# SPX29300 / SPX29301 / SPX29302

Data Sheet

3A Low Dropout Voltage Regulator

## General Description

The SPX29300/01/02 are 3A, highly accurate voltage regulators with a low dropout voltage of 600mV (typical) at 3A.

These regulators are specifically designed for low voltage applications that require a low dropout voltage and a fast transient response. They are fully fault protected against over-current, reverse battery, and positive and negative voltage transients. On-Chip trimming adjusts the reference voltage to 1% initial accuracy.

The SPX29300 is offered in a 3-pin TO-263 package, the SPX29301 and SPX29302 are offered in a 5-pin TO-263 package.

## Features

- 3A guaranteed output current
- Low dropout voltage of 600mV @ 3A
- Adjustable output down to 1.25V
- 1% output accuracy
- Tight load and line regulation
- Fast transient response
- Reverse battery protection
- Zero current shutdown (SPX29301/02)
- Power Good flag (SPX29301)
- Lead free 3-pin TO-263 and 5-pin TO-263 packages

## Applications

- Adjustable power supplies
- Constant current regulators
- Audio and video / graphic cards
- Battery chargers

Ordering Information - page 9

## Typical Application Diagram

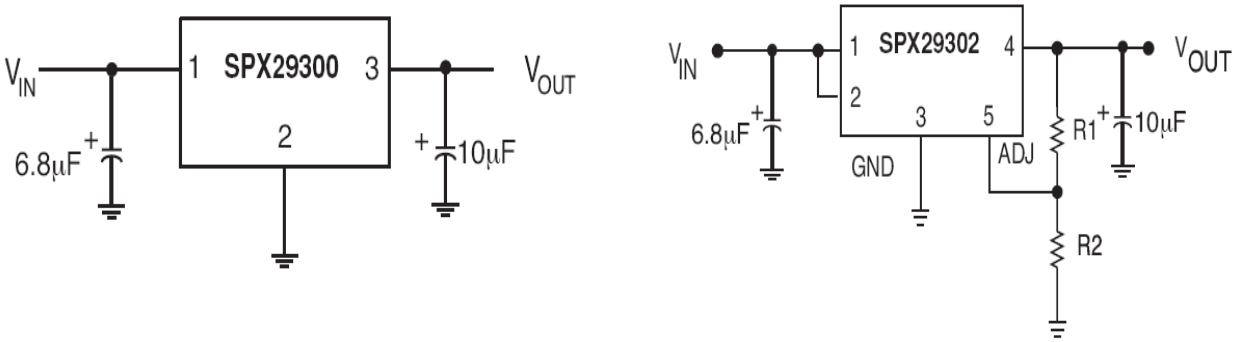



**Figure 1: SPX29300 and SPX29302 Application Diagrams**

# Revision History

| Revision | Release Date | Change Description |
|---|---|---|
| 1.0.0 | 12/17/2009 | Initial Release of Datasheet. |
| 2.0.0 | 3/31/2010 | Reformat of datasheet<br>Inserted ESD data<br>Modified Dropout Voltage and Ground Current values in electrical characteristics table<br>Corrected typographical error in result of calculus in note 8<br>Removed “Gound Current vs Load Current”, “Enable Threshold vs Temperature” and “Power Supply Rejection Ratio curves”<br>Updated “Dropout Voltage vs Load Current”, “Line Regulation” and “Load Regulation” curves<br>Added “start Up” curve |
| 2.1.0 | 10/19/2010 | Corrected Adjustable Regulator Design paragraph equation |
| 2.2.0 | 12/21/2016 | Updated package specification and ordering information. |
| 2.2.1 | 8/30/2019 | Updated to MaxLinear format. Updated ordering information and moved to end. Obsolete 1.8V version (SPX29300T-L-1-8/TR) removed. |
| 2.2.2 | 12/15/2020 | Clarified that package tabs are GND on pinout. |

# Table of Contents

# List of Figures

# List of Tables

# Specifications

## Absolute Maximum Ratings

**Important:** These are stress rating only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum ratings conditions for extended periods of time may affect reliability.

**Table 1: Absolute Maximum Ratings**

| Parameter | Minimum | Maximum | Units |
|---|---|---|---|
| Input voltage $V_{IN}$ (1) | | 20.0 | V |
| Storage temperature | -65 | 150 | °C |
| Lead temperature (soldering, 5 sec) | | 260 | °C |

1. Maximum positive supply voltage of 20V must be of limited duration (<100ms) and duty cycle of less than 1%. The maximum continuous supply voltage is 16V.

## ESD Ratings

**Table 2: ESD Ratings**

| Parameter | Value | Units |
|---|---|---|
| HBM (Human Body Model) all pins except EN | 2 | kV |
| HBM (Human Body Model) EN pin | 1 | kV |

## Operating Ratings

**Table 3: Operating Ratings**

| Parameter | Value | Units |
|---|---|---|
| Input voltage range $V_{IN}$ | 16 | V |
| Junction temperature range | -40 to 125 | °C |
| Thermal Resistance | | |
| TO-263-3 junction to ambient | 31.4 | °C/W |
| TO-263-5 junction to ambient | 31.2 | °C/W |
| TO-263-3, TO-263-5 junction to case | 3 | °C/W |

# Electrical Characteristics

Specifications with standard type are for an Operating Junction Temperature of $T_J = T_A = 25°C$ only; limits applying over the full Operating Junction Temperature range are denoted by a "•". Minimum and Maximum limits are guaranteed through test, design, or statistical correlation. Typical values represent the most likely parametric norm at $T_J = 25°C$, and are provided for reference purposes only. Unless otherwise noted, $V_{IN} = V_{OUT} + 1V$ and $I_{OUT} = 10mA$. $C_{IN} = 6.8\mu F$, $C_{OUT} = 10\mu F$, $T_A = 25°C$.

**Table 4: Electrical Characteristics**

| Parameter | Test Condition | | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|
| Fixed Voltage Versions | | | | | | |
| Output voltage, 2.5V version | $I_{OUT}$= 10mA | | 2.475 | 2.500 | 2.525 | V |
| | 10mA ≤ $I_{OUT}$ ≤ 3A, 3.5V ≤ $V_{IN}$ ≤ 16V | • | 2.450 | 2.500 | 2.550 | |
| Output voltage, 3.3V version | $I_{OUT}$= 10mA | | 3.267 | 3.300 | 3.333 | V |
| | 10mA ≤ $I_{OUT}$ ≤ 3A, 4.3V ≤ $V_{IN}$ ≤ 16V | • | 3.234 | 3.300 | 3.366 | |
| Output voltage, 5.0V version | $I_{OUT}$= 10mA | | 4.950 | 5.000 | 5.050 | V |
| | 10mA ≤ $I_{OUT}$ ≤ 3A, 6.0V ≤ $V_{IN}$ ≤ 16V | • | 4.900 | 5.000 | 5.100 | |
| All Voltage Versions | | | | | | |
| Line regulation | $I_{OUT}$= 10mA, ($V_{OUT}$ + 1V) ≤ $V_{IN}$ ≤ 16V | | | 0.06 | 0.5 | % |
| Load regulation | $V_{IN} = V_{OUT}$ + 1V, 10mA ≤ $I_{OUT}$ ≤ $I_{FL}$[2] | | | 0.2 | 1 | % |
| ΔV / ΔT | $V_{OUT}$ temp coefficient[6] | • | | 20 | 100 | ppm/°C |
| Dropout voltage[3] | $I_{OUT}$= 100mA | • | | 120 | 300 | mV |
| | $I_{OUT}$= 1.5A | | | 380 | | |
| | $I_{OUT}$= 3A | • | | 600 | 800 | |
| Ground current[5] | $I_{OUT}$= 1.5A | • | | 30 | 60 | mA |
| | $I_{OUT}$= 3A | | | 40 | | |
| Ground pin current at dropout | $V_{IN}$ = 0.5V less than specified $V_{OUT}$, $I_{OUT}$ = 10mA | | | 0.9 | | mA |
| Current limit | $V_{OUT}$ = 0V[4] | | 3.0 | 4.5 | | A |
| Output noise voltage | 10Hz - 100kHz, $I_{OUT}$ = 100mA, $C_{OUT}$ = 10μF | | | 400 | | $\mu V_{RMS}$ |
| | 10Hz - 100kHz, $I_{OUT}$ = 100mA, $C_{OUT}$ = 33μF | | | 260 | | |
| Reference voltage temperature coefficient[7] | | | | 20 | | ppm/°C |
| Reference Voltage and Adjustable Pin - SPX29302 | | | | | | |
| Reference voltage | | | 1.228 | 1.24 | 1.252 | V |
| | | • | 1.215 | | 1.265 | |
| | $V_{REF} ≤ V_{OUT} ≤ (V_{IN} - 1)$, 2.3 ≤ $V_{IN}$ ≤ 16V, 10mA ≤ $I_L$ ≤ $I_{FL}$, $T_J < T_{JMAX}$ | | 1.203 | | 1.277 | |
| Adjust pin bias current | | | | 40 | 80 | nA |
| | | • | | | 120 | |
| Adjust pin bias current temperature coefficient | | | | 0.1 | | nA/°C |

**Table 4: Electrical Characteristics**

| Parameter | Test Condition | | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|
| Power Good Flag Output - SPX29301 | | | | | | |
| Output leakage current | $V_{OH}$ = 16V | | | 0.01 | 1 | µA |
| | | • | | | 2 | |
| Output low voltage | Device set for 5V, $V_{IN}$ = 4.5V, $I_{OL}$ = 250µA | | | 220 | 300 | mV |
| | | • | | | 400 | |
| Upper threshold voltage | Device set for 5V(8) | | 40 | 60 | | mV |
| | | • | 25 | | | |
| Lower threshold voltage | Device set for 5V(8) | | | 75 | 95 | mV |
| | | • | | | 140 | |
| Hysteresis | Device set for 5V(8) | | | 15 | | mV |
| Enable Input - SPX29301 / 02 | | | | | | |
| Input logic voltage low (OFF) | $V_{IN}$ < 10V | • | | | 0.8 | V |
| Input logic voltage high (ON) | | • | 2.4 | | | |
| Enable input pin | $V_{EN}$ = 16V | | | 100 | 600 | µA |
| | | • | | | 750 | |
| | $V_{EN}$ = 0.8V | • | | | 1 | |
| | | • | | | 2 | |
| Regulator output current in shutdown(9) | | • | | 10 | 500 | µA |

2. Full load current ($I_{FL}$) is defined as 3.0A.

3. Dropout voltage is defined ($V_{IN}$ - $V_{OUT}$) when the output voltage drops to 99% of its nominal value.

4. $V_{IN}$ = $V_{OUT}$(nom) + 1V. Use pulse-testing procedures to minimize temperature rise.

5. Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the load current to the ground current.

6. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

7. Thermal regulation is defined as the change in output voltage at time T after a change in power dissipation is applied, excluding load / line regulation effects. Specifications for a 200mA load pulse as $V_{IN}$ = 20V (a 4W pulse) for t = 10ms.

8. Comparator threshold is expressed in terms of a voltage differential at the Adjust terminal below the nominal reference voltage measured 6V input. To express these thresholds in terms of output voltage change, multiply the error amplifier gain = $V_{OUT}$ / $V_{REF}$ = (R1 + R2) / R2. For example, at a programmable output voltage of 5V, the Error output is guaranteed to go low when the output drops by 95mV x 5V / 1.240V = 383mV. Threshold remains constant as a percent of $V_{OUT}$ as $V_{OUT}$ is varied, with the dropout warning occurring at typically 5% below nominal, 7.7% guaranteed.

9. $V_{EN} \leq 0.8V$ and $V_{IN} \leq 16V$, $V_{OUT}$ = 0V.

# Block Diagram

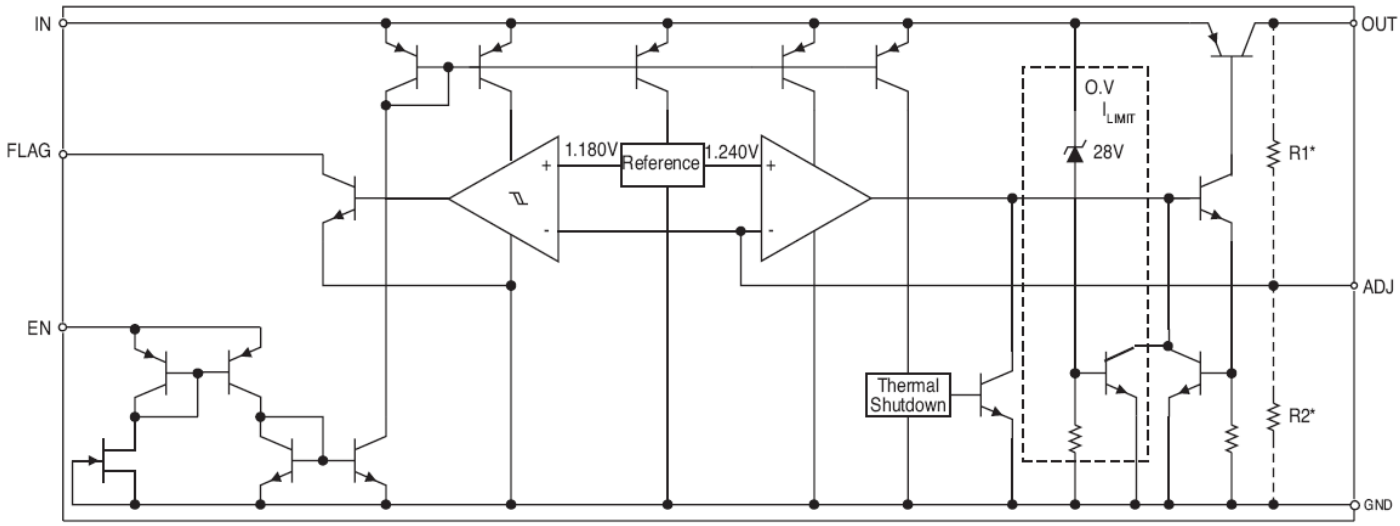
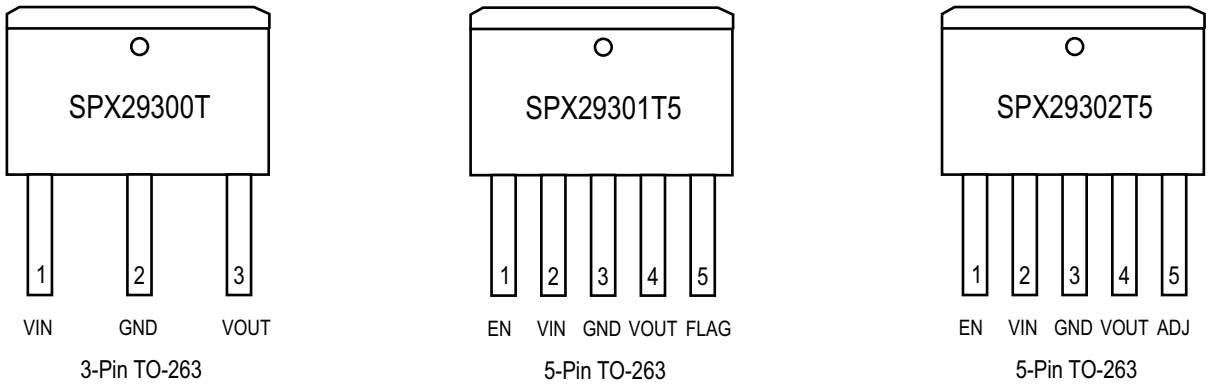



**Figure 2: SPX29300, SPX29301, SPX29302 Block Diagram**

# Pin Information(1)




1. On all devices, the Tab is GND.

**Figure 3: SPX29300, SPX29301, SPX29302 Pin Assignments**

# Typical Performance Characteristics

All data taken at $V_{IN} = V_{OUT} + 1V$, $T_J = T_A = 25°C$, unless otherwise specified.

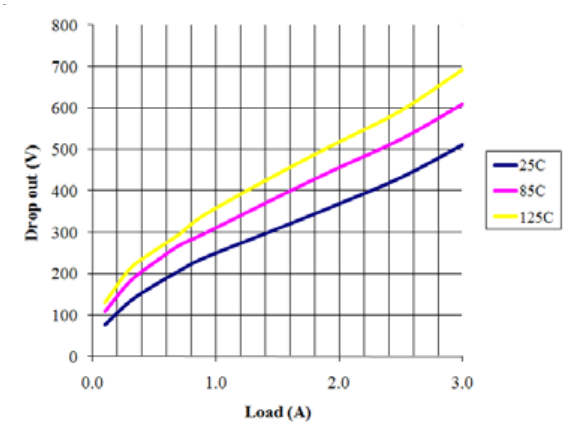



**Figure 4: Dropout Voltage vs. Load Current**

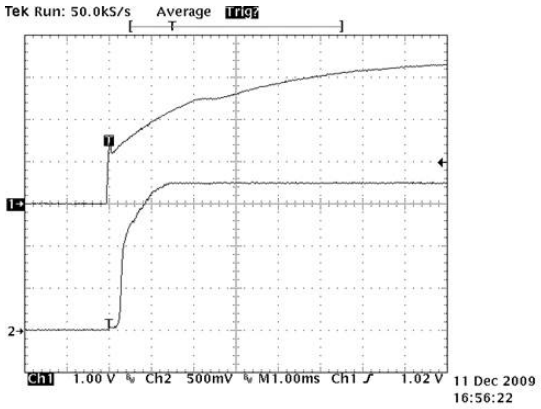



**Figure 5: Startup**

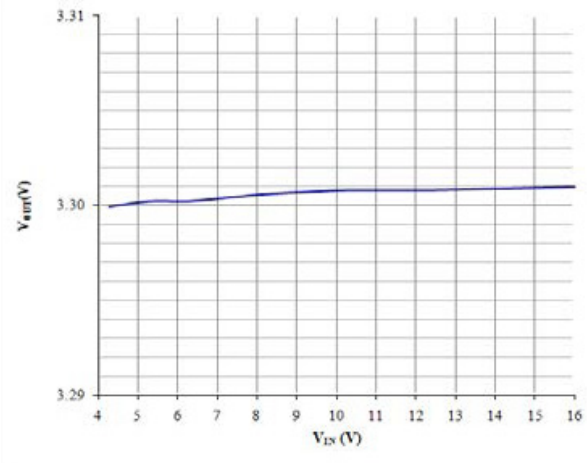



**Figure 6: Line Regulation: $I_{OUT}$ = 10mA, $V_{OUT}$ = 3.3V**

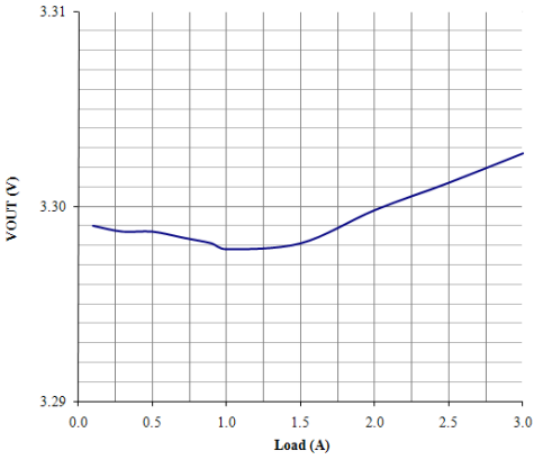



**Figure 7: Load Regulation: $V_{OUT}$ = 3.3V**

# Theory of Operation

The SPX29300/01/02 incorporates protection against over-current faults, reversed load insertion, over temperature operation, and positive and negative transient voltage.

## Thermal Considerations

Although the SPX29300/01/02 offers limiting circuitry for overload conditions, it is still necessary to insure that the maximum junction temperature is not exceeded in the application. Heat will flow through the lowest resistance path, the junction-to-case path. In order to insure the best thermal flow of the component, proper mounting is required.

## TO-263 Design Example

Assume that $V_{IN}$ = 5V, $V_{OUT}$ = 3.3V, $I_{OUT}$ = 1.0A, $T_A$ = 50°C and $\theta_{JA}$ = 31.4°C/W, where:

$T_A$ = ambient temperature,

$\theta_{JA}$ = junction to ambient thermal resistance

The power calculated under these conditions is:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} = 1.7W$$

And the junction temperature is calculated as

$$T_J = T_A + P_D \times \theta_{JA}$$

or

$$T_J = 50 + 1.7 \times 31.4 = 103.4°C$$

Reliable operation is insured.

## Capacitor Requirements

The output capacitor is needed to insure stability and minimize the output noise. The value of the capacitor varies with the load. However, a minimum value of 10µF aluminum capacitor will guarantee stability over all load conditions.

A tantalum capacitor is recommended if a faster load transient response is needed. If the power source has high AC impedance, a 0.1µF ceramic capacitor between input and ground is recommended.

## Minimum Load Current

To ensure a proper behavior of the regulator under light load, a minimum load of 5mA for SPX29300/01/02 is required.

## Adjustable Regulator Design

The SPX29300/01/02 is an adjustable regulator that can be programmed to any value between 1.25V and 16V using 2 external resistors, R1 and R2. The relationship between the resistors and the output voltage is:

$$R_1 = R_2 \times \left(\frac{V_{OUT}}{1.240} - 1\right)$$

## Error Flag

The SPX29301 features an error flag that indicates either an over current or under current voltage condition. The flag output goes low, sinking 10mA when either condition occurs.

## Enable Input

The SPX29301/02 has an Enable function that switches the regulator on and off. Its thresholds are TTL compatible. When the regulator is active, approximately 20µA flows through the Enable pin.

## Typical Application Circuits

Figure 1 represents the typical implementation for an adjustable output regulator. The values of R1 and R2 set the output voltage value as follows:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_1}{R_2}\right)$$

A minimum value of 10kΩ is recommended for R2 with a range between 10kΩ and 47kΩ.

# Mechanical Dimensions

## 3-pin and 5-pin TO-263

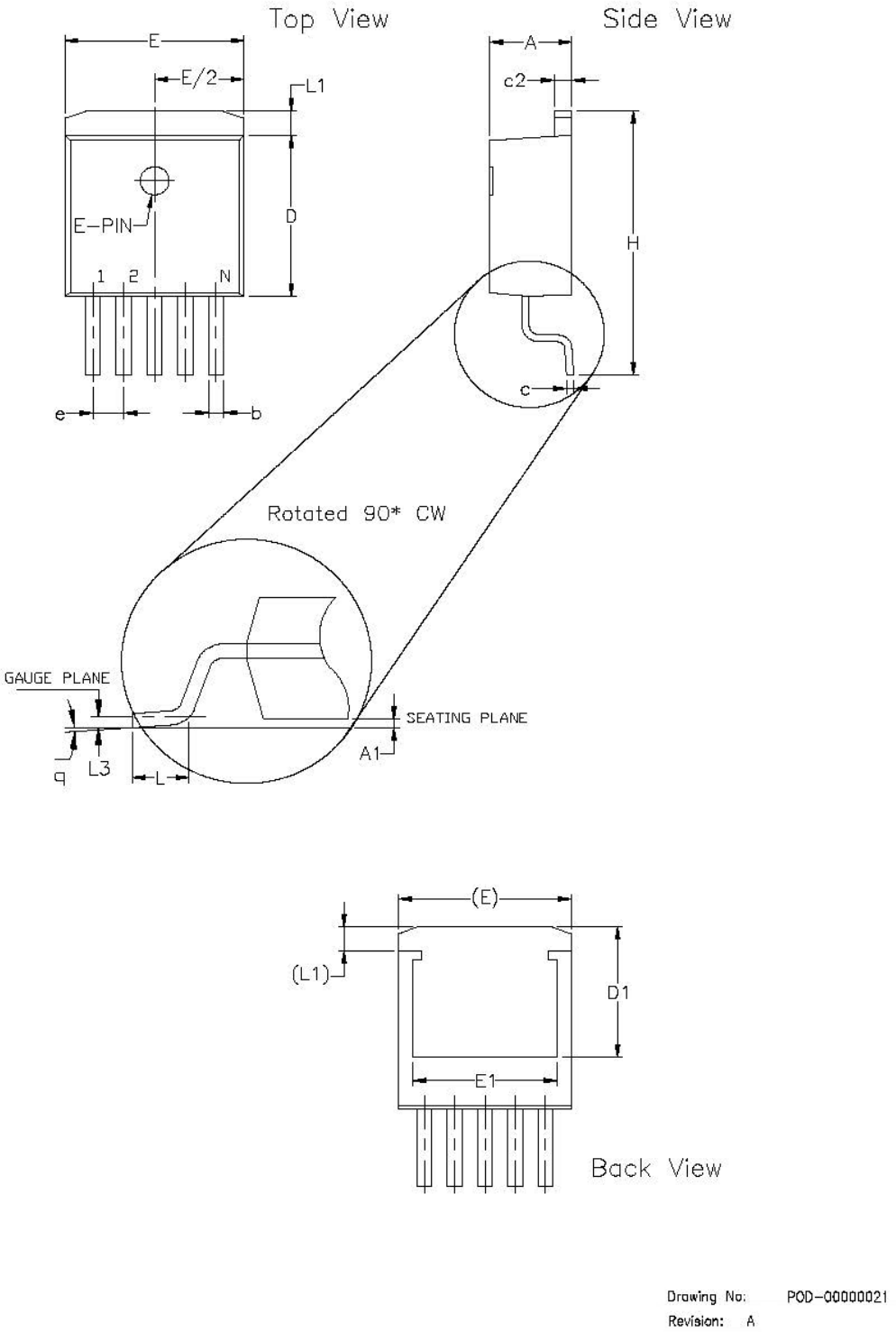



**Figure 8: Mechanical Dimensions, 3-pin and 5-pin TO-263**

# Mechanical Dimensions, continued

## 3-pin and 5-pin TO-263, continued

| 3 Pin TO-263 JEDEC TO-263 Variation AA | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOLS | DIMENSIONS IN INCH (Control Unit) | | | DIMENSIONS IN MM (Reference Unit) | | |
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 0.160 | — | 0.190 | 4.06 | — | 4.83 |
| A1 | 0.000 | — | 0.010 | 0.00 | — | 0.25 |
| b | 0.020 | — | 0.039 | 0.51 | — | 0.99 |
| b2 | 0.045 | — | 0.070 | 1.14 | — | 1.78 |
| c | 0.015 | — | 0.029 | 0.38 | — | 0.74 |
| c2 | 0.045 | — | 0.065 | 1.14 | — | 1.65 |
| D | 0.330 | — | 0.380 | 8.38 | — | 9.65 |
| D1 | 0.270 | — | — | 6.86 | — | — |
| E | 0.380 | — | 0.420 | 9.65 | — | 10.67 |
| E1 | 0.245 | — | — | 6.22 | — | — |
| e | 0.100 BSC | | | 2.54 BSC | | |
| H | 0.575 | — | 0.625 | 14.61 | — | 15.88 |
| L | 0.070 | — | 0.110 | 1.78 | — | 2.79 |
| L1 | — | — | 0.066 | — | — | 1.68 |
| L3 | 0.010 BSC | | | 0.25 BSC | | |
| q | 0° | | 8° | 0° | | 8° |
| N | 3 | | | 3 | | |

| 5 Pin TO-263 JEDEC TO-263 Variation BA | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOLS | DIMENSIONS IN INCH (Control Unit) | | | DIMENSIONS IN MM (Reference Unit) | | |
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 0.160 | — | 0.190 | 4.06 | — | 4.83 |
| A1 | 0.000 | — | 0.010 | 0.00 | — | 0.25 |
| b | 0.020 | — | 0.039 | 0.51 | — | 0.99 |
| c | 0.015 | — | 0.029 | 0.38 | — | 0.74 |
| c2 | 0.045 | — | 0.065 | 1.14 | — | 1.65 |
| D | 0.330 | — | 0.380 | 8.38 | — | 9.65 |
| D1 | 0.270 | — | — | 6.86 | — | — |
| E | 0.380 | — | 0.420 | 9.65 | — | 10.67 |
| E1 | 0.245 | — | — | 6.22 | — | — |
| e | 0.067 BSC | | | 1.70 BSC | | |
| H | 0.575 | — | 0.625 | 14.61 | — | 15.88 |
| L | 0.070 | — | 0.110 | 1.78 | — | 2.79 |
| L1 | — | — | 0.066 | — | — | 1.68 |
| L3 | 0.010 BSC | | | 0.25 BSC | | |
| q | 0° | | 8° | 0° | | 8° |
| N | 5 | | | 5 | | |

Drawing No: POD-00000021
Revision: A

**Figure 9: Mechanical Dimensions, 3-pin and 5-pin TO-263, continued**

# Ordering Information

**Table 5: Ordering Information**

| Ordering Part Number | Operating Temperature Range | Package | Packaging Method | Lead-Free(2) |
|---|---|---|---|---|
| SPX29300T-L-2-5/TR | -40°C ≤ $T_J$ ≤ 125°C | 3-pin TO-263 | Tape and Reel | Yes |
| SPX29300T-L-3-3/TR | -40°C ≤ $T_J$ ≤ 125°C | 3-pin TO-263 | Tape and Reel | Yes |
| SPX29300T-L-5-0/TR | -40°C ≤ $T_J$ ≤ 125°C | 3-pin TO-263 | Tape and Reel | Yes |
| SPX29301T5-L-5-0/TR | -40°C ≤ $T_J$ ≤ 125°C | 5-pin TO-263 | Tape and Reel | Yes |
| SPX29302T5-L/TR | -40°C ≤ $T_J$ ≤ 125°C | 5-pin TO-263 | Tape and Reel | Yes |

1. Refer to www.maxlinear.com/SPX29300, www.maxlinear.com/SPX29301, and www.maxlinear.com/SPX29302 for most up-to-date Ordering Information.

2. Visit www.maxlinear.com for additional information on Environmental Rating.

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