

## HM4N65K / HM4N65I

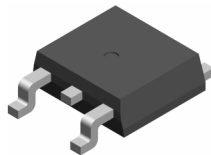
### 650V N-Channel MOSFET

#### General Description

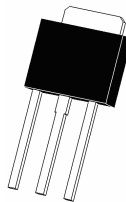
This Power MOSFET is produced using SL semi's advanced planar stripe DMOS technology. This advanced technology has been especially tailored to minimize on-state resistance, provide superior switching performance, and withstand high energy pulse in the avalanche and commutation mode. These devices are well suited for low voltage applications such as DC/DC converters and high efficiency switching for power management in portable and battery operated products.

#### Features

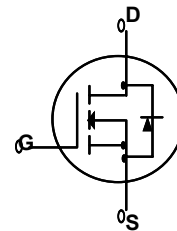
- 4.0A, 650V,  $R_{DS(on)} = 2.6\Omega$ (Typ) @  $V_{GS} = 10V$
- Low gate charge ( typical 15nC)
- High ruggedness
- Fast switching
- 100% avalanche tested
- Improved dv/dt capability



TO-252



TO-251



#### Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ unless otherwise noted

| Symbol         | Parameter                                                                     | HM4N65K     | HM4N65I | Units               |
|----------------|-------------------------------------------------------------------------------|-------------|---------|---------------------|
| $V_{DSS}$      | Drain-Source Voltage                                                          | 650         |         | V                   |
| $I_D$          | Drain Current - Continuous ( $T_C = 25^\circ\text{C}$ )                       | 4.0         | 4.0 *   | A                   |
|                | - Continuous ( $T_C = 100^\circ\text{C}$ )                                    | 2.4         | 2.4 *   | A                   |
| $I_{DM}$       | Drain Current - Pulsed (Note 1)                                               | 16          | 16 *    | A                   |
| $V_{GSS}$      | Gate-Source Voltage                                                           | $\pm 30$    |         | V                   |
| $E_{AS}$       | Single Pulsed Avalanche Energy (Note 2)                                       | 180         |         | mJ                  |
| $E_{AR}$       | Repetitive Avalanche Energy (Note 1)                                          | 10          |         | mJ                  |
| dv/dt          | Peak Diode Recovery dv/dt (Note 3)                                            | 4.5         |         | V/ns                |
| $P_D$          | Power Dissipation ( $T_C = 25^\circ\text{C}$ )                                | 104         | 34      | W                   |
|                | - Derate above $25^\circ\text{C}$                                             | 0.83        | 0.27    | W/ $^\circ\text{C}$ |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range                                       | -55 to +150 |         | $^\circ\text{C}$    |
| $T_L$          | Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds | 300         |         | $^\circ\text{C}$    |

\* Drain current limited by maximum junction temperature.

#### Thermal Characteristics

| Symbol          | Parameter                               | HM4N65K | HM4N65I | Units                     |
|-----------------|-----------------------------------------|---------|---------|---------------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case    | 1.2     | 3.65    | $^\circ\text{C}/\text{W}$ |
| $R_{\theta CS}$ | Thermal Resistance, Case-to-Sink Typ.   | 0.5     | --      | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 62.5    | 62.5    | $^\circ\text{C}/\text{W}$ |

## Electrical Characteristics

$T_C = 25^\circ\text{C}$  unless otherwise noted

| Symbol                         | Parameter                                 | Test Conditions                                                   | Min | Typ | Max  | Units                     |
|--------------------------------|-------------------------------------------|-------------------------------------------------------------------|-----|-----|------|---------------------------|
| <b>Off Characteristics</b>     |                                           |                                                                   |     |     |      |                           |
| $BV_{DSS}$                     | Drain-Source Breakdown Voltage            | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$               | 650 | --  | --   | V                         |
| $\Delta BV_{DSS} / \Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D = 250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$ | --  | 0.6 | --   | $\text{V}/^\circ\text{C}$ |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current           | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$                      | --  | --  | 1    | $\mu\text{A}$             |
|                                |                                           | $V_{DS} = 520\text{ V}, T_C = 125^\circ\text{C}$                  | --  | --  | 10   | $\mu\text{A}$             |
| $I_{GSSF}$                     | Gate-Body Leakage Current, Forward        | $V_{GS} = 30\text{ V}, V_{DS} = 0\text{ V}$                       | --  | --  | 100  | nA                        |
| $I_{GSSR}$                     | Gate-Body Leakage Current, Reverse        | $V_{GS} = -30\text{ V}, V_{DS} = 0\text{ V}$                      | --  | --  | -100 | nA                        |

## On Characteristics

|              |                                   |                                                 |     |     |     |          |
|--------------|-----------------------------------|-------------------------------------------------|-----|-----|-----|----------|
| $V_{GS(th)}$ | Gate Threshold Voltage            | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | 2.0 | 3.0 | 4.0 | V        |
| $R_{DS(on)}$ | Static Drain-Source On-Resistance | $V_{GS} = 10\text{ V}, I_D = 2.0\text{ A}$      | --  | 2.6 | 3.1 | $\Omega$ |

## Dynamic Characteristics

|           |                              |                                                                      |    |     |    |    |
|-----------|------------------------------|----------------------------------------------------------------------|----|-----|----|----|
| $C_{iss}$ | Input Capacitance            | $V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V},$<br>$f = 1.0\text{ MHz}$ | -- | 560 | -- | pF |
| $C_{oss}$ | Output Capacitance           |                                                                      | -- | 55  | -- | pF |
| $C_{rss}$ | Reverse Transfer Capacitance |                                                                      | -- | 7   | -- | pF |

## Switching Characteristics

|              |                     |                                                                                             |    |     |    |    |
|--------------|---------------------|---------------------------------------------------------------------------------------------|----|-----|----|----|
| $t_{d(on)}$  | Turn-On Delay Time  | $V_{DD} = 325\text{ V}, I_D = 4.0\text{ A},$<br>$R_G = 25\text{ }\Omega$<br><br>(Note 4, 5) | -- | 10  | -- | ns |
| $t_r$        | Turn-On Rise Time   |                                                                                             | -- | 40  | -- | ns |
| $t_{d(off)}$ | Turn-Off Delay Time |                                                                                             | -- | 40  | -- | ns |
| $t_f$        | Turn-Off Fall Time  |                                                                                             | -- | 50  | -- | ns |
| $Q_g$        | Total Gate Charge   | $V_{DS} = 520\text{ V}, I_D = 4.0\text{ A},$<br>$V_{GS} = 10\text{ V}$<br><br>(Note 4, 5)   | -- | 16  | -  | nC |
| $Q_{gs}$     | Gate-Source Charge  |                                                                                             | -- | 2.5 | -- | nC |
| $Q_{gd}$     | Gate-Drain Charge   |                                                                                             | -- | 6.5 | -- | nC |

## Drain-Source Diode Characteristics and Maximum Ratings

|                 |                                                       |                                                                                            |    |     |     |    |
|-----------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------|----|-----|-----|----|
| I <sub>S</sub>  | Maximum Continuous Drain-Source Diode Forward Current |                                                                                            | -- | --  | 4.0 | A  |
| I <sub>SM</sub> | Maximum Pulsed Drain-Source Diode Forward Current     |                                                                                            | -- | --  | 16  | A  |
| V <sub>SD</sub> | Drain-Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 4.0 A                                              | -- | --  | 1.4 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                 | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 4.0 A,<br>di <sub>F</sub> / dt = 100 A/μs (Note 4) | -- | 300 | --  | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                               |                                                                                            | -- | 2.0 | --  | μC |

### Notes:

1. Repetitive Rating : Pulse width limited by maximum junction temperature
2.  $L = 22\text{ mH}, I_{AS} = 4.0\text{ A}, V_{DD} = 25\text{ V}, R_G = 25\text{ }\Omega$ , Starting  $T_J = 25^\circ\text{C}$
3.  $I_{SD} \leq 4.0\text{ A}, di/dt \leq 200\text{ A}/\mu\text{s}, V_{DD} \leq BV_{DSS}$ , Starting  $T_J = 25^\circ\text{C}$
4. Pulse Test : Pulse width  $\leq 300\mu\text{s}$ , Duty cycle  $\leq 2\%$
5. Essentially independent of operating temperature

## Typical Characteristics

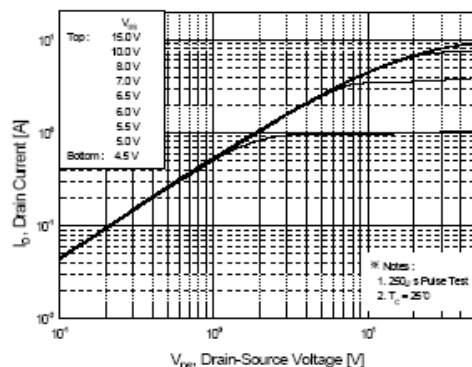


Figure 1. On-Region Characteristics

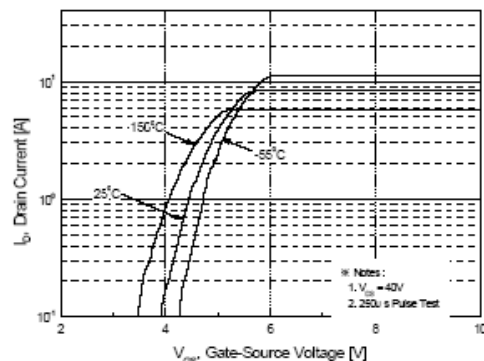


Figure 2. Transfer Characteristics

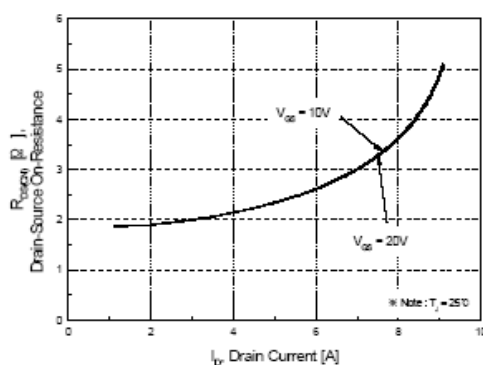


Figure 3. On-Resistance Variation vs Drain Current and Gate Voltage

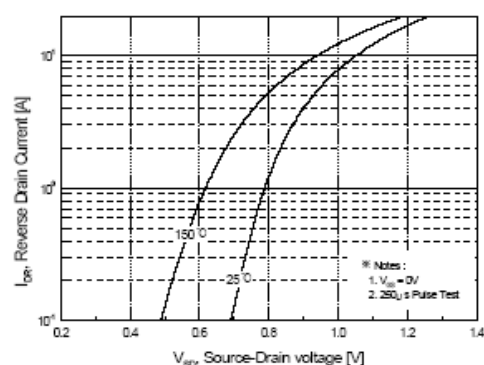


Figure 4. Body Diode Forward Voltage Variation with Source Current

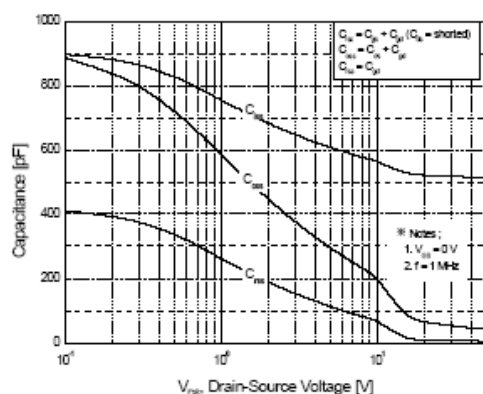


Figure 5. Capacitance Characteristics

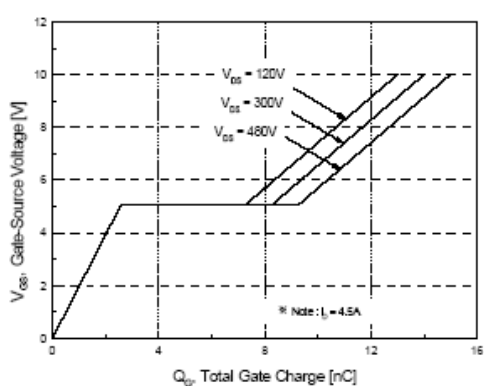


Figure 6. Gate Charge Characteristics

# Typical Characteristics (Continued)

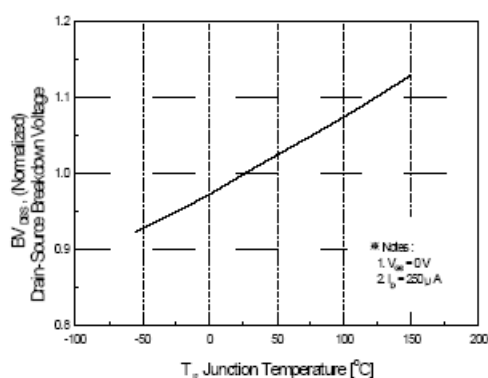


Figure 7. Breakdown Voltage Variation vs Temperature

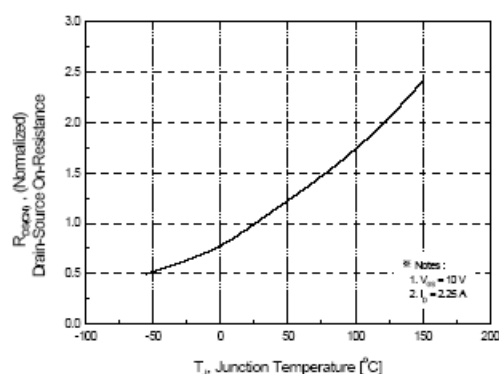


Figure 8. On-Resistance Variation vs Temperature

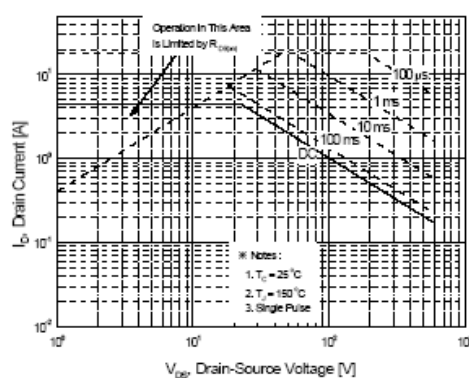


Figure 9-1. Maximum Safe Operating Area for HM4N65K

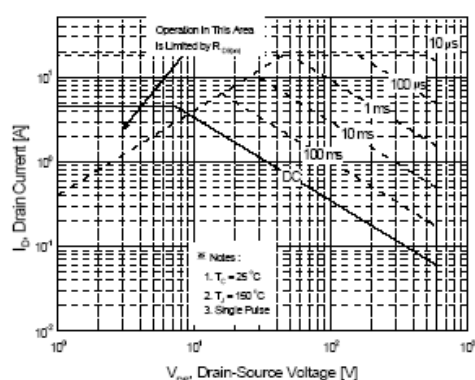


Figure 9-2. Maximum Safe Operating Area for HM4N65I

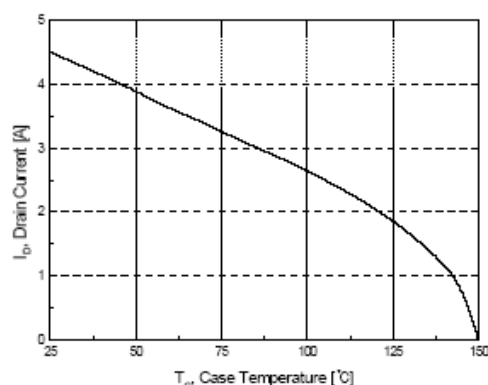


Figure 10. Maximum Drain Current vs Case Temperature

Typical Characteristics (Continued)

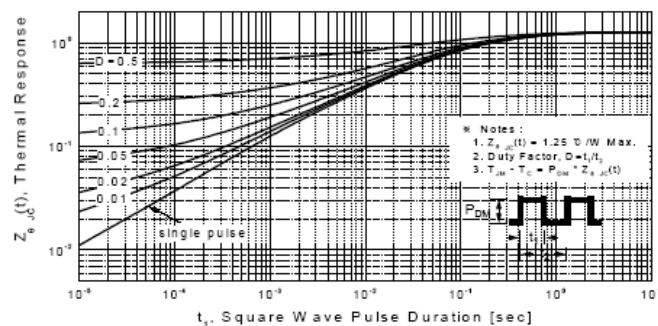


Figure 11-1. Transient Thermal Response Curve  
for HM4N65K

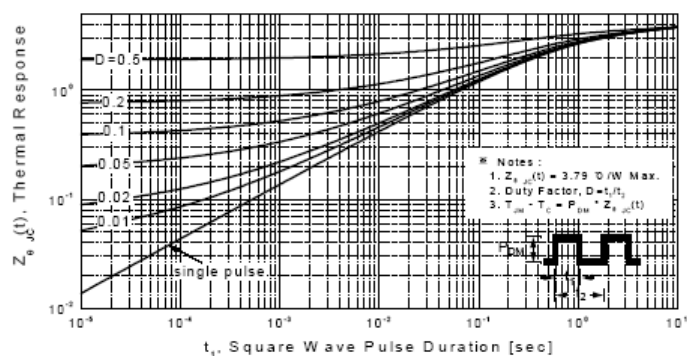
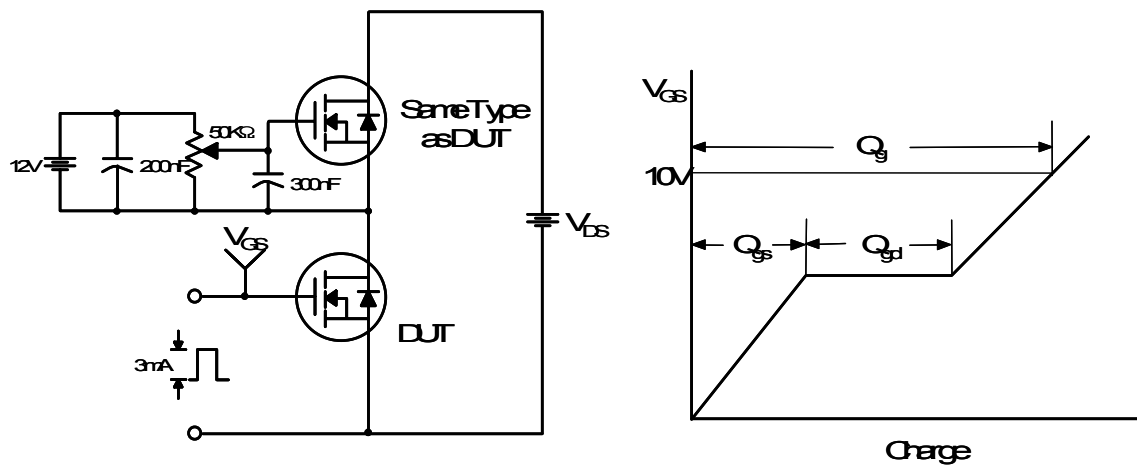
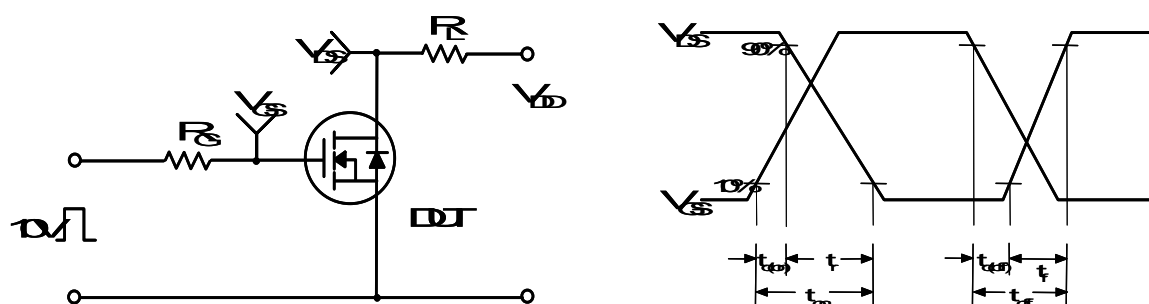


Figure 11-2. Transient Thermal Response Curve  
for HM4N65I

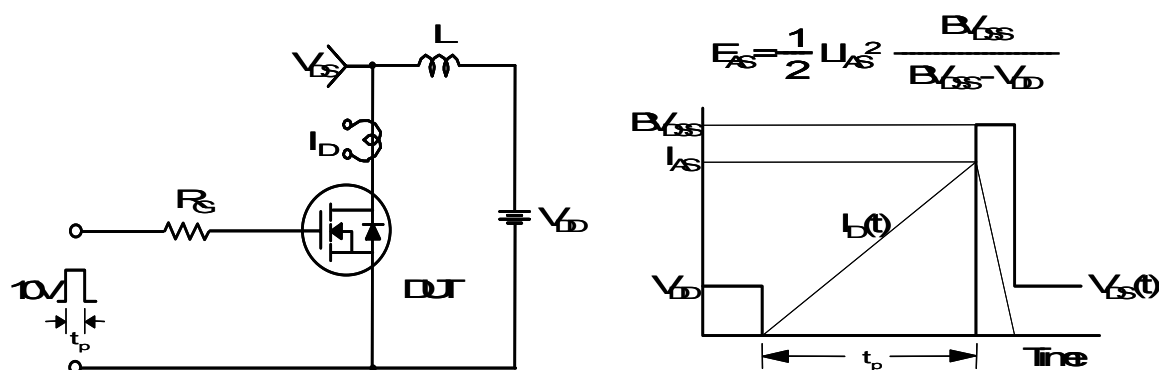
Gate Charge Test Circuit & Waveform



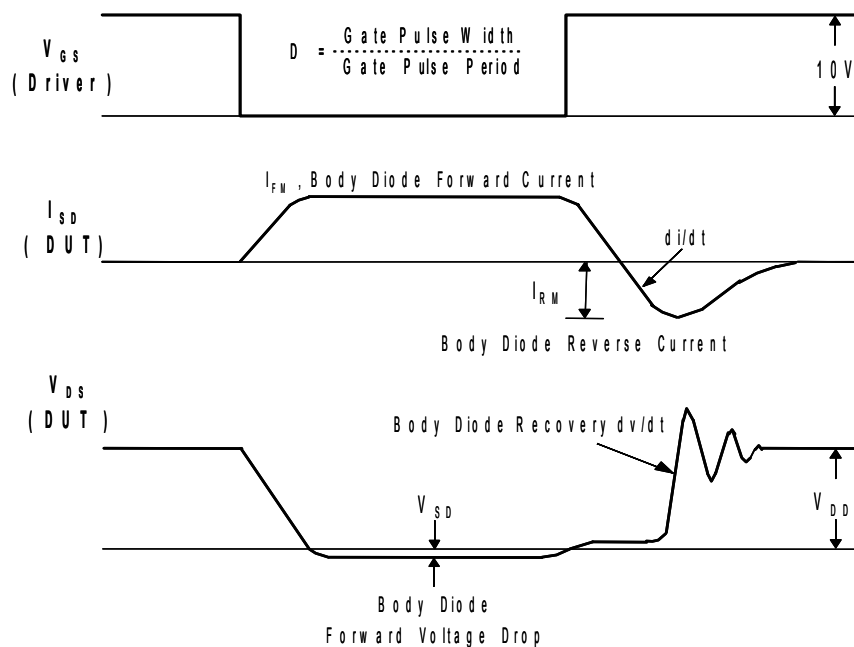
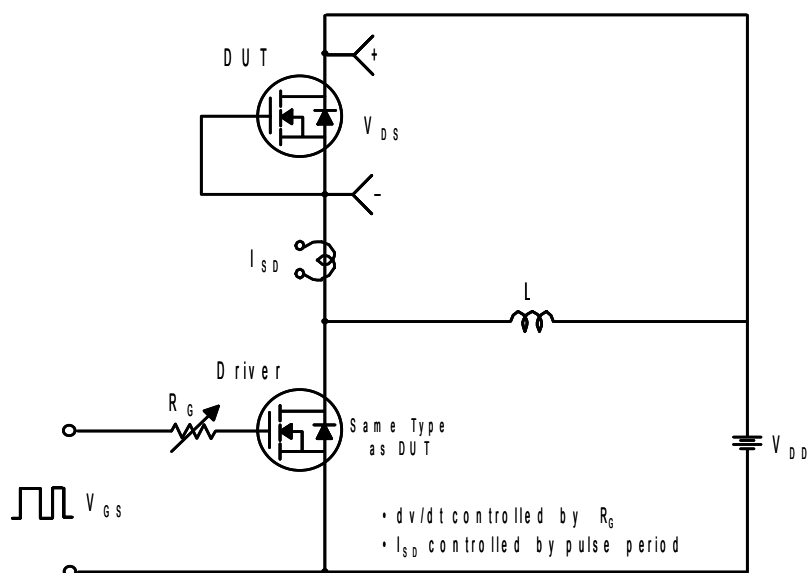
Resistive Switching Test Circuit & Waveforms



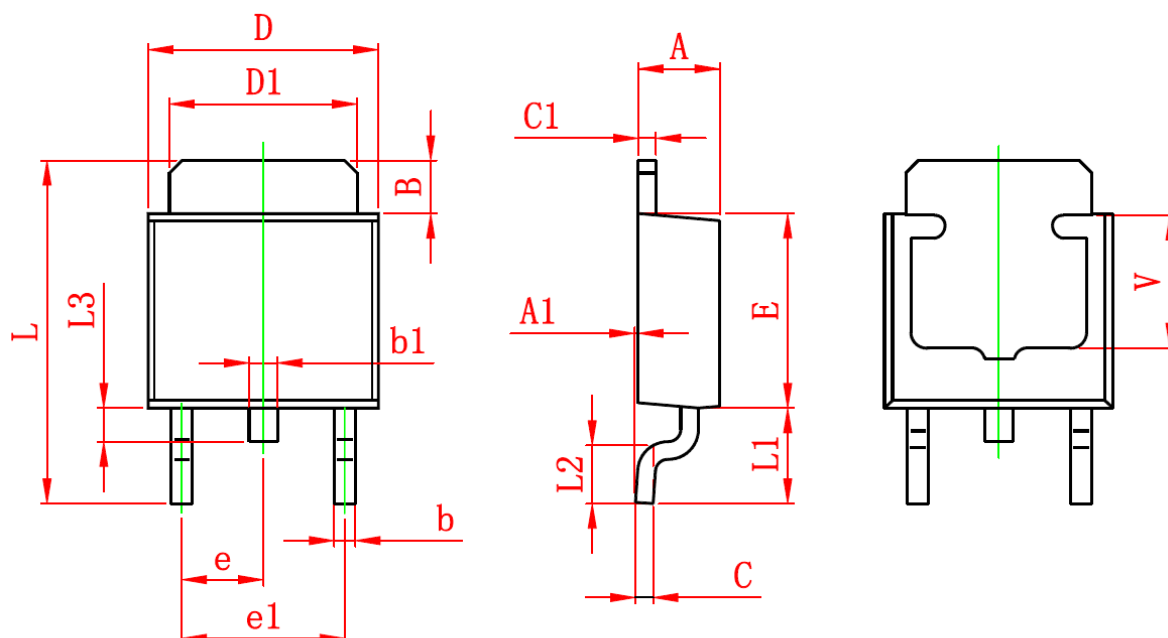
Unclamped Inductive Switching Test Circuit & Waveforms



Peak Diode Recovery dv/dt Test Circuit & Waveforms



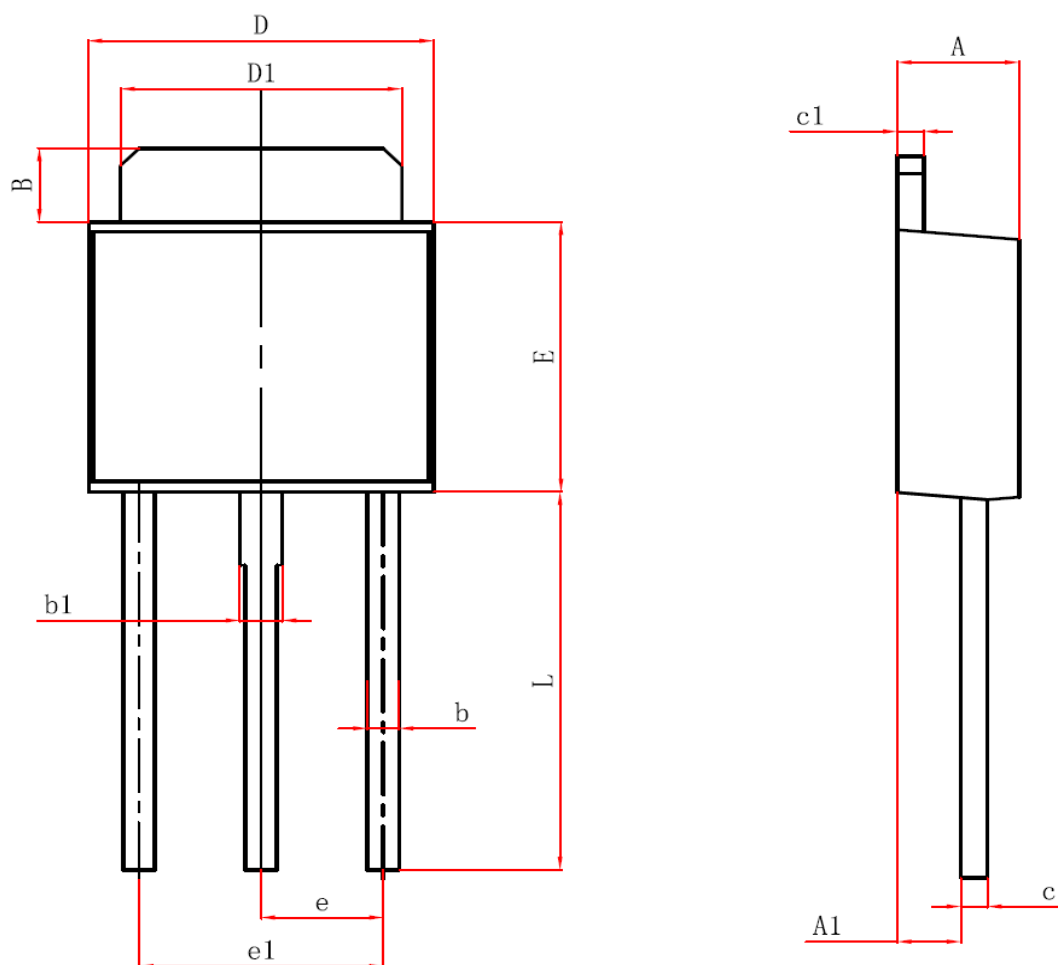
TO-252-2L PACKAGE OUTLINE DIMENSIONS



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min.                      | Max.  | Min.                 | Max.  |
| A      | 2.200                     | 2.400 | 0.087                | 0.094 |
| A1     | 0.000                     | 0.127 | 0.000                | 0.005 |
| B      | 1.350                     | 1.650 | 0.053                | 0.065 |
| b      | 0.500                     | 0.700 | 0.020                | 0.028 |
| b1     | 0.700                     | 0.900 | 0.028                | 0.035 |
| c      | 0.430                     | 0.580 | 0.017                | 0.023 |
| c1     | 0.430                     | 0.580 | 0.017                | 0.023 |
| D      | 6.350                     | 6.650 | 0.250                | 0.262 |
| D1     | 5.200                     | 5.400 | 0.205                | 0.213 |
| E      | 5.400                     | 5.700 | 0.213                | 0.224 |
| e      | 2.300 TYP.                |       | 0.091 TYP.           |       |
| e1     | 4.500                     | 4.700 | 0.177                | 0.185 |
| L      | 9.500                     | 9.900 | 0.374                | 0.390 |
| L1     | 2.550                     | 2.900 | 0.100                | 0.114 |
| L2     | 1.400                     | 1.780 | 0.055                | 0.070 |
| L3     | 0.600                     | 0.900 | 0.024                | 0.035 |
| V      | 3.800 REF.                |       | 0.150 REF.           |       |



## TO-251 PACKAGE OUTLINE DIMENSIONS



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 2.200                     | 2.400 | 0.087                | 0.094 |
| A1     | 1.050                     | 1.350 | 0.042                | 0.054 |
| B      | 1.350                     | 1.650 | 0.053                | 0.065 |
| b      | 0.500                     | 0.700 | 0.020                | 0.028 |
| b1     | 0.700                     | 0.900 | 0.028                | 0.035 |
| c      | 0.430                     | 0.580 | 0.017                | 0.023 |
| c1     | 0.430                     | 0.580 | 0.017                | 0.023 |
| D      | 6.350                     | 6.650 | 0.250                | 0.262 |
| D1     | 5.200                     | 5.400 | 0.205                | 0.213 |
| E      | 5.400                     | 5.700 | 0.213                | 0.224 |
| e      | 2.300 TYP                 |       | 0.091 TYP            |       |
| e1     | 4.500                     | 4.700 | 0.177                | 0.185 |
| L      | 7.500                     | 7.900 | 0.295                | 0.311 |