

| <div><div>TSC</div><div></div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <div>TS39151/52</div> <div>1.5A Ultra Low Dropout Positive Voltage Regulator</div> |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------------|----------------------------|------------|--------------|----------------|-----------|--------------|-----------|---------------------------|-----------|------------|-----------|-------------------------------------|--|---|---|--|--|----------|--|
| <div><div>TO-220-5L</div><div></div></div> <div><div>TO-263-5L</div><div></div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                    | <div>Low Dropout Voltage 0.4V (typ.)</div> <div>Enable Input Control</div> <div>Adjustable Output</div> <div>Error Flag Detection</div>                                                                                                                                                                                                                                                                                                                      |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| <div>General Description</div> <div>The TS39151/52 series are 1.5A ultra low dropout linear voltage regulators that provide low voltage, high current output from an extremely small package. These regulator offers extremely low dropout (typically 400mV at 1.5A) and very low ground current (typically 12mA at 1.5A).</div> <div>The TS39151/52 series are fully protected against over current faults, reversed input polarity, reversed lead insertion, over temperature operation, positive and negative transient voltage spikes, logic level enable control and error flag which signals whenever the output falls out of regulation.</div> <div>On the TS39151/52, the enable pin may be tied to Vin if it is not required for enable control. This series are offered in 5-pin TO-220, TO-263 package.</div> |                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| <div>Features</div> <div><div>✧ Dropout voltage typically 0.4V @Io=1.5A</div><div>✧ Output current up to 1.5A</div><div>✧ Low ground current</div><div>✧ Output voltage trimmed before assembly</div><div>✧ Extremely fast transient response</div><div>✧ Reversed leakage protection</div><div>✧ Reverse battery protection</div><div>✧ Error flag signals output out of regulation</div><div>✧ Internal current limit</div><div>✧ Thermal shutdown protection</div></div>                                                                                                                                                                                                                                                                                                                                              |                                                                                    | <div>Ordering Information</div> <table><tr><th>Part No.</th><th>Operating Temp. (Junction)</th><th>Package</th></tr><tr><td>TS39151CZ5xx</td><td rowspan="4">-40 ~ +125 °C</td><td>TO-220-5L</td></tr><tr><td>TS39151CM5xx</td><td>TO-263-5L</td></tr><tr><td>TS39152CZ5</td><td>TO-220-5L</td></tr><tr><td>TS39152CM5</td><td>TO-263-5L</td></tr></table> <div>Note: Where <u>xx</u> denotes voltage option, available are 5.0V, 3.3V, 2.5V and 1.8V.</div> |    | Part No.       | Operating Temp. (Junction) | Package    | TS39151CZ5xx | -40 ~ +125 °C  | TO-220-5L | TS39151CM5xx | TO-263-5L | TS39152CZ5                | TO-220-5L | TS39152CM5 | TO-263-5L |                                     |  |   |   |  |  |          |  |
| Part No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Operating Temp. (Junction)                                                         | Package                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| TS39151CZ5xx                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | -40 ~ +125 °C                                                                      | TO-220-5L                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| TS39151CM5xx                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                    | TO-263-5L                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| TS39152CZ5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                    | TO-220-5L                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| TS39152CM5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                    | TO-263-5L                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| <div>Applications</div> <div><div><div>✧ Battery power equipment</div><div>✧ LDO linear regulator for PC add-in cards</div><div>✧ PowerPC™ power supplies</div><div>✧ Multimedia and PC processor supplies</div></div><div><div>✧ High efficiency linear power supplies</div><div>✧ High efficiency post regulator for switching supply</div><div>✧ Low-voltage microcontrollers and digital logic</div><div>✧ SMPS post regulator</div></div></div>                                                                                                                                                                                                                                                                                                                                                                     |                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| <div>Absolute Maximum Rating (Note 1)</div> <table><tr><td>Supply Voltage</td><td>Vin</td><td>-20V ~ +20</td><td>V</td></tr><tr><td>Enable Voltage</td><td>Ven</td><td>+20</td><td>V</td></tr><tr><td>Storage Temperature Range</td><td>TSTG</td><td>-65 ~ +150</td><td>°C</td></tr><tr><td>Lead Soldering Temperature (260 °C)</td><td></td><td>5</td><td>S</td></tr><tr><td></td><td></td><td>(Note 3)</td><td></td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    | Supply Voltage | Vin                        | -20V ~ +20 | V            | Enable Voltage | Ven       | +20          | V         | Storage Temperature Range | TSTG      | -65 ~ +150 | °C        | Lead Soldering Temperature (260 °C) |  | 5 | S |  |  | (Note 3) |  |
| Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Vin                                                                                | -20V ~ +20                                                                                                                                                                                                                                                                                                                                                                                                                                                   | V  |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| Enable Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Ven                                                                                | +20                                                                                                                                                                                                                                                                                                                                                                                                                                                          | V  |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| Storage Temperature Range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | TSTG                                                                               | -65 ~ +150                                                                                                                                                                                                                                                                                                                                                                                                                                                   | °C |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
| Lead Soldering Temperature (260 °C)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                    | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                            | S  |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                    | (Note 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                     |    |                |                            |            |              |                |           |              |           |                           |           |            |           |                                     |  |   |   |  |  |          |  |



| Operating Rating (Note 2)                                               |                                       |          |                    |         |          |        |
|-------------------------------------------------------------------------|---------------------------------------|----------|--------------------|---------|----------|--------|
| Operation Input Voltage                                                 | Vin (operate)                         |          | +2.25 ~ +16        | V       |          |        |
| Operation Enable Voltage                                                | Ven (operate)                         |          | +2.25 ~ +16        | V       |          |        |
| Power Dissipation (Note 4)                                              | PD                                    |          | Internally Limited | W       |          |        |
| Operating Junction Temperature Range                                    | TJ                                    |          | -40 ~ +125         | °C      |          |        |
| Electrical Characteristics                                              |                                       |          |                    |         |          |        |
| Vin = Vout + 1V, Venable= 2.4V, Tj = 25 °C, unless otherwise specified. |                                       |          |                    |         |          |        |
| Parameter                                                               | Conditions                            |          | Min                | Typ     | Max      | Unit   |
| Output Voltage                                                          | IL=10mA                               |          | 0.990 Vo           | 5.0/3.3 | 1.010 Vo | V      |
| Output Voltage                                                          | 10mA ≤ IL ≤ 1.5A,<br>Vo+1V ≤ Vin ≤ 8V |          | 0.980 Vo           | 2.5/1.8 | 1.020 Vo |        |
| Line Regulation                                                         | IL=10mA, Vo+1V ≤Vin≤ 16V              |          | --                 | 0.05    | 0.5      | %      |
| Load Regulation                                                         | Vin=Vout+1V,<br>10mA≤IL≤1.5A          |          | --                 | 0.2     | 1.0      | %      |
| Output Voltage Temp. Coefficient                                        |                                       |          | --                 | 40      | 100      | ppm/°C |
| Dropout Voltage (Note 5)                                                | ΔVout= -1%                            | IL=100mA | --                 | 100     | 200      | mV     |
|                                                                         |                                       | IL=750mA | --                 | 275     | --       |        |
|                                                                         |                                       | IL=1.5A  | --                 | 400     | 600      |        |
| Quiescent Current (Note 6)                                              | Vin=Vout+1V                           | IL=750mA | --                 | 7       | 20       | mA     |
|                                                                         |                                       | IL=1.5A  | --                 | 17      | --       |        |
| Current Limited                                                         | Vout=0, Vin=Vout+1V                   |          | --                 | 2.0     | 2.5      | A      |
| Minimum Load Current                                                    |                                       |          | --                 | 7       | 10       | mA     |
| Reference (TS39152)                                                     |                                       |          |                    |         |          |        |
| Reference Voltage                                                       |                                       |          | 0.980 Vo           | 1.24    | 1.020 Vo | V      |
| Reference Voltage                                                       | (Note 7)                              |          | 0.970 Vo           |         | 1.030 Vo |        |
| Adjust Pin Bias Current                                                 |                                       |          | --                 | 40      | 120      | nA     |
| Reference Voltage Temp. Coefficient                                     | (Note 8)                              |          | --                 | 20      | --       | ppm/°C |
| Adjust Pin Bias Current Temp. Coefficient                               |                                       |          | --                 | 0.1     | --       | nA/°C  |
| Flag Output (TS39151)                                                   |                                       |          |                    |         |          |        |
| Output Leakage Current                                                  | VOH=16V                               |          | --                 | --      | 2        | uA     |
| Output Low Voltage (Note 9)                                             | Vin=0.9 * Vout, IOL=250uA             |          | --                 | --      | 400      | mV     |
| Upper Threshold Voltage                                                 | % of Vout                             |          | --                 | --      | 99       | %      |
| Lower Threshold Voltage                                                 | % of Vout                             |          | 93                 | --      | --       | %      |
| Hysteresis                                                              |                                       |          | --                 | 1       | --       | %      |
| Enable Input (TS39151 / 2)                                              |                                       |          |                    |         |          |        |
| Input Logic Voltage                                                     | Low (OFF)                             |          | --                 | --      | 0.8      | V      |
|                                                                         | High (ON)                             |          | 2.25               | --      | --       |        |
| Enable Pin Input Current                                                | Ven=2.25V                             |          | --                 | --      | 75       | uA     |
|                                                                         | Ven=0.8V                              |          | --                 | --      | 4        |        |



## Thermal Performance

| Condition          | Package type      | Typ | Unit |
|--------------------|-------------------|-----|------|
| Thermal Resistance | TO-220, TO-220-5L | 2.0 | °C/W |
| Junction to Case   | TO-263, TO-263-5L | 2.0 |      |

Note 1: Absolute Maximum Rating is limits beyond which damage to the device may occur. For guaranteed specifications and test conditions see the Electrical Characteristics.

Note 2: The device is not guaranteed to operate outside its operating rating.

Note 3: Devices are ESD sensitive. Handling precautions recommended.

Note 4: The maximum allowable power dissipation is a function of the maximum junction temperature,  $T_j$ , the junction to ambient thermal resistance,  $\theta_{ja}$ , and the ambient temperature,  $T_a$ . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. The effective value of  $\theta_{ja}$  can be reduced by using a heatsink,  $P_{d(max)} = (T_{j(max)} - T_a) / \theta_{ja}$ .

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops -1% below its nominal value measured at 1V differential.

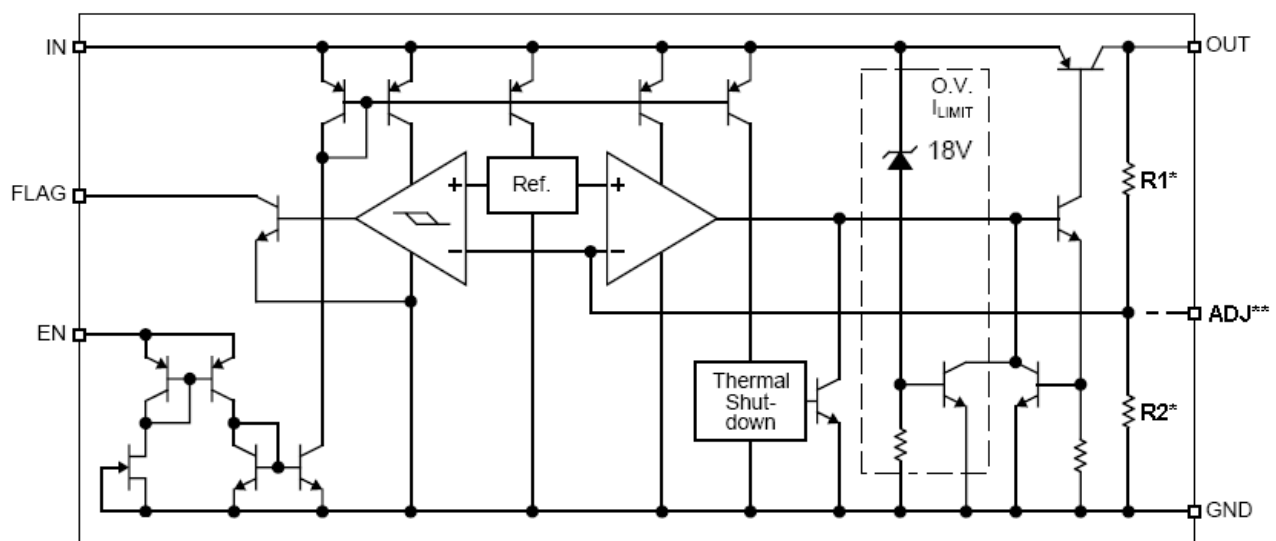
Note 6: Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the ground pin current and output load current,  $I_{in} = I_{gnd} + I_{out}$ .

Note 7:  $V_{ref} \leq V_{out} \leq (V_{in} - 1V)$ ,  $2.25V \leq V_{in} \leq 16V$ ,  $10mA \leq I_L \leq 1.5A$ .

Note 8: Output voltage temperature coefficient is  $\Delta V_{out}$  (worse cast) /  $(T_{j(max)} - T_{j(min)})$  where is  $T_{j(max)} + 125^\circ C$  and  $T_{j(min)}$  is  $0^\circ C$ .

Note 9: For adjustable device and fixed device with  $V_{out} > 2.25V$ .

## Block Diagram



\* Flag network is fixed output versions only (TS39151)

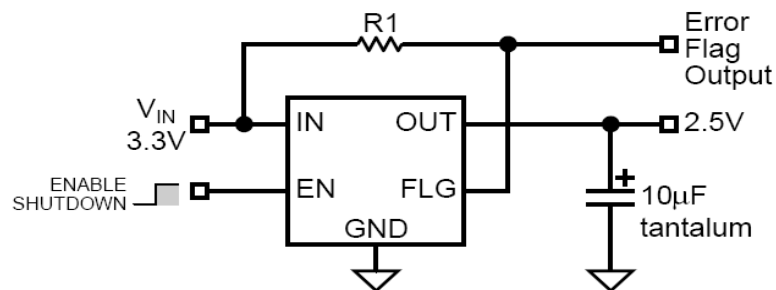
\*\* Adjustable output version only (TS39152)



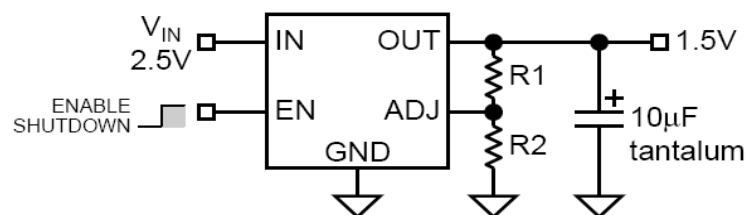
| Pin Assignment |         |                   |                                                                                                |
|----------------|---------|-------------------|------------------------------------------------------------------------------------------------|
| Pin No.        |         | Pin Configuration | Pin Description                                                                                |
| TS39151        | TS39152 |                   |                                                                                                |
| 1              | 1       | Enable            | Enable (input): TTL/COMS compatible input. Logic high is enable; logic low or open is shutdown |
| 2              | 2       | Input             | Unregulated input: +16V maximum supply                                                         |
| 3              | 3       | Ground            | Ground: Ground pin and TAB/heatsink are internally connected.                                  |
| 4              | 4       | Output            | Regulator output                                                                               |
| 5              |         | Flag              | Error Flag (output): Open-collector output. Active low indicates an output fault condition.    |
|                | 5       | Adjust            | Adjustment input: Feedback input. Connect to resistive voltage-divider network.                |

## Typical Application Circuit

### TS39151



### TS39152





## Application Information

### Application Information

The TS39151/52 series are high performance with low dropout voltage regulator suitable for moderate to high current and voltage regulator application. Its 400mV(typ) dropout voltage at full load and over temperature makes it especially valuable in battery power systems and as high efficiency noise filters in post regulator applications. Unlike normal NPN transistor design, where the base to emitter voltage drop and collector to emitter saturation voltage limit the minimum dropout voltage, dropout performance of the PNP output of these devices is limited only by low Vce saturation voltage.

The TS39151/52 series is fully protected from damage due to fault conditions. Linear current limiting is provided. Output current during overload conditions is constant. Thermal shutdown the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

### Capacitor Requirement

The TS39151/52 series requires an output capacitor to maintain stability and improve transient response is necessary. The value of this capacitor is dependent upon the output current, lower currents allow smaller capacitors. TS39151/52 series regulators are stable with the 10uF minimum capacitor value at full load. Where the regulator is powered from a source with high AC impedance, a 0.1uF capacitor connected between input and ground is recommended. The capacitor should have good characteristics to above 250KHz. The capacitance values will be help to improved transient response, ripple rejection and output noise.

### Minimum Load Current

The TS39151/52 series is specified between finite loads. If the output current is too small leakage currents dominate and the output voltage rises. A 10mA minimum load current swamps any expected leakage current across the operating temperature range.

### Thermal Characteristics

TS39151/52 series linear regulators are simple to use, the most complicated design parameters to consider are thermal characteristics, thermal design requires the following application specification parameters:

- Maximum ambient temperature, Ta
- Output current, Iout
- Output voltage, Vout
- Input voltage, Vin

We calculate the power dissipation of the regulator from these numbers and the device parameters from this data sheet. A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under absolute maximum ratings. To determine if the heatsink is required, the power dissipated by the regulator,  $P_D$  must be calculated.

The below formula shows the voltages and currents for calculating the  $P_D$  in the regulator:

$$I_{in} = I_L + I_G$$

$$P_D = (V_{in} - V_{out}) * I_L + (V_{in}) * I_G$$

$$\begin{aligned} \text{Ex. } P_D &= (3.3V - 2.5V) * 0.5A + 3.3V * 11mA \\ &= 400mW + 36mW \\ &= 436mW \end{aligned}$$

Remark:  $I_L$  is output load current,

$I_G$  is ground current.

$V_{in}$  is input voltage

$V_{out}$  is output voltage

The next parameter which must be calculated is the maximum allowable temperature rise,  $T_R(\text{max})$ . this is calculated by the using to formula:

$$T_R(\text{max}) = T_J(\text{max}) - T_A(\text{max})$$

Where:  $T_J(\text{max})$  is the maximum allowable junction temperature, which is 125 °C for commercial grade parts.

$T_A(\text{max})$  is the maximum ambient temperature which will be encountered in the application. Using the calculated values for  $T_R(\text{max})$  and  $P_D$ , the maximum allowable value for the junction to ambient thermal resistance,  $\theta_{ja}$ , can now be found:

$$\theta_{ja} = T_R(\text{max}) / P_D$$

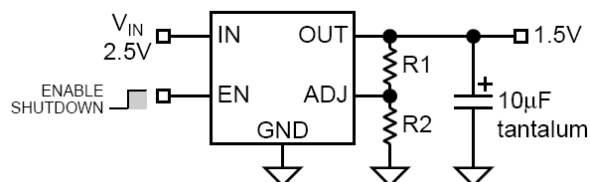


## Application Information (continues)

### Adjustable Regulator Design

The adjustable regulator versions (TS39152) allow to programming the output voltage anywhere between 1.25 and the 16V maximum operating rating of the family.

Two resistors are used. Resistors can be quite large up to 1MΩ, because of the very high input impedance and low bias current of the sense comparator, the resistor values are calculated by:



$$R1 = R2 * [(V_{out} / 1.24) - 1]$$

Where is  $V_{out}$  the desired output voltage. Above application circuit shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation.

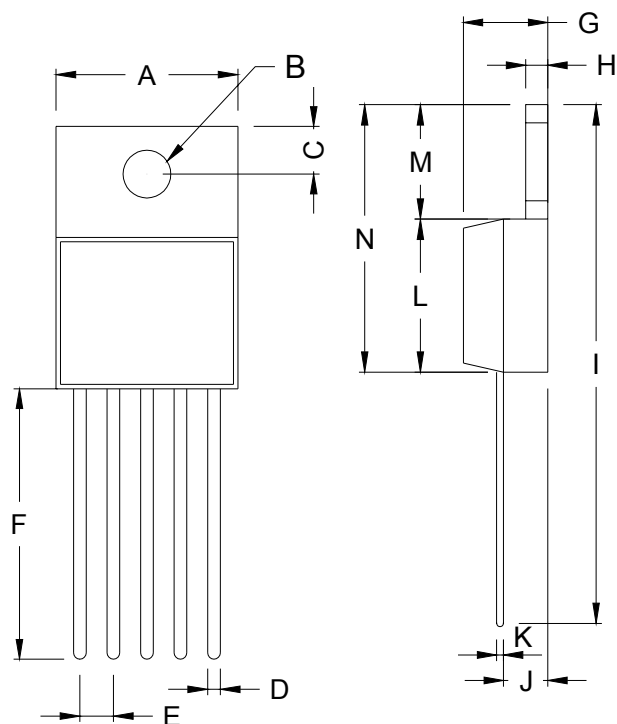
### Error Flag

TS39151 versions feature an Error Flag, which looks at the output voltage and signals an error condition when this voltage drops 5% below its expected value. The error flag is an open-collector output that pulls low under fault conditions. It may sink 10mA. Low output voltage signifies a number of possible problems, including an over-current fault (the device is in current limit) and low input voltage. The flag output is inoperative during over temperature shutdown conditions.

### Enable Input

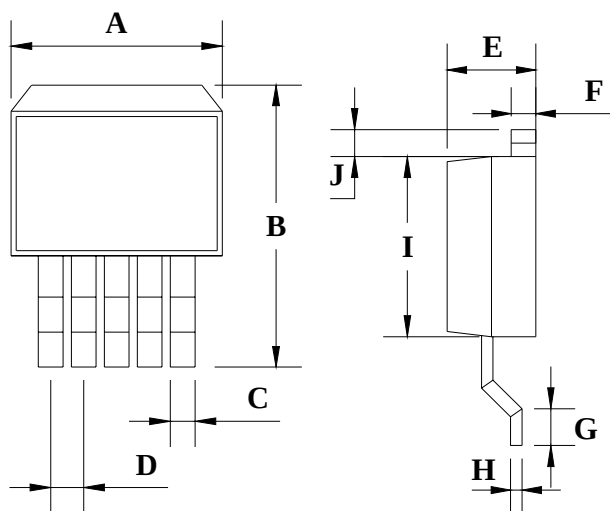
TS39151 and TS39152 versions feature an enable (EN) input that allows ON/OFF control of the device. Special design allows “zero” current drain when the device is disabled—only microamperes of leakage current flow. The EN input has TTL/CMOS compatible thresholds for simple interfacing with logic, or may be directly tied to ≤20V. Enabling the regulator requires approximately 30uA of current.

## TO-220-5L Mechanical Drawing



| TO-220 DIMENSION |             |       |        |       |
|------------------|-------------|-------|--------|-------|
| DIM              | MILLIMETERS |       | INCHES |       |
|                  | MIN         | MAX   | MIN    | MAX   |
| A                | 10.00       | 10.50 | 0.394  | 0.413 |
| B                | 3.240       | 4.440 | 0.128  | 0.175 |
| C                | 2.440       | 2.940 | 0.096  | 0.116 |
| D                | 0.260       | 1.020 | 0.010  | 0.040 |
| E                | 1.570       | 1.830 | 0.062  | 0.072 |
| F                | 13.31       | 14.13 | 0.524  | 0.556 |
| G                | 4.475       | 5.225 | 0.176  | 0.206 |
| H                | 1.170       | 1.370 | 0.046  | 0.054 |
| I                | 27.60       | 29.44 | 1.087  | 1.159 |
| J                | 2.175       | 2.925 | 0.086  | 0.115 |
| K                | 0.297       | 0.477 | 0.012  | 0.019 |
| L                | 8.280       | 8.800 | 0.326  | 0.346 |
| M                | 6.010       | 6.510 | 0.237  | 0.256 |
| N                | 14.29       | 15.31 | 0.563  | 0.603 |

## TO-263-5L Mechanical Drawing



| TO-263 DIMENSION |             |        |        |       |
|------------------|-------------|--------|--------|-------|
| DIM              | MILLIMETERS |        | INCHES |       |
|                  | MIN         | MAX    | MIN    | MAX   |
| A                | 10.220      | 10.260 | 0.402  | 0.404 |
| B                | 14.600      | 15.870 | 0.575  | 0.625 |
| C                | 0.750       | 0.770  | 0.030  | 0.030 |
| D                | 1.573       | 1.827  | 0.062  | 0.072 |
| E                | 4.560       | 4.570  | 0.179  | 0.180 |
| F                | 1.240       | 1.270  | 0.049  | 0.050 |
| G                | 2.280       | 2.790  | 0.090  | 0.110 |
| H                | 0.280       | 0.320  | 0.011  | 0.013 |
| I                | 8.240       | 8.280  | 0.324  | 0.326 |
| J                | 1.540       | 1.800  | 0.060  | 0.071 |