

# NSI45020AT1G

## Constant Current Regulator & LED Driver

45 V, 20 mA  $\pm$  10%

The solid state series of linear constant current regulators (CCRs) are Simple, Economical and Robust (SER) devices designed to provide a cost effective solution for regulating current in LEDs. The SER series regulators are based on patent-pending Self-Biased Transistor (SBT) technology and regulate current over a wide range of voltage. The series is designed with a negative temperature coefficient to protect LEDs from thermal runaway at extreme voltage and operating temperature.

The SER series of constant current regulators require no external components and their high anode-cathode voltage rating withstands surges common in Automotive, Industrial and Commercial Signage Applications. The SER series is available in thermally robust packages and is qualified to stringent AEC 101 standard. The SER series devices are lead-free ROHS compliant and use halogen-free molding compound.

### Applications

- Refer to Application Note AND8391/D for Power Dissipation Consideration
- Refer to Application Note AND8349/D for Automotive Center High Mount Stop Lamp (CHMSL) Application
- Automotive Chevron Side Mirror Markers, Cluster, Display & Instrument Backlighting
- Switch Contact Wetting
- Display Signage
- Channel Letters
- AC Lighting Panels
- Decorative Lighting

### Features

- This Device uses Halogen-Free Molding Compound
- This is a Pb-Free Device

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

Rating	Symbol	Value	Unit
Anode-Cathode Voltage	$V_{AK\text{ Max}}$	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 Machine Model	ESD	Class 1C Class B	

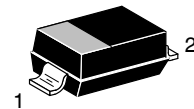
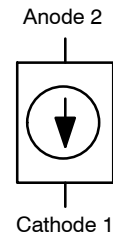
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.



ON Semiconductor®

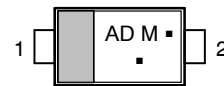
<http://onsemi.com>

$I_{reg(SS)} = 20\text{ mA}$   
@  $V_{AK} = 7.5\text{ V}$



SOD-123  
CASE 425  
STYLE 1

### MARKING DIAGRAM



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

(Note: Microdot may be in either location)

### ORDERING INFORMATION

Device	Package	Shipping†
NSI45020AT1G	SOD-123 (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.

# NSI45020AT1G

## 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)	$I_{reg(SS)}$	18	20	22	mA
Voltage Overhead (Note 2)	$V_{overhead}$		1.8		V
Pulse Current @ $V_{AK} = 7.5\text{ V}$ (Note 3)	$I_{reg(P)}$	19.85	22.5	25.15	mA

- $I_{reg(SS)}$  steady state is the voltage ( $V_{AK}$ ) applied for a time duration  $\geq 10$  sec, using FR-4 @ 300 mm<sup>2</sup> 1 oz. Copper traces, in still air.
- $V_{overhead} = V_{in} - V_{LEDs}$ .  $V_{overhead}$  is minimum value for 85%  $I_{reg(SS)}$ .
- $I_{reg(P)}$  non-repetitive pulse test. Pulse width  $t \leq 300\ \mu\text{sec}$ .

## THERMAL CHARACTERISTICS

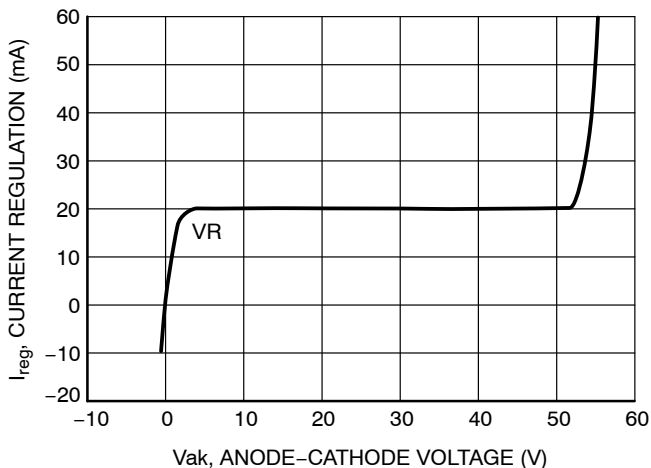
Characteristic	Symbol	Max	Unit
Total Device Dissipation (Note 4) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	208 1.66	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 4)	$R_{\theta JA}$	600	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 4)	$R_{\psi JL}$	196	$^\circ\text{C/W}$
Total Device Dissipation (Note 5) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	227 1.8	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 5)	$R_{\theta JA}$	550	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 5)	$R_{\psi JL}$	160	$^\circ\text{C/W}$
Total Device Dissipation (Note 6) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	347 2.8	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 6)	$R_{\theta JA}$	360	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 6)	$R_{\psi JL}$	160	$^\circ\text{C/W}$
Total Device Dissipation (Note 7) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	368 2.9	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 7)	$R_{\theta JA}$	340	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 7)	$R_{\psi JL}$	132	$^\circ\text{C/W}$
Total Device Dissipation (Note 8) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	436 3.5	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 8)	$R_{\theta JA}$	287	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 8)	$R_{\psi JL}$	148	$^\circ\text{C/W}$
Total Device Dissipation (Note 9) $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	463 3.7	mW mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 9)	$R_{\theta JA}$	270	$^\circ\text{C/W}$
Thermal Reference, Junction-to-Cathode Lead (Note 9)	$R_{\psi JL}$	120	$^\circ\text{C/W}$
Junction and Storage Temperature Range	$T_J, T_{stg}$	-55 to +150	$^\circ\text{C}$

- FR-4 @ 100 mm<sup>2</sup>, 1 oz. copper traces, still air.
- FR-4 @ 100 mm<sup>2</sup>, 2 oz. copper traces, still air.
- FR-4 @ 300 mm<sup>2</sup>, 1 oz. copper traces, still air.
- FR-4 @ 300 mm<sup>2</sup>, 2 oz. copper traces, still air.
- FR-4 @ 500 mm<sup>2</sup>, 1 oz. copper traces, still air.
- FR-4 @ 500 mm<sup>2</sup>, 2 oz. copper traces, still air.

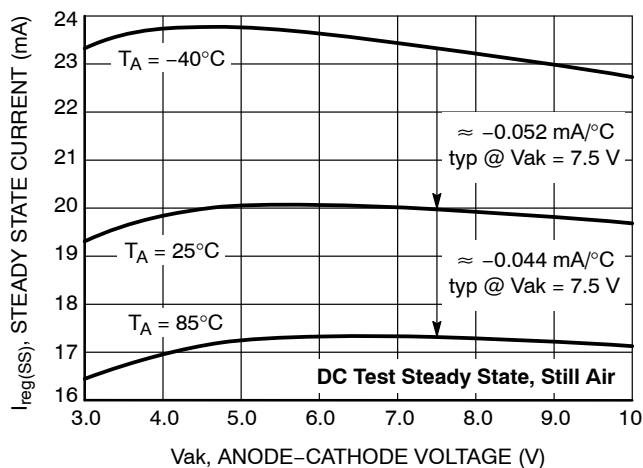
NOTE: Lead measurements are made by non-contact methods such as IR with treated surface to increase emissivity to 0.9.

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.

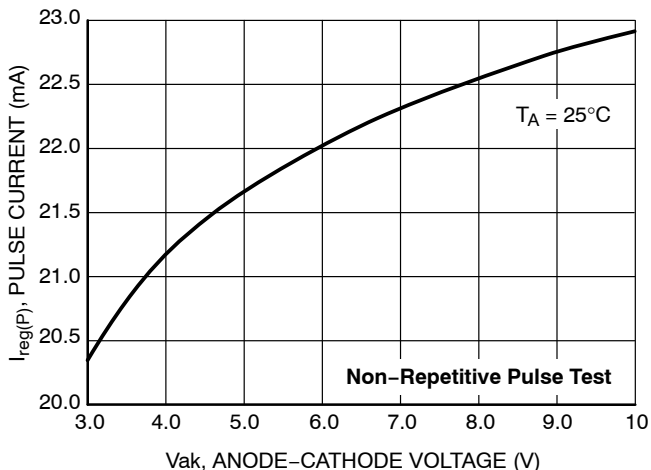
**TYPICAL PERFORMANCE CURVES**  
 Minimum FR-4 @ 300 mm<sup>2</sup>, 1 oz Copper Trace, Still Air



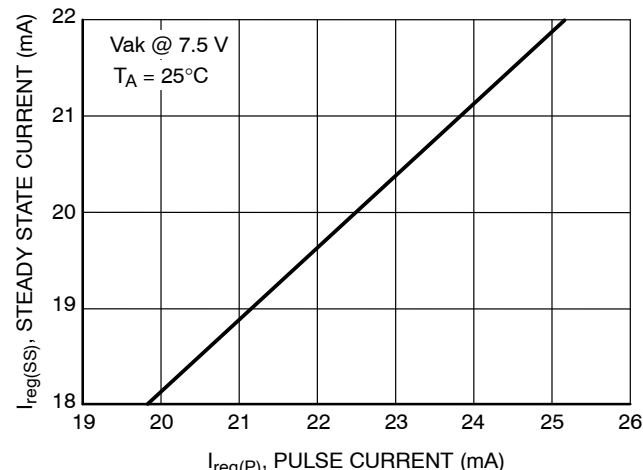
**Figure 1. General Performance Curve for CCR**



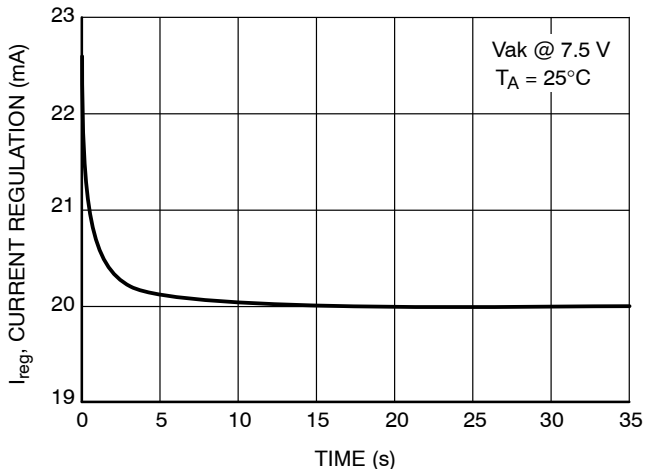
**Figure 2. Steady State Current ( $I_{reg(SS)}$ ) vs. Anode-Cathode Voltage ( $V_{ak}$ )**



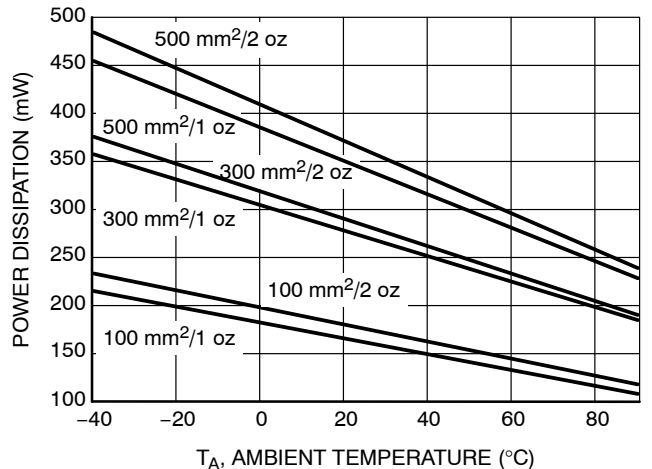
**Figure 3. Pulse Current ( $I_{reg(P)}$ ) vs. Anode-Cathode Voltage ( $V_{ak}$ )**



**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  
(20 mA each LED String)**

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:  $V_{in} = 12 \text{ Vdc}$ ,  $Q_X V_F = 3.5 \text{ Vdc}$ ,  $D1 V_F = 0.7 \text{ V}$**   
**LED  $V_F = 2.2 \text{ Vdc @ 20 mA}$**   
 **$(12 \text{ Vdc} - 4.2 \text{ Vdc}) / 2.2 \text{ Vdc} = 3 \text{ LEDs in series.}$**



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

Number of LED's that can be connected is determined by:  
**D1 is a reverse battery protection diode**  
**Example:  $V_{in} = 12 \text{ Vdc}$ ,  $Q_X V_F = 3.5 \text{ Vdc}$ ,  $D1 V_F = 0.7 \text{ V}$**   
**LED  $V_F = 2.6 \text{ Vdc @ 60 mA}$**   
 **$(12 \text{ Vdc} - (3.5 + 0.7 \text{ Vdc})) / 2.6 \text{ Vdc} = 3 \text{ LEDs in series.}$**   
**Number of Drivers = LED current / 20 mA**  
 **$60 \text{ mA} / 20 \text{ mA} = 3 \text{ Drivers (Q1, Q2, Q3)}$**

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

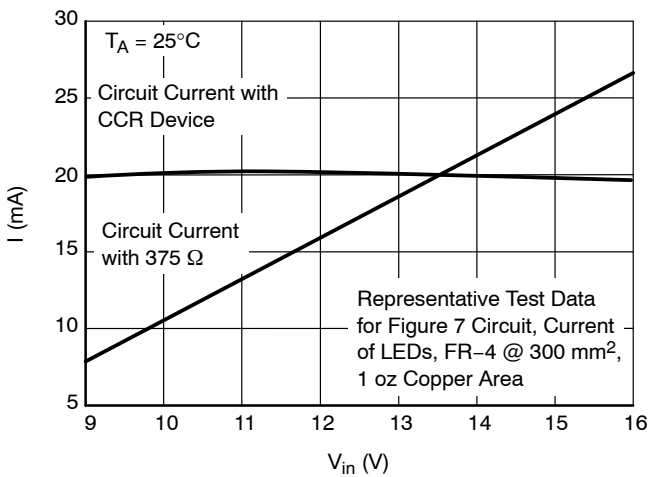


Figure 9. Series Circuit Current

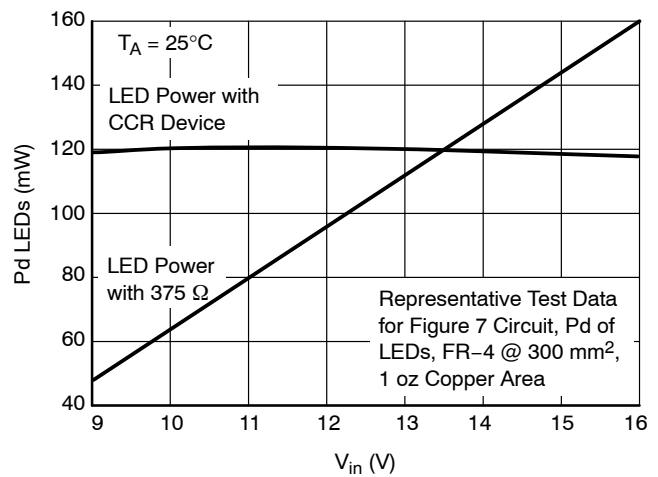


Figure 10. LED Power

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

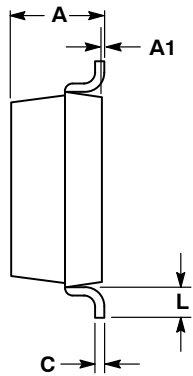
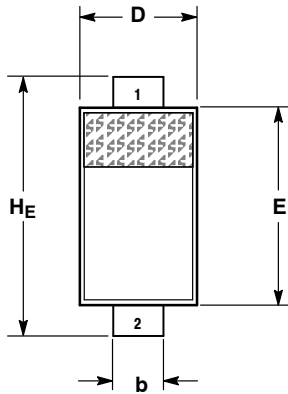
There are two methods to measure current regulation: Pulse mode ( $I_{reg(P)}$ ) testing is applicable for factory and incoming inspection of a CCR where test times are a minimum. ( $t \leq 300 \mu\text{s}$ ). DC Steady-State ( $I_{reg(SS)}$ ) testing is applicable for application verification where 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).

# NSI45020AT1G

## PACKAGE DIMENSIONS

SOD-123  
CASE 425-04  
ISSUE E

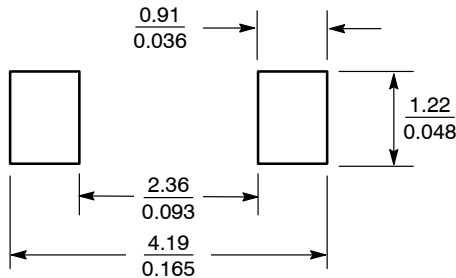


- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

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
HE	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 ( $\frac{\text{mm}}{\text{inches}}$ )

\*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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