NSI45090DDT4G

Adjustable Constant Current Regulator & LED Driver

45 V, 90 – 160 mA ± 15%, 2.7 W Package

The adjustable constant current regulator (CCR) is a simple, economical and robust device designed to provide a cost effective solution for regulating current in LEDs. The CCR is based on patent-pending Self-Biased Transistor (SBT) technology and regulates current over a wide voltage range. It is designed with a negative temperature coefficient to protect LEDs from thermal runaway at extreme voltages and currents.

The CCR turns on immediately and is at 20% of regulation with only 0.5 V Vak. The R_adj pin allows I_reg(SS) to be adjusted to higher currents by attaching a resistor between R_adj (Pin 3) and the Cathode (Pin 4). The R_adj pin can also be left open (No Connect) if no adjustment is required. It requires no external components allowing it to be designed as a high or low-side regulator. The high anode-cathode voltage rating withstands surges common in Automotive, Industrial and Commercial Signage applications. This device is available in a thermally robust package, which is lead-free RoHS compliant and uses halogen-free molding compound. For the AEC-Q101 part please see the NSI45090JD datasheet.

Features

- Robust Power Package: 2.7 Watts
- Adjustable up to 160 mA
- Wide Operating Voltage Range
- Immediate Turn-On
- Voltage Surge Suppressing – Protecting LEDs
- SBT (Self-Biased Transistor) Technology
- Negative Temperature Coefficient
- Eliminates Additional Regulation
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- Automobile: Chevron Side Mirror Markers, Cluster, Display & Instrument Backlighting, CHMSL, Map Light
- AC Lighting Panels, Display Signage, Decorative Lighting, Channel Lettering
- Switch Contact Wetting
- Application Note AND8391/D – Power Dissipation Considerations
- Application Note AND8349/D – Automotive CHMSL

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I_reg(SS) = 90 – 160 mA
@ Vak = 7.5 V

MARKING DIAGRAM

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping†</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSI45090DDT4G</td>
<td>DPAK</td>
<td>2500/Tape &amp; Reel</td>
</tr>
</tbody>
</table>

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
### MAXIMUM RATINGS  ($TA = 25°C$ unless otherwise noted)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anode–Cathode Voltage</td>
<td>$V_{ak\ Max}$</td>
<td>45</td>
<td>V</td>
</tr>
<tr>
<td>Reverse Voltage</td>
<td>$V_R$</td>
<td>500</td>
<td>mV</td>
</tr>
<tr>
<td>Operating and Storage Junction Temperature Range</td>
<td>$T_J, T_{stg}$</td>
<td>–55 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>ESD Rating: Human Body Model</td>
<td>ESD</td>
<td>Class 3A</td>
<td></td>
</tr>
<tr>
<td>ESD Rating: Machine Model</td>
<td>ESD</td>
<td>Class B</td>
<td></td>
</tr>
</tbody>
</table>

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

### ELECTRICAL CHARACTERISTICS  ($TA = 25°C$ unless otherwise noted)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady State Current @ $V_{ak} = 7.5$ V</td>
<td>$I_{\text{reg}(SS)}$</td>
<td>76.5</td>
<td>90</td>
<td>103.5</td>
<td>mA</td>
</tr>
<tr>
<td>Voltage Overhead (Note 2)</td>
<td>$V_{\text{overhead}}$</td>
<td>1.8</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Pulse Current @ $V_{ak} = 7.5$ V (Note 3)</td>
<td>$I_{\text{reg}(P)}$</td>
<td>86.2</td>
<td>103</td>
<td>119.6</td>
<td>mA</td>
</tr>
<tr>
<td>Capacitance @ $V_{ak} = 7.5$ V (Note 4)</td>
<td>$C$</td>
<td>17</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Capacitance @ $V_{ak} = 0$ V (Note 4)</td>
<td>$C$</td>
<td>70</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
</tbody>
</table>

1. $I_{\text{reg}(SS)}$ steady state is the voltage ($V_{ak}$) applied for a time duration $\geq 80$ sec, using FR–4 @ 300 mm$^2$ 2 oz. Copper traces, in still air.
2. $V_{\text{overhead}} = V_{in} - V_{\text{LEDs}}$. $V_{\text{overhead}}$ is typical value for 65% $I_{\text{reg}(SS)}$.
3. $I_{\text{reg}(P)}$ non-repetitive pulse test. Pulse width $t \leq 300 \mu$s.
4. $f = 1$ MHz, 0.02 V RMS.

### THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Device Dissipation (Note 5) $TA = 25°C$</td>
<td>$P_D$</td>
<td>1771</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 5)</td>
<td>$R_{\theta JA}$</td>
<td>70.6</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 5)</td>
<td>$R_{\psi JL4}$</td>
<td>6.8</td>
<td>°C/W</td>
</tr>
<tr>
<td>Total Device Dissipation (Note 6) $TA = 25°C$</td>
<td>$P_D$</td>
<td>2083</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 6)</td>
<td>$R_{\theta JA}$</td>
<td>60</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 6)</td>
<td>$R_{\psi JL4}$</td>
<td>6.3</td>
<td>°C/W</td>
</tr>
<tr>
<td>Total Device Dissipation (Note 7) $TA = 25°C$</td>
<td>$P_D$</td>
<td>2080</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 7)</td>
<td>$R_{\theta JA}$</td>
<td>60.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 7)</td>
<td>$R_{\psi JL4}$</td>
<td>6.5</td>
<td>°C/W</td>
</tr>
<tr>
<td>Total Device Dissipation (Note 8) $TA = 25°C$</td>
<td>$P_D$</td>
<td>2441</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 8)</td>
<td>$R_{\theta JA}$</td>
<td>51.2</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 8)</td>
<td>$R_{\psi JL4}$</td>
<td>5.9</td>
<td>°C/W</td>
</tr>
<tr>
<td>Total Device Dissipation (Note 9) $TA = 25°C$</td>
<td>$P_D$</td>
<td>2309</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 9)</td>
<td>$R_{\theta JA}$</td>
<td>54.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 9)</td>
<td>$R_{\psi JL4}$</td>
<td>6.2</td>
<td>°C/W</td>
</tr>
<tr>
<td>Total Device Dissipation (Note 10) $TA = 25°C$</td>
<td>$P_D$</td>
<td>2713</td>
<td>mW</td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Ambient (Note 10)</td>
<td>$R_{\theta JA}$</td>
<td>46.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Reference, Junction–to–Lead 4 (Note 10)</td>
<td>$R_{\psi JL4}$</td>
<td>5.7</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

| Junction and Storage Temperature Range       | $T_J, T_{stg}$ | –55 to +150 | °C |

**NOTE:** Lead measurements are made by non-contact methods such as IR with treated surface to increase emissivity to 0.9.

Lead temperature measurement by attaching a T/C may yield values as high as 30% higher °C/W values based upon empirical measurements and method of attachment.

5. FR–4 @ 300 mm$^2$, 1 oz. copper traces, still air.
6. FR–4 @ 300 mm$^2$, 2 oz. copper traces, still air.
7. FR–4 @ 500 mm$^2$, 1 oz. copper traces, still air.
8. FR–4 @ 500 mm$^2$, 2 oz. copper traces, still air.
9. FR–4 @ 700 mm$^2$, 1 oz. copper traces, still air.
10. FR–4 @ 700 mm$^2$, 2 oz. copper traces, still air.
TYPICAL PERFORMANCE CURVES
Minimum FR-4 @ 300 mm², 2 oz Copper Trace, Still Air

Figure 1. General Performance Curve for CCR

Figure 2. Steady State Current (I_{reg(SS)}) vs. Anode–Cathode Voltage (Vak)

Figure 3. Pulse Current (I_{reg(P)}) vs. Anode–Cathode Voltage (Vak)

Figure 4. Steady State Current vs. Pulse Current Testing

Figure 5. Current Regulation vs. Time

Figure 6. I_{reg(SS)} vs. R_{adj}

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**APPLICATIONS**

![Figure 8. Typical Application Circuit (30 mA each LED String)](image)

Number of LED's that can be connected is determined by:

D1 is a reverse battery protection diode

LED's = \((V_{in} - Q_x V_F - D1 V_F)/LED V_F\)

Example: \(V_{in} = 12 \text{ Vdc, } Q_x V_F = 3.5 \text{ Vdc, } D1V_F = 0.7 \text{ V}\)

LED \(V_F = 2.2 \text{ Vdc @ 30 mA}\)

(12 Vdc – 4.2 Vdc)/2.2 Vdc = 3 LEDs in series.

![Figure 9. Typical Application Circuit (90 mA each LED String)](image)

Number of LED's that can be connected is determined by:

D1 is a reverse battery protection diode

Example: \(V_{in} = 12 \text{ Vdc, } Q_x V_F = 3.5 \text{ Vdc, } D1V_F = 0.7 \text{ V}\)

LED \(V_F = 2.6 \text{ Vdc @ 90 mA}\)

\((12 \text{ Vdc} – (3.5 + 0.7 \text{ Vdc}))/2.6 \text{ Vdc} = 3 \text{ LEDs in series.}\)

Number of Drivers = LED current/30 mA

90 mA/30 mA = 3 Drivers (Q1, Q2, Q3)
Comparison of LED Circuit using CCR vs. Resistor Biasing

<table>
<thead>
<tr>
<th>ON Semiconductor CCR Design</th>
<th>Resistor Biased Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant brightness over full Supply Voltage (more efficient), see Figure 10</td>
<td>Large variations in brightness over full Automotive Supply Voltage</td>
</tr>
<tr>
<td>Little variation of power in LEDs, see Figure 11</td>
<td>Large variations of current (power) in LEDs</td>
</tr>
<tr>
<td>Constant current extends LED strings lifetime, see Figure 10</td>
<td>High Supply Voltage/Higher Current in LED strings limits lifetime</td>
</tr>
<tr>
<td>Current decreases as voltage increases, see Figure 10</td>
<td>Current increases as voltage increases</td>
</tr>
<tr>
<td>Current supplied to LED string decreases as temperature increases (self-limiting), see Figure 2</td>
<td>LED current decreases as temperature increases</td>
</tr>
<tr>
<td>Single resistor is used for current select</td>
<td>Requires costly inventory (need for several resistor values to match LED intensity)</td>
</tr>
<tr>
<td>Fewer components, less board space required</td>
<td>More components, more board space required</td>
</tr>
<tr>
<td>Surface mount component</td>
<td>Through-hole components</td>
</tr>
</tbody>
</table>

**Figure 10. Series Circuit Current**

**Figure 11. LED Power**

**Current Regulation: Pulse Mode ($I_{\text{reg}}(P)$) vs DC Steady-State ($I_{\text{reg}}(SS)$)**

There are two methods to measure current regulation: Pulse mode ($I_{\text{reg}}(P)$) testing is applicable for factory and incoming inspection of a CCR where test times are a minimum. ($t \leq 300 \mu s$). DC Steady-State ($I_{\text{reg}}(SS)$) testing is applicable for application verification where the CCR will be operational for seconds, minutes, or even hours. ON Semiconductor has correlated the difference in $I_{\text{reg}}(P)$ to $I_{\text{reg}}(SS)$ for stated board material, size, copper area and copper thickness. $I_{\text{reg}}(P)$ will always be greater than $I_{\text{reg}}(SS)$ due to the die temperature rising during $I_{\text{reg}}(SS)$. This heating effect can be minimized during circuit design with the correct selection of board material, metal trace size and weight, for the operating current, voltage, board operating temperature ($T_A$) and package. (Refer to Thermal Characteristics table).
PACKAGE DIMENSIONS

DPAK (SINGLE GAUGE)

CASE 369C−01

ISSUE C

NOTES:

1. DIMENSIONING AND TOLERANCING

2. CONTROLLING DIMENSION: INCH.

<table>
<thead>
<tr>
<th>DIM</th>
<th>INCHES</th>
<th>MILLIMETERS</th>
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<tbody>
<tr>
<td>A</td>
<td>0.235</td>
<td>5.97</td>
</tr>
<tr>
<td>B</td>
<td>0.250</td>
<td>6.35</td>
</tr>
<tr>
<td>C</td>
<td>0.086</td>
<td>2.19</td>
</tr>
<tr>
<td>D</td>
<td>0.027</td>
<td>0.69</td>
</tr>
<tr>
<td>E</td>
<td>0.018</td>
<td>0.46</td>
</tr>
<tr>
<td>F</td>
<td>0.037</td>
<td>0.94</td>
</tr>
<tr>
<td>G</td>
<td>0.160</td>
<td>4.06</td>
</tr>
<tr>
<td>H</td>
<td>0.034</td>
<td>0.86</td>
</tr>
<tr>
<td>J</td>
<td>0.018</td>
<td>0.46</td>
</tr>
<tr>
<td>K</td>
<td>0.102</td>
<td>2.60</td>
</tr>
<tr>
<td>L</td>
<td>0.005</td>
<td>0.13</td>
</tr>
<tr>
<td>R</td>
<td>0.180</td>
<td>4.57</td>
</tr>
<tr>
<td>S</td>
<td>0.005</td>
<td>0.13</td>
</tr>
<tr>
<td>U</td>
<td>0.001</td>
<td>0.03</td>
</tr>
<tr>
<td>V</td>
<td>0.035</td>
<td>0.89</td>
</tr>
<tr>
<td>Z</td>
<td>0.155</td>
<td>3.93</td>
</tr>
</tbody>
</table>

SCALE 3:1

RECOMMENDED FOOTPRINT

<table>
<thead>
<tr>
<th>DIM</th>
<th>MIN</th>
<th>MAX</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>0.13</td>
<td>(0.005)</td>
</tr>
<tr>
<td>T</td>
<td>0.13</td>
<td>D 2 PL</td>
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</table>

SCALE 3:1