

### GENERAL DESCRIPTION

The EC4304 is a high-efficiency continuous mode inductive step-down converter which drives N-channel MOSFET and it is designed for driving single or multiple series connected LEDs from a voltage source higher than the LED voltage. It operates from input supply between 7V and 40V and provides an externally adjustable output current to 1A which is depending on supply voltage and external components.

This EC4304 includes the output switch and high-side output current sensing circuit, which uses an external resistor to set the output current.

The ADJ pin will accept either a DC voltage or a PWM waveform. This will provide either a continuous or gated output current depending upon the control frequency. The PWM filter components contain a soft-start rising time setting. The soft-start time can be increased by using an external capacitor from the ADJ pin to ground. Applying a 0.2V or lower to the ADJ pin turns the output off and switches the device into a low current standby state.

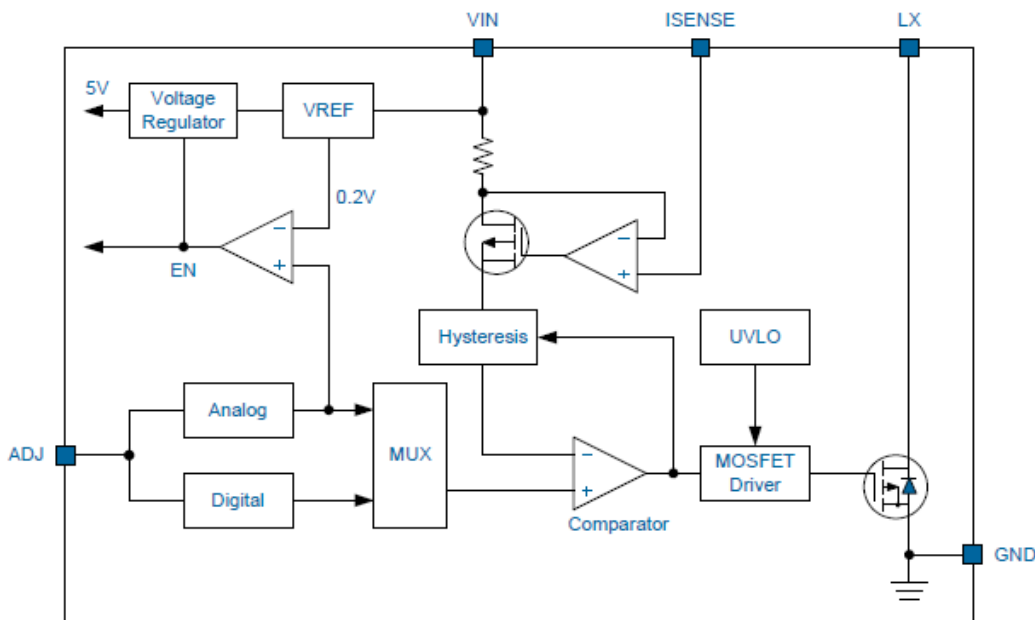
### FEATURES

- Operates from 7V to 40V Supply Voltage
- Internal 40V NDMOS Switch
- Output Current 1A
- Single Pin On/Off and Brightness Control Using DC Voltage or PWM
- EC4304 to 95% Efficiency
- Typical +/-5% LED Current Accuracy
- Input Under Voltage Lockout
- SOT23-5L、DFN 3x3 8L、SOT89-5L Package
- RoHS Compliant and Halogen-Free

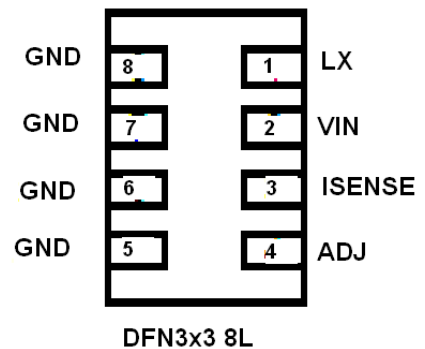
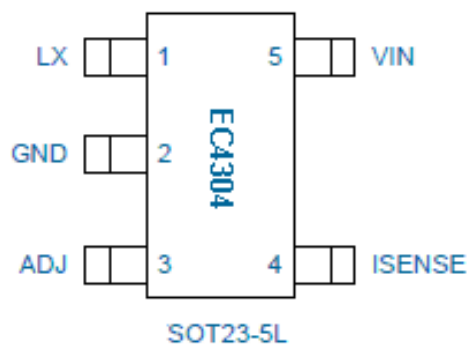
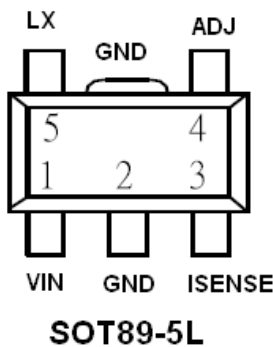
### Applications

- Automotive LED Lighting
- High Power LED Lighting
- Indicator and Emergency Lighting
- Architectural Lighting
- Low Voltage Industrial Lighting
- Signage and Decorative LED Lighting

### Functional Block Diagram

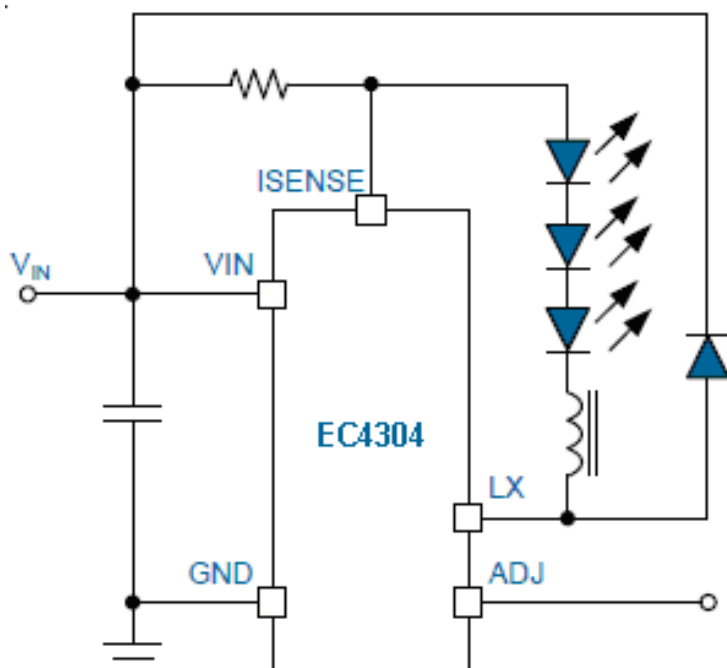


### Pin Configuration



| Pin Name | Pin Function                                                                                                                                                                                                                                                                                       |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LX       | <b>Drain of NDMOS Switch.</b>                                                                                                                                                                                                                                                                      |
| GND      | <b>Ground for the IC.</b> All voltages levels are measured with respect to this pin.                                                                                                                                                                                                               |
| ADJ      | <b>Multi-Function ON/OFF and Brightness Control Pin:</b><br>-Analog signal input for analog control of PWM dimming.<br>-PWM signal input for digital PWM dimming.                                                                                                                                  |
| ISENSE   | <b>Current Sense Pin: Sense LED String Current.</b>                                                                                                                                                                                                                                                |
| VIN      | <b>Power supply input pin.</b> Connect a nominal (7V~40V) power supply to this pin. The power- on-reset (POR) function monitors the input voltage by this pin. It is recommended that a decoupling capacitor (4.7μF or Higher X7R Ceramic capacitor) be connected to the GND for noise decoupling. |

### Typical Application



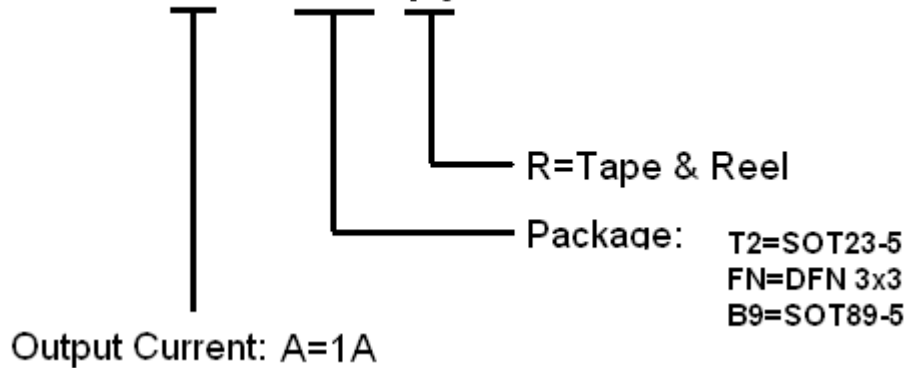


# 1A, Hysteretic, High Brightness LED Driver with Internal Switch

EC4304

## Ordering/ Marking Information

EC4304XNXXR



| Part Number | Package  | Marking         | Marking Information            |
|-------------|----------|-----------------|--------------------------------|
| EC4304ANT2R | SOT23-5  | 4304A<br>LLLLLL | LLLLLL is Lot No               |
| EC4304ANFNR | DFN3x3-8 | 4304A<br>YWLLL  | YW : Date Code<br>LLL : Lot No |
| EC4304ANB9R | SOT89-5L |                 |                                |



### Functional Description

The EC4304 is a simple high-efficiency, continuous mode inductive step-down converter. The device operates with an input voltage range from 7V to 40V and delivers output current 1A. A high-side current-sense resistor sets the output current and a dedicated PWM dimming input enables pulsed LED dimming over a wide range of brightness levels. A high-side current-sensing scheme and an on-board current-setting circuitry minimize the number of external components which is required while delivering LED current with +5% accuracy, using a 1% sense resistor.

### Adjusting Output Current

The device contains a low pass filter between the ADJ pin and the threshold comparator and an internal current limiting resistor between ADJ and the internal reference voltage. This allows the ADJ pin to be overdriven with either DC or pulse signals to change the VSENSE switching threshold and adjust the output current. Details of the different modes of adjusting output current are given in the applications section by:

$$I_{OUTdc} = \frac{V_{ADJ}}{1.25} \times \frac{100mV}{R_{SENSE}} \quad (\text{for } 0.3V < V_{ADJ} < 2.5V)$$

The value of the output current is 1A at 0.1Ω (0.5A at 0.2Ω) and this is a calculated output current when the ADJ terminal is 1.25V floating.

### Shutdown Mode

Taking the ADJ pin to a voltage below 0.2V for more than approximately 100μs will turn off the output, and supply current will fall to a low standby level of 20μA nominal.

### Soft-Start

The device has inbuilt soft-start action due to the delay through the PWM filter. An external capacitor from the ADJ pin to ground will provide additional soft-start delay, by increasing the time taken for the voltage on this pin to rise to the turn-on threshold and by slowing down the rate of rise of the control voltage at the input of the comparator.

With no external capacitor, the time taken for the output to reach 90% of its final value is approximately 500μs. Adding capacitance increases this delay by approximately 0.5ms/ nF.

### Inherent open-circuit LED protection

If the connection to the LED(s) is open-circuited, the coil is isolated from the LX pin of the chip, so the chip will not be damaged. Unlike in many boost converters, where the back EMF may damage the internal switch by forcing the drain above its breakdown voltage.



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## Absolute Maximum Rating

|                                         |                                                  |
|-----------------------------------------|--------------------------------------------------|
| Supply Input Voltage, $V_{IN}$ (Note 1) | -0.3V to + 45V                                   |
| ISENSE Voltage, $V_{ISENSE}$            | +0.3V to -5V(measured with respect to $V_{IN}$ ) |
| LX Output Voltage, $V_{LX}$             | -0.3V to + 45V                                   |
| Adjust Pin Input Voltage, $V_{ADJ}$     | -0.3V to + 6V                                    |
| Switch Output Current, $I_{LX}$         | 1.2A                                             |
| Operation Temperature Range             | -40°C to +125°C                                  |
| Storage Temperature Range               | -55°C to +150°C                                  |
| Junction Temperature                    | 150°C                                            |
| Lead Temperature (Soldering, 10 sec)    | 260°C                                            |
| ESD Rating (Note 2)                     |                                                  |
| HBM (Human Body Mode)                   | 4kV                                              |
| MM (Machine Mode)                       | 200V                                             |

## Thermal Information

### Package Thermal Resistance (Note 3)

|                        |         |
|------------------------|---------|
| SOT23-5L $\theta_{JA}$ | 250°C/W |
| SOT23-5L $\theta_{JC}$ | 100°C/W |
| SOT89-5L $\theta_{JA}$ | 175°C/W |
| SOT89-5L $\theta_{JC}$ | 58°C/W  |

### Package Thermal Resistance (Note 4)

|                         |         |
|-------------------------|---------|
| DFN3x3-8L $\theta_{JA}$ | 70°C/W  |
| DFN3x3-8L $\theta_{JC}$ | 8.2°C/W |

### Power Dissipation, $P_D$ @ $T_A = 25^\circ\text{C}$

|           |      |
|-----------|------|
| SOT23-5L  | 0.4W |
| DFN3x3 8L | 1.4W |
| SOT89-5L  | 0.7W |

## Recommended Operation Conditions

|                                               |                 |
|-----------------------------------------------|-----------------|
| Operating Junction Temperature Range (Note 5) | -40°C to +125°C |
| Operating Ambient Temperature Range           | -40°C to +85°C  |

- Note 1. Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. 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 remain possibility to affect device reliability.
- Note 2. Devices are ESD sensitive. Handling precaution recommended.
- Note 3.  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.
- Note 4.  $\theta_{JA}$  is measured at  $T_A = 25^\circ\text{C}$  on a high effective thermal conductivity four-layer test board per JEDEC 51-7.  $\theta_{JC}$  is measured at the exposed pad of the package.
- Note 5. The device is not guaranteed to function outside its operating conditions.



# 1A, Hysteretic, High Brightness LED Driver with Internal Switch

**EC4304**

## Electrical Characteristics

(V<sub>IN</sub> = 12V, T<sub>A</sub> = 25°C, unless otherwise specified)

| Parameter                                       | Symbol               | Test Conditions                             | Min  | Typ  | Max  | Units |
|-------------------------------------------------|----------------------|---------------------------------------------|------|------|------|-------|
| <b>Supply Input</b>                             |                      |                                             |      |      |      |       |
| Supply Voltage Range                            | V <sub>IN</sub>      |                                             | 7    | -    | 40   | V     |
| VIN POR Threshold                               | V <sub>INRTH</sub>   | V <sub>IN</sub> Rising                      | -    | 4.95 | -    | V     |
| VIN POR Threshold                               | V <sub>INFTH</sub>   | V <sub>IN</sub> Falling                     | -    | 4.8  | -    | V     |
| Quiescent Current with Output Off               | I <sub>QOFF</sub>    | ADJ pin grounded                            | -    | 20   | 40   | μA    |
| Quiescent Current with Output Switching         | I <sub>QON</sub>     | ADJ pin floating f = 250KHz                 | -    | 0.5  | 1.0  | mA    |
| <b>ISENSE Pin</b>                               |                      |                                             |      |      |      |       |
| Current Sense Threshold Voltage                 | V <sub>SENSE</sub>   | ISENSE pin with respect to VIN, ADJ = 1.25V | 95   | 100  | 105  | mV    |
| ISENSE Input Current                            | ISENSE               | V <sub>SENSE</sub> = VIN-0,1                | -    | -    | 1.0  | μA    |
| <b>Reference</b>                                |                      |                                             |      |      |      |       |
| Reference Voltage                               | V <sub>REF</sub>     | ADJ pin Voltage                             | -    | 1.25 | -    | V     |
| Reference Voltage Temperature Coefficient       |                      |                                             | -    | 50   | -    | ppm/V |
| <b>ADJ Pin</b>                                  |                      |                                             |      |      |      |       |
| ADJ Pin for DC Control Level                    | V <sub>ADJ</sub>     |                                             | 0.3  | -    | 2.5  | V     |
| ADJ to Switch Device from On State to Off State | V <sub>ADJ_OFF</sub> | V <sub>ADJ</sub> falling                    | 0.15 | 0.2  | 0.25 | V     |
| ADJ to Switch Device from Off State to On State | V <sub>ADJ_ON</sub>  | V <sub>ADJ</sub> rising                     | 0.2  | 0.25 | 0.3  | V     |
| ADJ to VREF Resistance                          | R <sub>ADJ</sub>     | 0 < V <sub>ADJ</sub> < VREF                 | 135  | -    | 250  | KΩ    |
|                                                 |                      | V <sub>ADJ</sub> > VREF+100mV               | 13.5 | -    | 25   | KΩ    |
| ADJ Pin Low Frequency Duty Cycle Range          | DPWM (LF)            | PWM frequency < 500Hz                       | 10   | -    | 100  | %     |
| ADJ Pin High Frequency Duty Cycle Range         | DPWM (HF)            | PWM frequency >10KHz                        | 16   | -    | 100  | %     |
| <b>LX pin</b>                                   |                      |                                             |      |      |      |       |
| LX Switch Current                               | I <sub>LXmean</sub>  | EC4304A                                     | -    | -    | 1    | A     |



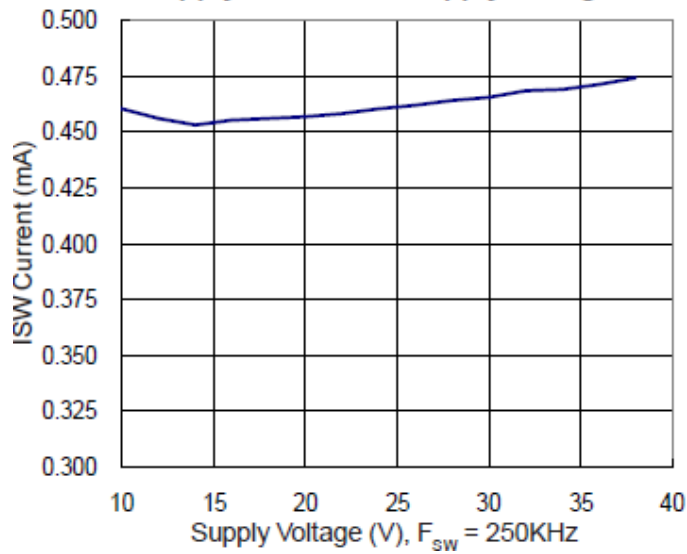
# 1A, Hysteretic, High Brightness LED Driver with Internal Switch

EC4304

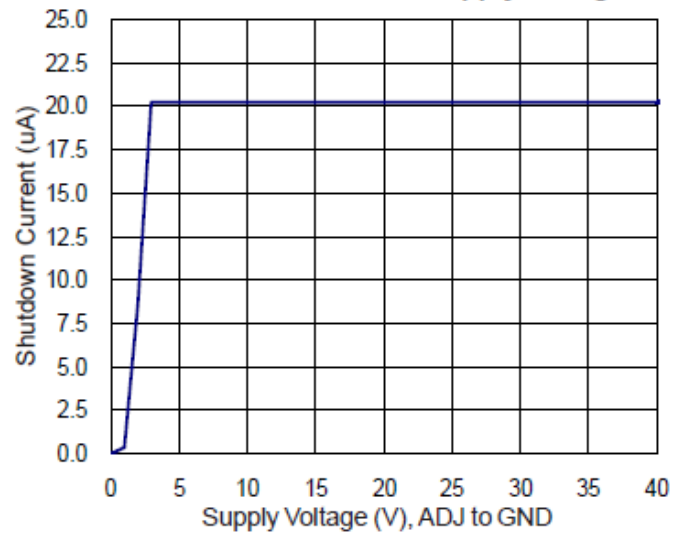
| Parameter                                                | Symbol                  | Test Conditions                                                                                          | Min | Typ | Max | Units |
|----------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------|-----|-----|-----|-------|
| LX R <sub>DS_ON</sub>                                    | R <sub>LX</sub>         | @I <sub>LX</sub> = 1A, EC4304A                                                                           | -   | 0.3 | 0.6 | Ω     |
| LX Leakage Current                                       |                         |                                                                                                          | -   | -   | 5   | μA    |
| Minimum Switch ON Time                                   | T <sub>ON_min</sub>     | LX Switch ON                                                                                             | -   | 240 | -   | ns    |
| Minimum Switch OFF Time                                  | T <sub>OFF_min</sub>    | LX Switch OFF                                                                                            | -   | 200 | -   | ns    |
| Recommended Minimum Switch ON Time                       | T <sub>ON_min_rec</sub> |                                                                                                          | -   | 800 | -   | ns    |
| <b>Frequency</b>                                         |                         |                                                                                                          |     |     |     |       |
| Operation Frequency                                      | F <sub>LX</sub>         | ADJ pin floating, L=33μH (0.093Ω )<br>I <sub>OUT</sub> = 1A @ V <sub>LED</sub> =3.6V driving 1LED        | -   | 280 | -   | kHz   |
| Recommended Maximum Operation Frequency                  | F <sub>LXmax</sub>      |                                                                                                          | -   | -   | 1   | MHz   |
| Duty Cycle Range of Output Switch of Operation Frequency | D <sub>LX</sub>         |                                                                                                          | 30  | -   | 70  | %     |
| Internal Comparator Propagation Delay                    | TPD                     |                                                                                                          | -   | 50  | -   | ns    |
| <b>Soft-Start</b>                                        |                         |                                                                                                          |     |     |     |       |
| Soft-Start Time                                          |                         | Time taken for output current to reach 90% of final value after voltage on ADJ pin has risen above 0.3V. | -   | 500 | -   | μs    |

### Typical Operation Characteristics

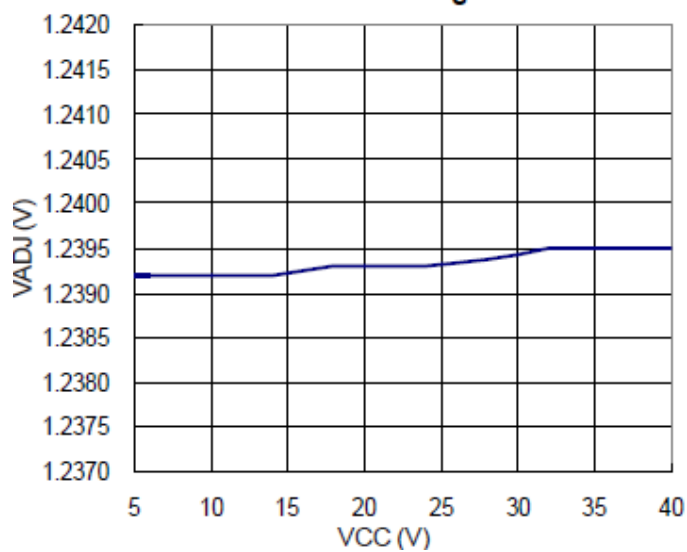
Supply Current vs. Supply Voltage



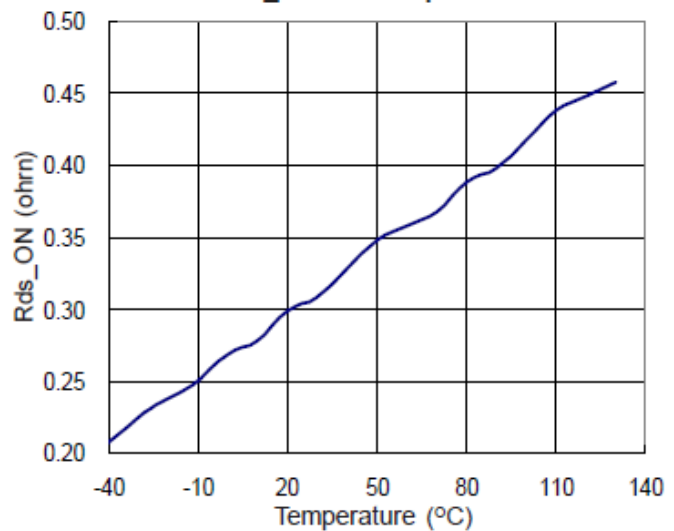
Shutdown Current vs. Supply Voltage



Reference Voltage vs. VCC



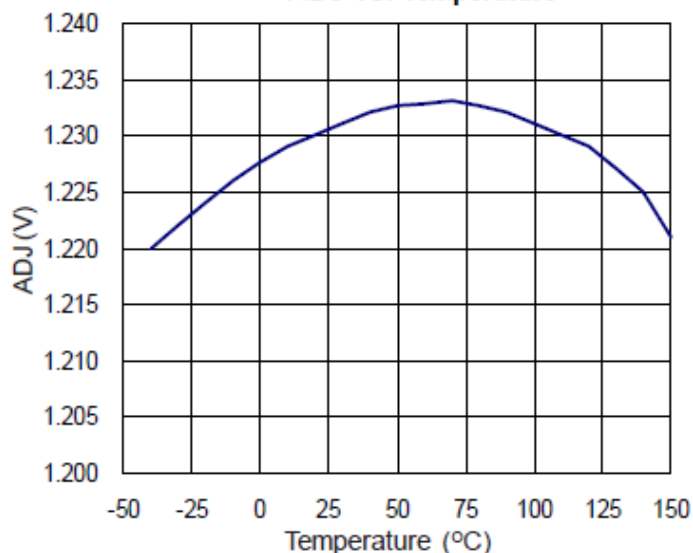
Rds\_ON vs. Temperature



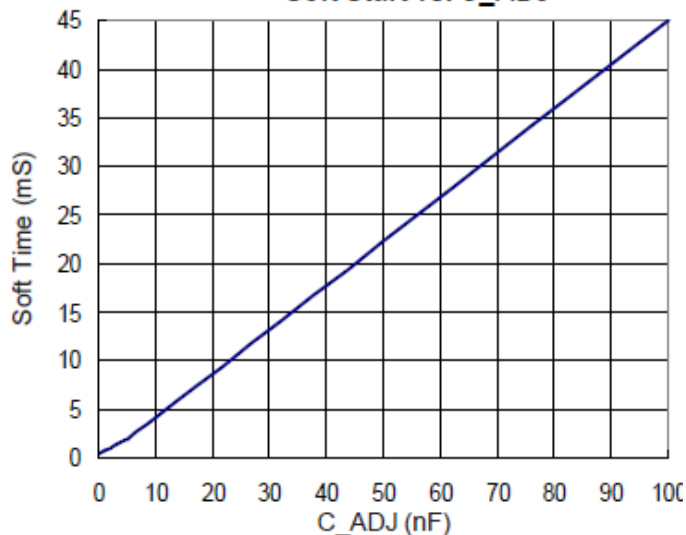


### Typical Operation Characteristics

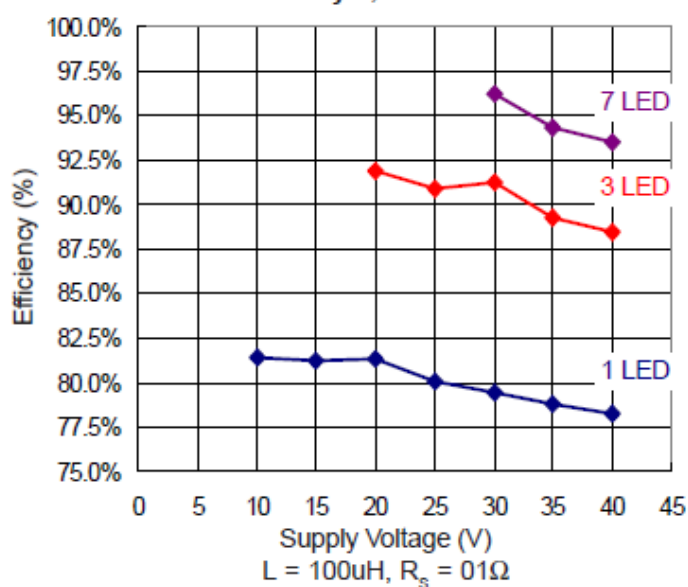
ADJ vs. Temperature



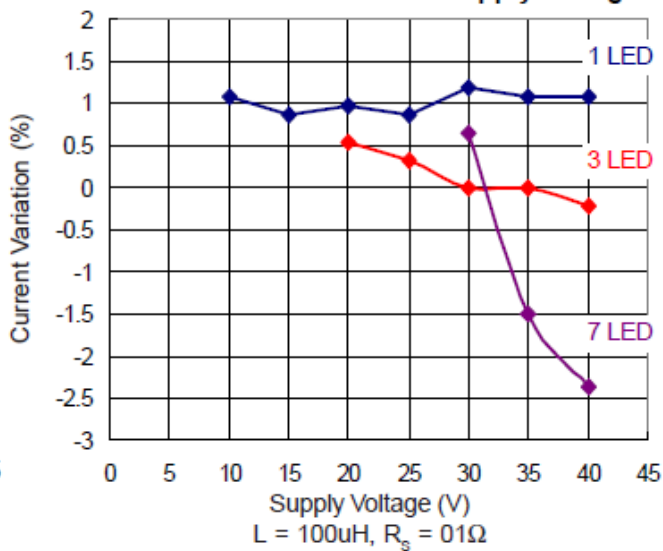
Soft Start vs. C\_ADJ



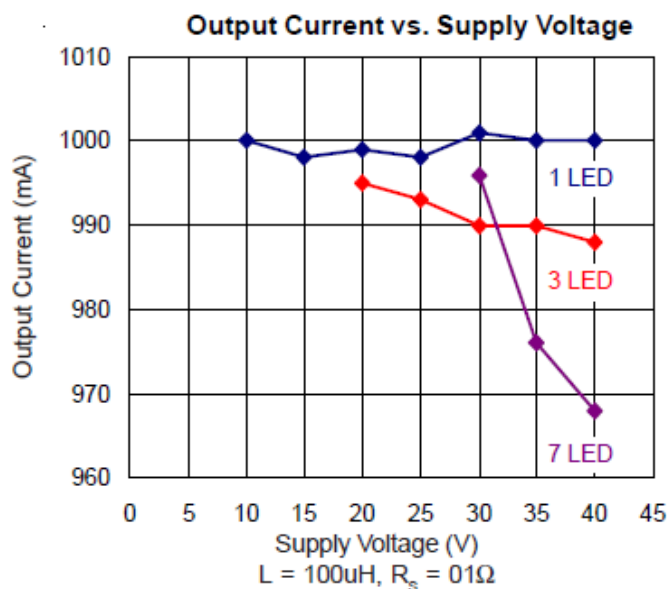
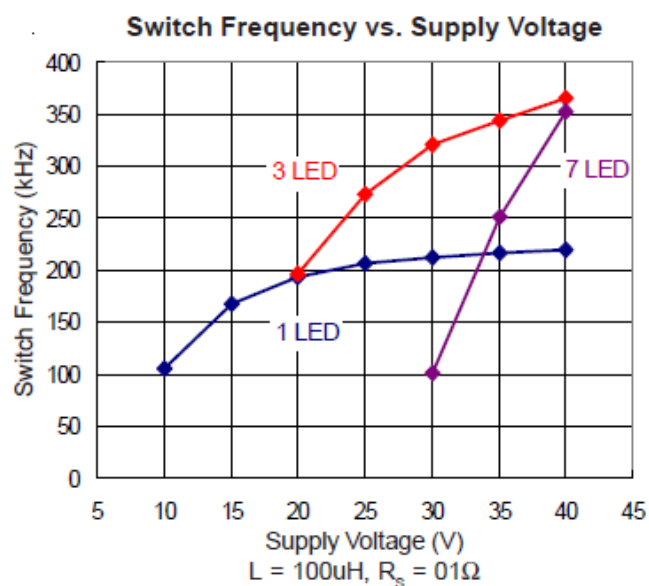
Efficiency 1, 3 and 7 LEDs



Current Variation vs. Supply Voltage



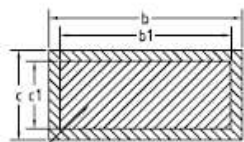
### Typical Operation Characteristics



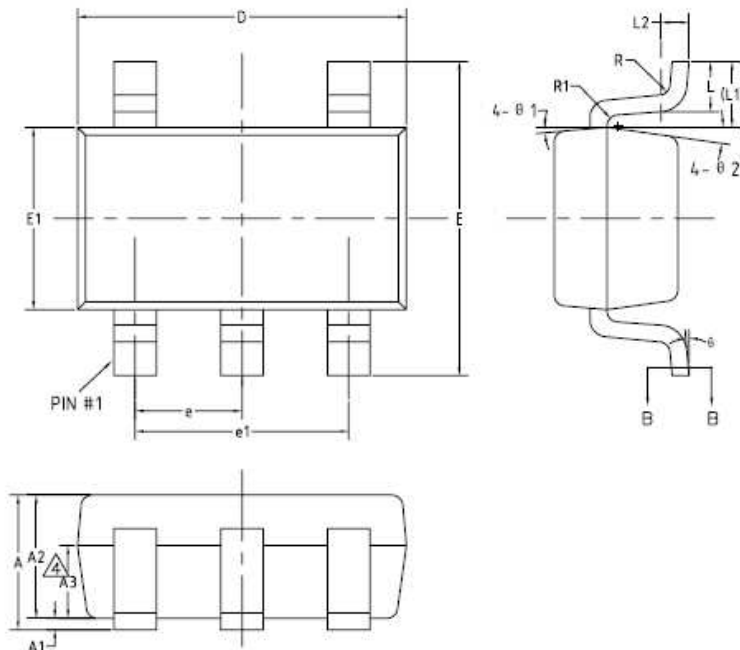
### Package Information SOT23-5L

COMMON DIMENSIONS  
(UNITS OF MEASURE=MILLIMETER)

| SYMBOL | MIN     | NOM  | MAX  |
|--------|---------|------|------|
| A      | —       | —    | 1.45 |
| A1     | 0       | —    | 0.15 |
| A2     | 0.90    | 1.10 | 1.30 |
| A3     | 0.60    | 0.65 | 0.70 |
| b      | 0.39    | —    | 0.49 |
| b1     | 0.38    | 0.40 | 0.45 |
| c      | 0.12    | —    | 0.19 |
| c1     | 0.11    | 0.13 | 0.15 |
| D      | 2.85    | 2.95 | 3.05 |
| E      | 2.60    | 2.80 | 3.00 |
| E1     | 1.55    | 1.65 | 1.75 |
| e      | 0.85    | 0.95 | 1.05 |
| e1     | 1.80    | 1.90 | 2.00 |
| L      | 0.35    | 0.45 | 0.60 |
| L1     | 0.59REF |      |      |
| L2     | 0.25BSC |      |      |
| R      | 0.10    | —    | —    |
| R1     | 0.10    | —    | 0.25 |
| θ      | 0°      | —    | 8°   |
| θ 1    | 8°      | 10°  | 12°  |
| θ 2    | 8°      | 10°  | 12°  |



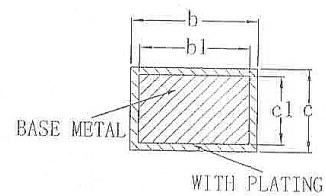
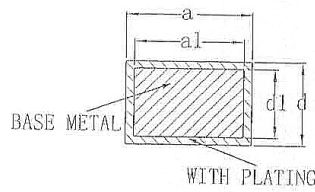
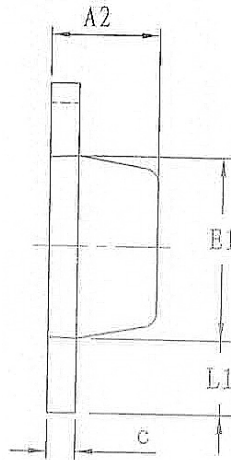
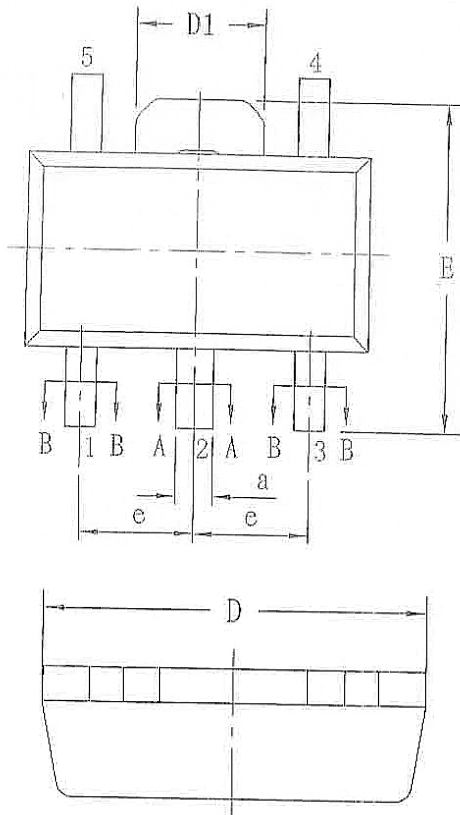
BASE METAL  
SECTION B-B



**NOTES:**

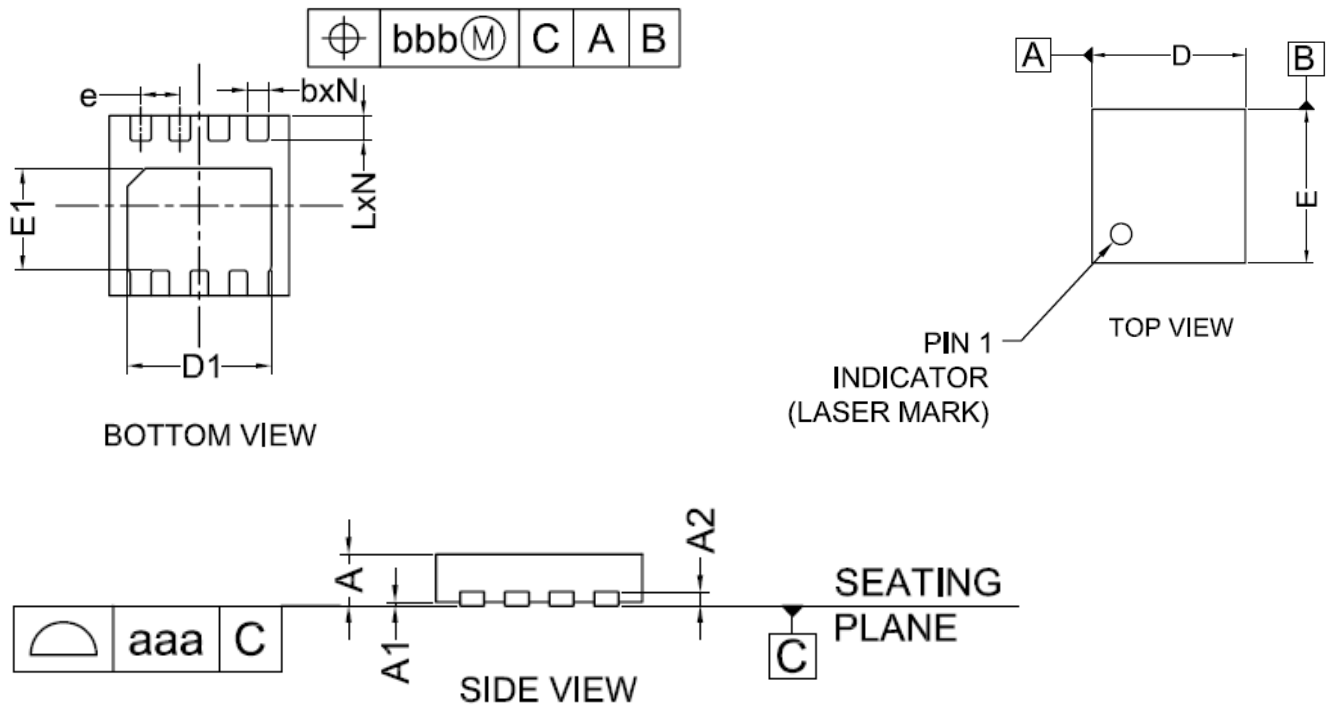
ALL DIMENSIONS REFER TO JEDEC STANDARD MO-178 AA  
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

### Package Information SOT89-5L



| SYMBOLS | DIMENSIONS IN MILLIMETERS |      |      |
|---------|---------------------------|------|------|
|         | MIN                       | NOM  | MAX  |
| A2      | 1.40                      | 1.50 | 1.60 |
| b       | 0.38                      | ---  | 0.47 |
| b1      | 0.37                      | 0.40 | 0.43 |
| c       | 0.36                      | ---  | 0.46 |
| c1      | 0.35                      | 0.38 | 0.41 |
| a       | 0.46                      | ---  | 0.56 |
| a1      | 0.45                      | 0.48 | 0.51 |
| d       | 0.36                      | ---  | 0.46 |
| d1      | 0.35                      | 0.38 | 0.41 |
| D       | 4.30                      | 4.50 | 4.70 |
| D1      | 1.70REF                   |      |      |
| E       | 4.00                      | 4.20 | 4.40 |
| E1      | 2.30                      | 2.50 | 2.70 |
| e       | 1.50BSC                   |      |      |
| L1      | 0.80                      | 1.00 | 1.20 |

### Package Information DFN3x3-8L



#### NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS THE TERMINALS.

#### COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)

| SYMBOL | MIN  | TYP     | MAX  |
|--------|------|---------|------|
| A      | 0.70 | 0.75    | 0.80 |
| A1     | 0.00 | 0.02    | 0.05 |
| A2     |      | 0.203   |      |
| b      | 0.30 | 0.35    | 0.40 |
| D      | 2.90 | 3.00    | 3.10 |
| D1     | 2.35 | 2.40    | 2.45 |
| E      | 2.90 | 3.00    | 3.10 |
| E1     | 1.65 | 1.70    | 1.75 |
| e      |      | 0.65BSC |      |
| L      | 0.37 | 0.42    | 0.47 |
| N      |      | 8       |      |
| aaa    |      | 0.08    |      |
| bbb    |      | 0.10    |      |