

# 1NK60ZR-VB Datasheet

## Power MOSFET

### PRODUCT SUMMARY

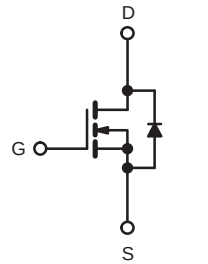
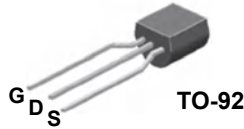
|                           |                        |   |
|---------------------------|------------------------|---|
| $V_{DS}$ (V)              | 650                    |   |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 8 |
| $Q_g$ (Max.) (nC)         | 18                     |   |
| $Q_{gs}$ (nC)             | 3.0                    |   |
| $Q_{gd}$ (nC)             | 8.9                    |   |
| Configuration             | Single                 |   |

### FEATURES

- Halogen-free According to IEC 61249-2-21 Definition
- Dynamic dV/dt Rating
- Repetitive Avalanche Rated
- Available in Tape and Reel
- Fast Switching
- Ease of Paralleling
- Compliant to RoHS Directive 2002/95/EC



**RoHS\***  
COMPLIANT  
**HALOGEN**  
**FREE**  
Available



N-Channel MOSFET

### ABSOLUTE MAXIMUM RATINGS $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted

| PARAMETER                                          |                         |                         | SYMBOL                            | LIMIT            | UNIT |
|----------------------------------------------------|-------------------------|-------------------------|-----------------------------------|------------------|------|
| Drain-Source Voltage                               |                         |                         | V <sub>DS</sub>                   | 650              | V    |
| Gate-Source Voltage                                |                         |                         | V <sub>GS</sub>                   | ± 20             |      |
| Continuous Drain Current                           | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 1.0              | A    |
|                                                    |                         | T <sub>C</sub> = 100 °C |                                   | 0.7              |      |
| Pulsed Drain Current <sup>a</sup>                  |                         |                         | I <sub>DM</sub>                   | 2.0              | W/°C |
| Linear Derating Factor                             |                         |                         |                                   | 0.33             |      |
| Linear Derating Factor (PCB Mount) <sup>e</sup>    |                         |                         |                                   | 0.020            |      |
| Single Pulse Avalanche Energy <sup>b</sup>         |                         |                         | E <sub>AS</sub>                   | 74               | mJ   |
| Repetitive Avalanche Current <sup>a</sup>          |                         |                         | I <sub>AR</sub>                   | 2.0              | A    |
| Repetitive Avalanche Energy <sup>a</sup>           |                         |                         | E <sub>AR</sub>                   | 4.2              | mJ   |
| Maximum Power Dissipation                          | T <sub>C</sub> = 25 °C  |                         | P <sub>D</sub>                    | 42               | W    |
| Maximum Power Dissipation (PCB Mount) <sup>e</sup> | T <sub>A</sub> = 25 °C  |                         |                                   | 2.5              |      |
| Peak Diode Recovery dV/dt <sup>c</sup>             |                         |                         | dV/dt                             | 3.0              | V/ns |
| Operating Junction and Storage Temperature Range   |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | - 55 to + 150    | °C   |
| Soldering Recommendations (Peak Temperature)       | for 10 s                |                         |                                   | 260 <sup>d</sup> |      |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = 50\text{ V}$ , starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 37\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 2.0\text{ A}$  (see fig. 12).
- $I_{SD} \leq 2.0\text{ A}$ ,  $dI/dt \leq 40\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 1.6 mm from case.
- When mounted on 1" square PCB (FR-4 or G-10 material).

\* Pb containing terminations are not RoHS compliant, exemptions may apply

**THERMAL RESISTANCE RATINGS**

| PARAMETER                                            | SYMBOL     | MIN. | TYP. | MAX. | UNIT |
|------------------------------------------------------|------------|------|------|------|------|
| Maximum Junction-to-Ambient                          | $R_{thJA}$ | -    | -    | 110  | °C/W |
| Maximum Junction-to-Ambient (PCB Mount) <sup>a</sup> | $R_{thJA}$ | -    | -    | 50   |      |
| Maximum Junction-to-Case (Drain)                     | $R_{thJC}$ | -    | -    | 3.0  |      |

**Note**

a. When mounted on 1" square PCB (FR-4 or G-10 material).

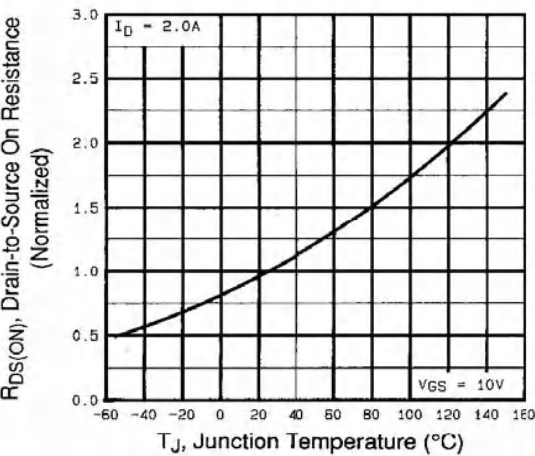
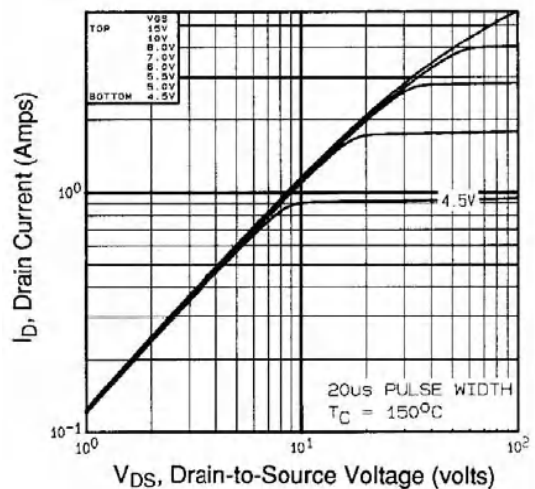
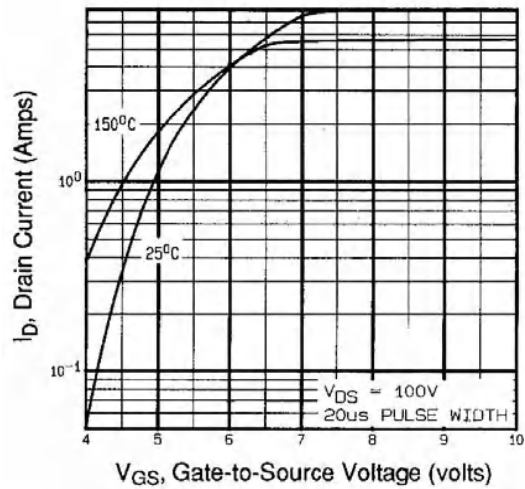
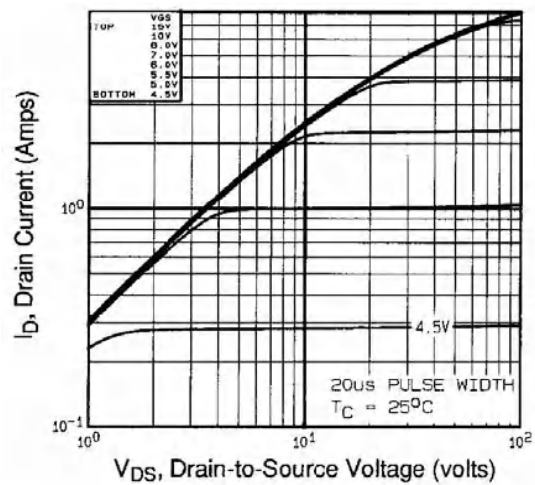
**SPECIFICATIONS**  $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted

| PARAMETER                                 | SYMBOL                           | TEST CONDITIONS                                                                                                             |                                                                                    | MIN. | TYP. | MAX.  | UNIT |
|-------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------|------|-------|------|
| Static                                    |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Drain-Source Breakdown Voltage            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                              |                                                                                    | 650  | -    | -     | V    |
| V <sub>DS</sub> Temperature Coefficient   | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 1 mA                                                                                   |                                                                                    | -    | 0.88 | -     | V/°C |
| Gate-Source Threshold Voltage             | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                 |                                                                                    | 2.0  | -    | 4.0   | V    |
| Gate-Source Leakage                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V                                                                                                    |                                                                                    | -    | -    | ± 100 | nA   |
| Zero Gate Voltage Drain Current           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V                                                                              |                                                                                    | -    | -    | 100   | μA   |
|                                           |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                     |                                                                                    | -    | -    | 500   |      |
| Drain-Source On-State Resistance          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                      | I <sub>D</sub> = 1.0A <sup>b</sup>                                                 | --   | 8    | -     | Ω    |
| Forward Transconductance                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 1.0 A                                                                              |                                                                                    | 1.4  | -    | -     | S    |
| Dynamic                                   |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Input Capacitance                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = - 25 V,<br>f = 1.0 MHz, see fig. 5                                              |                                                                                    | -    | 350  | -     | pF   |
| Output Capacitance                        | C <sub>oss</sub>                 |                                                                                                                             |                                                                                    | -    | 48   | -     |      |
| Reverse Transfer Capacitance              | C <sub>rss</sub>                 |                                                                                                                             |                                                                                    | -    | 8.6  | -     |      |
| Total Gate Charge                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                      | I <sub>D</sub> = 1.0 A, V <sub>DS</sub> = 360 V,<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 18    | nC   |
| Gate-Source Charge                        | Q <sub>gs</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 3.0   |      |
| Gate-Drain Charge                         | Q <sub>gd</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 8.9   |      |
| Turn-On Delay Time                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 1.0 A,<br>R <sub>g</sub> = 18 Ω, R <sub>D</sub> = 135 Ω, see fig. 10 <sup>b</sup> |                                                                                    | -    | 10   | -     | ns   |
| Rise Time                                 | t <sub>r</sub>                   |                                                                                                                             |                                                                                    | -    | 23   | -     |      |
| Turn-Off Delay Time                       | t <sub>d(off)</sub>              |                                                                                                                             |                                                                                    | -    | 30   | -     |      |
| Fall Time                                 | t <sub>f</sub>                   |                                                                                                                             |                                                                                    | -    | 25   | -     |      |
| Internal Drain Inductance                 | L <sub>D</sub>                   | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact                                                  |                                                                                    | -    | 4.5  | -     | nH   |
| Internal Source Inductance                | L <sub>S</sub>                   |                                                                                                                             |                                                                                    | -    | 7.5  | -     |      |
| Drain-Source Body Diode Characteristics   |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Continuous Source-Drain Diode Current     | I <sub>S</sub>                   | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode                                                    |                                                                                    | -    | -    | 2.0   | A    |
| Pulsed Diode Forward Current <sup>a</sup> | I <sub>SM</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 8.0   |      |
| Body Diode Voltage                        | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 2.0 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                          |                                                                                    | -    | -    | 1.6   | V    |
| Body Diode Reverse Recovery Time          | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 2.0 A, dI/dt = 100 A/μs <sup>b</sup>                                               |                                                                                    | -    | 290  | 580   | ns   |
| Body Diode Reverse Recovery Charge        | Q <sub>rr</sub>                  |                                                                                                                             |                                                                                    | -    | 0.67 | 1.3   | μC   |
| Forward Turn-On Time                      | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                           |                                                                                    |      |      |       |      |

**Notes**

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



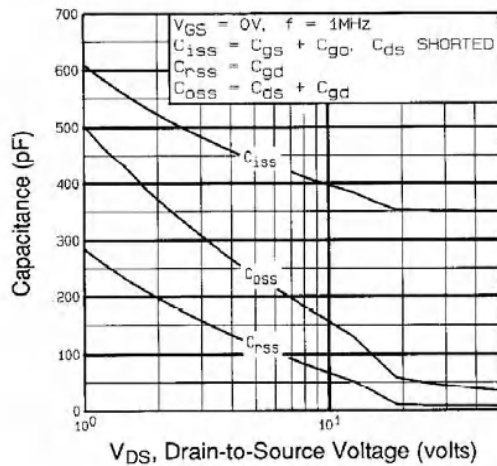


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

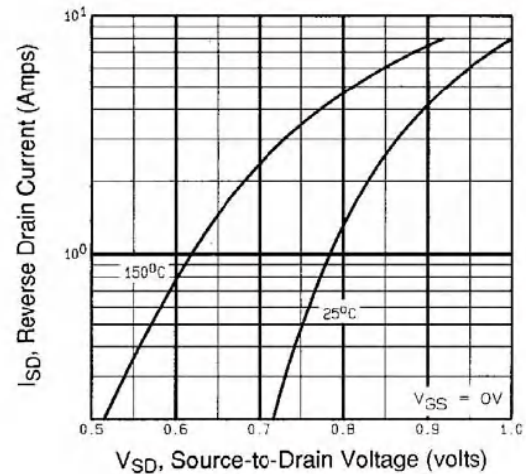


Fig. 7 - Typical Source-Drain Diode Forward Voltage

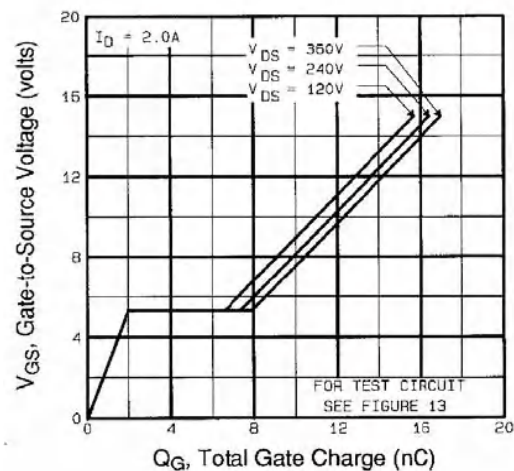


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

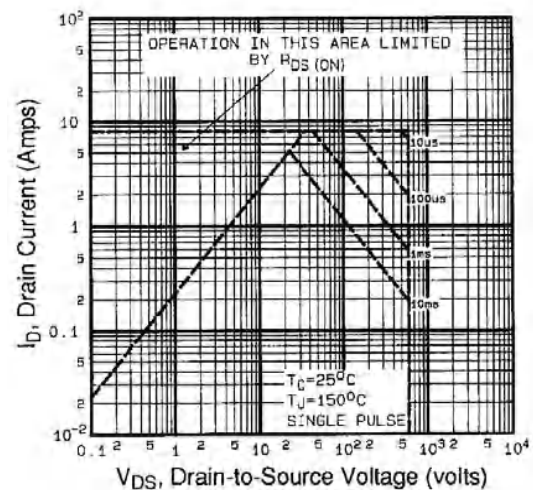


Fig. 8 - Maximum Safe Operating Area

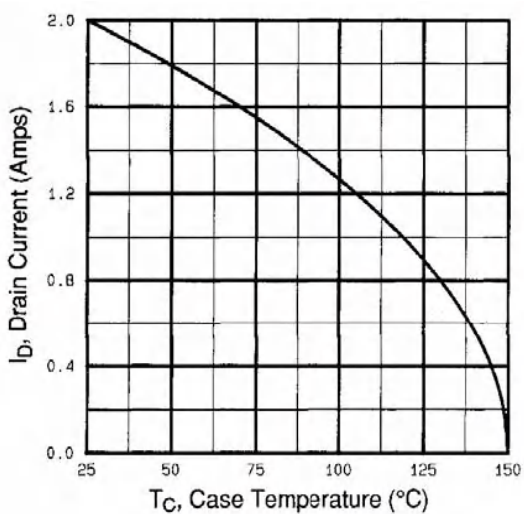


Fig. 9 - Maximum Drain Current vs. Case Temperature

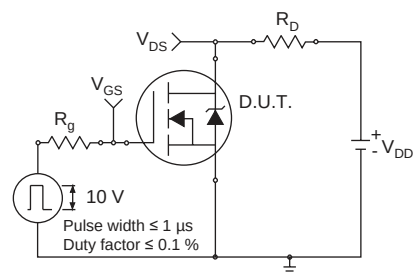


Fig. 10a - Switching Time Test Circuit

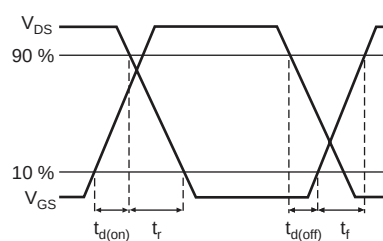


Fig. 10b - Switching Time Waveforms

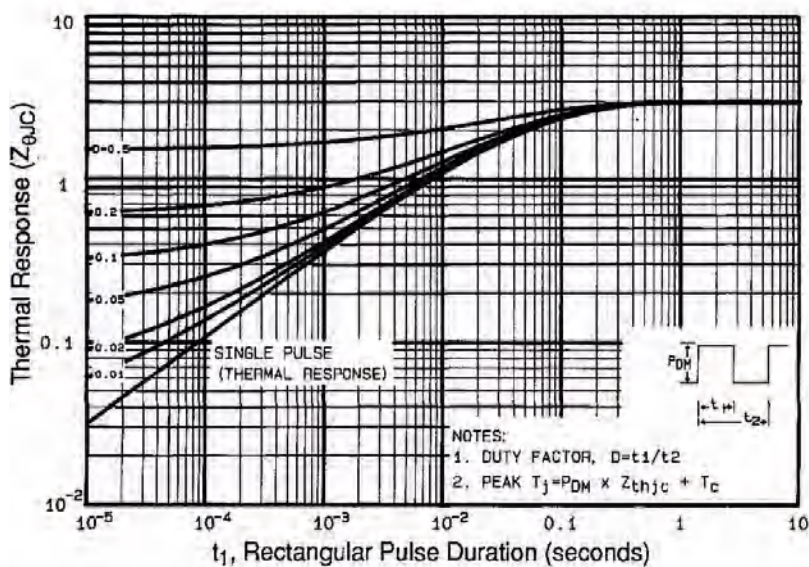


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

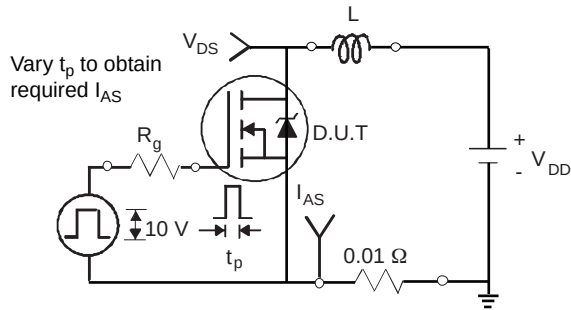


Fig. 12a - Unclamped Inductive Test Circuit

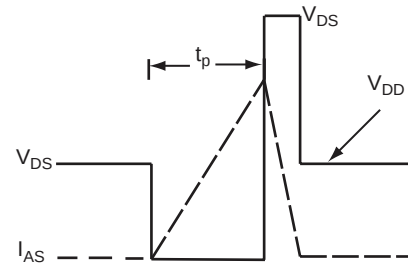


Fig. 12b - Unclamped Inductive Waveforms

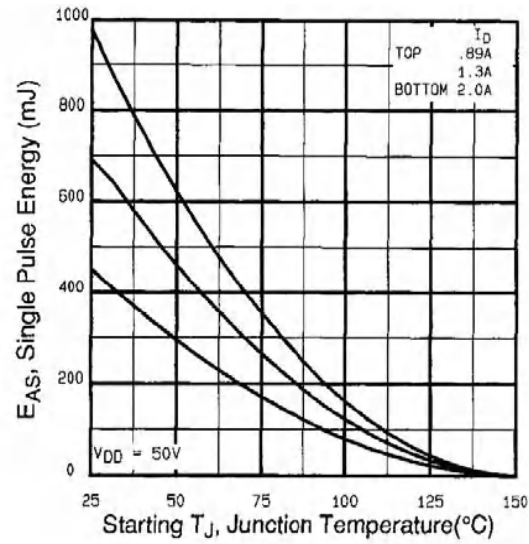


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

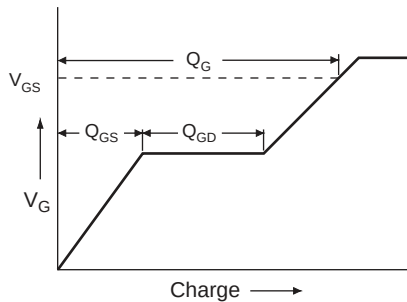


Fig. 13a - Basic Gate Charge Waveform

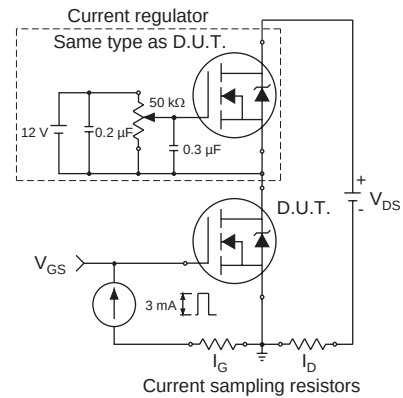
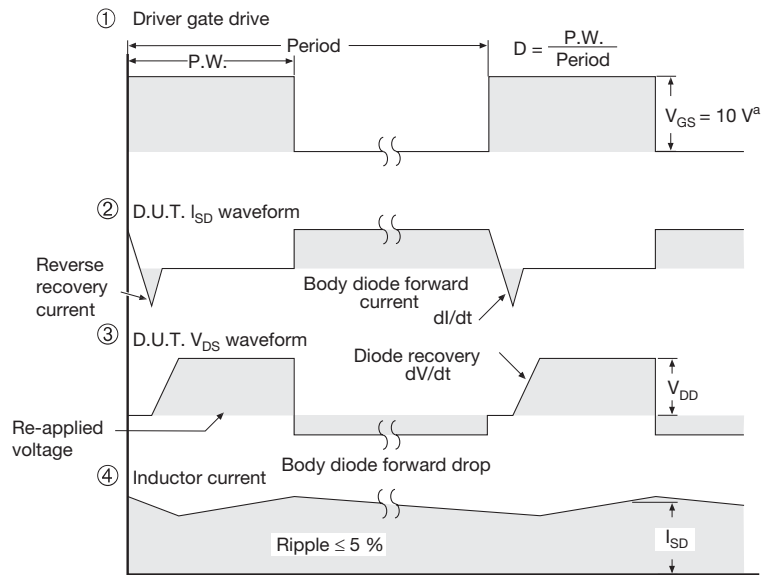
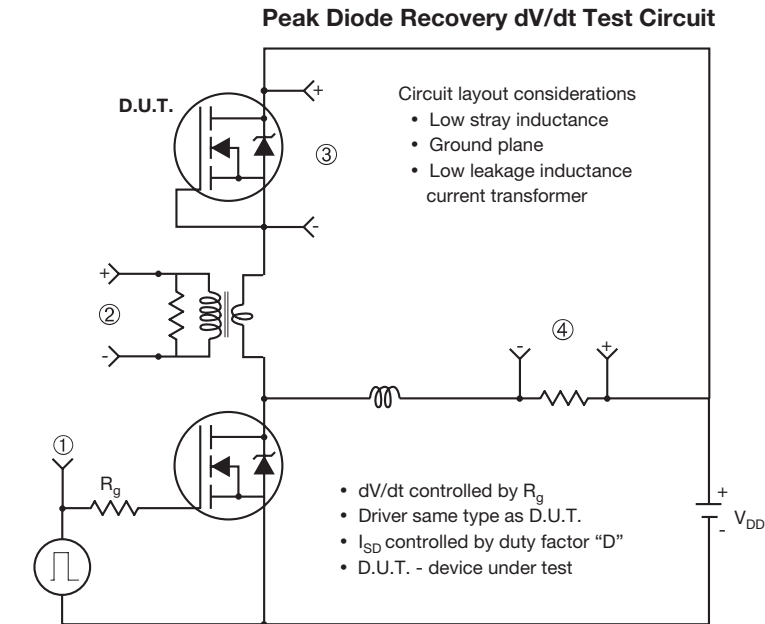


Fig. 13b - Gate Charge Test Circuit



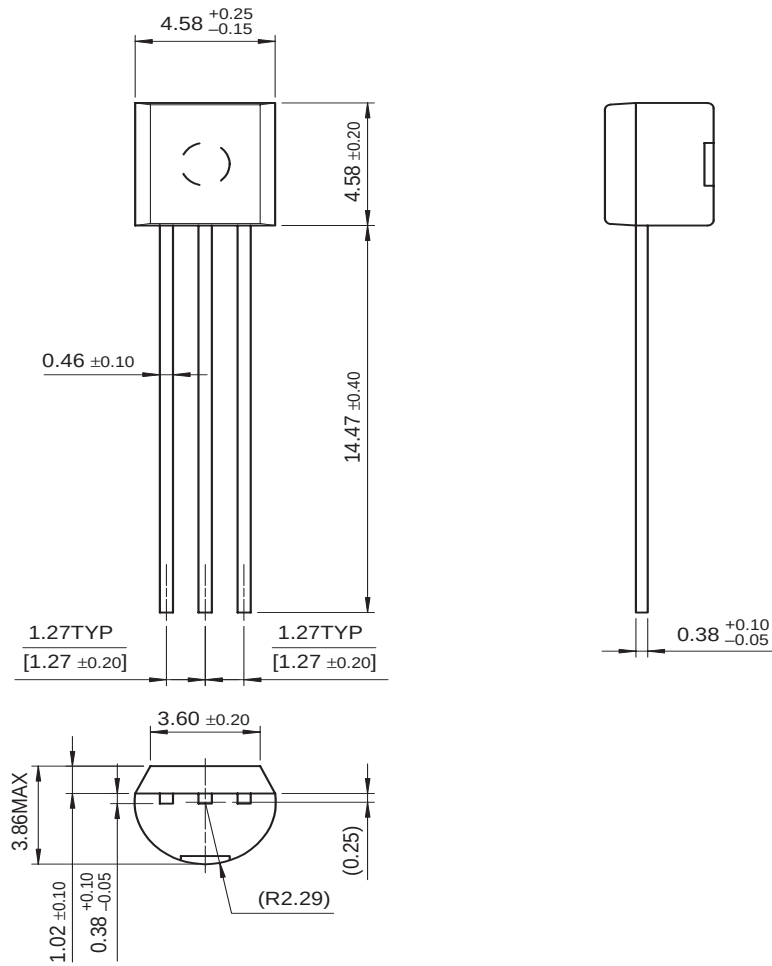
**Note**

a.  $V_{GS} = 5 V$  for logic level devices

**Fig. 14 - For N-Channel**

## Mechanical Dimensions

## TO-92



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