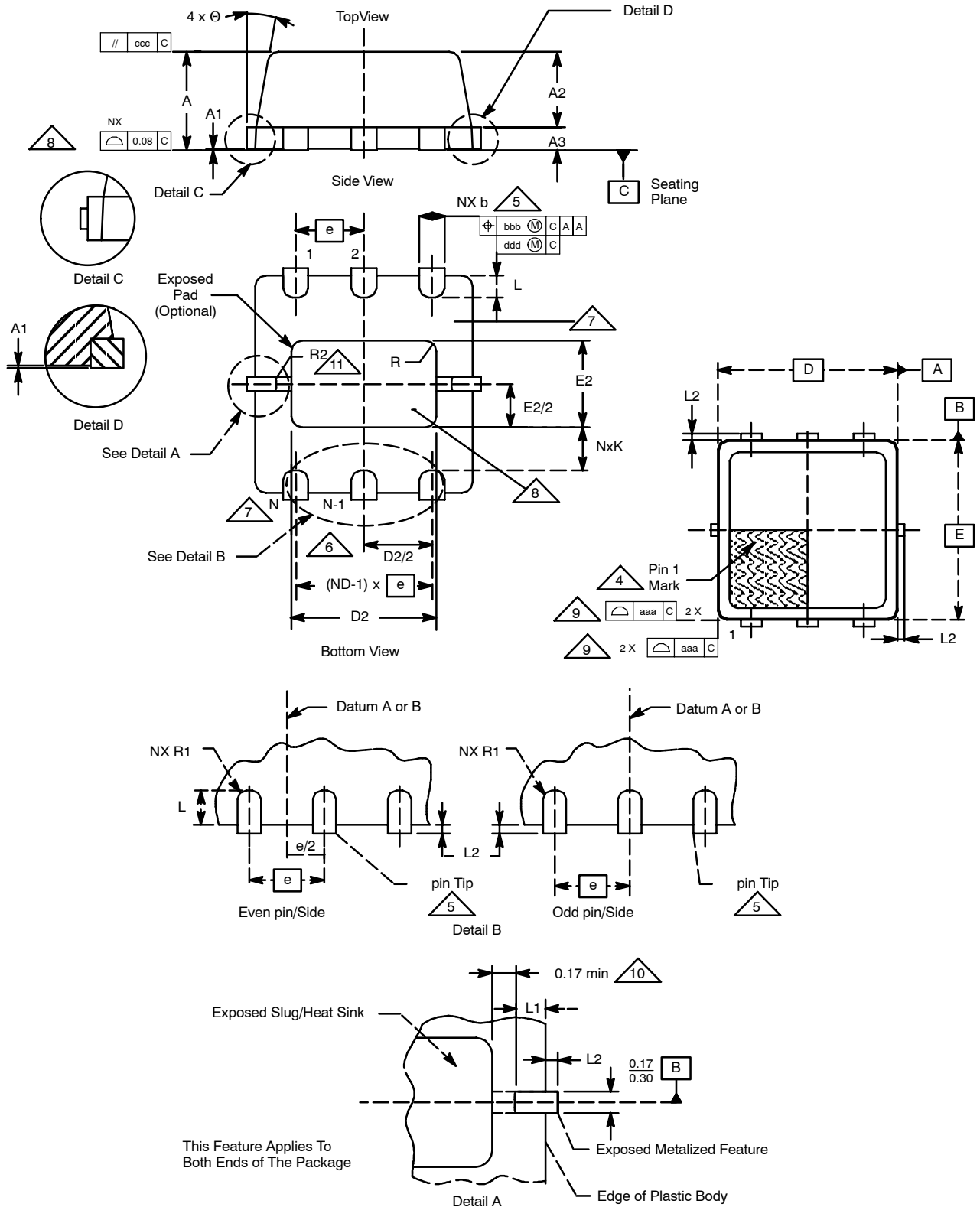


**Figure 1. PWM Dimming Control**  
200 Hz 50 % Duty Cycle PWM Signal on XSHD Pin



**Figure 3. Switching Waveforms:  $V_{IN}$ ,  $V_{OUT}$  and  $V_{EXT}$**   
 $V_{IN} = 3.6\text{ V}$ ,  $L = 22\text{ μH}$ ,  $C_{OUT} = 4.7\text{ μF}$ , Four LEDs in Series

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



# Package Information



## Vishay Siliconix

### 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 |
| ⊖         | -            | 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 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.





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