

# NUD4001, NSVD4001

## High Current LED Driver

This device is designed to replace discrete solutions for driving LEDs in low voltage AC-DC applications 5.0 V, 12 V or 24 V. An external resistor allows the circuit designer to set the drive current for different LED arrays. This discrete integration technology eliminates individual components by combining them into a single package, which results in a significant reduction of both system cost and board space. The device is a small surface mount package (SO-8).

### Features

- Supplies Constant LED Current for Varying Input Voltages
- External Resistor Allows Designer to Set Current – up to 500 mA
- Offered in Surface Mount Package Technology (SO-8)
- AEC-Q101 Qualified and PPAP Capable
- NSV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements
- Pb-Free Package is Available

### Benefits

- Maintains a Constant Light Output During Battery Drain
- One Device can be used for Many Different LED Products
- Reduces Board Space and Component Count
- Simplifies Circuit and System Designs

### Typical Applications

- Portables: For Battery Back-up Applications, also Simple Ni-CAD Battery Charging
- Industrial: Low Voltage Lighting Applications and Small Appliances
- Automotive: Tail Lights, Directional Lights, Back-up Light, Dome Light

### PIN FUNCTION DESCRIPTION

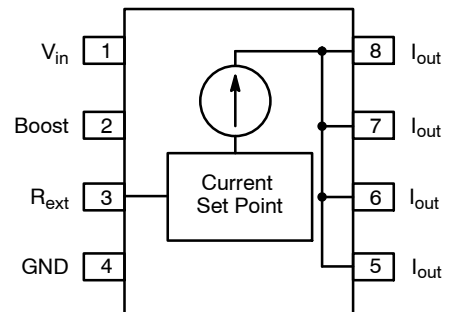
Pin	Symbol	Description
1	$V_{in}$	Positive input voltage to the device
2	Boost	This pin may be used to drive an external transistor as described in the App Note AND8198/D.
3	$R_{ext}$	An external resistor between $R_{ext}$ and $V_{in}$ pins sets different current levels for different application needs
4	GND	Ground
5, 6, 7, 8	$I_{out}$	The LEDs are connected from these pins to ground



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### PIN CONFIGURATION AND SCHEMATIC



### MARKING DIAGRAM



4001 = Specific Device Code  
 A = Assembly Location  
 Y = Year  
 WW = Work Week  
 ■ = Pb-Free Device

### ORDERING INFORMATION

Device	Package	Shipping†
NUD4001DR2	SO-8	2500 / Tape & Reel
NUD4001DR2G	SO-8 (Pb-Free)	2500 / Tape & Reel
NSVD4001DR2G	SO-8 (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 Specification Brochure, BRD8011/D.

# NUD4001, NSVD4001

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

Rating	Symbol	Value	Unit
Continuous Input Voltage	$V_{in}$	30	V
Non-repetitive Peak Input Voltage ( $t \leq 1.0$ ms)	$V_p$	60	V
Output Current (For $V_{drop} \leq 2.2$ V) (Note 1)	$I_{out}$	500	mA
Output Voltage	$V_{out}$	28	V
Human Body Model (HBM)	ESD	1000	V

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.

1.  $V_{drop} = V_{in} - 0.7 \text{ V} - V_{LEDs}$ .

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Operating Ambient Temperature	$T_A$	-40 to +125	$^\circ\text{C}$
Maximum Junction Temperature	$T_J$	150	$^\circ\text{C}$
Storage Temperature	$T_{STG}$	-55 to +150	$^\circ\text{C}$
Total Power Dissipation (Note 2) Derating above $25^\circ\text{C}$ (Figure 3)	$P_D$	1.13 9.0	W mW/ $^\circ\text{C}$
Thermal Resistance, Junction-to-Ambient (Note 2)	$R_{\theta JA}$	110	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction-to-Lead (Note 2)	$R_{\theta JL}$	77	$^\circ\text{C}/\text{W}$

2. Mounted on FR-4 board, 2 in sq pad, 2 oz coverage.

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

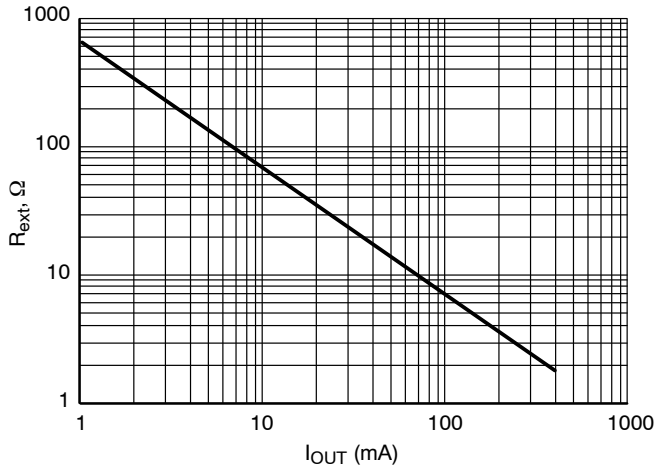
Characteristic	Symbol	Min	Typ	Max	Unit
Output Current1 ( $V_{in} = 12$ V, $R_{ext} = 2.0$ $\Omega$ , $V_{LEDs} = 10$ V)	$I_{out1}$	305	325	345	mA
Output Current2 ( $V_{in} = 30$ V, $R_{ext} = 7.0$ $\Omega$ , $V_{LEDs} = 24$ V)	$I_{out2}$	95	105	115	mA
Bias Current ( $V_{in} = 12$ V, $R_{ext} = \text{Open}$ , $V_{LEDs} = 10$ V)	$I_{Bias}$	-	5.0	8.0	mA
Voltage Overhead (Note 3)	$V_{over}$	1.4	-	-	V

3.  $V_{over} = V_{in} - V_{LEDs}$ .

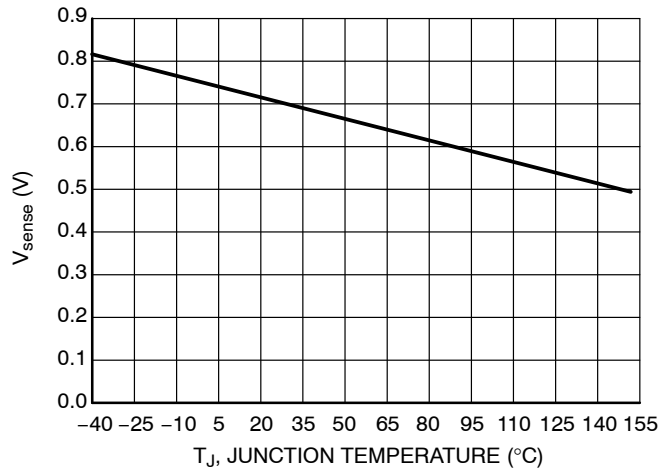
# NUD4001, NSVD4001

## TYPICAL PERFORMANCE CURVES

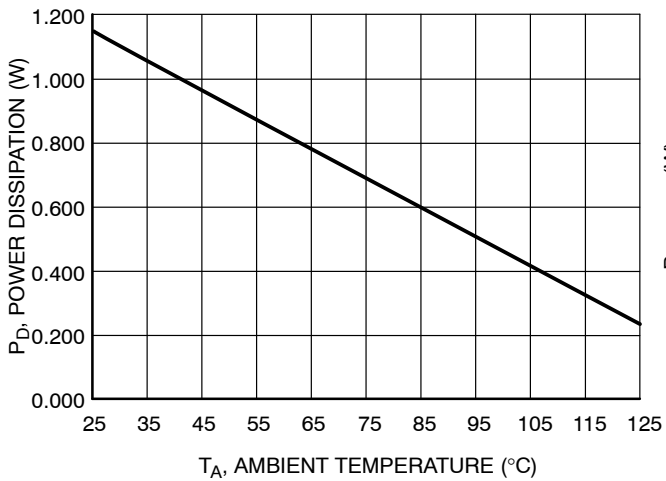
( $T_A = 25^\circ\text{C}$  unless otherwise noted)



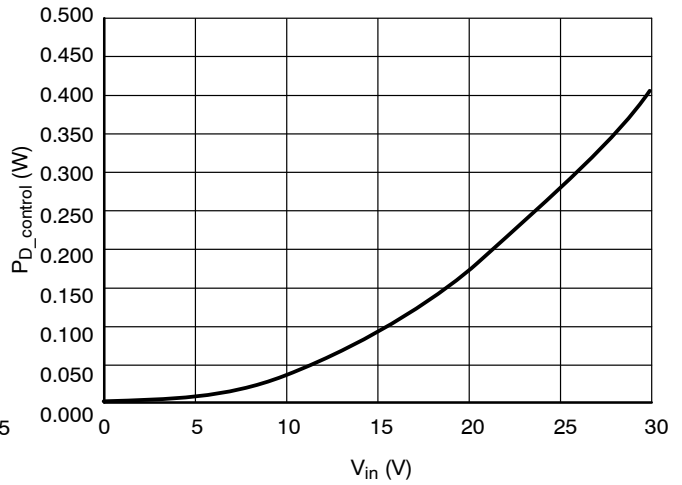
**Figure 1. Output Current ( $I_{OUT}$ ) vs. External Resistor ( $R_{ext}$ )**



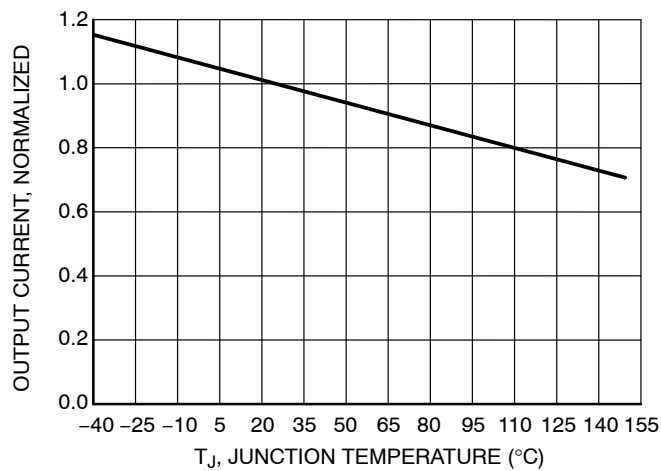
**Figure 2.  $V_{sense}$  vs. Junction Temperature**



**Figure 3. Total Power Dissipation ( $P_D$ ) vs. Ambient Temperature ( $T_A$ )**



**Figure 4. Internal Circuit Power Dissipation vs. Input Voltage**



**Figure 5. Current Regulation vs. Junction Temperature**

APPLICATION INFORMATION

Design Guide

1. Define LED's current:
  - a.  $I_{LED} = 350 \text{ mA}$
2. Calculate Resistor Value for  $R_{ext}$ :
  - a.  $R_{ext} = V_{sense} / I_{LED}$  (see Figure 2)
  - b.  $R_{ext} = 0.7 \text{ V} (T_J = 25 \text{ }^\circ\text{C}) / 0.350 = 2.0 \text{ } \Omega$
3. Define  $V_{in}$ :
  - a. Per example in Figure 6,  $V_{in} = 12 \text{ V}$
4. Define  $V_{LED} @ I_{LED}$  per LED supplier's data sheet:
  - a. Per example in Figure 6,  $V_{LED} = 3.5 \text{ V} + 3.5 \text{ V} + 3.5 \text{ V} = 10.5 \text{ V}$
5. Calculate  $V_{drop}$  across the NUD4001 device:
  - a.  $V_{drop} = V_{in} - V_{sense} - V_{LED}$
  - b.  $V_{drop} = 12 \text{ V} - 0.7 \text{ V} (T_J = 25 \text{ }^\circ\text{C}) - 10.5 \text{ V}$
  - c.  $V_{drop} = 0.8 \text{ V}$
6. Calculate Power Dissipation on the NUD4001 device's driver:
  - a.  $P_{D\_driver} = V_{drop} * I_{out}$
  - b.  $P_{D\_driver} = 0.8 \text{ V} \times 0.350 \text{ A}$
  - c.  $P_{D\_driver} = 0.280 \text{ Watts}$
7. Establish Power Dissipation on the NUD4001 device's control circuit per Figure 4:
  - a.  $P_{D\_control} =$  Figure 4, for 12 V input voltage
  - b.  $P_{D\_control} = 0.055 \text{ W}$
8. Calculate Total Power Dissipation on the device:
  - a.  $P_{D\_total} = P_{D\_driver} + P_{D\_control}$
  - b.  $P_{D\_total} = 0.280 \text{ W} + 0.055 \text{ W} = 0.335 \text{ W}$
9. If  $P_{D\_total} > 1.13 \text{ W}$  (or derated value per Figure 3), then select the most appropriate recourse and repeat steps 1 through 8:
  - a. Reduce  $V_{in}$
  - b. Reconfigure LED array to reduce  $V_{drop}$
  - c. Reduce  $I_{out}$  by increasing  $R_{ext}$
  - d. Use external resistors or parallel device's configuration (see application note AND8156)
10. Calculate the junction temperature using the thermal information on Page 7 and refer to Figure 5 to check the output current drop due to the calculated junction temperature. If desired, compensate it by adjusting the value of  $R_{ext}$ .

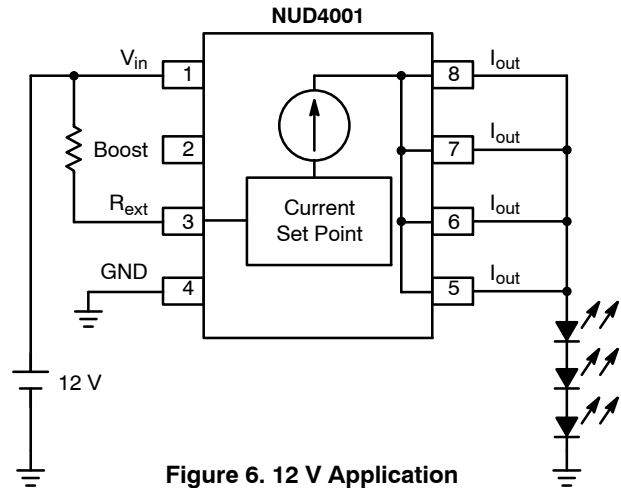


Figure 6. 12 V Application (Series LED's Array)

# NUD4001, NSVD4001

## TYPICAL APPLICATION CIRCUITS

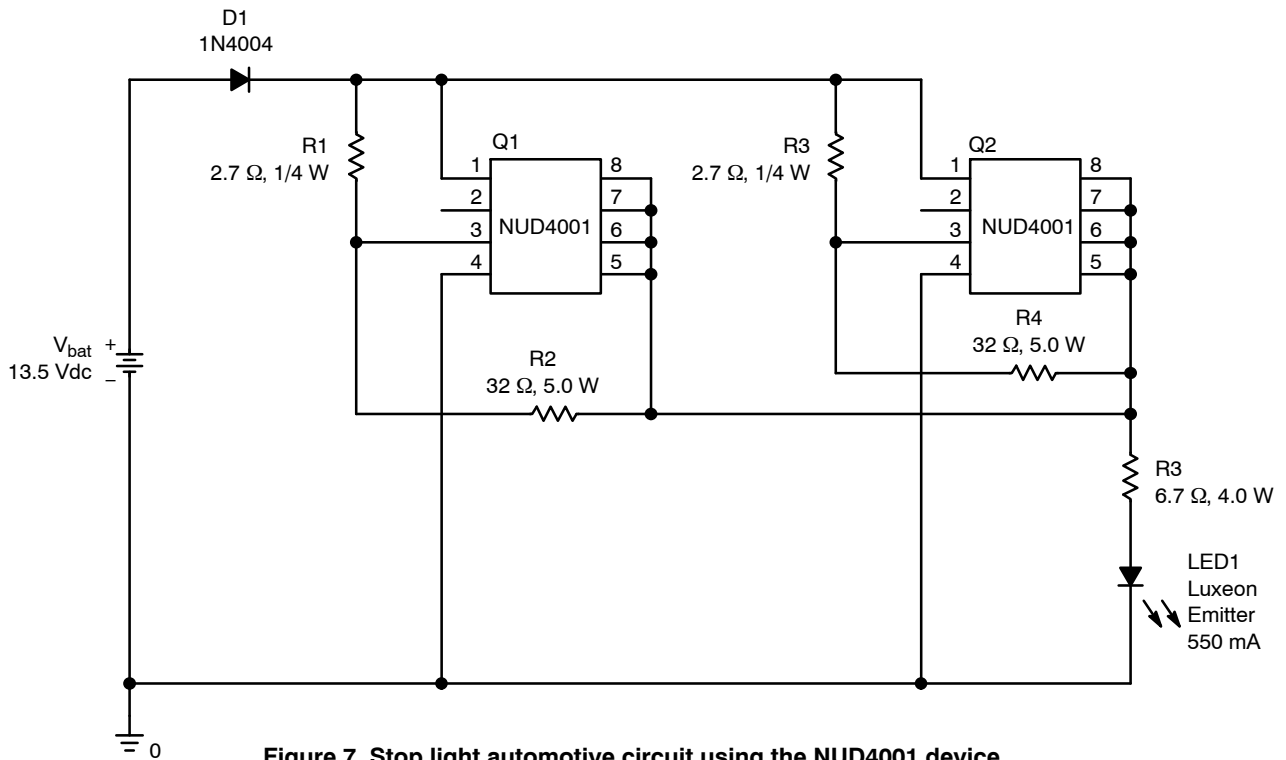


Figure 7. Stop light automotive circuit using the NUD4001 device to drive one high current LED (550 mA).

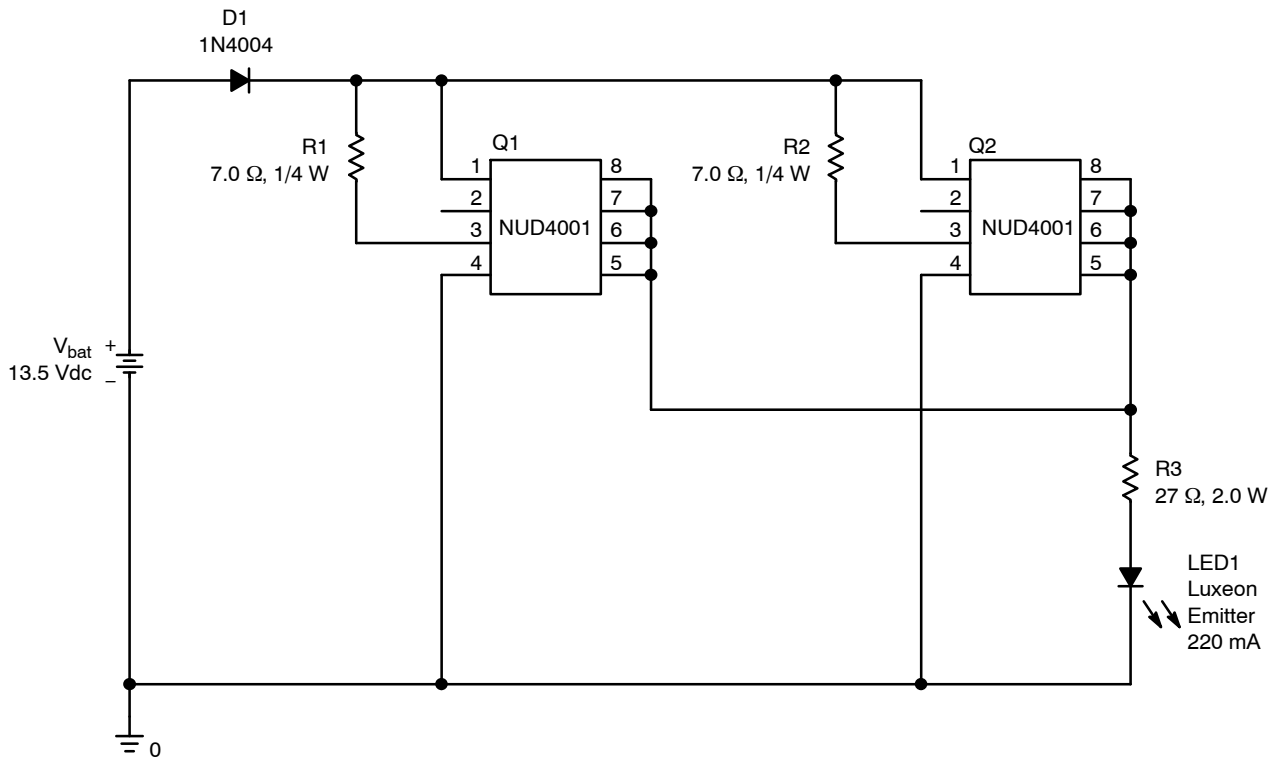
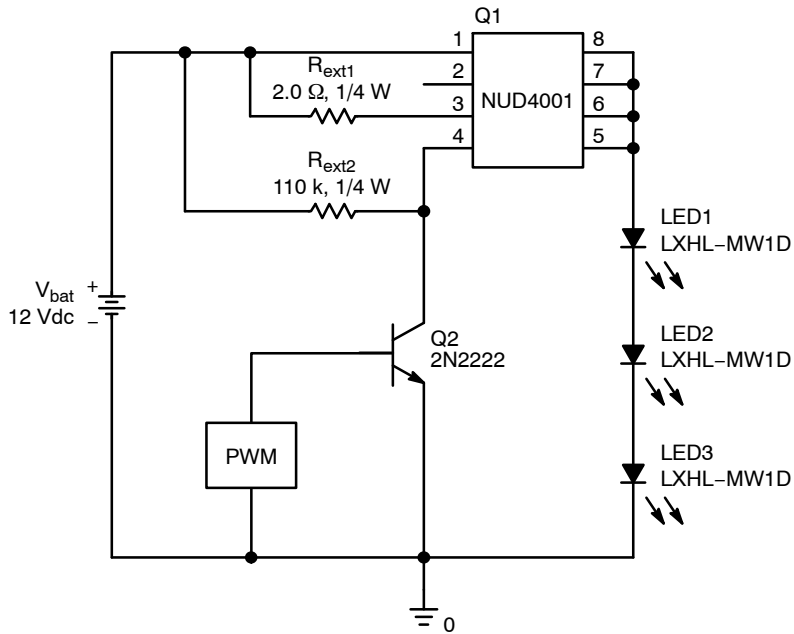
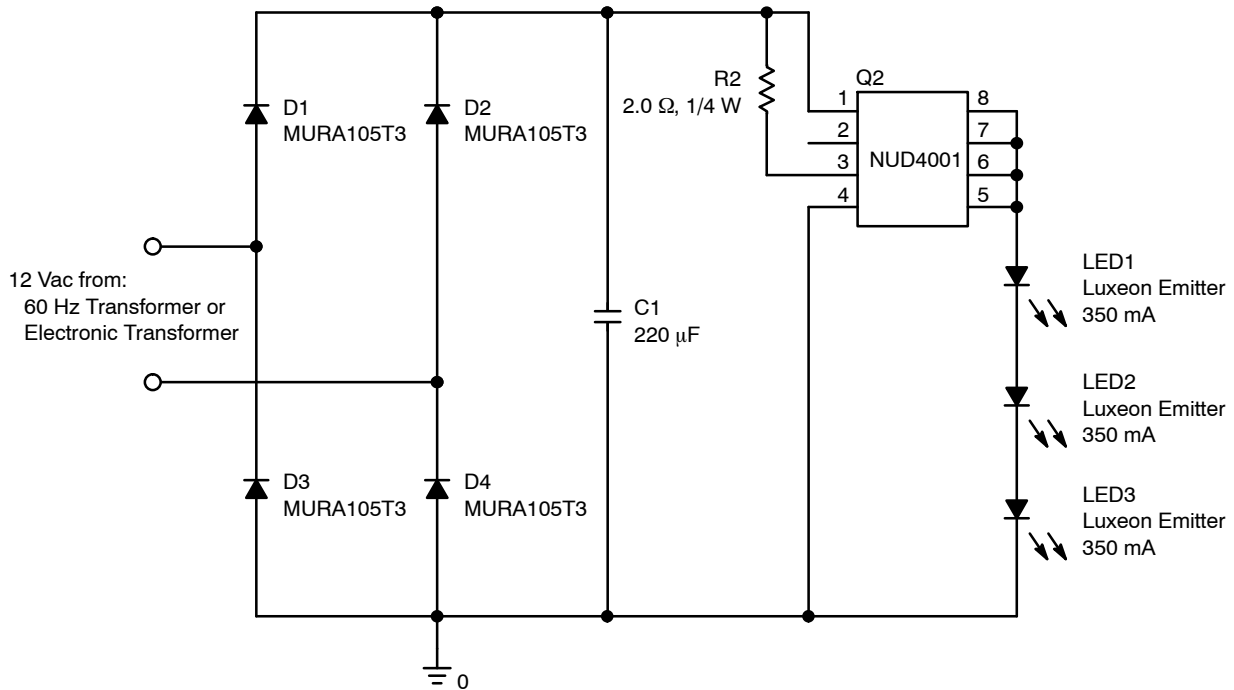


Figure 8. Dome light automotive circuit using the NUD4001 device to drive one LED (220 mA).

## NUD4001, NSVD4001



**Figure 9. NUD4001 Device Configuration for PWM**



**Figure 10. 12 Vac landscape lighting application circuit using the NUD4001 device to drive three 350 mA LEDs.**

# NUD4001, NSVD4001

## THERMAL INFORMATION

### NUD4001, NSVD4001 Power Dissipation

The power dissipation of the SO-8 is a function of the pad size. This can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by  $T_{J(max)}$ , the maximum rated junction temperature of the die,  $R_{\theta JA}$ , the thermal resistance from the device junction to ambient, and the operating temperature,  $T_A$ . Using the values provided on the data sheet for the SO-8 package,  $P_D$  can be calculated as follows:

$$P_D = \frac{T_{Jmax} - T_A}{R_{\theta JA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature  $T_A$  of 25°C, one can calculate the power dissipation of the device which in this case is 1.13 W.

$$P_D = \frac{150^\circ C - 25^\circ C}{110^\circ C} = 1.13 W$$

The 110°C/W for the SO-8 package assumes the use of a FR-4 copper board with an area of 2 square inches with 2 oz coverage to achieve a power dissipation of 1.13 W. There are other alternatives to achieving higher dissipation from the SOIC package. One of them is to increase the copper area to

reduce the thermal resistance. Figure 11 shows how the thermal resistance changes for different copper areas. Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad®. Using a board material such as Thermal Clad or an aluminum core board, the power dissipation can be even doubled using the same footprint.

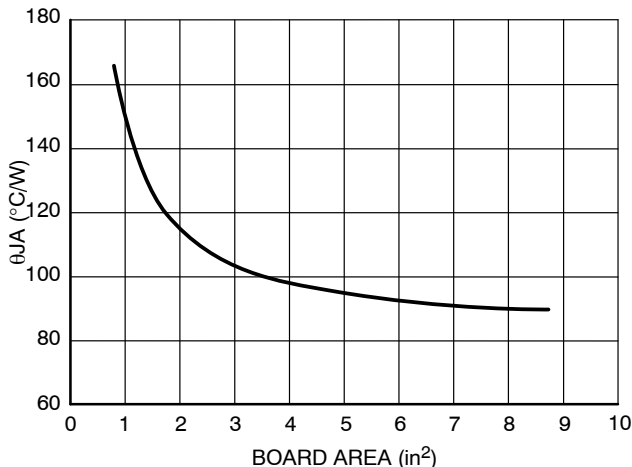


Figure 11.  $\theta_{JA}$  versus Board Area

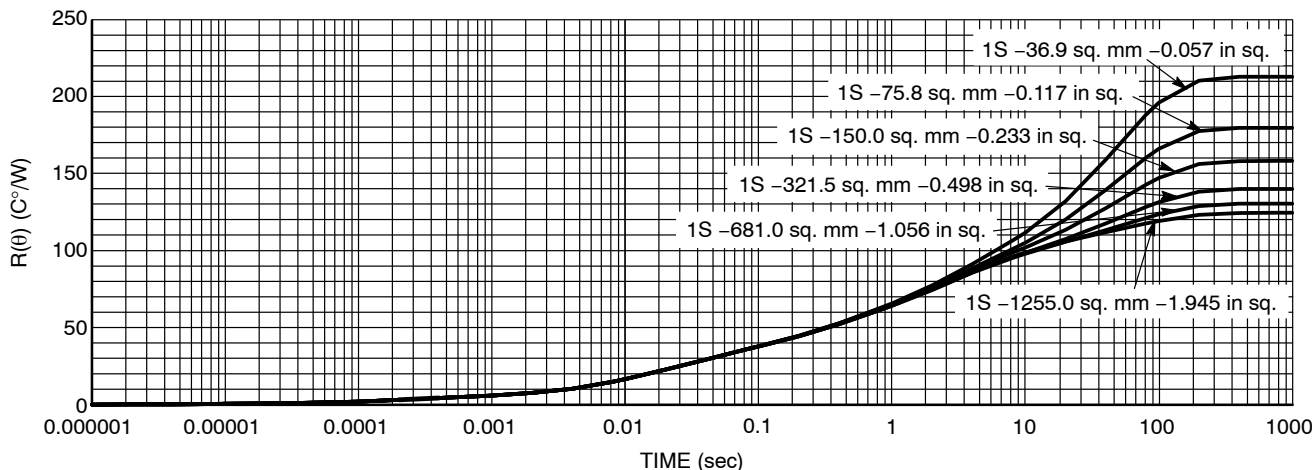


Figure 12. Transient Thermal Response

Thermal Clad is a registered trademark of the Bergquist Company.

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

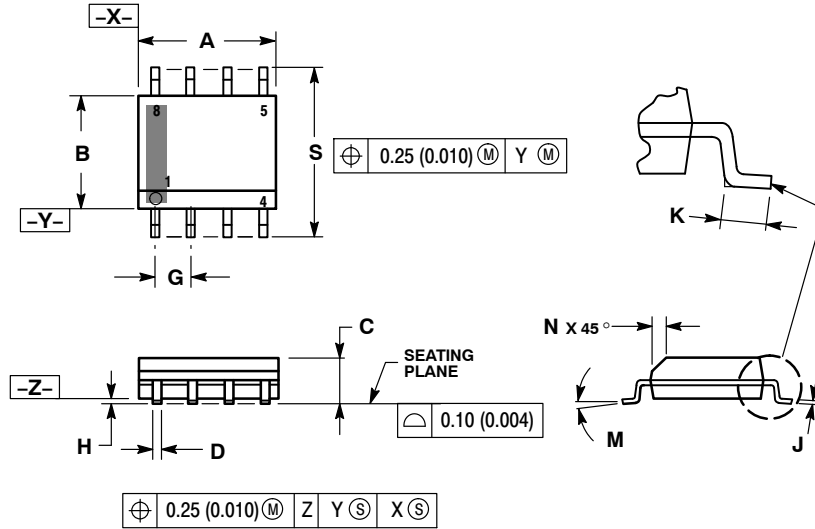
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SCALE 1:1

SOIC-8 NB  
CASE 751-07  
ISSUE AK

DATE 16 FEB 2011



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
  6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0°	8°	0°	8°
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

### SOLDERING 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.

### GENERIC MARKING DIAGRAM\*



XXXXXX = Specific Device Code  
 A = Assembly Location  
 L = Wafer Lot  
 Y = Year  
 W = Work Week  
 ■ = Pb-Free Package

XXXXXX = Specific Device Code  
 A = Assembly Location  
 Y = Year  
 WW = Work Week  
 ■ = 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.

STYLES ON PAGE 2

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DESCRIPTION:	SOIC-8 NB	PAGE 1 OF 2

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**SOIC-8 NB**  
**CASE 751-07**  
**ISSUE AK**

DATE 16 FEB 2011

- |  |   |   |   |
|--|---|---|---|
| <p><b>STYLE 1:</b><br/>         PIN 1. EMITTER<br/>         2. COLLECTOR<br/>         3. COLLECTOR<br/>         4. EMITTER<br/>         5. EMITTER<br/>         6. BASE<br/>         7. BASE<br/>         8. EMITTER</p>   | <p><b>STYLE 2:</b><br/>         PIN 1. COLLECTOR, DIE, #1<br/>         2. COLLECTOR, #1<br/>         3. COLLECTOR, #2<br/>         4. COLLECTOR, #2<br/>         5. BASE, #2<br/>         6. EMITTER, #2<br/>         7. BASE, #1<br/>         8. EMITTER, #1</p>               | <p><b>STYLE 3:</b><br/>         PIN 1. DRAIN, DIE #1<br/>         2. DRAIN, #1<br/>         3. DRAIN, #2<br/>         4. DRAIN, #2<br/>         5. GATE, #2<br/>         6. SOURCE, #2<br/>         7. GATE, #1<br/>         8. SOURCE, #1</p>                            | <p><b>STYLE 4:</b><br/>         PIN 1. ANODE<br/>         2. ANODE<br/>         3. ANODE<br/>         4. ANODE<br/>         5. ANODE<br/>         6. ANODE<br/>         7. ANODE<br/>         8. COMMON CATHODE</p>   |
| <p><b>STYLE 5:</b><br/>         PIN 1. DRAIN<br/>         2. DRAIN<br/>         3. DRAIN<br/>         4. DRAIN<br/>         5. GATE<br/>         6. GATE<br/>         7. SOURCE<br/>         8. SOURCE</p>   | <p><b>STYLE 6:</b><br/>         PIN 1. SOURCE<br/>         2. DRAIN<br/>         3. DRAIN<br/>         4. SOURCE<br/>         5. SOURCE<br/>         6. GATE<br/>         7. GATE<br/>         8. SOURCE</p>  | <p><b>STYLE 7:</b><br/>         PIN 1. INPUT<br/>         2. EXTERNAL BYPASS<br/>         3. THIRD STAGE SOURCE<br/>         4. GROUND<br/>         5. DRAIN<br/>         6. GATE 3<br/>         7. SECOND STAGE Vd<br/>         8. FIRST STAGE Vd</p>                    | <p><b>STYLE 8:</b><br/>         PIN 1. COLLECTOR, DIE #1<br/>         2. BASE, #1<br/>         3. BASE, #2<br/>         4. COLLECTOR, #2<br/>         5. COLLECTOR, #2<br/>         6. EMITTER, #2<br/>         7. EMITTER, #1<br/>         8. COLLECTOR, #1</p>                              |
| <p><b>STYLE 9:</b><br/>         PIN 1. EMITTER, COMMON<br/>         2. COLLECTOR, DIE #1<br/>         3. COLLECTOR, DIE #2<br/>         4. EMITTER, COMMON<br/>         5. EMITTER, COMMON<br/>         6. BASE, DIE #2<br/>         7. BASE, DIE #1<br/>         8. EMITTER, COMMON</p> | <p><b>STYLE 10:</b><br/>         PIN 1. GROUND<br/>         2. BIAS 1<br/>         3. OUTPUT<br/>         4. GROUND<br/>         5. GROUND<br/>         6. BIAS 2<br/>         7. INPUT<br/>         8. GROUND</p>  | <p><b>STYLE 11:</b><br/>         PIN 1. SOURCE 1<br/>         2. GATE 1<br/>         3. SOURCE 2<br/>         4. GATE 2<br/>         5. DRAIN 2<br/>         6. DRAIN 2<br/>         7. DRAIN 1<br/>         8. DRAIN 1</p>   | <p><b>STYLE 12:</b><br/>         PIN 1. SOURCE<br/>         2. SOURCE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>   |
| <p><b>STYLE 13:</b><br/>         PIN 1. N.C.<br/>         2. SOURCE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>  | <p><b>STYLE 14:</b><br/>         PIN 1. N-SOURCE<br/>         2. N-GATE<br/>         3. P-SOURCE<br/>         4. P-GATE<br/>         5. P-DRAIN<br/>         6. P-DRAIN<br/>         7. N-DRAIN<br/>         8. N-DRAIN</p>   | <p><b>STYLE 15:</b><br/>         PIN 1. ANODE 1<br/>         2. ANODE 1<br/>         3. ANODE 1<br/>         4. ANODE 1<br/>         5. CATHODE, COMMON<br/>         6. CATHODE, COMMON<br/>         7. CATHODE, COMMON<br/>         8. CATHODE, COMMON</p>               | <p><b>STYLE 16:</b><br/>         PIN 1. EMITTER, DIE #1<br/>         2. BASE, DIE #1<br/>         3. EMITTER, DIE #2<br/>         4. BASE, DIE #2<br/>         5. COLLECTOR, DIE #2<br/>         6. COLLECTOR, DIE #2<br/>         7. COLLECTOR, DIE #1<br/>         8. COLLECTOR, DIE #1</p> |
| <p><b>STYLE 17:</b><br/>         PIN 1. VCC<br/>         2. V2OUT<br/>         3. V1OUT<br/>         4. TXE<br/>         5. RXE<br/>         6. VEE<br/>         7. GND<br/>         8. ACC</p>  | <p><b>STYLE 18:</b><br/>         PIN 1. ANODE<br/>         2. ANODE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. CATHODE<br/>         8. CATHODE</p>   | <p><b>STYLE 19:</b><br/>         PIN 1. SOURCE 1<br/>         2. GATE 1<br/>         3. SOURCE 2<br/>         4. GATE 2<br/>         5. DRAIN 2<br/>         6. MIRROR 2<br/>         7. DRAIN 1<br/>         8. MIRROR 1</p>   | <p><b>STYLE 20:</b><br/>         PIN 1. SOURCE (N)<br/>         2. GATE (N)<br/>         3. SOURCE (P)<br/>         4. GATE (P)<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>   |
| <p><b>STYLE 21:</b><br/>         PIN 1. CATHODE 1<br/>         2. CATHODE 2<br/>         3. CATHODE 3<br/>         4. CATHODE 4<br/>         5. CATHODE 5<br/>         6. COMMON ANODE<br/>         7. COMMON ANODE<br/>         8. CATHODE 6</p>  | <p><b>STYLE 22:</b><br/>         PIN 1. I/O LINE 1<br/>         2. COMMON CATHODE/VCC<br/>         3. COMMON CATHODE/VCC<br/>         4. I/O LINE 3<br/>         5. COMMON ANODE/GND<br/>         6. I/O LINE 4<br/>         7. I/O LINE 5<br/>         8. COMMON ANODE/GND</p> | <p><b>STYLE 23:</b><br/>         PIN 1. LINE 1 IN<br/>         2. COMMON ANODE/GND<br/>         3. COMMON ANODE/GND<br/>         4. LINE 2 IN<br/>         5. LINE 2 OUT<br/>         6. COMMON ANODE/GND<br/>         7. COMMON ANODE/GND<br/>         8. LINE 1 OUT</p> | <p><b>STYLE 24:</b><br/>         PIN 1. BASE<br/>         2. EMITTER<br/>         3. COLLECTOR/ANODE<br/>         4. COLLECTOR/ANODE<br/>         5. CATHODE<br/>         6. CATHODE<br/>         7. COLLECTOR/ANODE<br/>         8. COLLECTOR/ANODE</p>                                      |
| <p><b>STYLE 25:</b><br/>         PIN 1. VIN<br/>         2. N/C<br/>         3. REXT<br/>         4. GND<br/>         5. IOUT<br/>         6. IOUT<br/>         7. IOUT<br/>         8. IOUT</p>   | <p><b>STYLE 26:</b><br/>         PIN 1. GND<br/>         2. dv/dt<br/>         3. ENABLE<br/>         4. ILIMIT<br/>         5. SOURCE<br/>         6. SOURCE<br/>         7. SOURCE<br/>         8. VCC</p>  | <p><b>STYLE 27:</b><br/>         PIN 1. ILIMIT<br/>         2. OVLO<br/>         3. UVLO<br/>         4. INPUT+<br/>         5. SOURCE<br/>         6. SOURCE<br/>         7. SOURCE<br/>         8. DRAIN</p>  | <p><b>STYLE 28:</b><br/>         PIN 1. SW_TO_GND<br/>         2. DASIC OFF<br/>         3. DASIC_SW_DET<br/>         4. GND<br/>         5. V_MON<br/>         6. VBULK<br/>         7. VBULK<br/>         8. VIN</p>  |
| <p><b>STYLE 29:</b><br/>         PIN 1. BASE, DIE #1<br/>         2. EMITTER, #1<br/>         3. BASE, #2<br/>         4. EMITTER, #2<br/>         5. COLLECTOR, #2<br/>         6. COLLECTOR, #2<br/>         7. COLLECTOR, #1<br/>         8. COLLECTOR, #1</p>                        | <p><b>STYLE 30:</b><br/>         PIN 1. DRAIN 1<br/>         2. DRAIN 1<br/>         3. GATE 2<br/>         4. SOURCE 2<br/>         5. SOURCE 1/DRAIN 2<br/>         6. SOURCE 1/DRAIN 2<br/>         7. SOURCE 1/DRAIN 2<br/>         8. GATE 1</p>                           |   |   |

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