

# Industrial Inductive Load Driver

## NUD3160, SZNUD3160

This micro-integrated part provides a single component solution to switch inductive loads such as relays, solenoids, and small DC motors without the need of a free-wheeling diode. It accepts logic level inputs, thus allowing it to be driven by a large variety of devices including logic gates, inverters, and microcontrollers.

### Features

- Provides Robust Interface between D.C. Relay Coils and Sensitive Logic
- Capable of Driving Relay Coils Rated up to 150 mA at 12 V, 24 V or 48 V
- Replaces 3 or 4 Discrete Components for Lower Cost
- Internal Zener Eliminates Need for Free-Wheeling Diode
- Meets Load Dump and other Automotive Specs
- SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

- Automotive and Industrial Environment
- Drives Window, Latch, Door, and Antenna Relays

### Benefits

- Reduced PCB Space
- Standardized Driver for Wide Range of Relays
- Simplifies Circuit Design and PCB Layout
- Compliance with Automotive Specifications

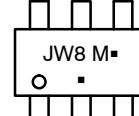
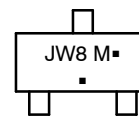


SOT-23  
CASE 318  
STYLE 21



SC-74  
CASE 318F  
STYLE 7

### MARKING DIAGRAMS



JW8 = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package  
(Note: Microdot may be in either location)

JW8 = Specific Device Code  
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### ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
SZNUD3160LT1G	SOT-23 (Pb-Free)	3000 / Tape & Reel
SZNUD3160DMT1G	SC-74 (Pb-Free)	3000 / Tape & Reel

### DISCONTINUED (Note 1)

NU31D60LT1G	SOT-23 (Pb-Free)	3000 / Tape & Reel
NUD3160DMT1G	SC-74 (Pb-Free)	3000 / Tape & Reel

<sup>†</sup>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](http://BRD8011/D).

1. **DISCONTINUED:** These devices are not recommended for new design. Please contact your **onsemi** representative for information. The most current information on these devices may be available on [www.onsemi.com](http://www.onsemi.com).

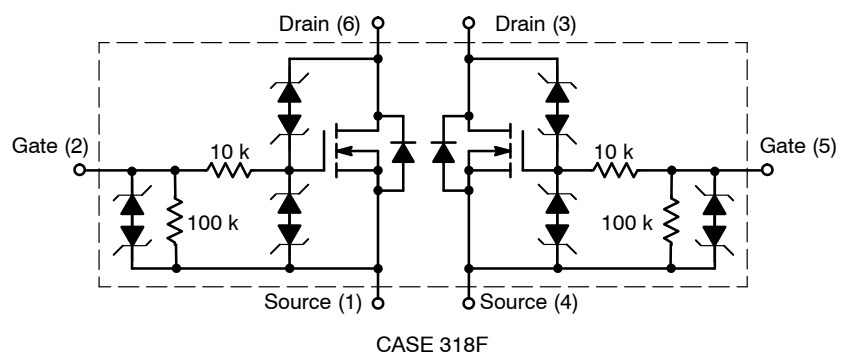
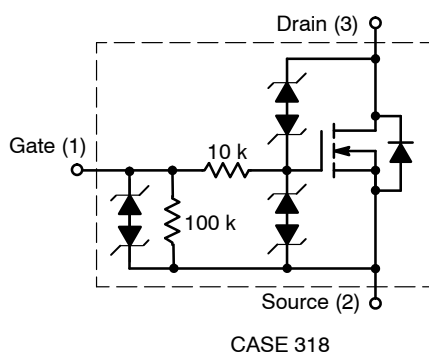


Figure 1. Internal Circuit Diagrams

# **NUD3160, SZNUD3160**

## **MAXIMUM RATINGS** ( $T_J = 25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Rating	Value	Unit
$V_{DSS}$	Drain-to-Source Voltage – Continuous ( $T_J = 125^{\circ}\text{C}$ )	60	V
$V_{GSS}$	Gate-to-Source Voltage – Continuous ( $T_J = 125^{\circ}\text{C}$ )	12	V
$I_D$	Drain Current – Continuous ( $T_J = 125^{\circ}\text{C}$ ) Minimum copper, double sided board, $T_A = 80^{\circ}\text{C}$ SOT-23 SC74 Single device driven SC74 Both devices driven 1 in <sup>2</sup> copper, double sided board, $T_A = 25^{\circ}\text{C}$ SOT-23 SC74 Single device driven SC74 Both devices driven	158 157 132 ea  272 263 230 ea	mA
$E_Z$	Single Pulse Drain-to-Source Avalanche Energy (For Relay's Coils/Inductive Loads of 80 $\Omega$ or Higher) ( $T_J$ Initial = $85^{\circ}\text{C}$ )	200	mJ
$P_{PK}$	Peak Power Dissipation, Drain-to-Source (Notes 2 and 3) ( $T_J$ Initial = $85^{\circ}\text{C}$ )	20	W
$E_{LD1}$	Load Dump Pulse, Drain-to-Source (Note 4) $R_{SOURCE} = 0.5 \Omega$ , $T = 300 \text{ ms}$ (For Relay's Coils/Inductive Loads of 80 $\Omega$ or Higher) ( $T_J$ Initial = $85^{\circ}\text{C}$ )	60	V
$E_{LD2}$	Inductive Switching Transient 1, Drain-to-Source (Waveform: $R_{SOURCE} = 10 \Omega$ , $T = 2.0 \text{ ms}$ ) (For Relay's Coils/Inductive Loads of 80 $\Omega$ or Higher) ( $T_J$ Initial = $85^{\circ}\text{C}$ )	100	V
$E_{LD3}$	Inductive Switching Transient 2, Drain-to-Source (Waveform: $R_{SOURCE} = 4.0 \Omega$ , $T = 50 \mu\text{s}$ ) (For Relay's Coils/Inductive Loads of 80 $\Omega$ or Higher) ( $T_J$ Initial = $85^{\circ}\text{C}$ )	300	V
Rev-Bat	Reverse Battery, 10 Minutes (Drain-to-Source) (For Relay's Coils/Inductive Loads of 80 $\Omega$ or more)	-14	V
Dual-Volt	Dual Voltage Jump Start, 10 Minutes (Drain-to-Source)	28	V
ESD	Human Body Model (HBM) According to EIA/JESD22/A114 Specification	2000	V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## **THERMAL CHARACTERISTICS**

Symbol	Rating	Value	Unit	
T <sub>A</sub>	Operating Ambient Temperature	−40 to 125	°C	
T <sub>J</sub>	Maximum Junction Temperature	150	°C	
T <sub>STG</sub>	Storage Temperature Range	−65 to 150	°C	
P <sub>D</sub>	Total Power Dissipation (Note 5) Derating above 25°C	SOT-23 225 1.8	mW mW/°C	
P <sub>D</sub>	Total Power Dissipation (Note 5) Derating above 25°C	SC-74 380 3.0	mW mW/°C	
R <sub>θJA</sub>	Thermal Resistance, Junction-to-Ambient Minimum Copper  300 mm <sup>2</sup> Copper	SOT-23 SC-74 One Device Powered SC-74 Both Devices Equally Powered  SOT-23 SC-74 One Device Powered SC-74 Both Devices Equally Powered	556 556 398  395 420 270	°C/W

- Nonrepetitive current square pulse 1.0 ms duration.
- For different square pulse durations, see Figure 12.
- Nonrepetitive load dump pulse per Figure 3.
- Mounted onto minimum pad board.

# NUD3160, SZNUD3160

## **ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$ unless otherwise specified)

Characteristic	Symbol	Min	Typ	Max	Unit
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### **OFF CHARACTERISTICS**

Drain to Source Sustaining Voltage ( $I_D = 10\text{ mA}$ )	$V_{BRDSS}$	61	66	70	V
Drain to Source Leakage Current ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 0\text{ V}$ ) ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125^\circ\text{C}$ ) ( $V_{DS} = 60\text{ V}$ , $V_{GS} = 0\text{ V}$ ) ( $V_{DS} = 60\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125^\circ\text{C}$ )	$I_{DSS}$	– – – –	– – – –	0.5 1.0 50 80	$\mu\text{A}$
Gate Body Leakage Current ( $V_{GS} = 3.0\text{ V}$ , $V_{DS} = 0\text{ V}$ ) ( $V_{GS} = 3.0\text{ V}$ , $V_{DS} = 0\text{ V}$ , $T_J = 125^\circ\text{C}$ ) ( $V_{GS} = 5.0\text{ V}$ , $V_{DS} = 0\text{ V}$ ) ( $V_{GS} = 5.0\text{ V}$ , $V_{DS} = 0\text{ V}$ , $T_J = 125^\circ\text{C}$ )	$I_{GSS}$	– – – –	– – – –	60 80 90 110	$\mu\text{A}$

### **ON CHARACTERISTICS**

Gate Threshold Voltage ( $V_{GS} = V_{DS}$ , $I_D = 1.0\text{ mA}$ ) ( $V_{GS} = V_{DS}$ , $I_D = 1.0\text{ mA}$ , $T_J = 125^\circ\text{C}$ )	$V_{GS(th)}$	1.3 1.3	1.8 –	2.0 2.0	V
Drain to Source On-Resistance ( $I_D = 150\text{ mA}$ , $V_{GS} = 3.0\text{ V}$ ) ( $I_D = 150\text{ mA}$ , $V_{GS} = 3.0\text{ V}$ , $T_J = 125^\circ\text{C}$ ) ( $I_D = 150\text{ mA}$ , $V_{GS} = 5.0\text{ V}$ ) ( $I_D = 150\text{ mA}$ , $V_{GS} = 5.0\text{ V}$ , $T_J = 125^\circ\text{C}$ )	$R_{DS(on)}$	– – – –	– – – –	2.4 3.7 1.8 2.9	$\Omega$
Output Continuous Current ( $V_{DS} = 0.3\text{ V}$ , $V_{GS} = 5.0\text{ V}$ ) ( $V_{DS} = 0.3\text{ V}$ , $V_{GS} = 5.0\text{ V}$ , $T_J = 125^\circ\text{C}$ )	$I_{DS(on)}$	150 100	200 –	– –	mA
Forward Transconductance ( $V_{DS} = 12\text{ V}$ , $I_D = 150\text{ mA}$ )	$g_{FS}$	–	400	–	mmho

### **DYNAMIC CHARACTERISTICS**

Input Capacitance ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ )	$C_{iss}$	–	30	–	pf
Output Capacitance ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ )	$C_{oss}$	–	14	–	pf
Transfer Capacitance ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ )	$C_{rss}$	–	6.0	–	pf

### **SWITCHING CHARACTERISTICS**

Propagation Delay Times: High to Low Propagation Delay; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 3.0\text{ V}$ ) Low to High Propagation Delay; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 3.0\text{ V}$ )  High to Low Propagation Delay; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 5.0\text{ V}$ ) Low to High Propagation Delay; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 5.0\text{ V}$ )	$t_{PHL}$ $t_{PLH}$  $t_{PHL}$ $t_{PLH}$	– –  – –	918 798  331 1160	– –  – –	ns
Transition Times: Fall Time; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 3.0\text{ V}$ ) Rise Time; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 3.0\text{ V}$ )  Fall Time; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 5.0\text{ V}$ ) Rise Time; Figure 2, ( $V_{DS} = 12\text{ V}$ , $V_{GS} = 5.0\text{ V}$ )	$t_f$ $t_r$  $t_f$ $t_r$	– –  – –	2290 618  622 600	– –  – –	ns

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

# NUD3160, SZNUD3160

## TYPICAL WAVEFORMS

( $T_J = 25^\circ\text{C}$  unless otherwise specified)

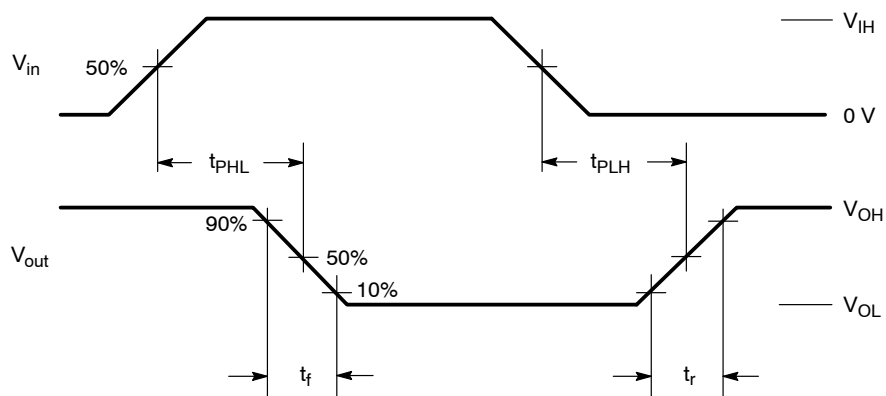


Figure 2. Switching Waveforms

### Load Dump Pulse Not Suppressed:

$V_f = 13.5\text{ V}$  Nominal  $\pm 10\%$

$V_S = 60\text{ V}$  Nominal  $\pm 10\%$

$T = 300\text{ ms}$  Nominal  $\pm 10\%$

$t_r = 1 - 10\text{ ms}$   $\pm 10\%$

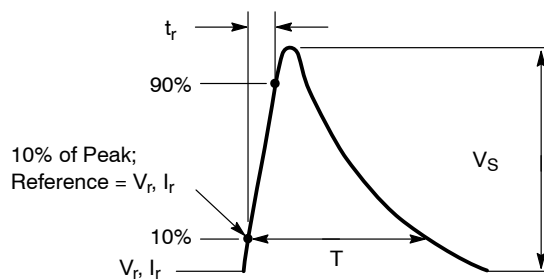


Figure 3. Load Dump Waveform Definition

TYPICAL PERFORMANCE CURVES

( $T_J = 25^\circ\text{C}$  unless otherwise specified)

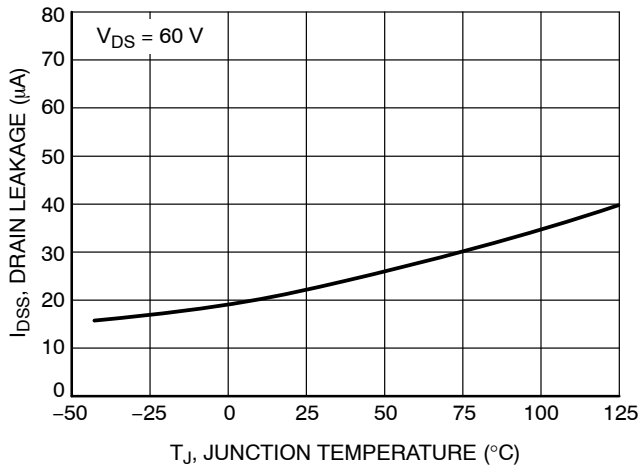


Figure 4. Drain-to-Source Leakage vs. Junction Temperature

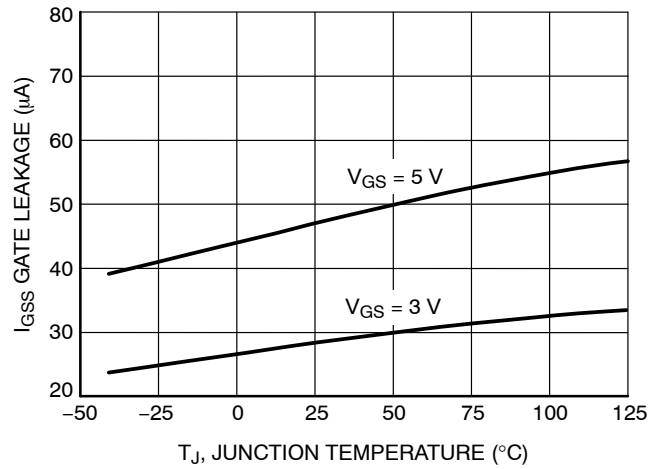


Figure 5. Gate-to-Source Leakage vs. Junction Temperature

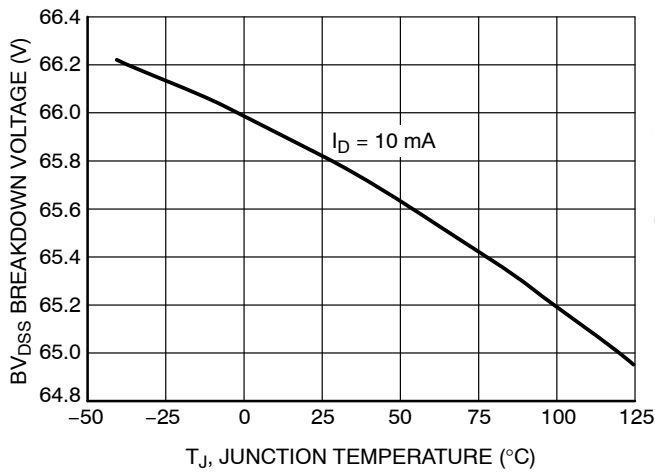


Figure 6. Breakdown Voltage vs. Junction Temperature

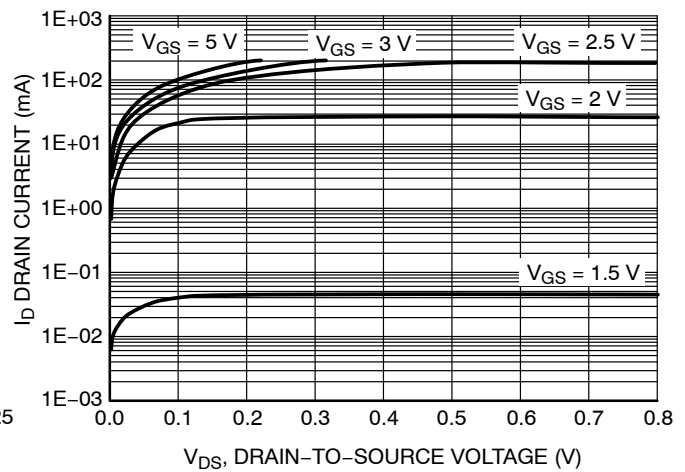


Figure 7. Output Characteristics

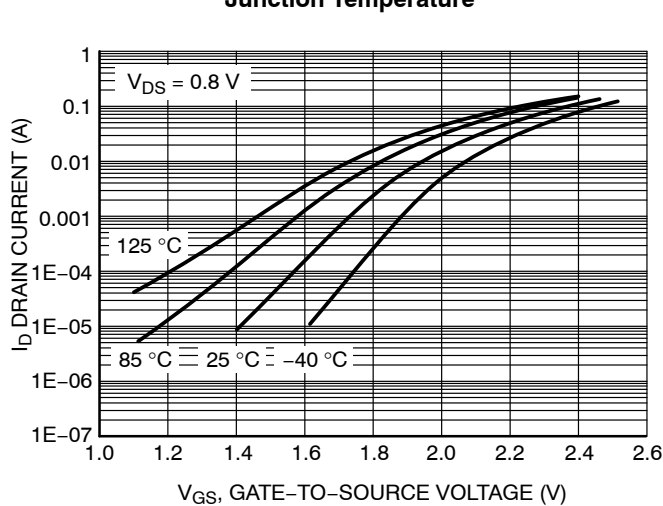


Figure 8. Transfer Function

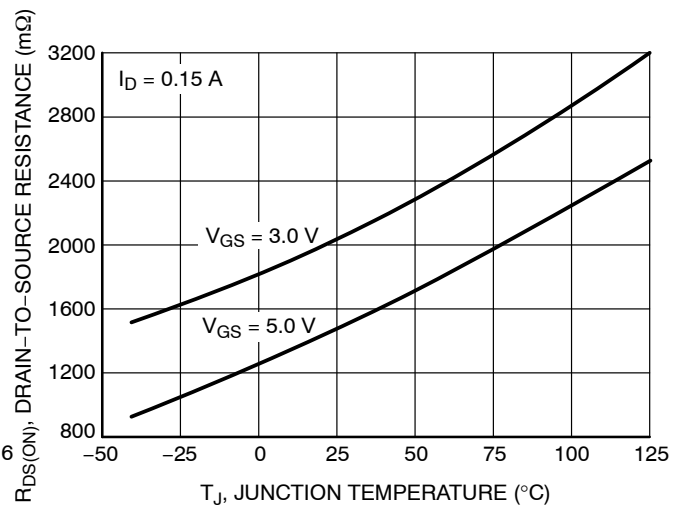
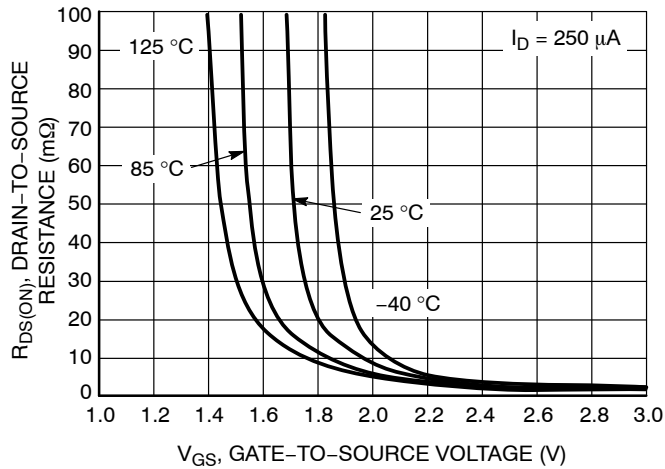


Figure 9. On Resistance Variation vs. Junction Temperature

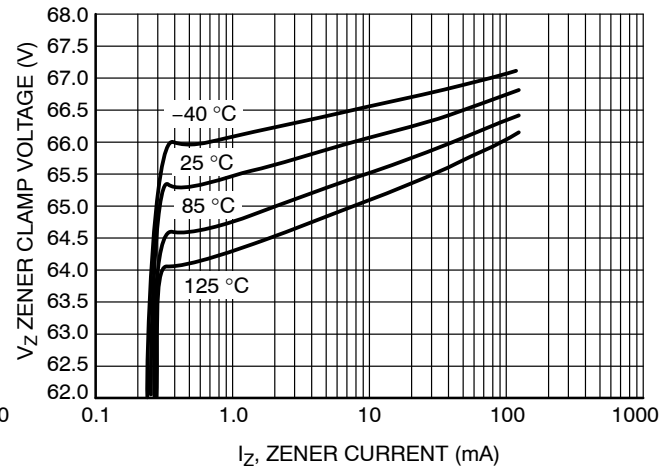
# NUD3160, SZNUD3160

## TYPICAL PERFORMANCE CURVES

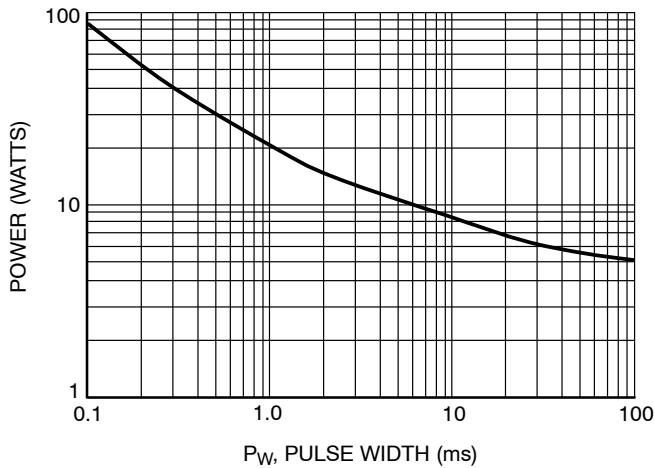
( $T_J = 25^\circ\text{C}$  unless otherwise specified)



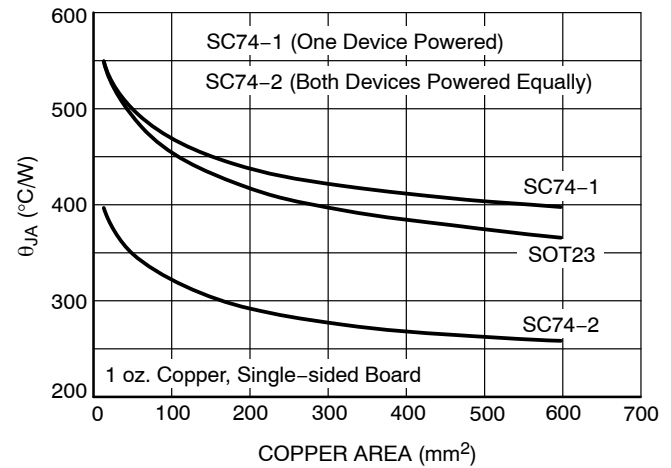
**Figure 10. On Resistance Variation vs. Gate-to-Source Voltage**



**Figure 11. Zener Clamp Voltage vs. Zener Current**



**Figure 12. Maximum Non-repetitive Surge Power vs. Pulse Width**



**Figure 13. Thermal Performance vs. Board Copper Area**

# NUD3160, SZNUD3160

## APPLICATIONS INFORMATION

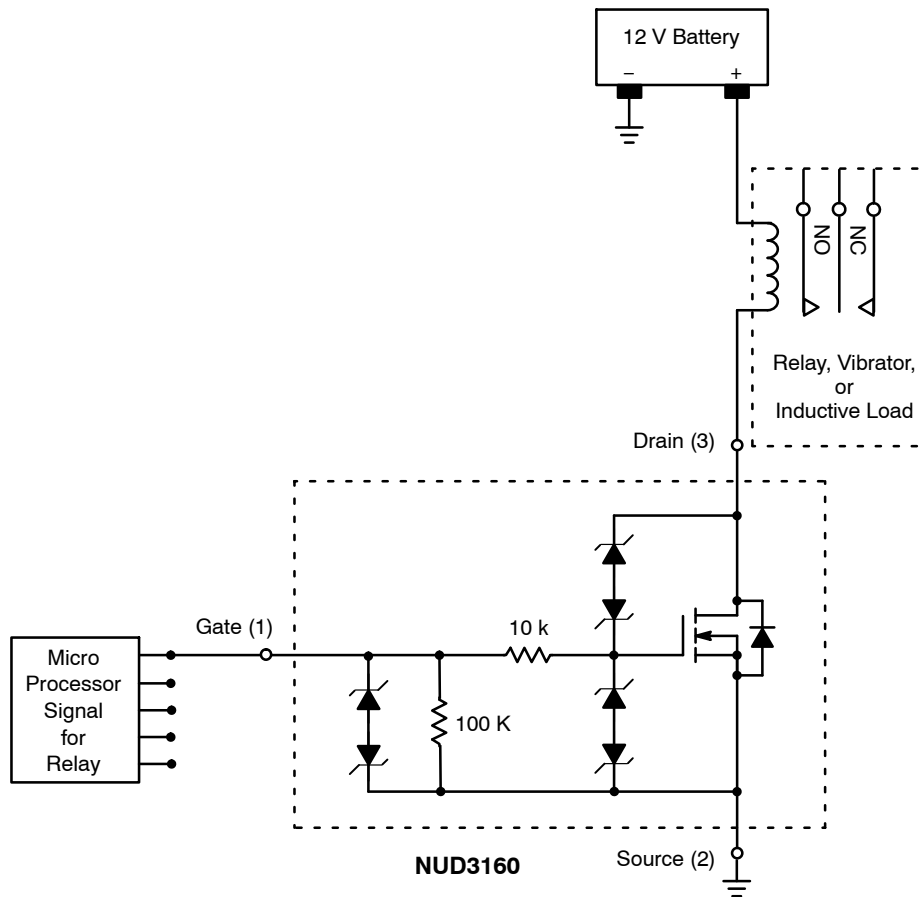


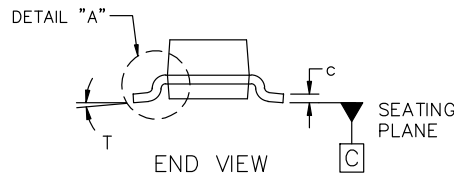
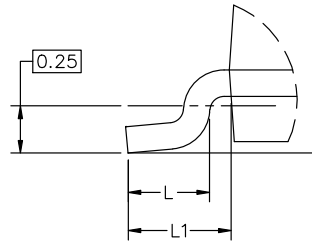
Figure 14. Applications Diagram



SCALE 4:1

**SOT-23 (TO-236) 2.90x1.30x1.00 1.90P**  
CASE 318  
ISSUE AU

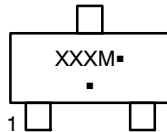
DATE 14 AUG 2024



MILLIMETERS			
DIM	MIN	NOM	MAX
A	0.89	1.00	1.11
A1	0.01	0.06	0.10
b	0.37	0.44	0.50
c	0.08	0.14	0.20
D	2.80	2.90	3.04
E	1.20	1.30	1.40
e	1.78	1.90	2.04
L	0.30	0.43	0.55
L1	0.35	0.54	0.69
HE	2.10	2.40	2.64
T	0°	---	10°

## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
2. CONTROLLING DIMENSIONS: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

**GENERIC MARKING DIAGRAM\***


XXX = Specific Device Code  
M = Date Code  
▪ = 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.


**RECOMMENDED MOUNTING FOOTPRINT**

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

**STYLES ON PAGE 2**

<b>DOCUMENT NUMBER:</b>	<b>98ASB42226B</b>	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
<b>DESCRIPTION:</b>	<b>SOT-23 (TO-236) 2.90x1.30x1.00 1.90P</b>	<b>PAGE 1 OF 2</b>

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**SOT-23 (TO-236) 2.90x1.30x1.00 1.90P**  
**CASE 318**  
**ISSUE AU**

DATE 14 AUG 2024

STYLE 1 THRU 5: CANCELLED	STYLE 6: PIN 1. BASE 2. EMITTER 3. COLLECTOR	STYLE 7: PIN 1. EMITTER 2. BASE 3. COLLECTOR	STYLE 8: PIN 1. ANODE 2. NO CONNECTION 3. CATHODE		
STYLE 9: PIN 1. ANODE 2. ANODE 3. CATHODE	STYLE 10: PIN 1. DRAIN 2. SOURCE 3. GATE	STYLE 11: PIN 1. ANODE 2. CATHODE 3. CATHODE-ANODE	STYLE 12: PIN 1. CATHODE 2. CATHODE 3. ANODE	STYLE 13: PIN 1. SOURCE 2. DRAIN 3. GATE	STYLE 14: PIN 1. CATHODE 2. GATE 3. ANODE
STYLE 15: PIN 1. GATE 2. CATHODE 3. ANODE	STYLE 16: PIN 1. ANODE 2. CATHODE 3. CATHODE	STYLE 17: PIN 1. NO CONNECTION 2. ANODE 3. CATHODE	STYLE 18: PIN 1. NO CONNECTION 2. CATHODE 3. ANODE	STYLE 19: PIN 1. CATHODE 2. ANODE 3. CATHODE-ANODE	STYLE 20: PIN 1. CATHODE 2. ANODE 3. GATE
STYLE 21: PIN 1. GATE 2. SOURCE 3. DRAIN	STYLE 22: PIN 1. RETURN 2. OUTPUT 3. INPUT	STYLE 23: PIN 1. ANODE 2. ANODE 3. CATHODE	STYLE 24: PIN 1. GATE 2. DRAIN 3. SOURCE	STYLE 25: PIN 1. ANODE 2. CATHODE 3. GATE	STYLE 26: PIN 1. CATHODE 2. ANODE 3. NO CONNECTION
STYLE 27: PIN 1. CATHODE 2. CATHODE 3. CATHODE	STYLE 28: PIN 1. ANODE 2. ANODE 3. ANODE				

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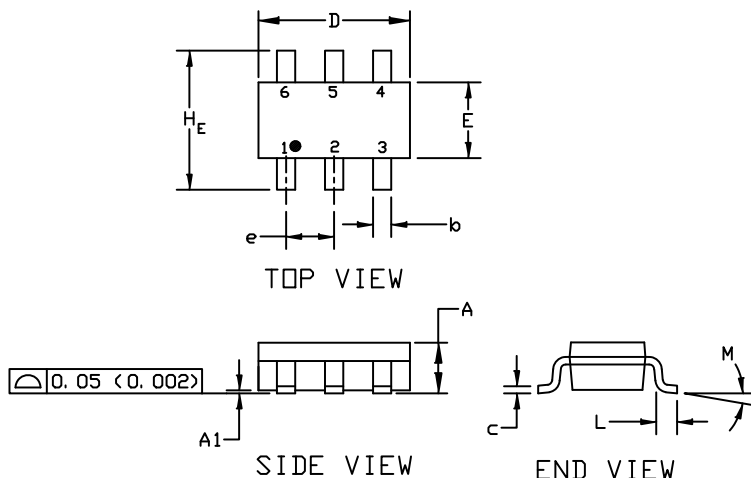
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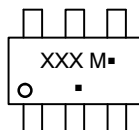
SCALE 2:1

SC-74  
CASE 318F  
ISSUE P

DATE 07 OCT 2021



GENERIC  
MARKING DIAGRAM\*



XXX = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

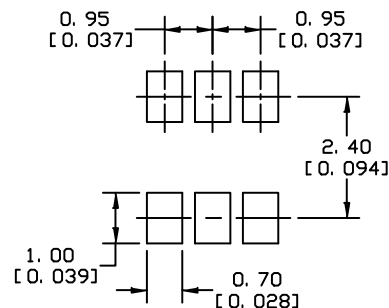
(Note: Microdot may be in either location)

\*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.

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994
2. CONTROLLING DIMENSION: INCHES
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.

DIM	MILLIMETERS			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.90	1.00	1.10	0.035	0.039	0.043
A1	0.01	0.06	0.10	0.001	0.002	0.004
b	0.25	0.37	0.50	0.010	0.015	0.020
c	0.10	0.18	0.26	0.004	0.007	0.010
D	2.90	3.00	3.10	0.114	0.118	0.122
E	1.30	1.50	1.70	0.051	0.059	0.067
e	0.85	0.95	1.05	0.034	0.037	0.041
H <sub>E</sub>	2.50	2.75	3.00	0.099	0.108	0.118
L	0.20	0.40	0.60	0.008	0.016	0.024
M	0*	---	10*	0*	---	10*



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

SOLDERING FOOTPRINT

<b>STYLE 1:</b> PIN 1. CATHODE 2. ANODE 3. CATHODE 4. CATHODE 5. ANODE 6. CATHODE	<b>STYLE 2:</b> PIN 1. NO CONNECTION 2. COLLECTOR 3. EMITTER 4. NO CONNECTION 5. COLLECTOR 6. BASE	<b>STYLE 3:</b> PIN 1. EMITTER 1 2. BASE 1 3. COLLECTOR 2 4. EMITTER 2 5. BASE 2 6. COLLECTOR 1	<b>STYLE 4:</b> PIN 1. COLLECTOR 2 2. EMITTER 1/EMITTER 2 3. COLLECTOR 1 4. EMITTER 3 5. BASE 1/BASE 2/COLLECTOR 3 6. BASE 3	<b>STYLE 5:</b> PIN 1. CHANNEL 1 2. ANODE 3. CHANNEL 2 4. CHANNEL 3 5. CATHODE 6. CHANNEL 4	<b>STYLE 6:</b> PIN 1. CATHODE 2. ANODE 3. CATHODE 4. CATHODE 5. CATHODE 6. CATHODE
<b>STYLE 7:</b> PIN 1. SOURCE 1 2. GATE 1 3. DRAIN 2 4. SOURCE 2 5. GATE 2 6. DRAIN 1	<b>STYLE 8:</b> PIN 1. EMITTER 1 2. BASE 2 3. COLLECTOR 2 4. EMITTER 2 5. BASE 1 6. COLLECTOR 1	<b>STYLE 9:</b> PIN 1. EMITTER 2 2. BASE 2 3. COLLECTOR 1 4. EMITTER 1 5. BASE 1 6. COLLECTOR 2	<b>STYLE 10:</b> PIN 1. ANODE/CATHODE 2. BASE 3. EMITTER 4. COLLECTOR 5. ANODE 6. CATHODE	<b>STYLE 11:</b> PIN 1. EMITTER 2. BASE 3. ANODE/CATHODE 4. ANODE 5. CATHODE 6. COLLECTOR	

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