NSI45060DDT4G

Adjustable Constant Current Regulator & LED Driver

45 V, 60 − 100 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 NSI45060JD datasheet.

Features

- Robust Power Package: 2.7 Watts
- Adjustable up to 100 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

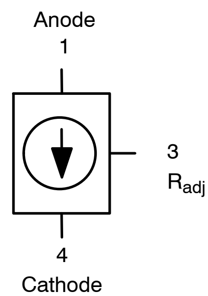
Applications

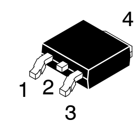
- Automobile: Chevron Side Mirror Markers, Cluster, Display & Instrument Backlighting, CHMSL, Map Light
- AC Lighting Panels, Display Signage, Decorative Lighting, Channel Lettering
- Switch Contact Wetting
- Application Note AND8391/D − Power Dissipation Considerations
- Application Note AND8349/D −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

ON Semiconductor®

http://onsemi.com

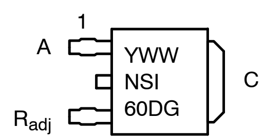
$I_{reg(SS)}$ = 60 − 100 mA
@ Vak = 7.5 V





DPAK
CASE 369C

MARKING DIAGRAM



Y = Year
WW = Work Week
NSI60D = Specific Device Code
G = Pb−Free Package

ORDERING INFORMATION

Device	Package	Shipping†
NSI45060DDT4G	DPAK (Pb−Free)	2500/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.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Anode−Cathode Voltage		Vak Max	45	V
Reverse Voltage		V_R	500	mV
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−55 to +150	°C
ESD Rating:	Human Body Model Machine Model	ESD	Class 2 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.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Steady State Current @ Vak = 7.5 V (Note 1)	$I_{reg(SS)}$	51	60	69	mA
Voltage Overhead (Note 2)	$V_{overhead}$		1.8		V
Pulse Current @ Vak = 7.5 V (Note 3)	$I_{reg(P)}$	54.7	66	76.95	mA
Capacitance @ Vak = 7.5 V (Note 4)	C		17		pF
Capacitance @ Vak = 0 V (Note 4)	C		70		pF

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation (Note 5) T_A = 25°C Derate above 25°C	P_D	1771 14.16	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 5)	$R_{\theta JA}$	70.6	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 5)	$R_{\psi JL4}$	6.8	°C/W
Total Device Dissipation (Note 6) T_A = 25°C Derate above 25°C	P_D	2083 16.67	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 6)	$R_{\theta JA}$	60	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 6)	$R_{\psi JL4}$	6.3	°C/W
Total Device Dissipation (Note 7) T_A = 25°C Derate above 25°C	P_D	2080 16.64	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 7)	$R_{\theta JA}$	60.1	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 7)	$R_{\psi JL4}$	6.5	°C/W
Total Device Dissipation (Note 8) T_A = 25°C Derate above 25°C	P_D	2441 19.53	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 8)	$R_{\theta JA}$	51.2	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 8)	$R_{\psi JL4}$	5.9	°C/W
Total Device Dissipation (Note 9) T_A = 25°C Derate above 25°C	P_D	2309 18.47	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 9)	$R_{\theta JA}$	54.1	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 9)	$R_{\psi JL4}$	6.2	°C/W
Total Device Dissipation (Note 10) T_A = 25°C Derate above 25°C	P_D	2713 21.71	mW mW/°C
Thermal Resistance, Junction−to−Ambient (Note 10)	$R_{\theta JA}$	46.1	°C/W
Thermal Reference, Junction−to−Lead 4 (Note 10)	$R_{\psi JL4}$	5.7	°C/W
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 mm^2, 2 oz Copper Trace, Still Air

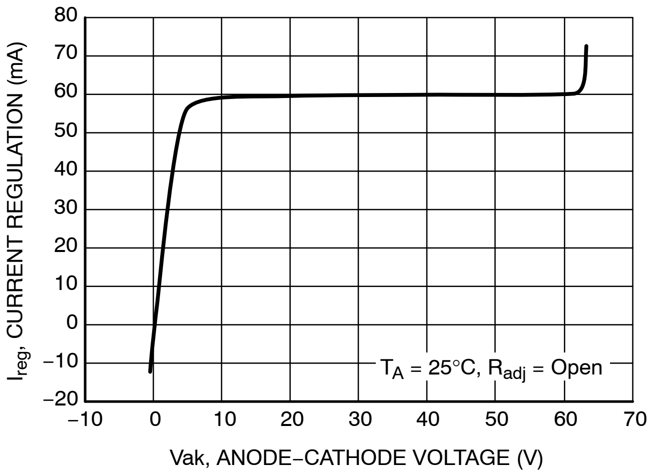


Figure 1. General Performance Curve for CCR

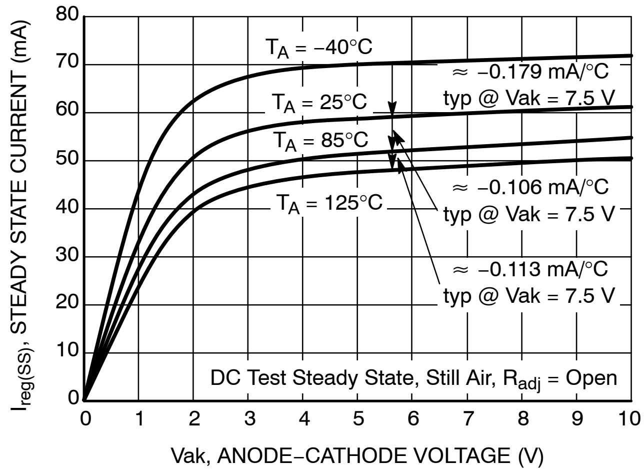


Figure 2. Steady State Current ($I_{reg(SS)}$) vs. Anode−Cathode Voltage (Vak)

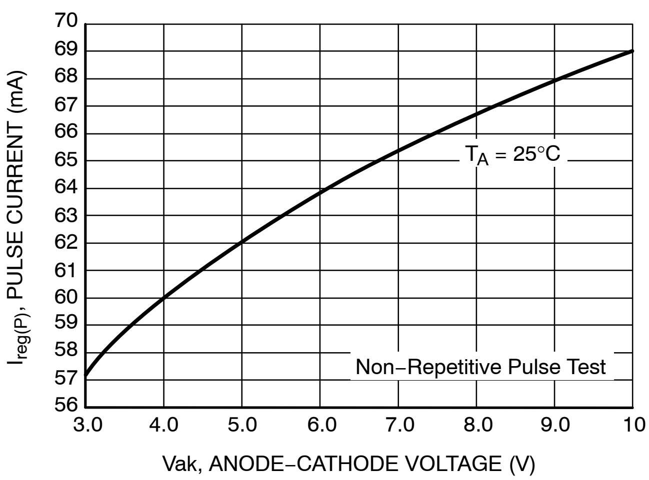


Figure 3. Pulse Current ($I_{reg(P)}$) vs. Anode−Cathode Voltage (Vak)

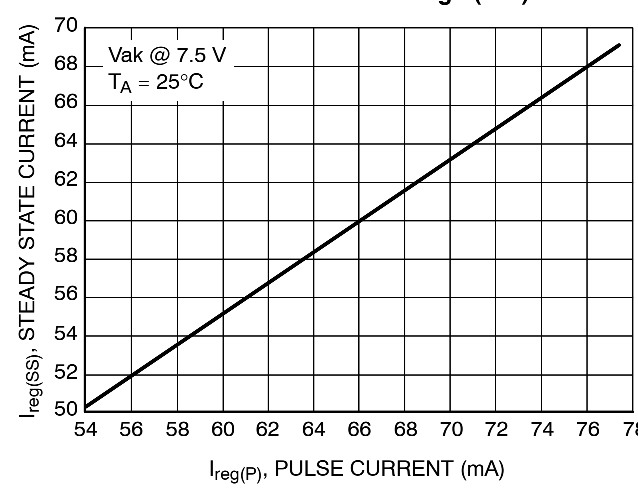


Figure 4. Steady State Current vs. Pulse Current Testing

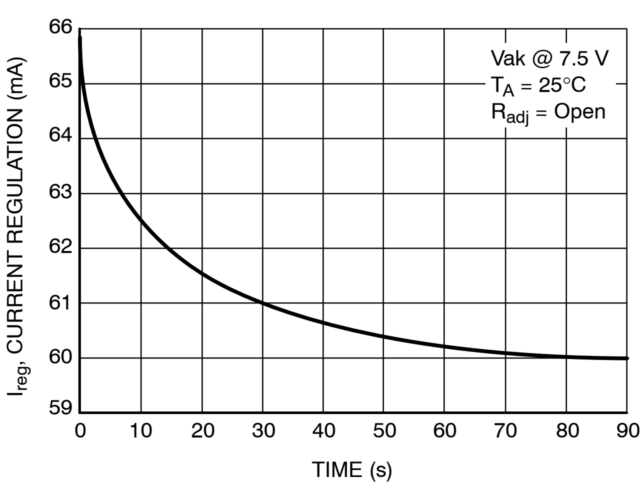


Figure 5. Current Regulation vs. Time

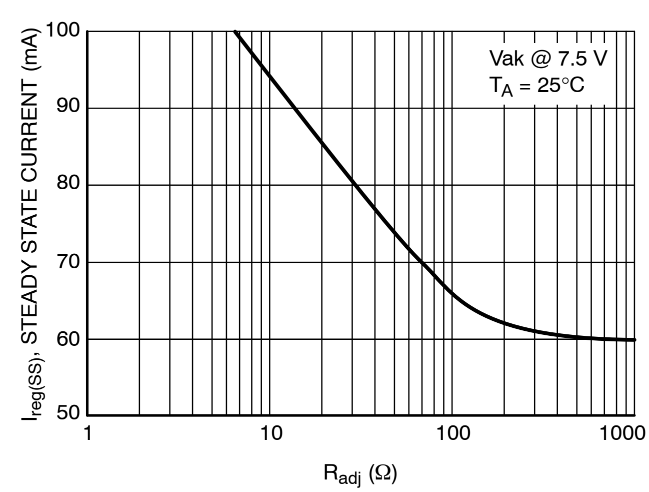


Figure 6. $I_{reg(SS)}$ vs. R_{adj}

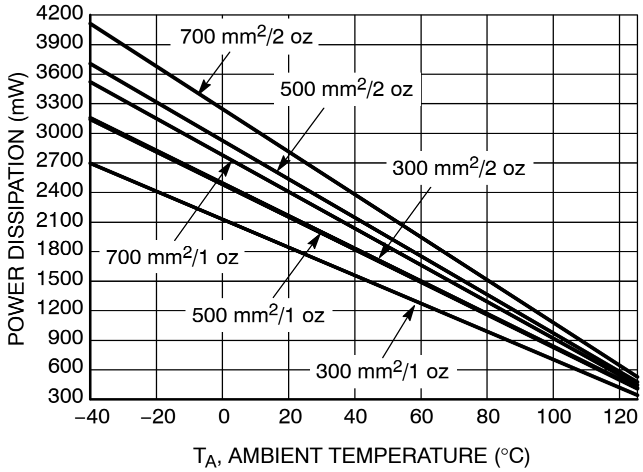


Figure 7. Power Dissipation vs. Ambient Temperature @ T_J = 150°C

APPLICATIONS

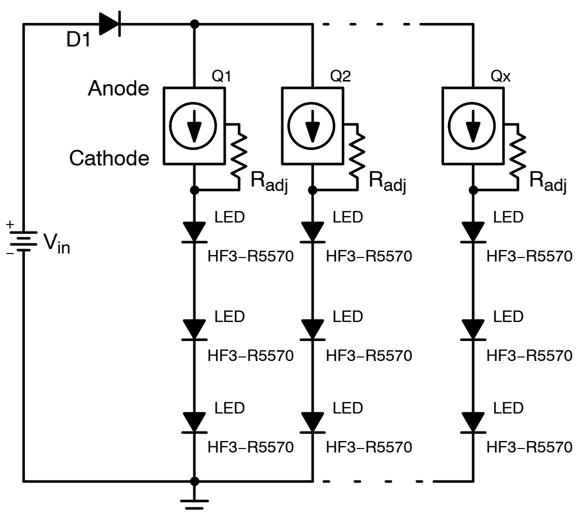


Figure 8. Typical Application Circuit (30 mA each LED String)

Number of LED's that can be connected is determined by:
D1 is a reverse battery protection diode
LED's = ((V_{in} − Q_X V_F − D1 V_F)/LED V_F)
Example: V_{in} = 12 Vdc, Q_X V_F = 3.5 Vdc, D1VF = 0.7 V
LED V_F = 2.2 Vdc @ 30 mA
(12 Vdc − 4.2 Vdc)/2.2 Vdc = 3 LEDs in series.

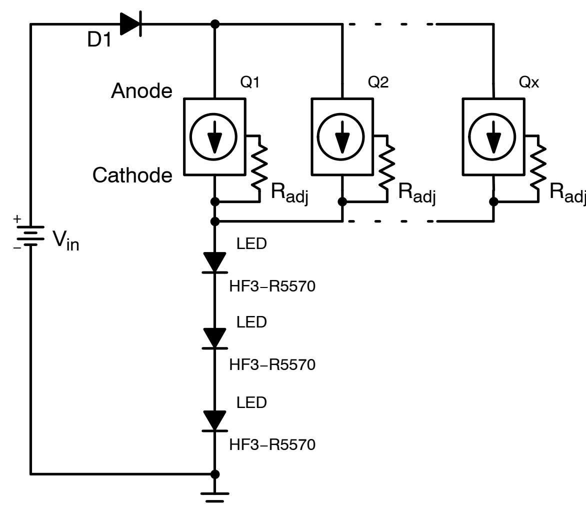


Figure 9. Typical Application Circuit (90 mA each LED String)

Number of LED's that can be connected is determined by:
D1 is a reverse battery protection diode
Example: V_{in} = 12 Vdc, Q_X V_F = 3.5 Vdc, D1VF = 0.7 V
LED V_F = 2.6 Vdc @ 90 mA
(12 Vdc − (3.5 + 0.7 Vdc))/2.6 Vdc = 3 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

ON Semiconductor CCR Design	Resistor Biased Design
Constant brightness over full Supply Voltage (more efficient), see Figure 10	Large variations in brightness over full Automotive Supply Voltage
Little variation of power in LEDs, see Figure 11	Large variations of current (power) in LEDs
Constant current extends LED strings lifetime, see Figure 10	High Supply Voltage/ Higher Current in LED strings limits lifetime
Current decreases as voltage increases, see Figure 10	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
Single resistor is used for current select	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

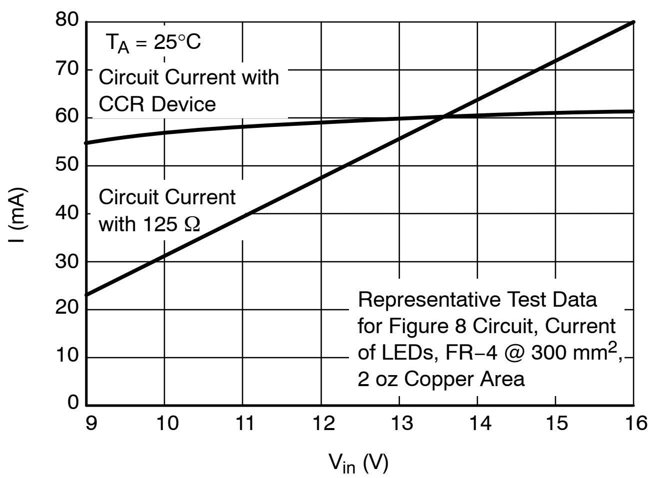


Figure 10. Series Circuit Current

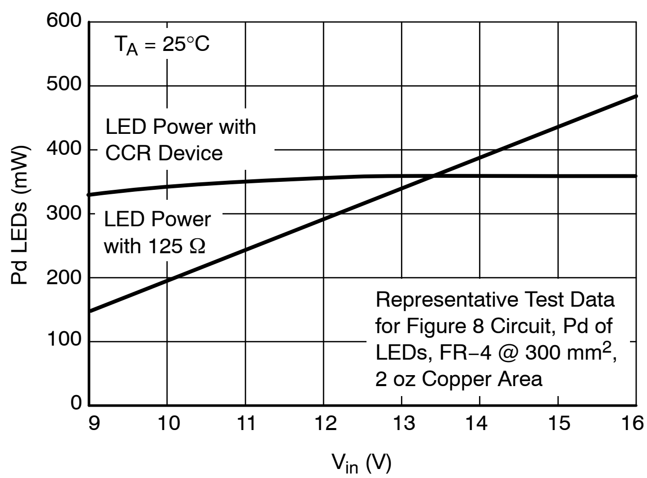
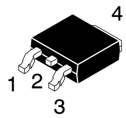


Figure 11. LED Power

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

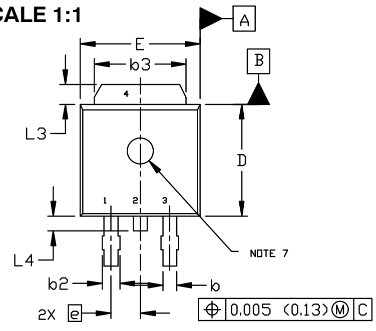
There are two methods to measure current regulation: Pulse mode ($I_{reg(P)}$) testing is applicable for factory and incoming inspection of a CCR where test times are a minimum. ($t \le 300$ μs). DC Steady-State ($I_{reg(SS)}$) testing is applicable for application verification where the CCR will be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



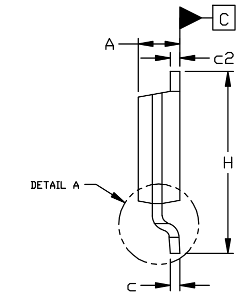
DPAK (SINGLE GAUGE)
CASE 369C
ISSUE G

DATE 31 MAY 2023

SCALE 1:1



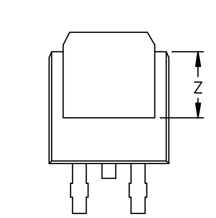
TOP VIEW



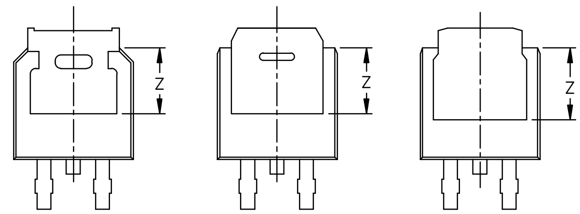
SIDE VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3, AND Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. DIMENSIONS D AND E ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
6. DATUMS A AND B ARE DETERMINED AT DATUM PLANE H.
7. OPTIONAL MOLD FEATURE.

DIM	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.086	0.094	2.18	2.38
A1	0.000	0.005	0.00	0.13
b	0.025	0.035	0.63	0.89
b2	0.028	0.045	0.72	1.14
b3	0.180	0.215	4.57	5.46
c	0.018	0.024	0.46	0.61
c2	0.018	0.024	0.46	0.61
D	0.235	0.245	5.97	6.22
E	0.250	0.265	6.35	6.73
e	0.090 BSC		2.29 BSC	
H	0.370	0.410	9.40	10.41
L	0.055	0.070	1.40	1.78
L1	0.114 REF		2.90 REF	
L2	0.020 BSC		0.51 BSC	
L3	0.035	0.050	0.89	1.27
L4	----	0.040	---	1.01
Z	0.155	----	3.93	---

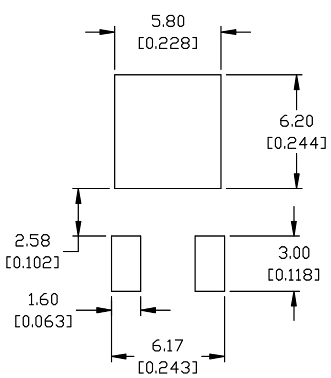


BOTTOM VIEW



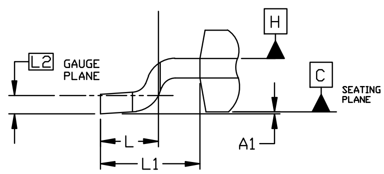
BOTTOM VIEW

ALTERNATE CONSTRUCTIONS



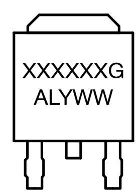
RECOMMENDED MOUNTING FOOTPRINT*

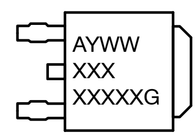
*FOR ADDITIONAL INFORMATION ON OUR PB-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ON SEMICONDUCTOR SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERRM/D.



DETAIL A
ROTATED 90° CW

GENERIC
MARKING DIAGRAM*





IC **Discrete**

XXXXXX = Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

STYLE 3:
PIN 1. ANODE
2. CATHODE
3. ANODE
4. CATHODE

STYLE 4:
PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

STYLE 5:
PIN 1. GATE
2. ANODE
3. CATHODE
4. ANODE

STYLE 6:
PIN 1. MT1
2. MT2
3. GATE
4. MT2

STYLE 7:
PIN 1. GATE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 8:
PIN 1. N/C
2. CATHODE
3. ANODE
4. CATHODE

STYLE 9:
PIN 1. ANODE
2. CATHODE
3. RESISTOR ADJUST
4. CATHODE

STYLE 10:
PIN 1. CATHODE
2. ANODE
3. CATHODE
4. ANODE

DOCUMENT NUMBER:	**98AON10527D**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.
DESCRIPTION:	**DPAK (SINGLE GAUGE)**	**PAGE 1 OF 1**

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical−documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support
For additional information, please contact your local Sales Representative at
www.onsemi.com/support/sales

◊