

# NSI45015WT1G

## Constant Current Regulator & LED Driver

### 45 V, 15 mA $\pm$ 20%, 460 mW Package

The linear 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 35% of regulation with only 0.5 V  $V_{AK}$ . 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. The CCR comes in thermally robust packages and is qualified to AEC-Q101 standard.

#### Features

- Robust Power Package: 460 mW
- Wide Operating Voltage Range
- Immediate Turn-On
- Voltage Surge Suppressing – Protecting LEDs
- AEC-Q101 Qualified
- SBT (Self-Biased Transistor) Technology
- Negative Temperature Coefficient
- 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

#### MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ unless otherwise noted)

| Rating                                           | Symbol         | Value               | Unit             |
|--------------------------------------------------|----------------|---------------------|------------------|
| Anode-Cathode Voltage                            | $V_{AK}$ Max   | 45                  | V                |
| Reverse Voltage                                  | $V_R$          | 500                 | mV               |
| Operating and Storage Junction Temperature Range | $T_J, T_{stg}$ | -55 to +150         | $^\circ\text{C}$ |
| ESD Rating: Human Body Model<br>Machine Model    | ESD            | Class 1C<br>Class B |                  |

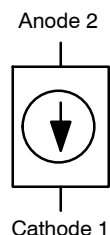
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.



ON Semiconductor®

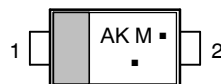
<http://onsemi.com>

$I_{reg(SS)} = 15 \text{ mA}$   
@  $V_{AK} = 7.5 \text{ V}$



SOD-123  
CASE 425  
STYLE 1

#### MARKING DIAGRAM



AK = Device Code  
M = Date Code  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

#### ORDERING INFORMATION

| Device       | Package              | Shipping†        |
|--------------|----------------------|------------------|
| NSI45015WT1G | SOD-123<br>(Pb-Free) | 3000/Tape & Reel |

† 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.

# NSI45015WT1G

## ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ unless otherwise noted)

| Characteristic                                          | Symbol         | Min  | Typ  | Max  | Unit |
|---------------------------------------------------------|----------------|------|------|------|------|
| Steady State Current @ $V_{AK} = 7.5\text{ V}$ (Note 1) | $I_{reg(SS)}$  | 12   | 15   | 18   | mA   |
| Voltage Overhead (Note 2)                               | $V_{overhead}$ |      | 1.8  |      | V    |
| Pulse Current @ $V_{AK} = 7.5\text{ V}$ (Note 3)        | $I_{reg(P)}$   | 12.7 | 16.5 | 19.4 | mA   |
| Capacitance @ $V_{AK} = 7.5\text{ V}$ (Note 4)          | C              |      | 2.5  |      | pF   |
| Capacitance @ $V_{AK} = 0\text{ V}$ (Note 4)            | C              |      | 5.7  |      | pF   |

1.  $I_{reg(SS)}$  steady state is the voltage ( $V_{AK}$ ) applied for a time duration  $\geq 10\text{ sec}$ , using FR-4 @ 300 mm<sup>2</sup> 1 oz. Copper traces, in still air.
2.  $V_{overhead} = V_{in} - V_{LEDs}$ .  $V_{overhead}$  is typical value for 75%  $I_{reg(SS)}$ .
3.  $I_{reg(P)}$  non-repetitive pulse test. Pulse width  $t \leq 300\text{ }\mu\text{sec}$ .
4.  $f = 1\text{ MHz}$ , 0.02 V RMS.

## THERMAL CHARACTERISTICS

| Characteristic                                                                                 | Symbol          | Max         | Unit                       |
|------------------------------------------------------------------------------------------------|-----------------|-------------|----------------------------|
| Total Device Dissipation (Note 5) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$  | $P_D$           | 208<br>1.66 | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 5)                                               | $R_{\theta JA}$ | 600         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 5)                                                    | $R_{\psi LA}$   | 404         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 5)                                           | $R_{\psi JL}$   | 196         | $^\circ\text{C/W}$         |
| Total Device Dissipation (Note 6) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$  | $P_D$           | 227<br>1.8  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 6)                                               | $R_{\theta JA}$ | 550         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 6)                                                    | $R_{\psi LA}$   | 390         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 6)                                           | $R_{\psi JL}$   | 160         | $^\circ\text{C/W}$         |
| Total Device Dissipation (Note 7) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$  | $P_D$           | 347<br>2.8  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 7)                                               | $R_{\theta JA}$ | 360         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 7)                                                    | $R_{\psi LA}$   | 200         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 7)                                           | $R_{\psi JL}$   | 160         | $^\circ\text{C/W}$         |
| Total Device Dissipation (Note 8) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$  | $P_D$           | 368<br>2.9  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 8)                                               | $R_{\theta JA}$ | 340         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 8)                                                    | $R_{\psi LA}$   | 208         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 8)                                           | $R_{\psi JL}$   | 132         | $^\circ\text{C/W}$         |
| Total Device Dissipation (Note 9) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$  | $P_D$           | 436<br>3.5  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 9)                                               | $R_{\theta JA}$ | 287         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 9)                                                    | $R_{\psi LA}$   | 139         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 9)                                           | $R_{\psi JL}$   | 148         | $^\circ\text{C/W}$         |
| Total Device Dissipation (Note 10) $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$           | 463<br>3.7  | mW<br>mW/ $^\circ\text{C}$ |
| Thermal Resistance, Junction-to-Ambient (Note 10)                                              | $R_{\theta JA}$ | 270         | $^\circ\text{C/W}$         |
| Thermal Reference, Lead-to-Ambient (Note 10)                                                   | $R_{\psi LA}$   | 150         | $^\circ\text{C/W}$         |
| Thermal Reference, Junction-to-Cathode Lead (Note 10)                                          | $R_{\psi JL}$   | 120         | $^\circ\text{C/W}$         |
| Junction and Storage Temperature Range                                                         | $T_J, T_{stg}$  | -55 to +150 | $^\circ\text{C}$           |

5. FR-4 @ 100 mm<sup>2</sup>, 1 oz. copper traces, still air.
6. FR-4 @ 100 mm<sup>2</sup>, 2 oz. copper traces, still air.
7. FR-4 @ 300 mm<sup>2</sup>, 1 oz. copper traces, still air.
8. FR-4 @ 300 mm<sup>2</sup>, 2 oz. copper traces, still air.
9. FR-4 @ 500 mm<sup>2</sup>, 1 oz. copper traces, still air.
10. FR-4 @ 500 mm<sup>2</sup>, 2 oz. copper traces, still air.

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  $^\circ\text{C/W}$  values based upon empirical measurements and method of attachment.

# TYPICAL PERFORMANCE CURVES

Minimum FR-4 @ 300 mm<sup>2</sup> 1 oz Copper Trace, Still Air

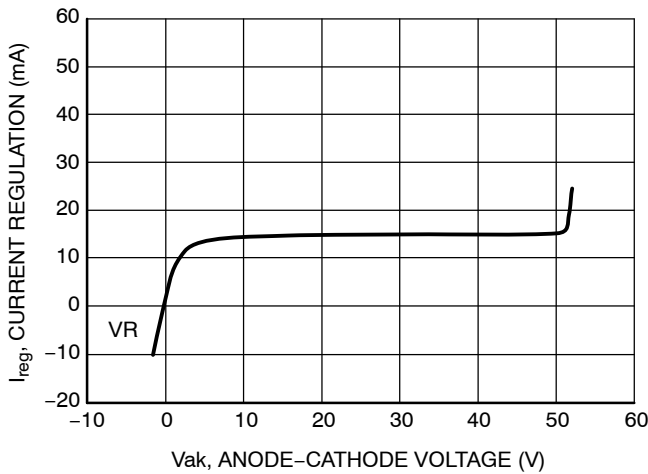


Figure 1. General Performance Curve for CCR

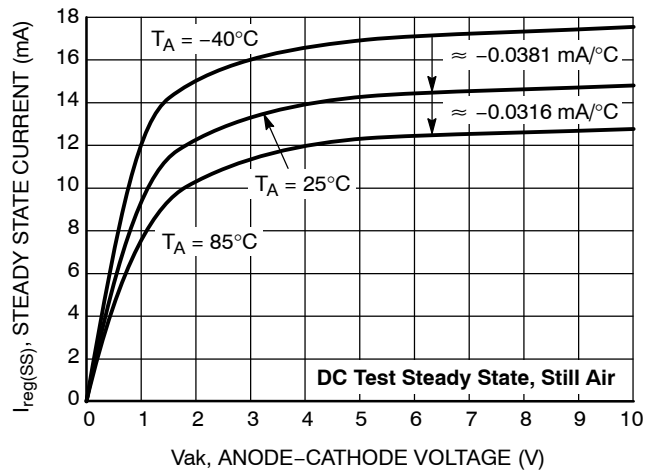


Figure 2. Steady State Current ( $I_{reg(SS)}$ ) vs. Anode-Cathode Voltage ( $V_{ak}$ )

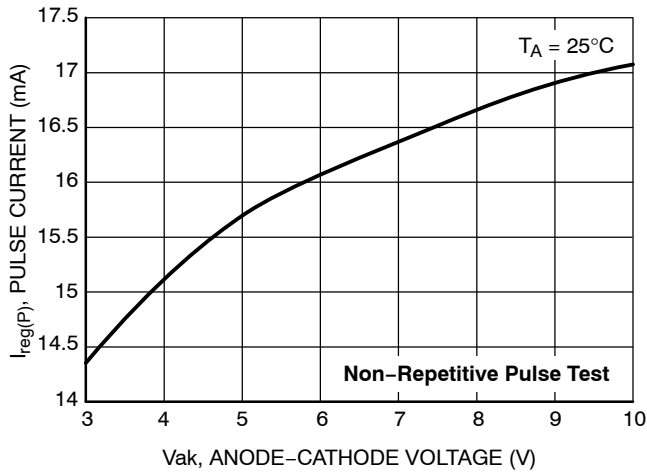


Figure 3. Pulse Current ( $I_{reg(P)}$ ) vs. Anode-Cathode Voltage ( $V_{ak}$ )

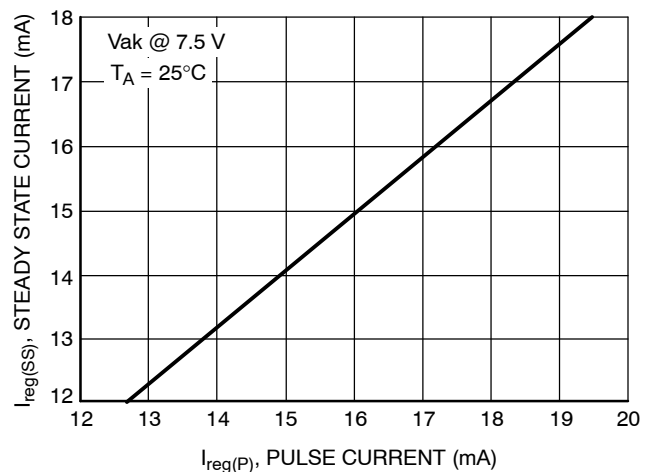


Figure 4. Steady State Current vs. Pulse Current Testing

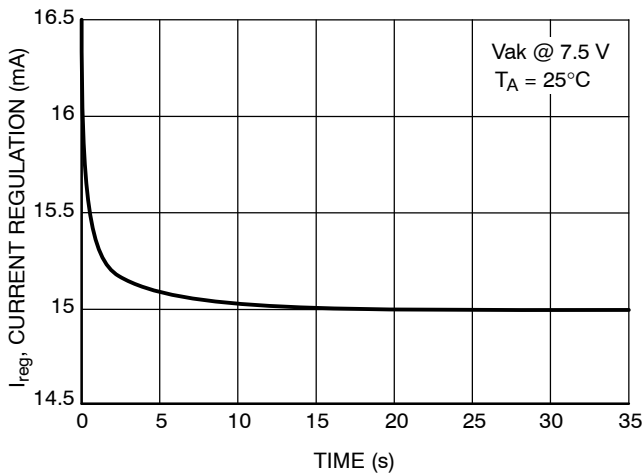


Figure 5. Current Regulation vs. Time

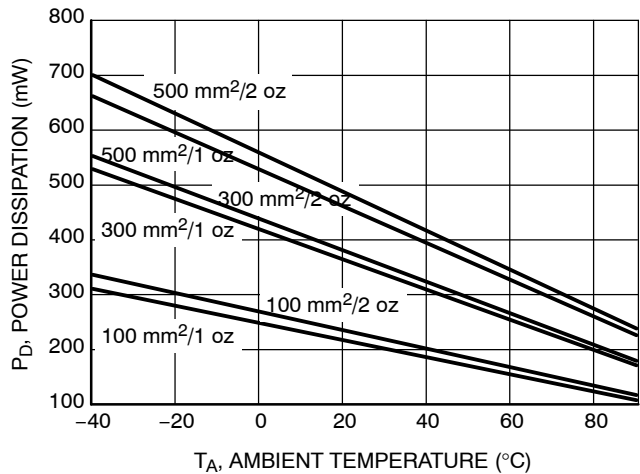
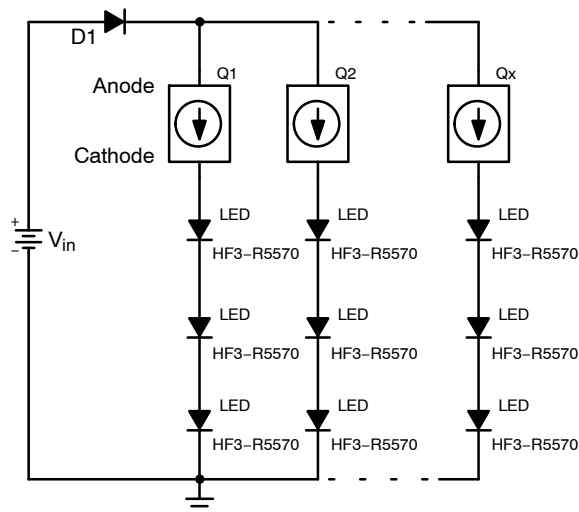


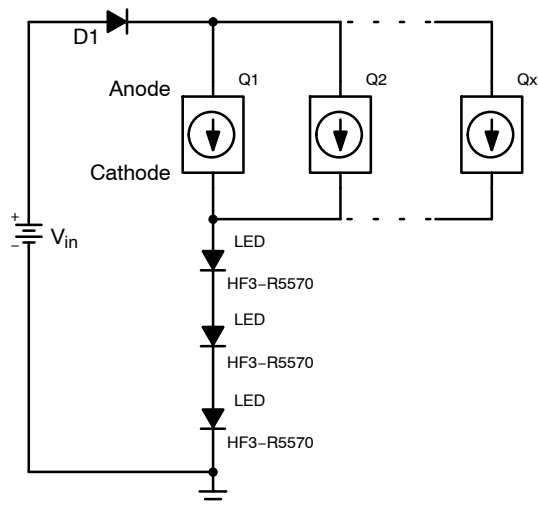
Figure 6. Power Dissipation vs. Ambient Temperature @  $T_J = 150^{\circ}\text{C}$

# APPLICATIONS



**Figure 7. Typical Application Circuit  
(10 mA each LED String)**

Number of LED's that can be connected is determined by:  
**D1 is a reverse battery protection diode**  
 $\text{LED's} = (V_{in} - Q_X V_F + D1 V_F) / \text{LED } V_F$   
**Example:**  $V_{in} = 12 \text{ Vdc}$ ,  $Q_X V_F = 3.5 \text{ Vdc}$ ,  $D1 V_F = 0.7 \text{ V}$   
 $\text{LED } V_F = 2.2 \text{ Vdc @ } 15 \text{ mA}$   
 $(12 \text{ Vdc} - 4.2 \text{ Vdc}) / 2.2 \text{ Vdc} = 3 \text{ LEDs in series.}$



**Figure 8. Typical Application Circuit  
(30 mA each LED String)**

Number of LED's that can be connected is determined by:  
**D1 is a reverse battery protection diode**  
**Example:**  $V_{in} = 12 \text{ Vdc}$ ,  $Q_X V_F = 3.5 \text{ Vdc}$ ,  $D1 V_F = 0.7 \text{ V}$   
 $\text{LED } V_F = 2.6 \text{ Vdc @ } 30 \text{ mA}$   
 $(12 \text{ Vdc} - (3.5 + 0.7 \text{ Vdc})) / 2.6 \text{ Vdc} = 3 \text{ LEDs in series.}$   
**Number of Drivers = LED current / 15 mA**  
 $45 \text{ mA} / 15 \text{ mA} = 3 \text{ Drivers (Q1, Q2, Q3)}$

### Comparison of LED Circuit using CCR vs. Resistor Biasing

| ON Semiconductor CCR Design                                                                     | Resistor Biased Design                                                              |
|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Constant brightness over full Automotive Supply Voltage (more efficient), see Figure 9          | Large variations in brightness over full Automotive Supply Voltage                  |
| Little variation of power in LEDs, see Figure 10                                                | Large variations of current (power) in LEDs                                         |
| Constant current extends LED strings lifetime, see Figure 9                                     | High Supply Voltage/ Higher Current in LED strings limits lifetime                  |
| Current decreases as voltage increases, see Figure 9                                            | Current increases as voltage increases                                              |
| Current supplied to LED string decreases as temperature increases (self-limiting), see Figure 2 | LED current decreases as temperature increases                                      |
| No resistors needed                                                                             | Requires costly inventory (need for several resistor values to match LED intensity) |
| Fewer components, less board space required                                                     | More components, more board space required                                          |
| Surface mount component                                                                         | Through-hole components                                                             |

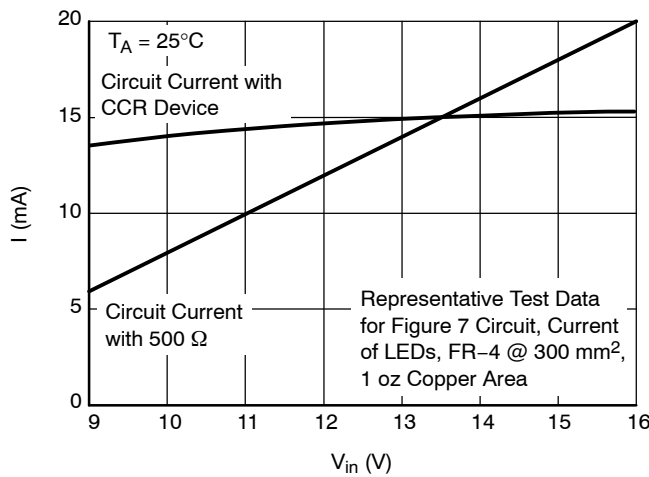


Figure 9. Series Circuit Current

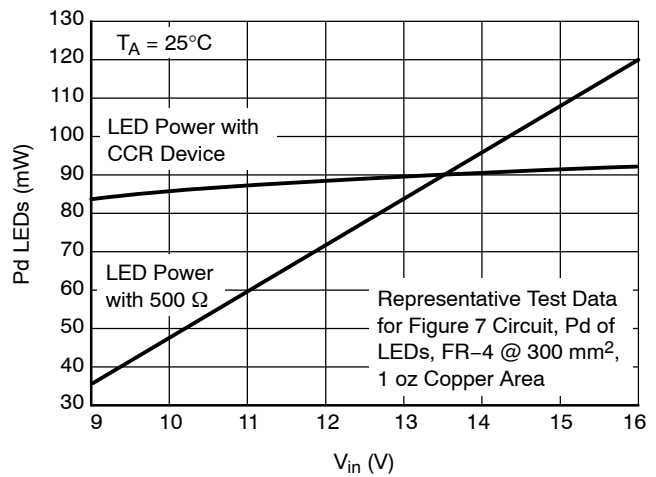


Figure 10. LED Power

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

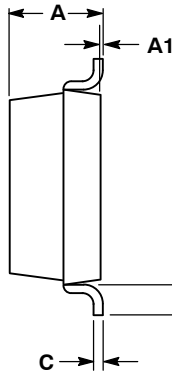
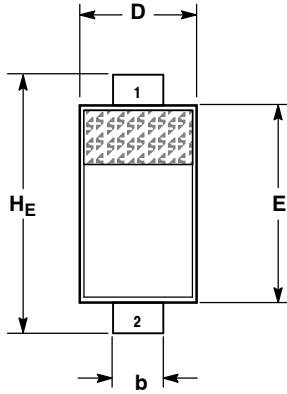
There are two methods to measure current regulation: Pulse mode ( $I_{reg(P)}$ ) testing is applicable for factory and incoming inspection of a CCR where test times are a minimum. ( $t \leq 300 \mu s$ ). DC Steady-State ( $I_{reg(SS)}$ ) testing is applicable for application verification where the CCR will be operational for seconds, minutes, or even hours. ON Semiconductor has correlated the difference in  $I_{reg(P)}$  to

$I_{reg(SS)}$  for stated board material, size, copper area and copper thickness.  $I_{reg(P)}$  will always be greater than  $I_{reg(SS)}$  due to the die temperature rising during  $I_{reg(SS)}$ . 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).

# NSI45015WT1G

## PACKAGE DIMENSIONS

SOD-123  
CASE 425-04  
ISSUE E

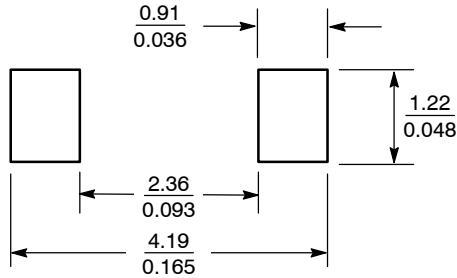


- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

| DIM | MILLIMETERS |      |      | INCHES |       |       |
|-----|-------------|------|------|--------|-------|-------|
|     | MIN         | NOM  | MAX  | MIN    | NOM   | MAX   |
| A   | 0.94        | 1.17 | 1.35 | 0.037  | 0.046 | 0.053 |
| A1  | 0.00        | 0.05 | 0.10 | 0.000  | 0.002 | 0.004 |
| b   | 0.51        | 0.61 | 0.71 | 0.020  | 0.024 | 0.028 |
| c   | ---         | ---  | 0.15 | ---    | ---   | 0.006 |
| D   | 1.40        | 1.60 | 1.80 | 0.055  | 0.063 | 0.071 |
| E   | 2.54        | 2.69 | 2.84 | 0.100  | 0.106 | 0.112 |
| H_E | 3.56        | 3.68 | 3.86 | 0.140  | 0.145 | 0.152 |
| L   | 0.25        | ---  | ---  | 0.010  | ---   | ---   |

STYLE 1:  
PIN 1. CATHODE  
2. ANODE

## SOLDERING FOOTPRINT\*



SCALE 10:1 (mm/inches)

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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