## ABSOLUTE MAXIMUM RATINGS

These are stress ratings 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 rating conditions for extended periods of time may affect reliability.

Input Voltage $V_{IN}$[1] ..... 20V
Storage Temperature ..... -65°C to 150°C
Lead Temperature (Soldering, 5 sec) ..... 260°C
ESD Rating (HBM - Human Body Model) .....
All pins except EN ..... 2kV
En pin ..... 1kV

## OPERATING RATINGS

Input Voltage Range $V_{IN}$ ..... 16V
Junction Temperature Range ..... -40°C to 125°C
Thermal Resistance .....
TO-220-5 Junction to Ambient ..... 29.3°C/W
TO-263-3 Junction to Ambient ..... 31.4°C/W
TO-263-5 Junction to Ambient ..... 31.2°C/W
TO-220-5, TO-263-3, TO-263-5 Junction to Case .. 3°C/W

Note 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.

## ELECTRICAL SPECIFICATIONS

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 indicated, $V_{IN} = V_{OUT} + 1V$ and $I_{OUT}$=10mA, $C_{IN}$ = 6.8µF, $C_{OUT}$ = 10µF, $T_A$= 25°C.

| Parameter | Min. | Typ. | Max. | Units | | Conditions |
|---|---|---|---|---|---|---|
| **Fixed Voltage Versions** | | | | | | |
| Output Voltage, 1.8V Version | 1.782 | 1.800 | 1.818 | V | | $I_{OUT}$=10mA |
| | 1.764 | 1.800 | 1.836 | | • | 10mA≤$I_{OUT}$≤3A, 2.8V≤$V_{IN}$≤16V |
| Output Voltage, 2.5V Version | 2.475 | 2.500 | 2.525 | V | | $I_{OUT}$=10mA |
| | 2.450 | 2.500 | 2.550 | | • | 10mA≤$I_{OUT}$≤3A, 3.5V≤$V_{IN}$≤16V |
| Output Voltage, 3.3V Version | 3.267 | 3.300 | 3.333 | V | | $I_{OUT}$=10mA |
| | 3.234 | 3.300 | 3.366 | | • | 10mA≤$I_{OUT}$≤3A, 4.3V≤$V_{IN}$≤16V |
| Output Voltage, 5.0V Version | 4.950 | 5.000 | 5.050 | V | | $I_{OUT}$=10mA |
| | 4.900 | 5.000 | 5.100 | | • | 10mA≤$I_{OUT}$≤3A, 6.0V≤$V_{IN}$≤16V |
| **All Voltage Versions** | | | | | | |
| Line Regulation | | 0.06 | 0.5 | % | | $I_{OUT}$=10mA, ($V_{OUT}$+1V)≤$V_{IN}$≤16V |
| Load Regulation | | 0.2 | 1 | % | | $V_{IN}$=$V_{OUT}$ + 1V, 10mA≤$I_{OUT}$ ≤$I_{FL}$ (note 2) |
| ΔV/ΔT | | 20 | 100 | ppm/°C | • | $V_{OUT}$ Temp Coefficient (note 6) |
| Dropout Voltage Except 1.8V Version (note 3) | | 120 | 300 | mV | • | $I_{OUT}$=100mA |
| | | 380 | | | | $I_{OUT}$=1.5A |
| | | 600 | 800 | | • | $I_{OUT}$=3A |
| Ground Current (note 5) | | 30 | 60 | mA | • | $I_{OUT}$=1.5A |
| | | 40 | | | | $I_{OUT}$=3A |
| Ground Pin Current at Dropout | | 0.9 | | mA | | $V_{IN}$ = 0.5V less than specified $V_{OUT}$ $I_{OUT}$=10mA |
| Current Limit | 3.0 | 4.5 | | A | | $V_{OUT}$=0V (note 4) |
| Output Noise Voltage | | 400 | | $\mu V_{RMS}$ | | 10Hz-100KHz, $I_{OUT}$=100mA, $C_{OUT}$=10µF |
| | | 260 | | | | 10Hz-100KHz, $I_{OUT}$=100mA, $C_{OUT}$=33µF |
| Reference Voltage Temperature Coefficient | | 20 | | ppm/°C | | Note 7 |
| **Reference Voltage and Adjustable Pin - SPX29302** | | | | | | |
| Reference Voltage | 1.228 | 1.24 | 1.252 | V | | |
| | 1.215 | | 1.265 | | • | |
| | 1.203 | | 1.277 | | | $V_{REF}$≤$V_{OUT}$≤($V_{IN}$-1), 2.3V≤$V_{IN}$≤16V<br>10mA≤$I_L$≤$I_{FL}$, $T_J$<$T_{JMAX}$ |
| Adjust Pin Bias Current | | 40 | 80 | nA | | |
| | | | 120 | | • | |
| Adjust Pin Bias Current Temperature Coefficient | | 0.1 | | nA/°C | | |

| Parameter | Min. | Typ. | Max. | Units | | Conditions |
|---|---|---|---|---|---|---|
| **Power Good Flag Output – SPX29301** | | | | | | |
| Output Leakage Current | | 0.01 | 1 | µA | | $V_{OH}$=16V |
| | | | 2 | | • | |
| Output Low Voltage | | 220 | 300 | mV | | Device set for 5V, $V_{IN}$=4.5V, $I_{OL}$=250µA |
| | | | 400 | | • | |
| Upper Threshold Voltage | 40 | 60 | | mV | | Device set for 5V, Note 8 |
| | 25 | | | | • | |
| Lower Threshold Voltage | | 75 | 95 | mV | | Device set for 5V, Note 8 |
| | | | 140 | | • | |
| Hysteresis | | 15 | | mV | | Device set for 5V, Note 8 |
| **Enable Input – SPX29301/02** | | | | | | |
| Input Logic Voltage Low (OFF) | | | 0.8 | V | • | $V_{IN}$<10V |
| Input Logic Voltage High (ON) | 2.4 | | | | • | |
| Enable Input Pin | | 100 | 600 | µA | | $V_{EN}$=16V |
| | | | 750 | | • | |
| | | | 1 | | • | $V_{EN}$=0.8V |
| | | | 2 | | • | |
| Regulator Output Current in Shutdown | | 10 | 500 | µA | • | Note 9 |

Note 2: Full load current ($I_{FL}$) is defined as 3.0A.
Note 3: Dropout voltage is defined ($V_{IN}$-$V_{OUT}$) when the output voltage drops to 99% of its nominal value.
Note 4: $V_{IN}$=$V_{OUT}$(nom)+1V. Use pulse-testing procedures to minimize temperature rise.
Note 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.
Note 6: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range
Note 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.
Note 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 95mVx 5V/ 1.240V = 383mV. Threshold remain 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.
Note 9: $V_{EN}$ ≤ 0.8V and $V_{IN}$ ≤ 16V, $V_{OUT}$ = 0.

## BLOCK DIAGRAM

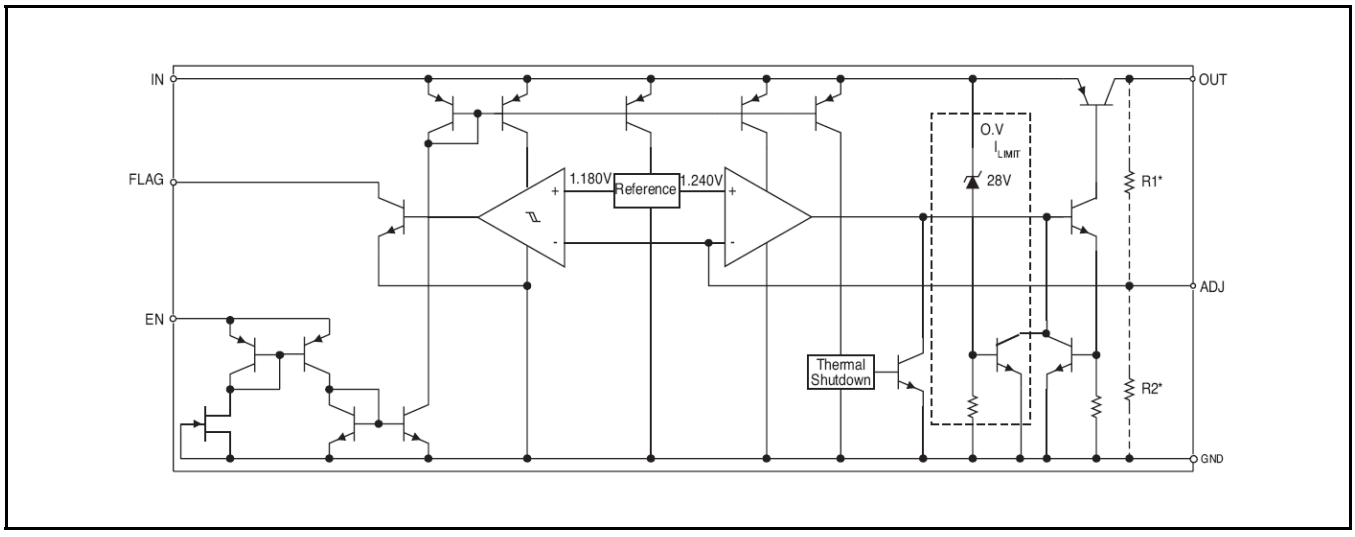



Fig. 2: SPX29300/01/02 Block Diagram

## PIN ASSIGNMENT

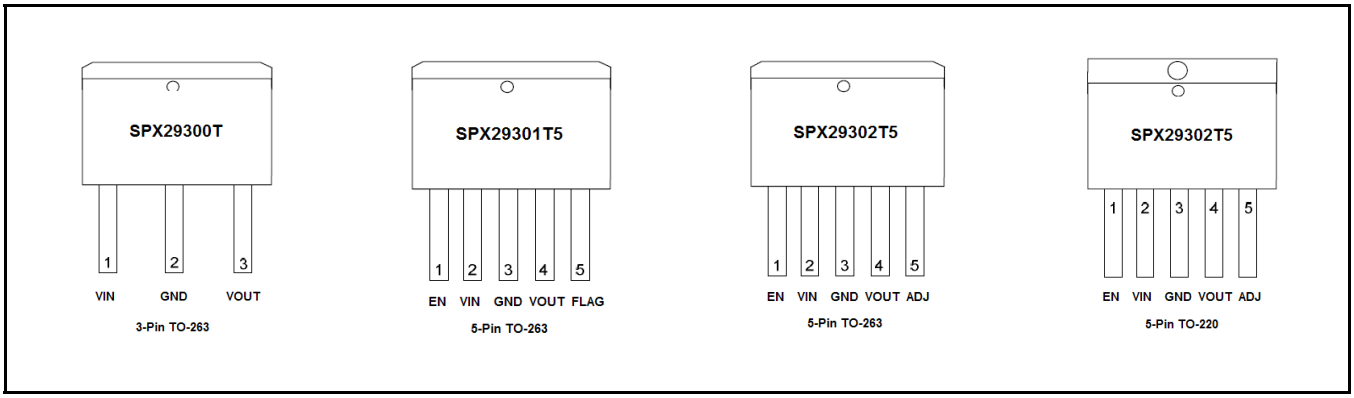



Fig. 3: SPX29300/01/02 Pin Assignment

## ORDERING INFORMATION

| Part Number | Junction Temperature Range | Marking | Package | Packing Quantity | Note 1 | Note 2 |
|---|---|---|---|---|---|---|
| SPX29300T-L-1-8 | -40°C≤$T_J$≤+125°C | SPX29300T 18YYWWLX | 3-pin TO263 | Bulk | Lead Free | |
| SPX29300T-L-1-8/TR | -40°C≤$T_J$≤+125°C | SPX29300T 18YYWWLX | 3-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29300T-L-2-5 | -40°C≤$T_J$≤+125°C | SPX29300T 25YYWWLX | 3-pin TO263 | Bulk | Lead Free | |
| SPX29300T-L-2-5/TR | -40°C≤$T_J$≤+125°C | SPX29300T 25YYWWLX | 3-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29300T-L-3-3 | -40°C≤$T_J$≤+125°C | SPX29300T 33YYWWLX | 3-pin TO263 | Bulk | Lead Free | |
| SPX29300T-L-3-3/TR | -40°C≤$T_J$≤+125°C | SPX29300T 33YYWWLX | 3-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29300T-L-5-0 | -40°C≤$T_J$≤+125°C | SPX29300T 50YYWWLX | 3-pin TO263 | Bulk | Lead Free | |
| SPX29300T-L-5-0/TR | -40°C≤$T_J$≤+125°C | SPX29300T 50YYWWLX | 3-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29301T5-L-3-3 | -40°C≤$T_J$≤+125°C | 293001T5 33YYWWLX | 5-pin TO263 | Bulk | Lead Free | |
| SPX29301T5-L-3-3/TR | -40°C≤$T_J$≤+125°C | 293001T5 33YYWWLX | 5-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29301T5-L-5-0 | -40°C≤$T_J$≤+125°C | 293001T5 50YYWWLX | 5-pin TO263 | Bulk | Lead Free | |
| SPX29301T5-L-5-0/TR | -40°C≤$T_J$≤+125°C | 293001T5 50YYWWLX | 5-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29302T5-L | -40°C≤$T_J$≤+125°C | 29302T5 YYWWLX | 5-pin TO263 | Bulk | Lead Free | |
| SPX29302T5-L/TR | -40°C≤$T_J$≤+125°C | 29302T5 YYWWLX | 5-pin TO263 | 500/Tape & Reel | Lead Free | |
| SPX29302U5-L | -40°C≤$T_J$≤+125°C | 29302U5 YYWWLX | 5-pin TO220 | Bulk | Lead Free | |

"YY" = Year – "WW" = Work Week – "L" = Lead Free Designator – "X" = Lot Number

## TYPICAL PERFORMANCE CHARACTERISTICS

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

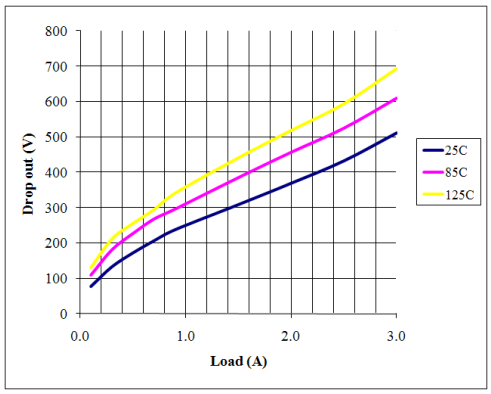



Fig. 4: Dropout Voltage vs Load Current

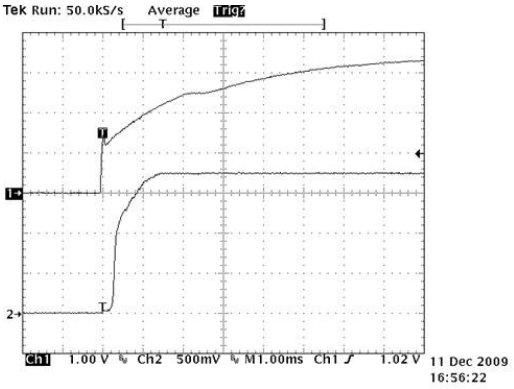



Fig. 5: Startup

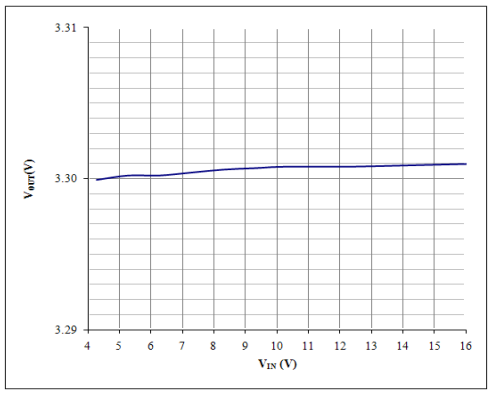



Fig. 6: Line Regulation
$I_{OUT}$=10mA, $V_{OUT}$=3.3V

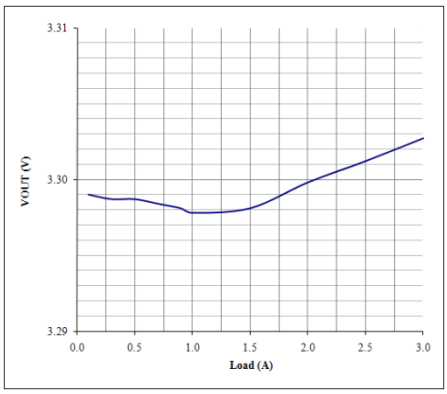



Fig. 7: Load Regulation
$V_{OUT}$=3.3V

## 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-220 DESIGN EXAMPLE:

Assume that $V_{IN}$ = 10V, $V_{OUT}$ = 5V, $I_{OUT}$ = 1.5A, $T_A$ = 50°C, $\theta_{HA}$= 1°C/W, $\theta_{CH}$= 2°C/W, and $\theta_{JC}$= 3C°/W, where:

$T_A$ = ambient temperature,

$\theta_{HA}$= heatsink to ambient thermal resistance

$\theta_{CH}$= case to heatsink thermal resistance

$\theta_{JC}$ = junction to case thermal resistance

The power calculated under these conditions is:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} = 7.5W$$

And the junction temperature is calculated as

$$T_J = T_A + P_D \times (\theta_{HA} + \theta_{CH} + \theta_{JC})$$

or

$$T_J = 50 + 7.5 \times (1 + 2 + 3) = 95°C$$

Reliable operation is insured.Capacitor Requirements

### 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 & 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 conditions occurs.

### ENABLE INPUT

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

### TYPICAL APPLICATION CIRCUITS

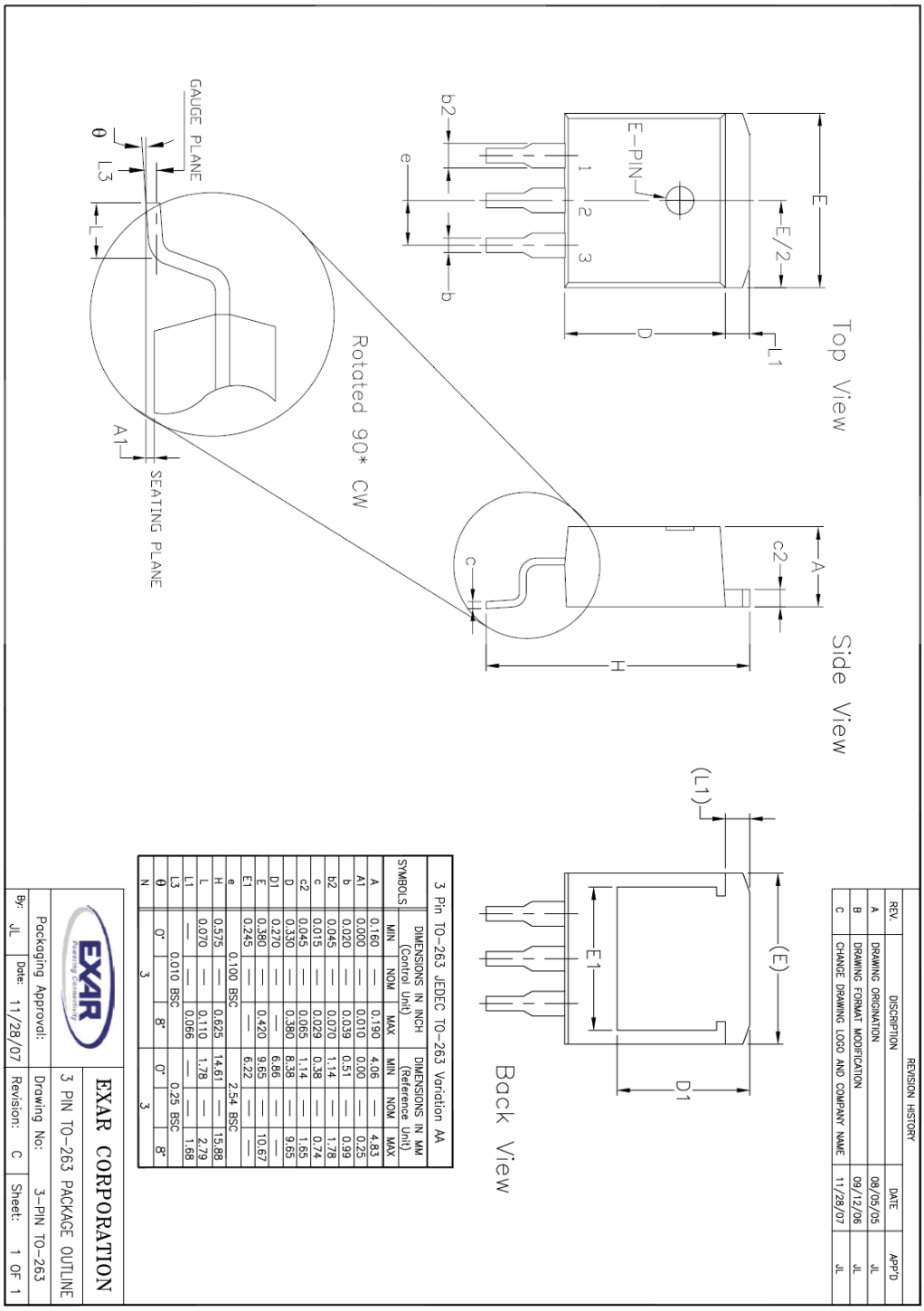
Figure 1 represents the typical implementation for an adjustable output regulator. The values of R1 and R2 set the output voltage value as follows:

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

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

## PACKAGE SPECIFICATION

### 3-PIN TO-263




REVISION HISTORY

| REV. | DISCRIPTION | DATE | APP'D |
|---|---|---|---|
| A | DRAWING ORIGINATION | 08/05/05 | JL |
| B | DRAWING FORMAT MODIFICATION | 09/12/06 | JL |
| C | CHANGE DRAWING LOGO AND COMPANY NAME | 11/28/07 | JL |

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 | |
| θ | 0° | 8° | | 0° | | 8° |
| N | 3 | | | 3 | | |

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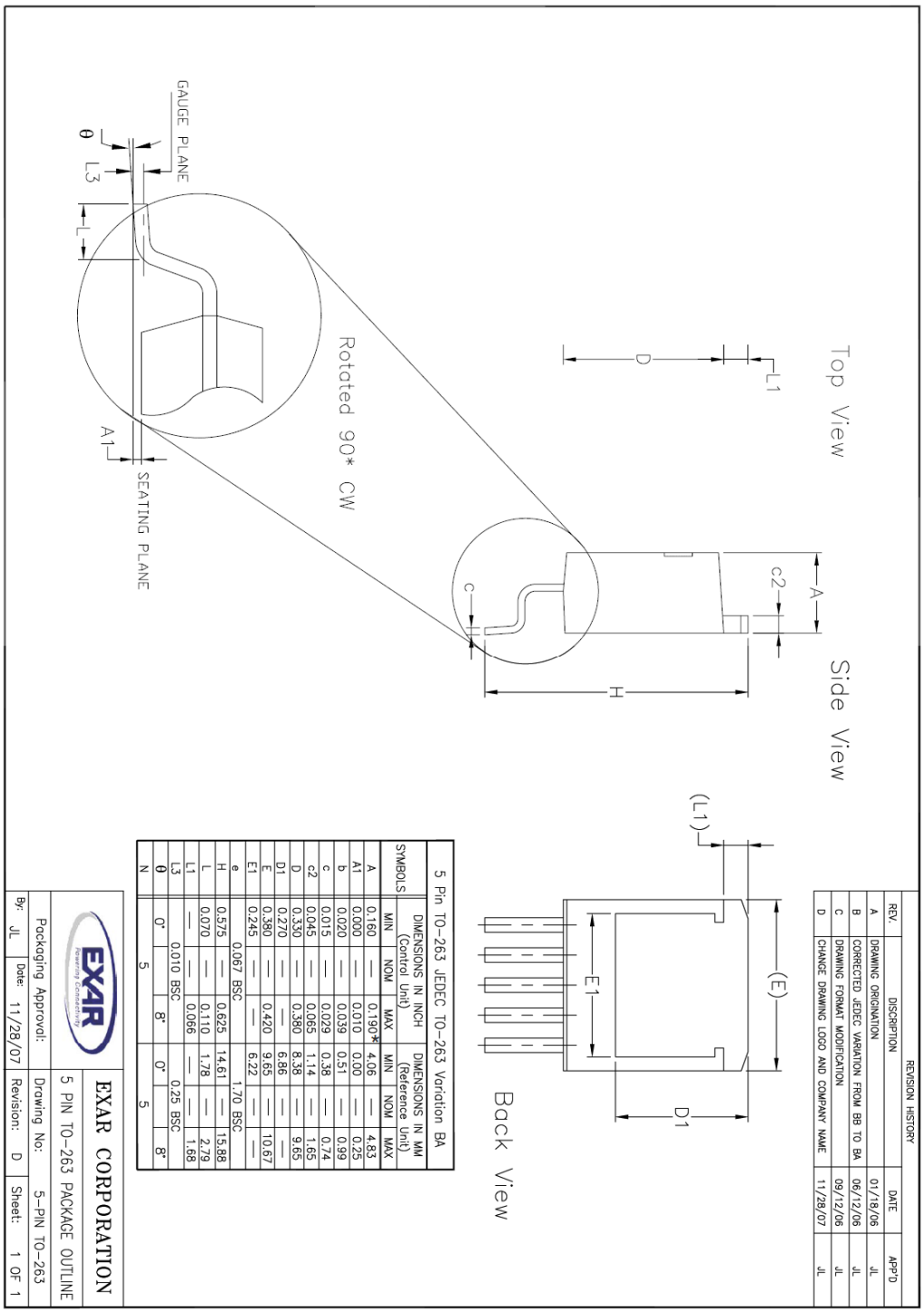
| | | | |
|---|---|---|---|
| 3 PIN TO-263 PACKAGE OUTLINE | | | |
| Packaging Approval: | Drawing No: | 3-PIN TO-263 | |
| By: JL | Date: 11/28/07 | Revision: C | Sheet: 1 OF 1 |

## 5-PIN TO-263




| REVISION HISTORY | | | |
|---|---|---|---|
| REV. | DISCRIPTION | DATE | APP'D |
| A | DRAWING ORGINATION | 01/18/06 | JL |
| B | CORRECTED JEDEC VARIATION FROM BB TO BA | 06/12/06 | JL |
| C | DRAWING FORMAT MODIFICATION | 09/12/06 | JL |
| D | CHANGE DRAWING LOGO AND COMPANY NAME | 11/28/07 | JL |

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 | |
| θ | 0° | 8° | | 0° | | 8° |
| N | 5 | | | 5 | | |

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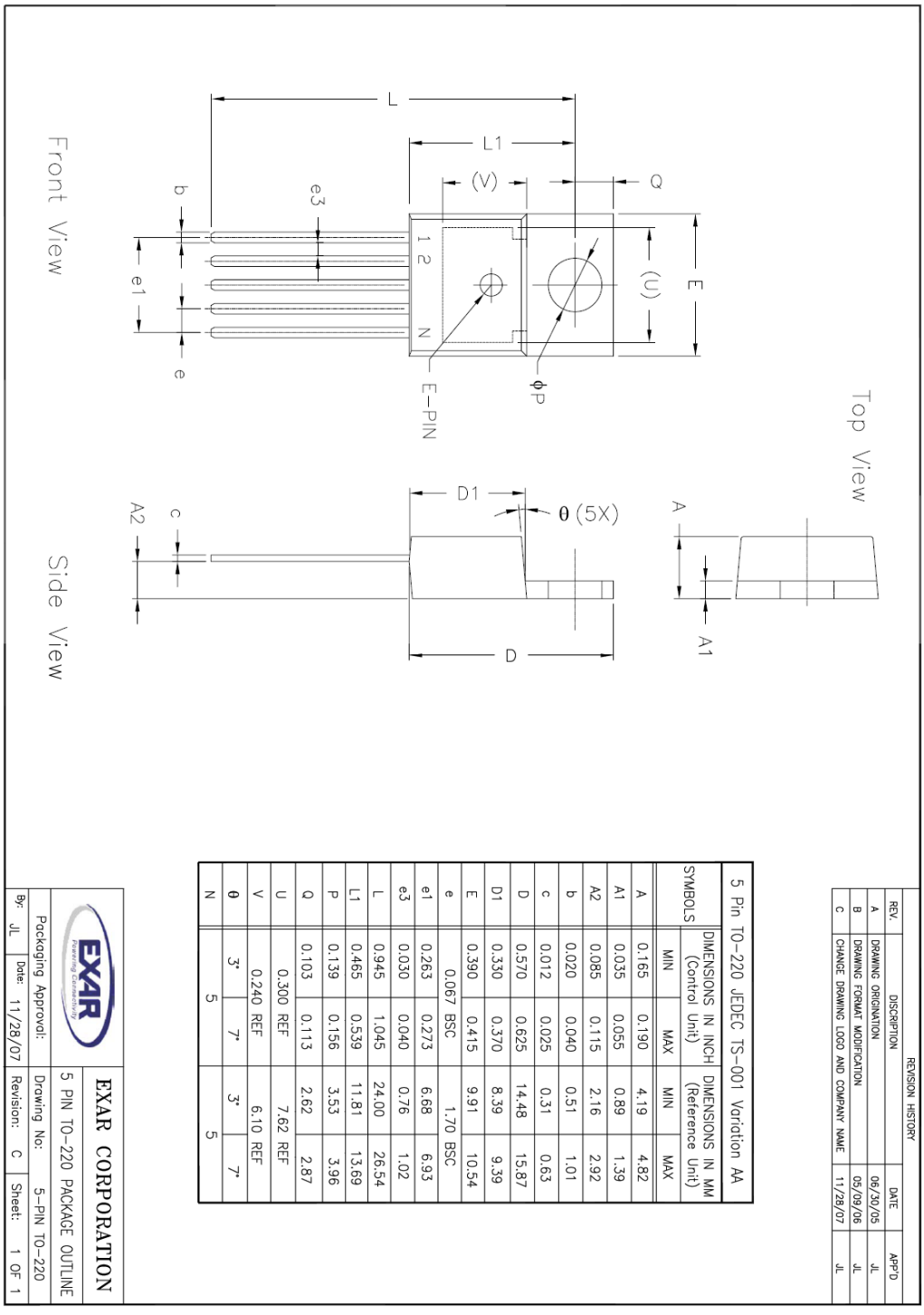
5 PIN TO-263 PACKAGE OUTLINE

| Packaging Approval: | Drawing No: | 5-PIN TO-263 |
|---|---|---|
| By: JL | Revision: D | Sheet: 1 OF 1 |
| Date: 11/28/07 | | |

## 5-PIN TO-220




| REVISION HISTORY | | | |
|---|---|---|---|
| REV. | DISCRIPTION | DATE | APP'D |
| A | DRAWING ORIGINATION | 06/30/05 | JL |
| B | DRAWING FORMAT MODIFICATION | 05/09/06 | JL |
| C | CHANGE DRAWING LOGO AND COMPANY NAME | 11/28/07 | JL |

5 Pin TO-220 JEDEC TS-001 Variation AA

| SYMBOLS | DIMENSIONS IN INCH (Control Unit) | | DIMENSIONS IN MM (Reference Unit) | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.165 | 0.190 | 4.19 | 4.82 |
| A1 | 0.035 | 0.055 | 0.89 | 1.39 |
| A2 | 0.085 | 0.115 | 2.16 | 2.92 |
| b | 0.020 | 0.040 | 0.51 | 1.01 |
| c | 0.012 | 0.025 | 0.31 | 0.63 |
| D | 0.570 | 0.625 | 14.48 | 15.87 |
| D1 | 0.330 | 0.370 | 8.39 | 9.39 |
| E | 0.390 | 0.415 | 9.91 | 10.54 |
| e | 0.067 BSC | | 1.70 BSC | |
| e1 | 0.263 | 0.273 | 6.68 | 6.93 |
| e3 | 0.030 | 0.040 | 0.76 | 1.02 |
| L | 0.945 | 1.045 | 24.00 | 26.54 |
| L1 | 0.465 | 0.539 | 11.81 | 13.69 |
| P | 0.139 | 0.156 | 3.53 | 3.96 |
| Q | 0.103 | 0.113 | 2.62 | 2.87 |
| U | 0.300 REF | | 7.62 REF | |
| V | 0.240 REF | | 6.10 REF | |
| θ | 3° | 7° | 3° | 7° |
| N | 5 | | 5 | |

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5 PIN TO-220 PACKAGE OUTLINE

| Packaging Approval: | Drawing No: | 5-PIN TO-220 |
|---|---|---|
| By: JL Date: 11/28/07 | Revision: C | Sheet: 1 OF 1 |

## REVISION HISTORY

| Revision | Date | Description |
|---|---|---|
| 1.0.0 | 12/17/2009 | Initial Release of Datasheet |
| 2.0.0 | 03/31/2010 | 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 |

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