

# Integrated Relay, Inductive Load Driver

## NUD3105

This device is used to switch inductive loads such as relays, solenoids incandescent lamps, and small DC motors without the need of a free-wheeling diode. The device integrates all necessary items such as the MOSFET switch, ESD protection, and Zener clamps. It accepts logic level inputs thus allowing it to be driven by a large variety of devices including logic gates, inverters, and microcontrollers.

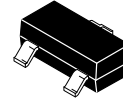
### Features

- Provides a Robust Driver Interface Between DC Relay Coil and Sensitive Logic Circuits
- Optimized to Switch Relays from 3.0 V to 5.0 V Rail
- Capable of Driving Relay Coils Rated up to 2.5 W at 5.0 V
- Internal Zener Eliminates the Need of Free-Wheeling Diode
- Internal Zener Clamp Routes Induced Current to Ground for Quieter Systems Operation
- Low  $V_{DS(on)}$  Reduces System Current Drain
- 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 and Halide Free

### Typical Applications

- Telecom: Line Cards, Modems, Answering Machines, FAX
- Computers and Office: Photocopiers, Printers, Desktop Computers
- Consumer: TVs and VCRs, Stereo Receivers, CD Players, Cassette Recorders
- Industrial: Small Appliances, Security Systems, Automated Test Equipment, Garage Door Openers
- Automotive: 5.0 V Driven Relays, Motor Controls, Power Latches, Lamp Drivers

## RELAY/INDUCTIVE LOAD DRIVER 0.5 AMPERE, 8.0 VOLT CLAMP

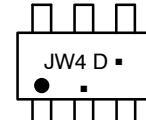
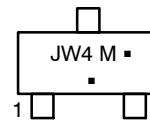


SOT-23  
(TO-236)  
CASE 318



SC-74  
CASE 318F  
STYLE 7

### MARKING DIAGRAMS



JW4 = Device Code  
M = Date Code\*  
D = Date Code  
▪ = Pb-Free Package

(Note: Microdot may be in either location)  
\*Date Code orientation and/or overbar may vary depending upon manufacturing location.

### ORDERING INFORMATION

| Device         | Package             | Shipping <sup>†</sup> |
|----------------|---------------------|-----------------------|
| NUD3105LT1G    | SOT-23<br>(Pb-Free) | 3000 / Tape & Reel    |
| NUD3105DMT1G   | SOT-74<br>(Pb-Free) | 3000 / Tape & Reel    |
| SZNUD3105DMT1G | SOT-74<br>(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://www.onsemi.com/BRD8011/D).

# NUD3105

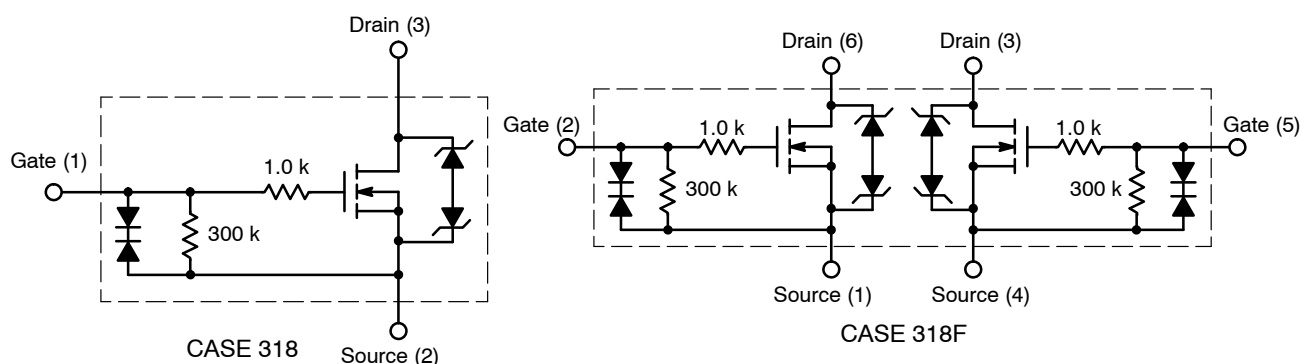


Figure 1. Internal Circuit Diagrams

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

| Symbol          | Rating                                                                                        | Value                | Unit                       |
|-----------------|-----------------------------------------------------------------------------------------------|----------------------|----------------------------|
| $V_{DS}$        | Drain to Source Voltage – Continuous                                                          | 6.0                  | $V_{dc}$                   |
| $V_{GS}$        | Gate to Source Voltage – Continuous                                                           | 6.0                  | $V_{dc}$                   |
| $I_D$           | Drain Current – Continuous                                                                    | 500                  | mA                         |
| $E_z$           | Single Pulse Drain-to-Source Avalanche Energy ( $T_{Jinitial} = 25^\circ\text{C}$ ) (Note 2)  | 50                   | mJ                         |
| $E_{zpk}$       | Repetitive Pulse Zener Energy Limit ( $DC \leq 0.01\%$ ) ( $f = 100\text{ Hz}$ , $DC = 0.5$ ) | 4.5                  | mJ                         |
| $T_J$           | Junction Temperature                                                                          | 150                  | $^\circ\text{C}$           |
| $T_A$           | Operating Ambient Temperature                                                                 | -40 to 85            | $^\circ\text{C}$           |
| $T_{stg}$       | Storage Temperature Range                                                                     | -65 to +150          | $^\circ\text{C}$           |
| $P_D$           | Total Power Dissipation (Note 1)<br>Derating Above $25^\circ\text{C}$                         | SOT-23<br>225<br>1.8 | mW<br>mW/ $^\circ\text{C}$ |
|                 | Total Power Dissipation (Note 1)<br>Derating Above $25^\circ\text{C}$                         | SC-74<br>380<br>1.5  | mW<br>mW/ $^\circ\text{C}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient                                                       | SOT-23               | 556                        |
|                 |                                                                                               | SC-74                | 329                        |
|                 |                                                                                               |                      | $^\circ\text{C/W}$         |

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.

1. This device contains ESD protection and exceeds the following tests:

Human Body Model 2000 V per MIL-STD-883, Method 3015.

Machine Model Method 200 V.

2. Refer to the section covering Avalanche and Energy.

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

| Symbol      | Characteristic                                                                                                                                 | Min      | Typ    | Max      | Unit          |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------|----------|---------------|
| $V_{BRDSS}$ | Drain to Source Sustaining Voltage (Internally Clamped), ( $I_D = 10\text{ mA}$ )                                                              | 6.0      | 8.0    | 9.0      | V             |
| $B_{VGSO}$  | $I_g = 1.0\text{ mA}$                                                                                                                          | -        | -      | 8.0      | V             |
| $I_{DSS}$   | Drain to Source Leakage Current<br>( $V_{DS} = 5.5\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 25^\circ\text{C}$ )                              | -        | -      | 15       | $\mu\text{A}$ |
|             | ( $V_{DS} = 5.5\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 85^\circ\text{C}$ )                                                                 | -        | -      | 15       | $\mu\text{A}$ |
| $I_{GSS}$   | Gate Body Leakage Current (318)<br>( $V_{GS} = 3.0\text{ V}$ , $V_{DS} = 0\text{ V}$ )<br>( $V_{GS} = 5.0\text{ V}$ , $V_{DS} = 0\text{ V}$ )  | 5.0<br>- | -<br>- | 19<br>50 | $\mu\text{A}$ |
|             | Gate Body Leakage Current (318F)<br>( $V_{GS} = 3.0\text{ V}$ , $V_{DS} = 0\text{ V}$ )<br>( $V_{GS} = 5.0\text{ V}$ , $V_{DS} = 0\text{ V}$ ) | 5.0<br>- | -<br>- | 35<br>65 | $\mu\text{A}$ |

# NUD3105

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

| Symbol                    | Characteristic                                                                                                                                                                                                                                                                                                                                                         | Min                   | Typ                   | Max                             | Unit     |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|---------------------------------|----------|
| <b>ON CHARACTERISTICS</b> |                                                                                                                                                                                                                                                                                                                                                                        |                       |                       |                                 |          |
| $V_{GS(th)}$              | Gate Threshold Voltage<br>( $V_{GS} = V_{DS}$ , $I_D = 1.0\text{ mA}$ )<br>( $V_{GS} = V_{DS}$ , $I_D = 1.0\text{ mA}$ , $T_J = 85^\circ\text{C}$ )                                                                                                                                                                                                                    | 0.8<br>0.8            | 1.2<br>–              | 1.4<br>1.4                      | V        |
| $R_{DS(on)}$              | Drain to Source On-Resistance<br>( $I_D = 250\text{ mA}$ , $V_{GS} = 3.0\text{ V}$ )<br>( $I_D = 500\text{ mA}$ , $V_{GS} = 3.0\text{ V}$ )<br>( $I_D = 500\text{ mA}$ , $V_{GS} = 5.0\text{ V}$ )<br>( $I_D = 500\text{ mA}$ , $V_{GS} = 3.0\text{ V}$ , $T_J = 85^\circ\text{C}$ )<br>( $I_D = 500\text{ mA}$ , $V_{GS} = 5.0\text{ V}$ , $T_J = 85^\circ\text{C}$ ) | –<br>–<br>–<br>–<br>– | –<br>–<br>–<br>–<br>– | 1.2<br>1.3<br>0.9<br>1.3<br>0.9 | $\Omega$ |
| $I_{DS(on)}$              | Output Continuous Current<br>( $V_{DS} = 0.25\text{ V}$ , $V_{GS} = 3.0\text{ V}$ )<br>( $V_{DS} = 0.25\text{ V}$ , $V_{GS} = 3.0\text{ V}$ , $T_J = 85^\circ\text{C}$ )                                                                                                                                                                                               | 300<br>200            | 400<br>–              | –<br>–                          | mA       |
| $g_{FS}$                  | Forward Transconductance<br>( $V_{OUT} = 5.0\text{ V}$ , $I_{OUT} = 0.25\text{ A}$ )                                                                                                                                                                                                                                                                                   | 350                   | 570                   | –                               | mmhos    |

## DYNAMIC CHARACTERISTICS

|           |                                                                                                   |   |     |   |    |
|-----------|---------------------------------------------------------------------------------------------------|---|-----|---|----|
| $C_{iss}$ | Input Capacitance<br>( $V_{DS} = 5.0\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ )    | – | 25  | – | pF |
| $C_{oss}$ | Output Capacitance<br>( $V_{DS} = 5.0\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ )   | – | 37  | – | pF |
| $C_{rss}$ | Transfer Capacitance<br>( $V_{DS} = 5.0\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 10\text{ kHz}$ ) | – | 8.0 | – | pF |

## SWITCHING CHARACTERISTICS

|                        |                                                                                                                                |        |          |        |    |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------|----------|--------|----|
| $t_{PHL}$<br>$t_{PLH}$ | Propagation Delay Times:<br>High to Low Propagation Delay; Figure 1 (5.0 V)<br>Low to High Propagation Delay; Figure 1 (5.0 V) | –<br>– | 25<br>80 | –<br>– | nS |
| $t_{PHL}$<br>$t_{PLH}$ | High to Low Propagation Delay; Figure 1 (3.0 V)<br>Low to High Propagation Delay; Figure 1 (3.0 V)                             | –<br>– | 44<br>44 | –<br>– |    |
| $t_f$<br>$t_r$         | Transition Times:<br>Fall Time; Figure 1 (5.0 V)<br>Rise Time; Figure 1 (5.0 V)                                                | –<br>– | 23<br>32 | –<br>– | nS |
| $t_f$<br>$t_r$         | Fall Time; Figure 1 (3.0 V)<br>Rise Time; Figure 1 (3.0 V)                                                                     | –<br>– | 53<br>30 | –<br>– |    |

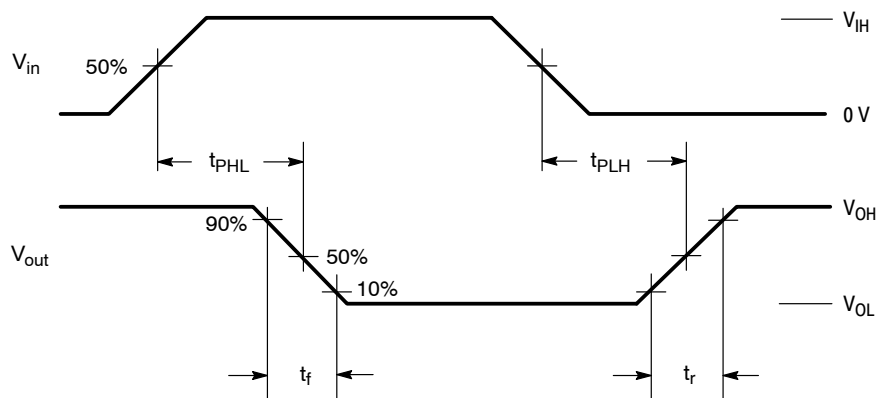


Figure 1. Switching Waveforms

TYPICAL CHARACTERISTICS

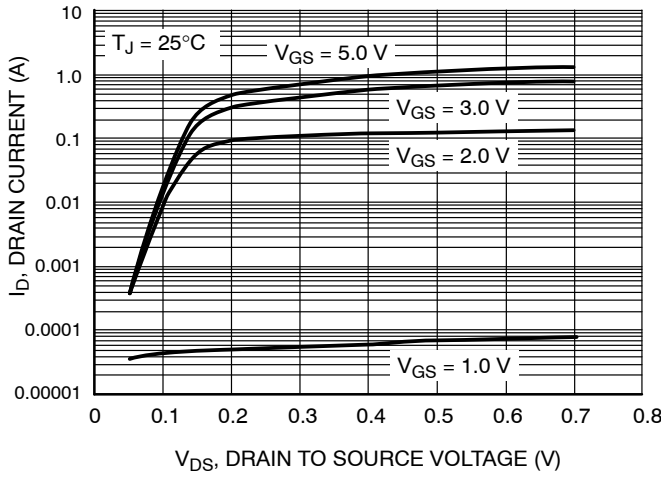


Figure 2. Output Characteristics

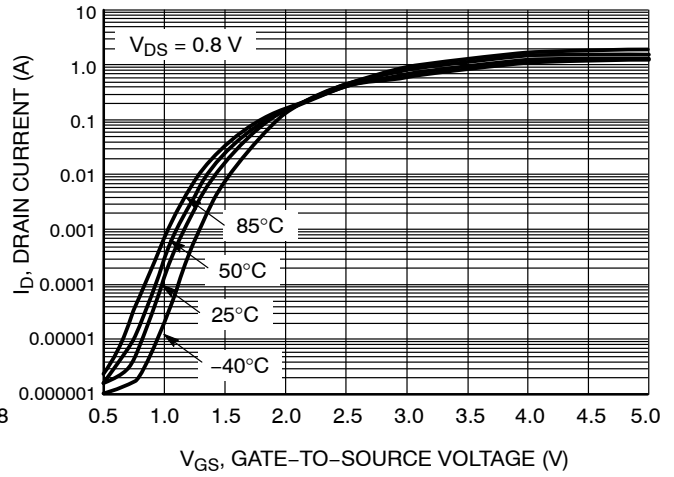


Figure 3. Transfer Function

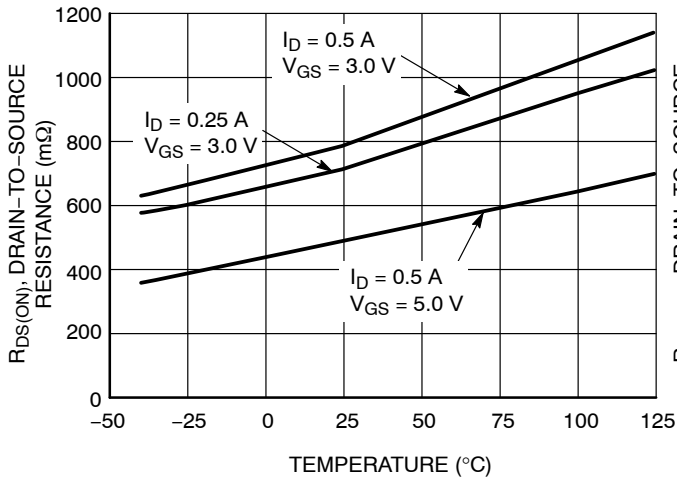


Figure 4. On Resistance Variation vs. Temperature

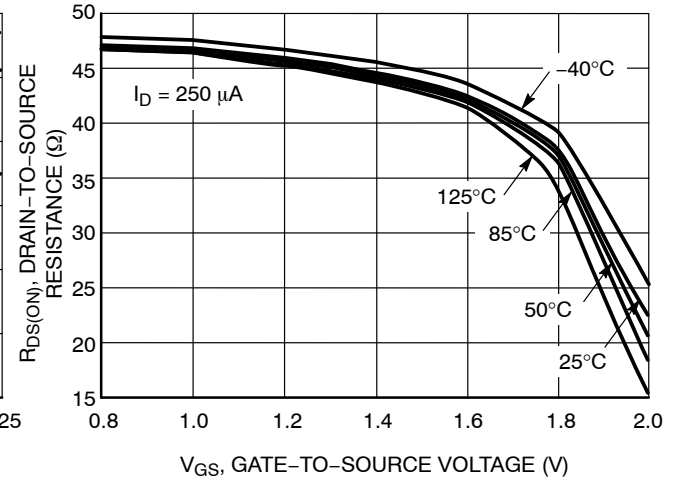


Figure 5.  $R_{DS(ON)}$  Variation with Gate-to-Source Voltage

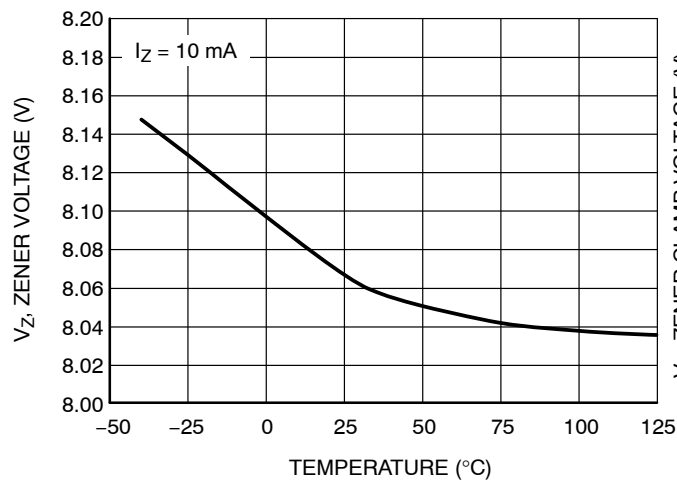


Figure 6. Zener Voltage vs. Temperature

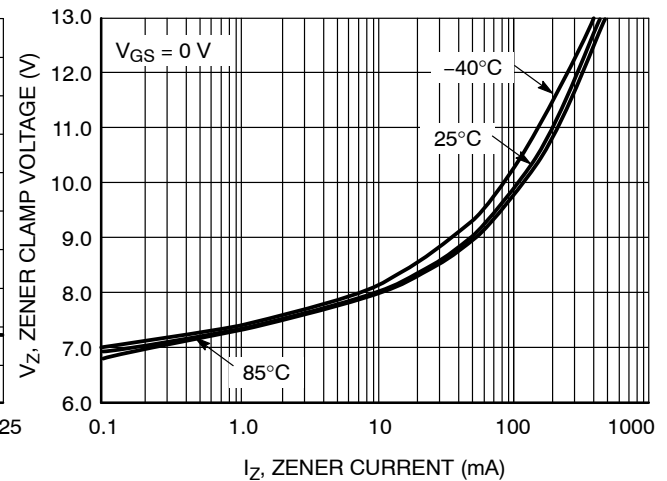


Figure 7. Zener Clamp Voltage vs. Zener Current

TYPICAL CHARACTERISTICS (continued)

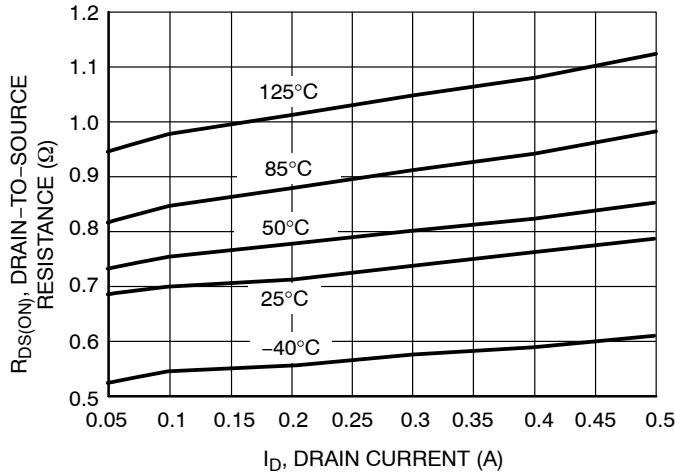


Figure 8. On-Resistance vs. Drain Current and Temperature

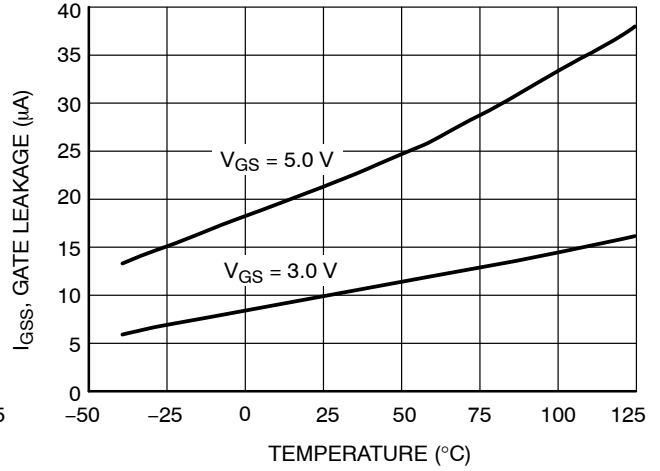


Figure 9. Gate Leakage vs. Temperature

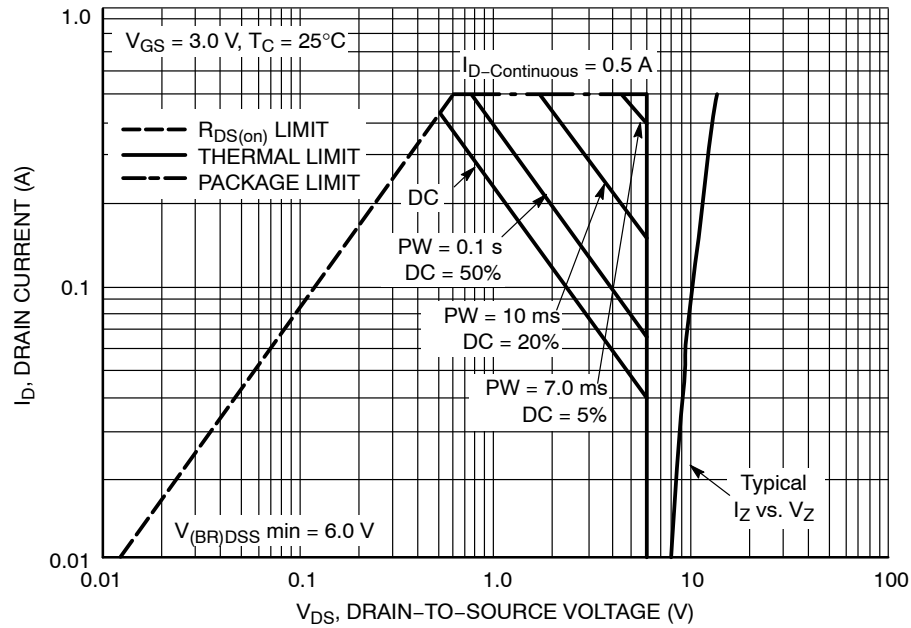


Figure 10. Safe Operating Area

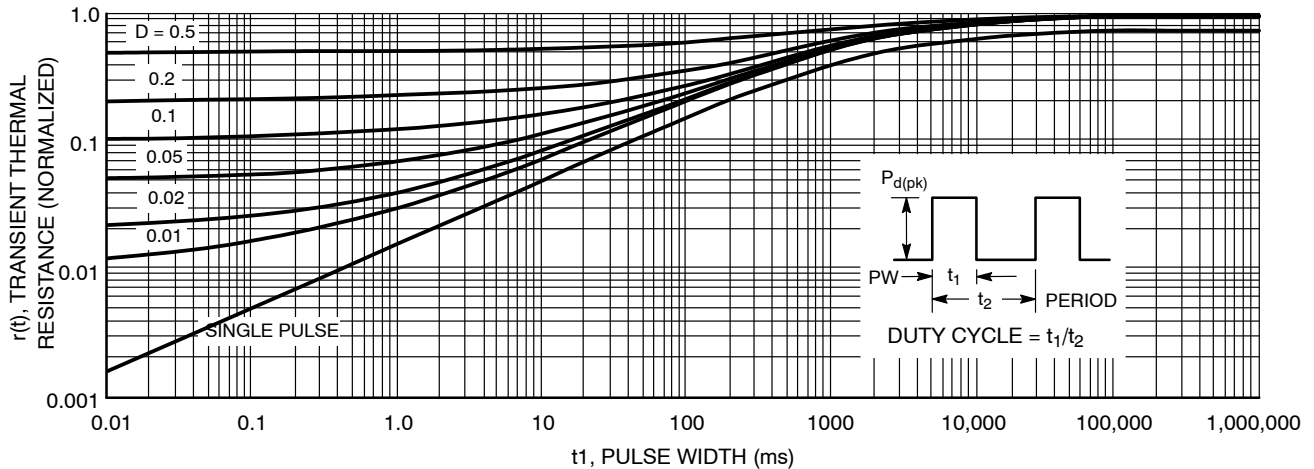


Figure 11. Transient Thermal Response

## Designing with this Data Sheet

1. Determine the maximum inductive load current (at max  $V_{CC}$ , min coil resistance & usually minimum temperature) that the NUD3105 will have to drive and make sure it is less than the max rated current.
2. For pulsed operation, use the Transient Thermal Response of Figure 11 and the instructions with it to determine the maximum limit on transistor power dissipation for the desired duty cycle and temperature range.
3. Use Figures 10 and 11 with the SOA notes to insure that instantaneous operation does not push the device beyond the limits of the SOA plot.
4. Verify that the circuit driving the gate will meet the  $V_{GS(th)}$  from the Electrical Characteristics table.
5. Using the max output current calculated in step 1, check Figure 7 to insure that the range of Zener clamp voltage over temperature will satisfy all system & EMI requirements.
6. Use  $I_{GSS}$  and  $I_{DSS}$  from the Electrical Characteristics table to ensure that "OFF" state leakage over temperature and voltage extremes does not violate any system requirements.
7. Review circuit operation and insure none of the device max ratings are being exceeded.

## APPLICATIONS DIAGRAMS

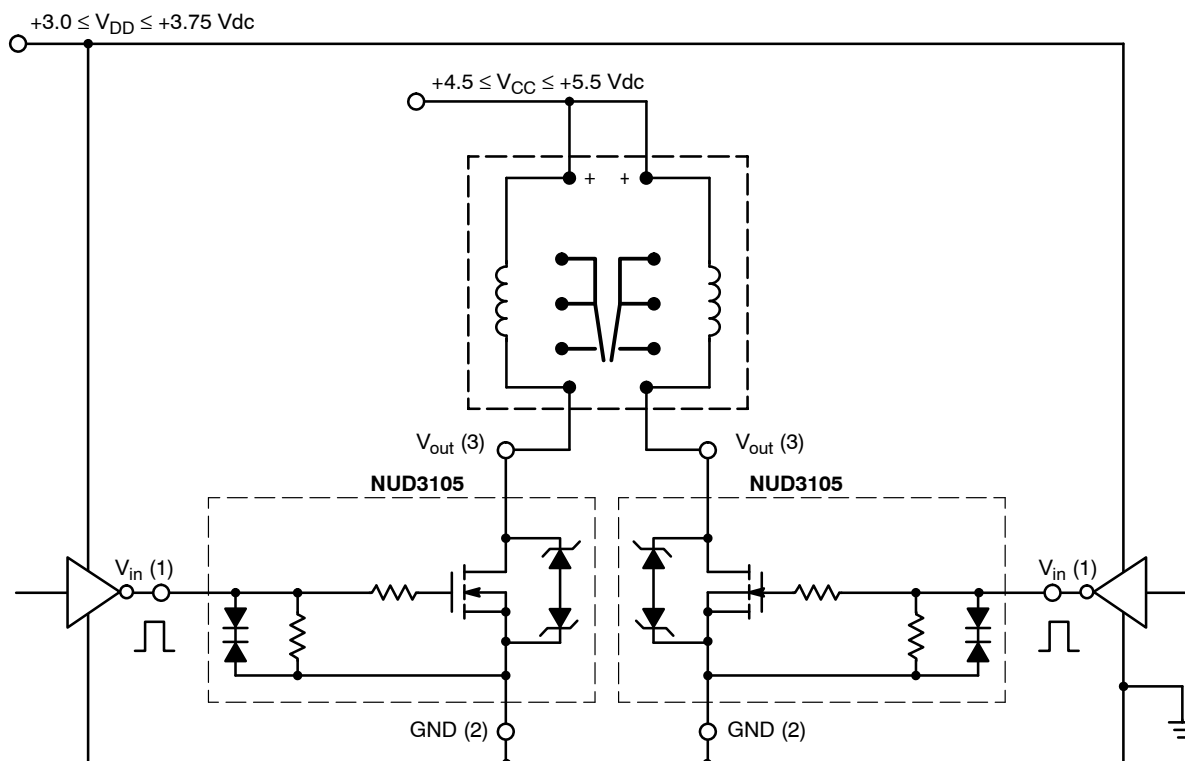


Figure 12. A 200 mW, 5.0 V Dual Coil Latching Relay Application with 3.0 V Level Translating Interface

## Max Continuous Current Calculation

for TX2-5V Relay,  $R_1 = 178 \, \Omega$  Nominal @  $R_A = 25^\circ\text{C}$

Assuming  $\pm 10\%$  Make Tolerance,

$R_1 = 178 \, \Omega * 0.9 = 160 \, \Omega$  Min @  $T_A = 25^\circ\text{C}$

$T_C$  for Annealed Copper Wire is  $0.4\%/^\circ\text{C}$

$R_1 = 160 \, \Omega * [1 + (0.004) * (-40^\circ - 25^\circ)] = 118 \, \Omega$  Min @  $-40^\circ\text{C}$

$I_O \text{ Max} = (5.5 \text{ V Max} - 0.25\text{V}) / 118 \, \Omega = 45 \text{ mA}$

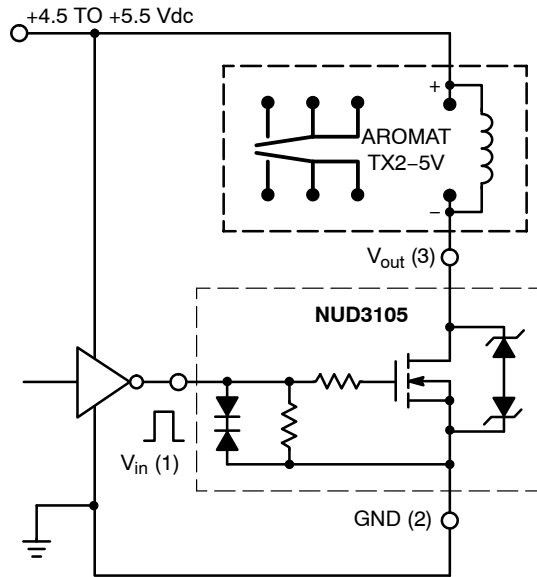


Figure 13. A 140 mW, 5.0 V Relay with TTL Interface

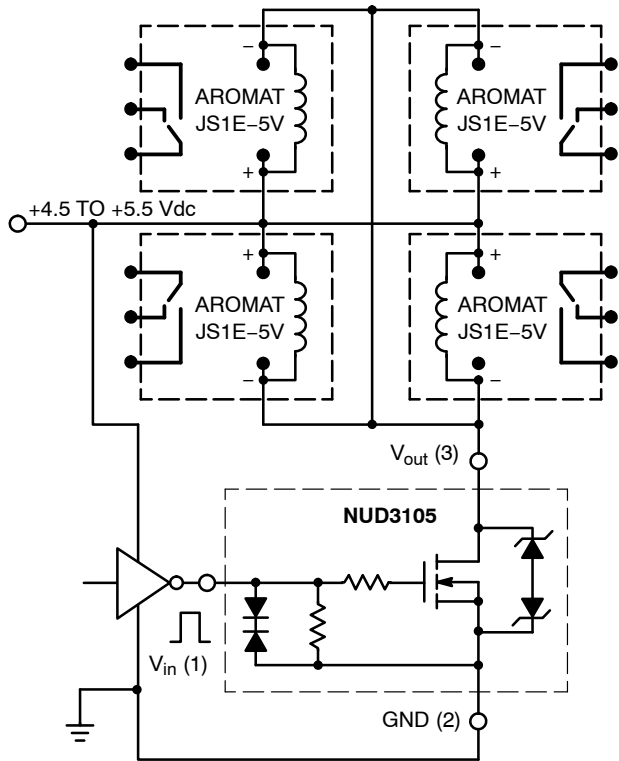


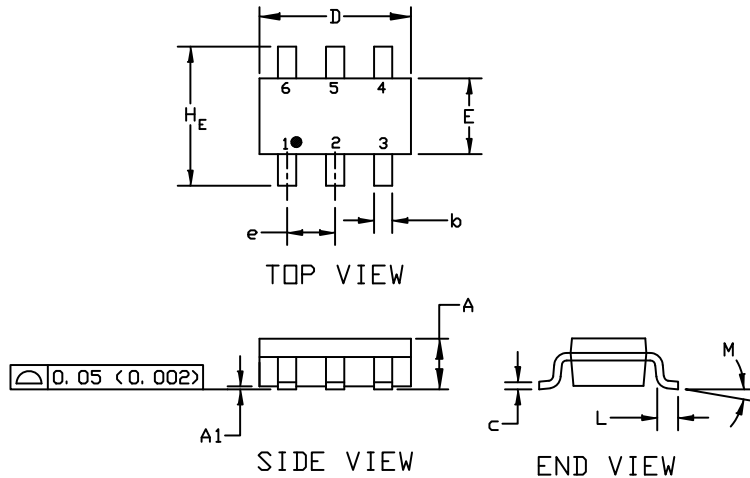
Figure 14. A Quad 5.0 V, 360 mW Coil Relay Bank



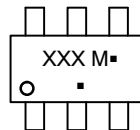
SCALE 2:1

SC-74  
CASE 318F  
ISSUE P

DATE 07 OCT 2021



GENERIC  
MARKING DIAGRAM\*



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

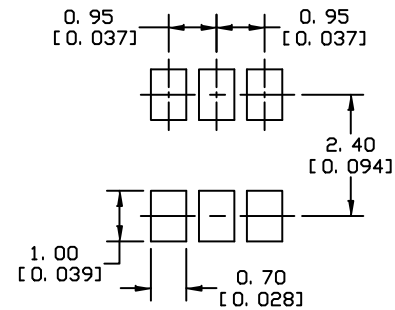
(Note: Microdot may be in either location)

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

|                         |                    |                                                                                                                                                                                     |
|-------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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