# NTMD6P02R2

**Preferred Device**

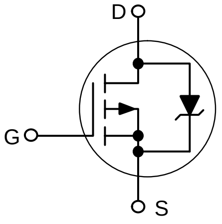
# Power MOSFET
# 6 Amps, 20 Volts
## P–Channel SO–8, Dual

**ON Semiconductor**™

http://onsemi.com

**6 AMPERES**
**20 VOLTS**
**$R_{DS(on)}$ = 33 mΩ**

**P–Channel**



### Features

- Ultra Low $R_{DS(on)}$
- Higher Efficiency Extending Battery Life
- Logic Level Gate Drive
- Miniature Dual SO–8 Surface Mount Package
- Diode Exhibits High Speed, Soft Recovery
- Avalanche Energy Specified
- SO–8 Mounting Information Provided

### Applications

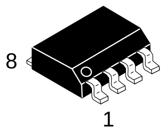
- Power Management in Portable and Battery–Powered Products, i.e.: Cellular and Cordless Telephones and PCMCIA Cards

**MAXIMUM RATINGS** ($T_J$ = 25°C unless otherwise noted)

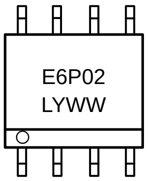
| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain–to–Source Voltage | $V_{DSS}$ | –20 | V |
| Gate–to–Source Voltage – Continuous | $V_{GS}$ | ± 12 | V |
| Thermal Resistance – | | | |
| Junction–to–Ambient (Note 1.) | $R_{\theta JA}$ | 62.5 | °C/W |
| Total Power Dissipation @ $T_A$ = 25°C | $P_D$ | 2.0 | W |
| Continuous Drain Current @ $T_A$ = 25°C | $I_D$ | –7.8 | A |
| Continuous Drain Current @ $T_A$ = 70°C | $I_D$ | –5.7 | A |
| Maximum Operating Power Dissipation | $P_D$ | 0.5 | W |
| Maximum Operating Drain Current | $I_D$ | –3.89 | A |
| Pulsed Drain Current (Note 4.) | $I_{DM}$ | –40 | A |
| Thermal Resistance – | | | |
| Junction–to–Ambient (Note 2.) | $R_{\theta JA}$ | 98 | °C/W |
| Total Power Dissipation @ $T_A$ = 25°C | $P_D$ | 1.28 | W |
| Continuous Drain Current @ $T_A$ = 25°C | $I_D$ | –6.2 | A |
| Continuous Drain Current @ $T_A$ = 70°C | $I_D$ | –4.6 | A |
| Maximum Operating Power Dissipation | $P_D$ | 0.3 | W |
| Maximum Operating Drain Current | $I_D$ | –3.01 | A |
| Pulsed Drain Current (Note 4.) | $I_{DM}$ | –35 | A |
| Thermal Resistance – | | | |
| Junction–to–Ambient (Note 3.) | $R_{\theta JA}$ | 166 | °C/W |
| Total Power Dissipation @ $T_A$ = 25°C | $P_D$ | 0.75 | W |
| Continuous Drain Current @ $T_A$ = 25°C | $I_D$ | –4.8 | A |
| Continuous Drain Current @ $T_A$ = 70°C | $I_D$ | –3.5 | A |
| Maximum Operating Power Dissipation | $P_D$ | 0.2 | W |
| Maximum Operating Drain Current | $I_D$ | –2.48 | A |
| Pulsed Drain Current (Note 4.) | $I_{DM}$ | –30 | A |

1. Mounted onto a 2″ square FR–4 Board (1″ sq. 2 oz. Cu 0.06″ thick single sided), t = 10 seconds.
2. Mounted onto a 2″ square FR–4 Board (1″ sq. 2 oz. Cu 0.06″ thick single sided), t = steady state.
3. Minimum FR–4 or G–10 PCB, t = steady state.
4. Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%.

### MARKING DIAGRAM

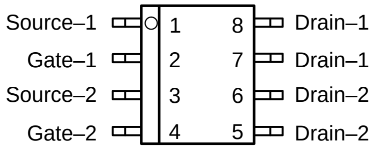


**SO–8, Dual**
**CASE 751**
**STYLE 11**



| | | |
|---|---|---|
| L | = | Location Code |
| Y | = | Year |
| WW | = | Work Week |

### PIN ASSIGNMENT



Top View

### ORDERING INFORMATION

| Device | Package | Shipping |
|---|---|---|
| NTMD6P02R2 | SO–8 | 2500 Tape & Reel |

**Preferred** devices are recommended choices for future use and best overall value.

**MAXIMUM RATINGS** ($T_J$ = 25°C unless otherwise noted) (continued)

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Operating and Storage Temperature Range | $T_J$, $T_{stg}$ | –55 to +150 | °C |
| Single Pulse Drain–to–Source Avalanche Energy – Starting $T_J$ = 25°C<br>($V_{DD}$ = –20 Vdc, $V_{GS}$ = –5.0 Vdc, Peak $I_L$ = –5.0 Apk, L = 40 mH, $R_G$ = 25 Ω) | $E_{AS}$ | 500 | mJ |
| Maximum Lead Temperature for Soldering Purposes for 10 seconds | $T_L$ | 260 | °C |

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted) *

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Drain–to–Source Breakdown Voltage<br>($V_{GS}$ = 0 Vdc, $I_D$ = –250 μAdc)<br>Temperature Coefficient (Positive) | $V_{(BR)DSS}$ | <br>–20<br>– | <br>–<br>–11.6 | <br>–<br>– | Vdc<br><br>mV/°C |
| Zero Gate Voltage Drain Current<br>($V_{DS}$ = –20 Vdc, $V_{GS}$ = 0 Vdc, $T_J$ = 25°C)<br>($V_{DS}$ = –20 Vdc, $V_{GS}$ = 0 Vdc, $T_J$ = 70°C) | $I_{DSS}$ | <br>–<br>– | <br>–<br>– | <br>–1.0<br>–5.0 | μAdc |
| Gate–Body Leakage Current<br>($V_{GS}$ = –12 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | – | – | –100 | nAdc |
| Gate–Body Leakage Current<br>($V_{GS}$ = +12 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | – | – | 100 | nAdc |
| **ON CHARACTERISTICS** | | | | | |
| Gate Threshold Voltage<br>($V_{DS}$ = $V_{GS}$, $I_D$ = –250 μAdc)<br>Temperature Coefficient (Negative) | $V_{GS(th)}$ | <br>–0.6<br>– | <br>–0.88<br>2.6 | <br>–1.20<br>– | Vdc<br><br>mV/°C |
| Static Drain–to–Source On–State Resistance<br>($V_{GS}$ = –4.5 Vdc, $I_D$ = –6.2 Adc)<br>($V_{GS}$ = –2.5 Vdc, $I_D$ = –5.0 Adc)<br>($V_{GS}$ = –2.5 Vdc, $I_D$ = –3.1 Adc) | $R_{DS(on)}$ | <br>–<br>–<br>– | <br>0.027<br>0.038<br>0.038 | <br>0.033<br>0.050<br>– | Ω |
| Forward Transconductance ($V_{DS}$ = –10 Vdc, $I_D$ = –6.2 Adc) | $g_{FS}$ | – | 15 | – | Mhos |

**DYNAMIC CHARACTERISTICS**

| | | | | | | |
|---|---|---|---|---|---|---|
| Input Capacitance | ($V_{DS}$ = –16 Vdc, $V_{GS}$ = 0 Vdc, f = 1.0 MHz) | $C_{iss}$ | – | 1380 | 1700 | pF |
| Output Capacitance | | $C_{oss}$ | – | 515 | 775 | |
| Reverse Transfer Capacitance | | $C_{rss}$ | – | 250 | 450 | |

**SWITCHING CHARACTERISTICS** (Notes 5. and 6.)

| | | | | | | |
|---|---|---|---|---|---|---|
| Turn–On Delay Time | ($V_{DD}$ = –10 Vdc, $I_D$ = –1.0 Adc, $V_{GS}$ = –10 Vdc, $R_G$ = 6.0 Ω) | $t_{d(on)}$ | – | 15 | 25 | ns |
| Rise Time | | $t_r$ | – | 20 | 50 | |
| Turn–Off Delay Time | | $t_{d(off)}$ | – | 85 | 125 | |
| Fall Time | | $t_f$ | – | 50 | 110 | |
| Turn–On Delay Time | ($V_{DD}$ = –16 Vdc, $I_D$ = –6.2 Adc, $V_{GS}$ = –4.5 Vdc, $R_G$ = 6.0 Ω) | $t_{d(on)}$ | – | 17 | – | ns |
| Rise Time | | $t_r$ | – | 65 | – | |
| Turn–Off Delay Time | | $t_{d(off)}$ | – | 50 | – | |
| Fall Time | | $t_f$ | – | 80 | – | |
| Total Gate Charge | ($V_{DS}$ = –16 Vdc, $V_{GS}$ = –4.5 Vdc, $I_D$ = –6.2 Adc) | $Q_{tot}$ | – | 20 | 35 | nC |
| Gate–Source Charge | | $Q_{gs}$ | – | 4.0 | – | |
| Gate–Drain Charge | | $Q_{gd}$ | – | 8.0 | – | |

5. Indicates Pulse Test: Pulse Width = 300 μs max, Duty Cycle = 2%.
6. Switching characteristics are independent of operating junction temperature.

* Handling precautions to protect against electrostatic discharge is mandatory.

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted) (continued) *

| Characteristic | | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **BODY–DRAIN DIODE RATINGS** (Note 5.) | | | | | | |
| Diode Forward On–Voltage | ($I_S$ = –1.7 Adc, $V_{GS}$ = 0 Vdc)<br>($I_S$ = –1.7 Adc, $V_{GS}$ = 0 Vdc, $T_J$ = 125°C) | $V_{SD}$ | –<br>– | –0.80<br>–0.65 | –1.2<br>– | Vdc |
| Diode Forward On–Voltage | ($I_S$ = –6.2 Adc, $V_{GS}$ = 0 Vdc)<br>($I_S$ = –6.2 Adc, $V_{GS}$ = 0 Vdc, $T_J$ = 125°C) | $V_{SD}$ | –<br>– | –0.95<br>–0.80 | –<br>– | Vdc |
| Reverse Recovery Time | ($I_S$ = –1.7 Adc, $V_{GS}$ = 0 Vdc, $dI_S/dt$ = 100 A/µs) | $t_{rr}$ | – | 50 | 80 | ns |
| | | $t_a$ | – | 20 | – | |
| | | $t_r$ | – | 30 | – | |
| Reverse Recovery Stored Charge | | $Q_{RR}$ | – | 0.04 | – | µC |

5. Indicates Pulse Test: Pulse Width = 300 µs max, Duty Cycle = 2%.

* Handling precautions to protect against electrostatic discharge is mandatory.

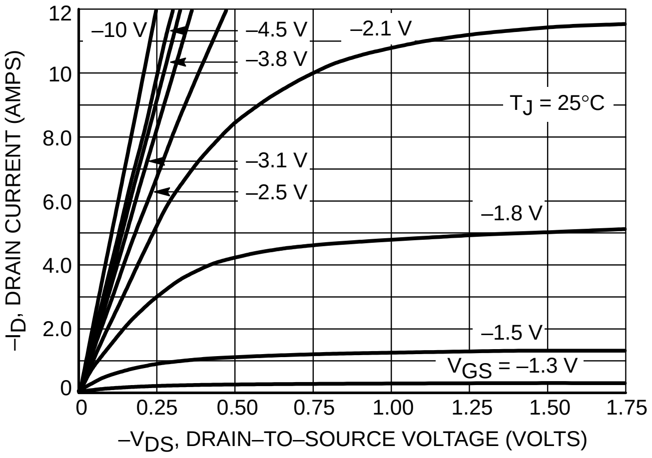


**Figure 1. On–Region Characteristics**

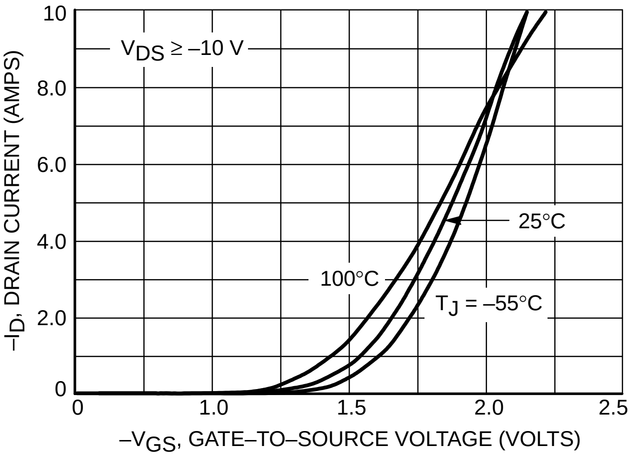


**Figure 2. Transfer Characteristics**

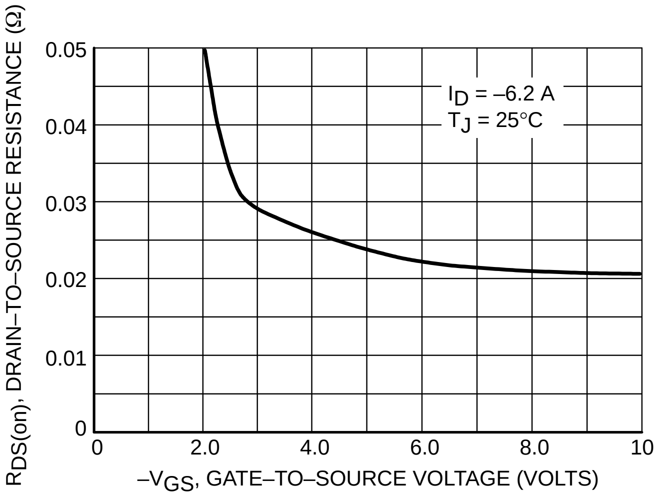


**Figure 3. On–Resistance versus Gate–To–Source Voltage**

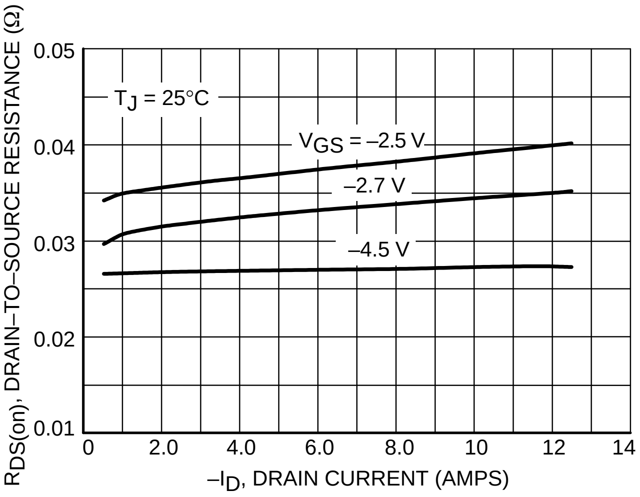


**Figure 4. On-Resistance versus Drain Current and Gate Voltage**

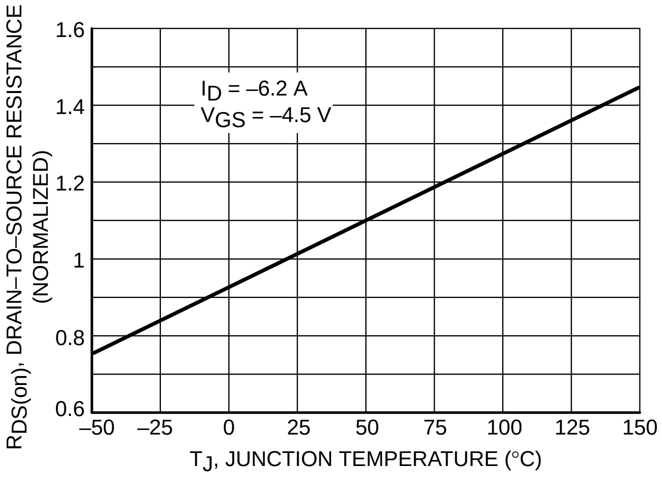


**Figure 5. On–Resistance Variation with Temperature**

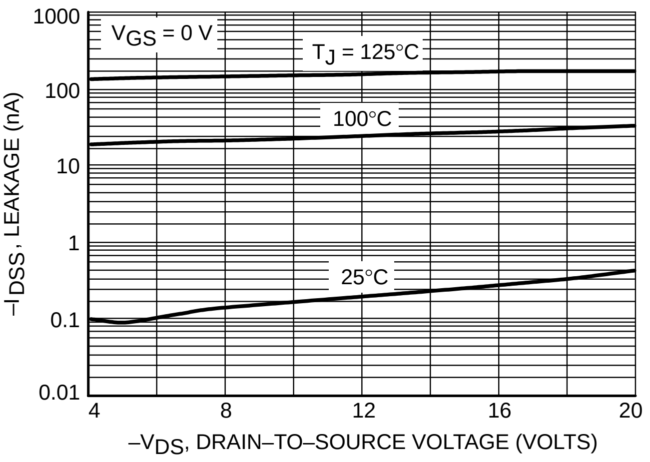


**Figure 6. Drain–To–Source Leakage Current versus Voltage**

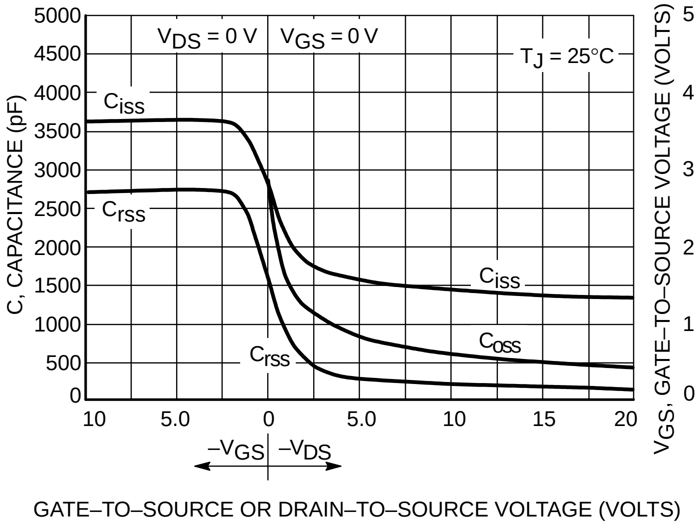


**Figure 7. Capacitance Variation**

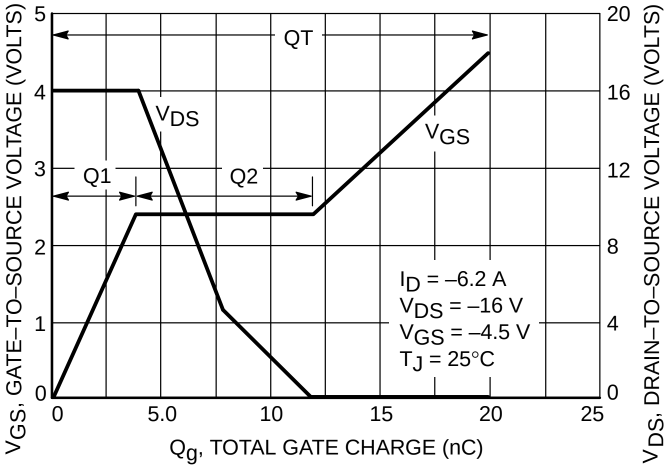


**Figure 8. Gate–To–Source and Drain–To–Source Voltage versus Total Charge**

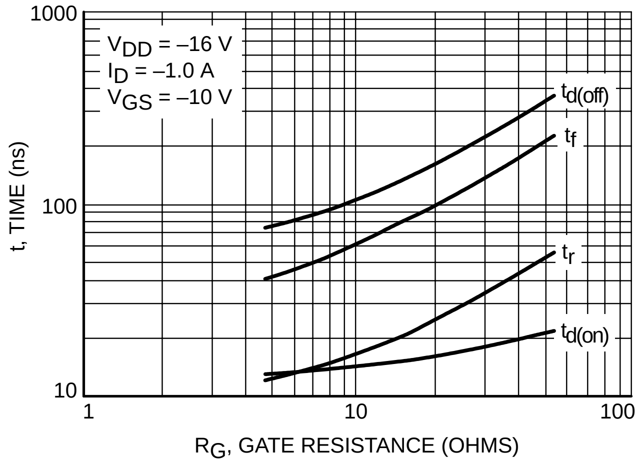


**Figure 9. Resistive Switching Time Variation versus Gate Resistance**

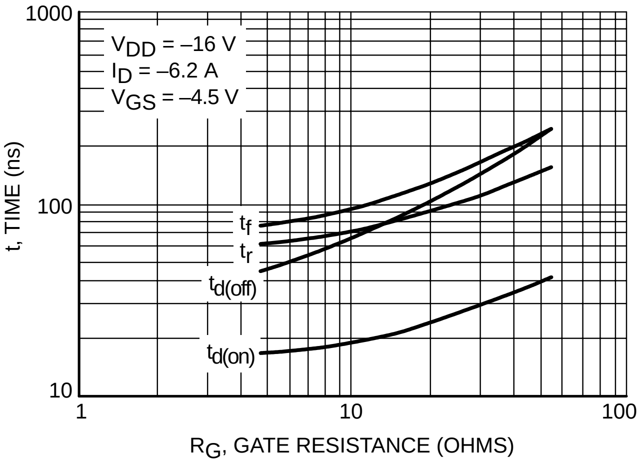


**Figure 10. Resistive Switching Time Variation versus Gate Resistance**

## DRAIN–TO–SOURCE DIODE CHARACTERISTICS

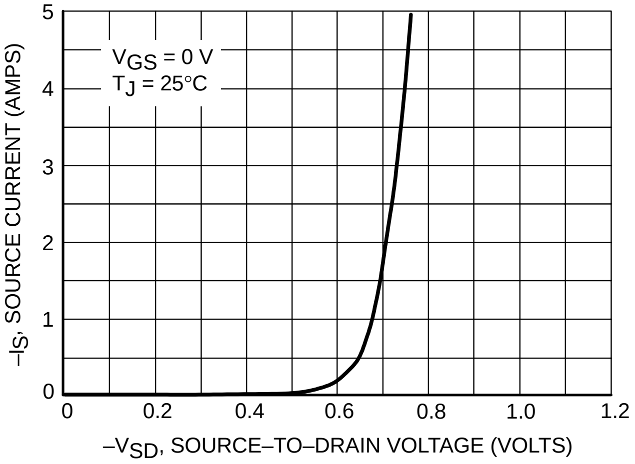


Figure 11. Diode Forward Voltage versus Current

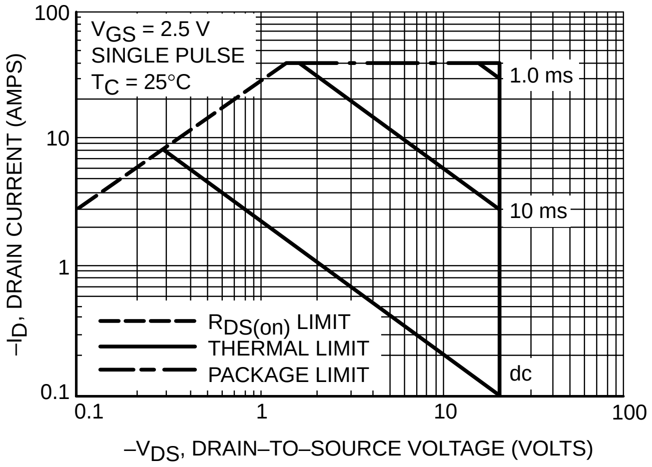


Figure 12. Maximum Rated Forward Biased Safe Operating Area

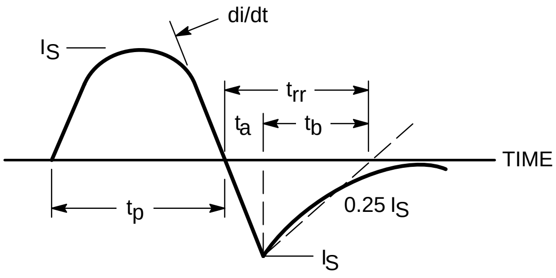


Figure 13. Diode Reverse Recovery Waveform

## TYPICAL ELECTRICAL CHARACTERISTICS

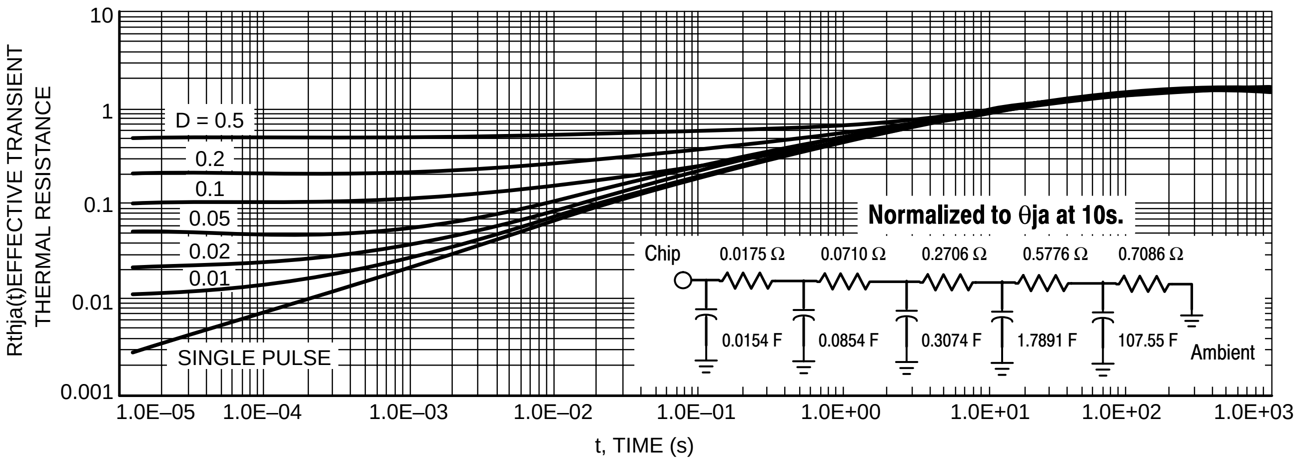
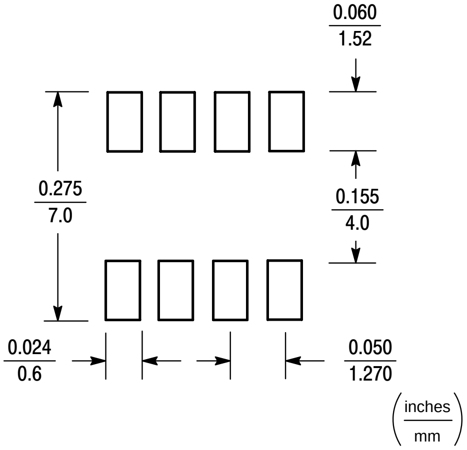


Figure 14. Thermal Response

# INFORMATION FOR USING THE SO–8 SURFACE MOUNT PACKAGE

## MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self–align when subjected to a solder reflow process.



## SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

## TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 15 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems, but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

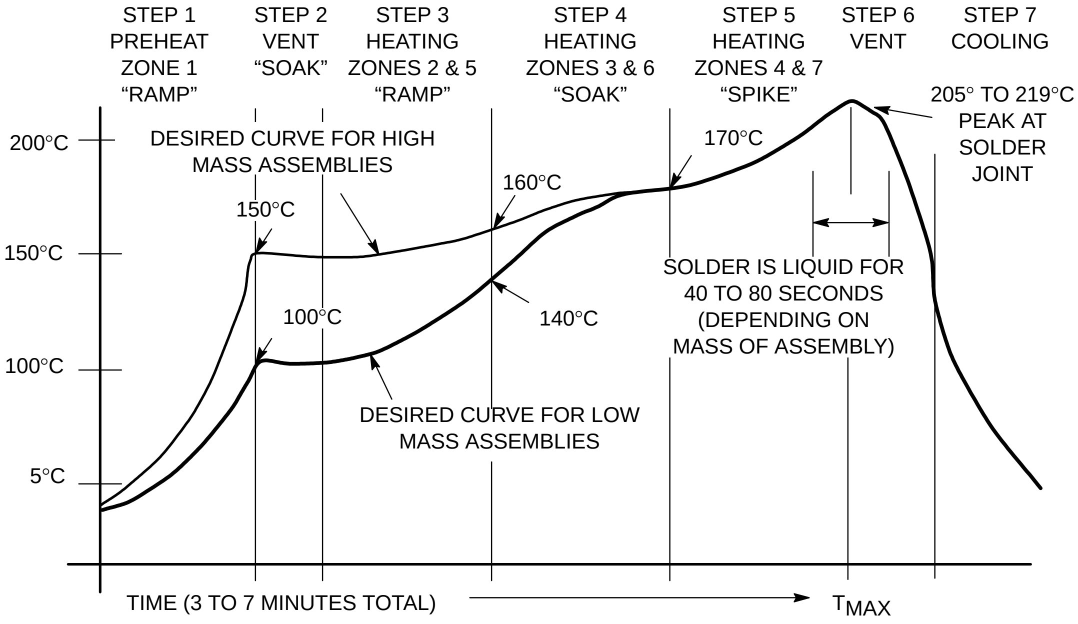
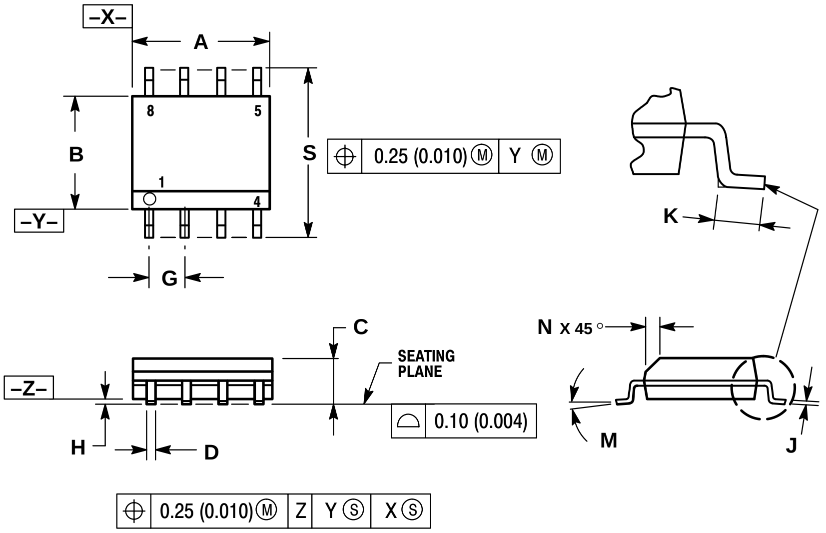


Figure 15. Typical Solder Heating Profile

## PACKAGE DIMENSIONS

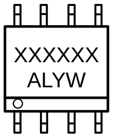
### SO–8

CASE 751–07
ISSUE V



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.

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | 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 |



STYLE 11:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

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