Green Package

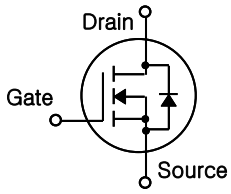
# PFU4N65EG/PFD4N65EG

## 650V N-Channel MOSFET

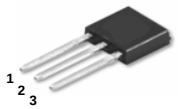
$BV_{DSS}$ = 650 V

$R_{DS(on)}$ = 2.0 Ω

$I_D$ = 3.0 A




**I-PAK(TO-251)**




1.Gate 2. Drain 3. Source

**D-PAK(TO-252)**


1.Gate 2. Drain 3. Source

## FEATURES

- Originative New Design
- 100% EAS Test
- Rugged Gate Oxide Technology
- Extremely Low Intrinsic Capacitances
- Remarkable Switching Characteristics
- Unequalled Gate Charge : 10 nC (Typ.)
- Extended Safe Operating Area
- Lower $R_{DS(ON)}$ : 2.0 Ω (Typ.) @$V_{GS}$=10V
- Halogen Free

## APPLICATION

- Low power battery chargers
- Switch mode power supply (SMPS)
- DC-AC converters.

## Absolute Maximum Ratings

$T_C$=25℃ unless otherwise specified

| Symbol | Parameter | | Value | Units |
|---|---|---|---|---|
| $V_{DSS}$ | Drain-Source Voltage | | 650 | V |
| $I_D$ | Drain Current – Continuous ($T_C$ = 25℃) | | 3.0 | A |
| | Drain Current – Continuous ($T_C$ = 100℃) | | 1.9 | A |
| $I_{DM}$ | Drain Current – Pulsed | (Note 1) | 11.9 | A |
| $V_{GS}$ | Gate-Source Voltage | | ±30 | V |
| $E_{AS}$ | Single Pulsed Avalanche Energy | (Note 2) | 240 | mJ |
| $I_{AR}$ | Avalanche Current | (Note 1) | 3.0 | A |
| $E_{AR}$ | Repetitive Avalanche Energy | (Note 1) | 5.0 | mJ |
| dv/dt | Peak Diode Recovery dv/dt | (Note 3) | 5.5 | V/ns |
| $P_D$ | Total Power Dissipation ($T_A$=25 °C) * | | 2.5 | W |
| | Power Dissipation ($T_C$ = 25℃) | | 50 | W |
| | - Derate above 25℃ | | 0.4 | W/℃ |
| $T_J$, $T_{STG}$ | Operating and Storage Temperature Range | | -55 to +150 | ℃ |
| $T_L$ | Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds | | 300 | ℃ |

## Thermal Resistance Characteristics

| Symbol | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | -- | 2.5 | ℃/W |
| $R_{\theta JA}$ | Junction-to-Ambient* | -- | 50 | |
| $R_{\theta JA}$ | Junction-to-Ambient | -- | 110 | |

* When mounted on the minimum pad size recommended (PCB Mount)

## Electrical Characteristics $T_C$=25 °C unless otherwise specified

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **On Characteristics** | | | | | | |
| $V_{GS}$ | Gate Threshold Voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 uA | 2.5 | -- | 4.5 | V |
| $R_{DS(ON)}$ | Static Drain-Source On-Resistance | $V_{GS}$ = 10 V, $I_D$ = 2.1 A | -- | 2.0 | 2.5 | Ω |
| **Off Characteristics** | | | | | | |
| $BV_{DSS}$ | Drain-Source Breakdown Voltage | $V_{GS}$ = 0 V, $I_D$ = 250 uA | 650 | -- | -- | V |
| $\Delta BV_{DSS}$ /$\Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D$ = 250 uA, Referenced to25℃ | -- | 0.6 | -- | V/℃ |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 650 V, $V_{GS}$ = 0 V | -- | -- | 1 | uA |
| | | $V_{DS}$ = 520 V, $T_C$ = 125℃ | -- | -- | 10 | uA |
| $I_{GSSF}$ | Gate-Body Leakage Current, Forward | $V_{GS}$ = 30 V, $V_{DS}$ = 0 V | -- | -- | 100 | nA |
| $I_{GSSR}$ | Gate-Body Leakage Current, Reverse | $V_{GS}$ = -30 V, $V_{DS}$ = 0 V | -- | -- | -100 | nA |
| **Dynamic Characteristics** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 25 V, $V_{GS}$ = 0 V, f = 1.0 MHz | -- | 585 | 760 | pF |
| $C_{oss}$ | Output Capacitance | | -- | 63 | 82 | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | -- | 4 | 6 | pF |
| **Switching Characteristics** | | | | | | |
| $t_{d(on)}$ | Turn-On Time | $V_{DS}$ = 325 V, $I_D$ = 4.2 A, $R_G$ = 25 Ω (Note 4,5) | -- | 14 | 28 | ns |
| $t_r$ | Turn-On Rise Time | | -- | 7.5 | 15 | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | -- | 28 | 56 | ns |
| $t_f$ | Turn-Off Fall Time | | -- | 6.5 | 13 | ns |
| $Q_g$ | Total Gate Charge | $V_{DS}$ = 520 V, $I_D$ = 4.2 A, $V_{GS}$ = 10 V (Note 4,5) | -- | 10 | 15 | nC |
| $Q_{gs}$ | Gate-Source Charge | | -- | 3.2 | -- | nC |
| $Q_{gd}$ | Gate-Drain Charge | | -- | 3.8 | -- | nC |
| **Source-Drain Diode Maximum Ratings and Characteristics** | | | | | | |
| $I_S$ | Continuous Source-Drain Diode Forward Current | | -- | -- | 3.0 | A |
| $I_{SM}$ | Pulsed Source-Drain Diode Forward Current | | -- | -- | 11.9 | A |
| $V_{SD}$ | Source-Drain Diode Forward Voltage | $I_S$ = 4.2 A, $V_{GS}$ = 0 V | -- | -- | 1.5 | V |
| trr | Reverse Recovery Time | $I_S$ = 4.2 A, $V_{GS}$ = 0 V, $di_F/dt$ = 100 A/μs (Note 4) | -- | 290 | -- | ns |
| Qrr | Reverse Recovery Charge | | -- | 1.8 | -- | μC |

**Notes ;**

1. Repetitive Rating : Pulse width limited by maximum junction temperature
2. $I_{AS}$=4.2A, $V_{DD}$=50V, $R_G$=25Ω, Starting $T_J$=25°C
3. $I_{SD}$≤4.2A, di/dt≤300A/μs, $V_{DD}$≤$BV_{DSS}$ , Starting $T_J$=25 °C
4. Pulse Test : Pulse Width ≤ 300μs, Duty Cycle ≤ 2%
5. Essentially Independent of Operating Temperature

## Typical Characteristics

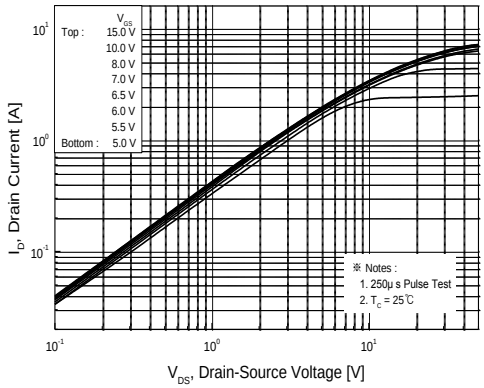



**Figure 1. On Region Characteristics**

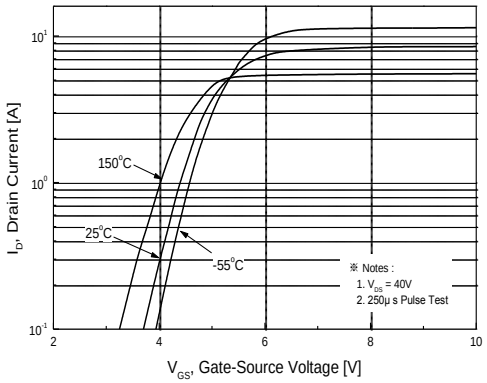



**Figure 2. Transfer Characteristics**

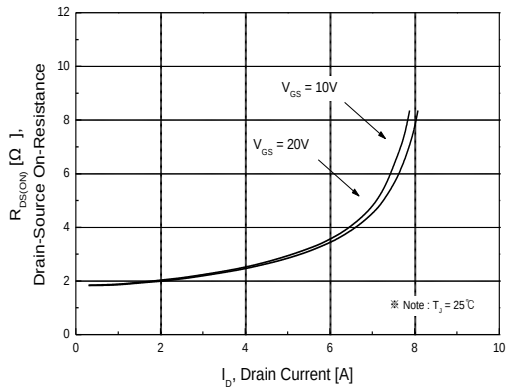



**Figure 3. On Resistance Variation vs Drain Current and Gate Voltage**

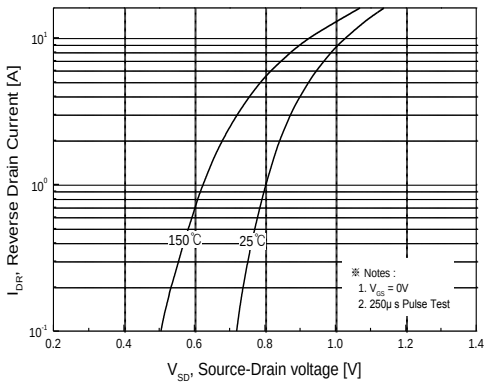



**Figure 4. Body Diode Forward Voltage Variation with Source Current and Temperature**

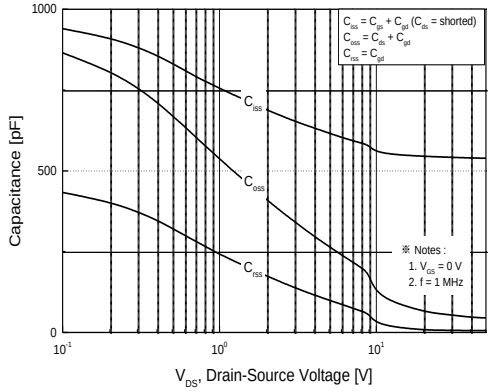



**Figure 5. Capacitance Characteristics**

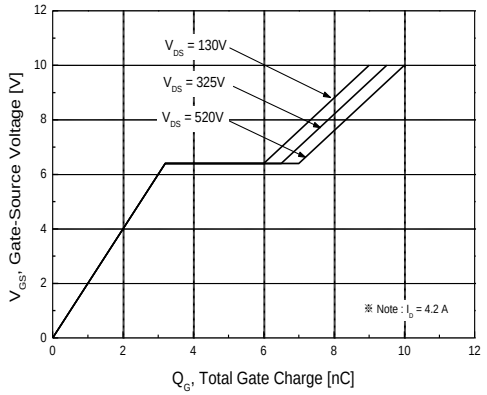



**Figure 6. Gate Charge Characteristics**

## Typical Characteristics (continued)

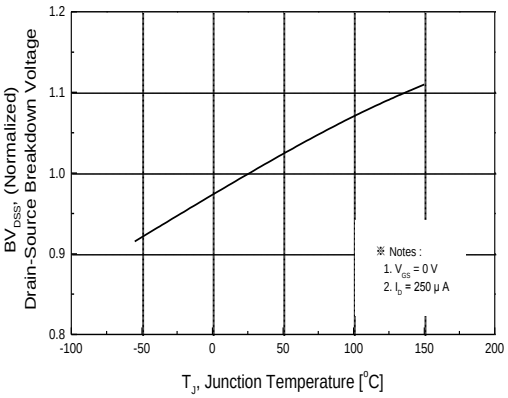



**Figure 7. Breakdown Voltage Variation vs Temperature**

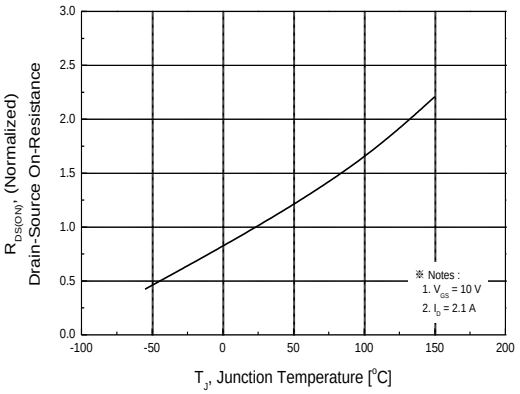



**Figure 8. On-Resistance Variation vs Temperature**

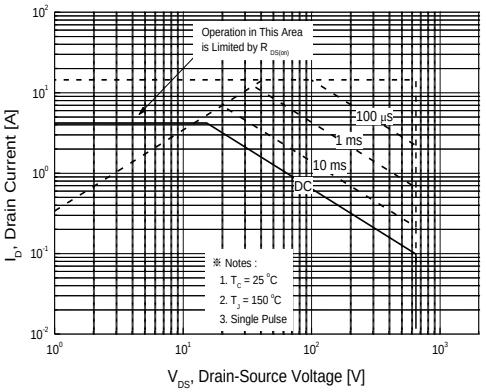



**Figure 9. Maximum Safe Operating Area**

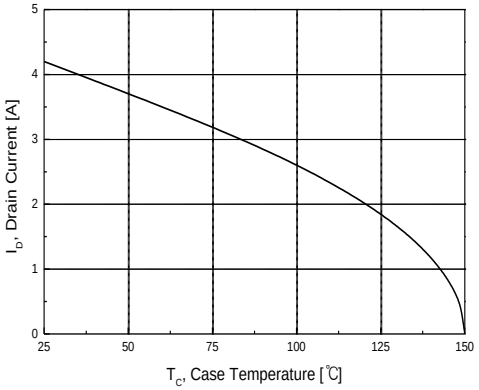



**Figure 10. Maximum Drain Current vs Case Temperature**

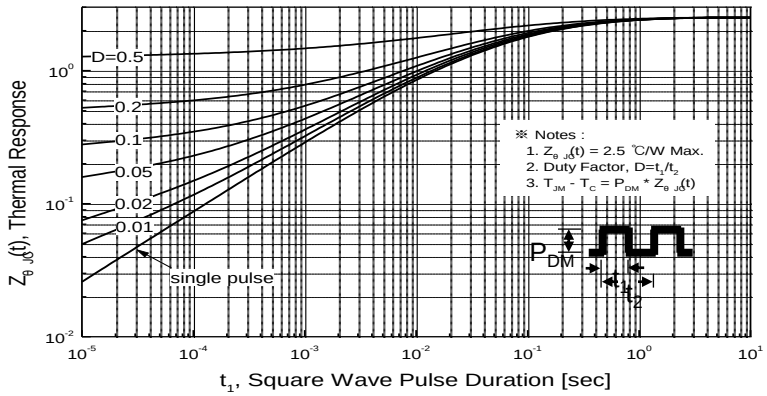



**Figure 11. Transient Thermal Response Curve**

## Characteristics Test Circuit & Waveform

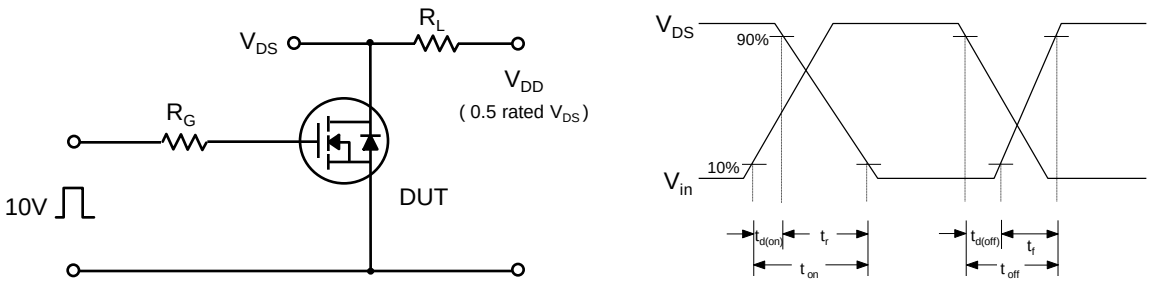



**Fig 14. Resistive Switching Test Circuit & Waveforms**

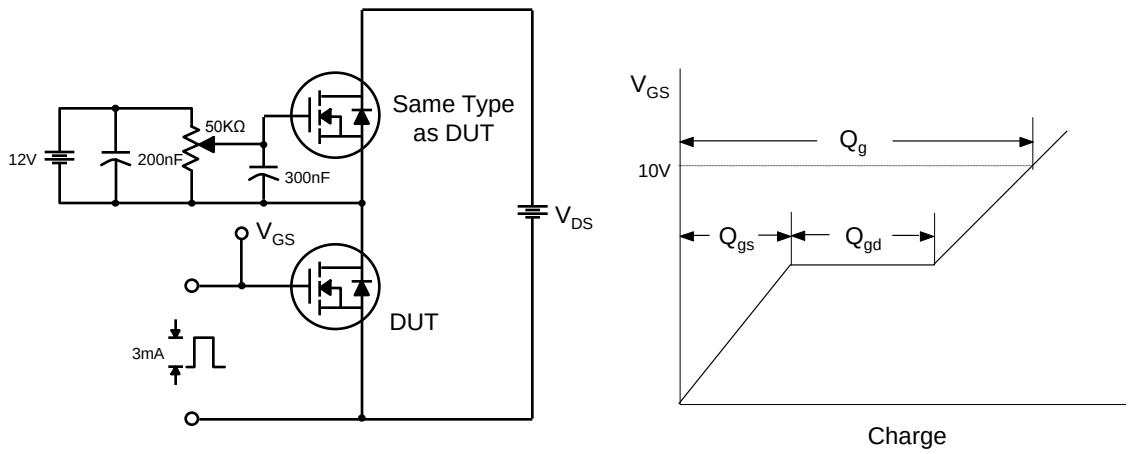



**Fig 15. Gate Charge Test Circuit & Waveform**

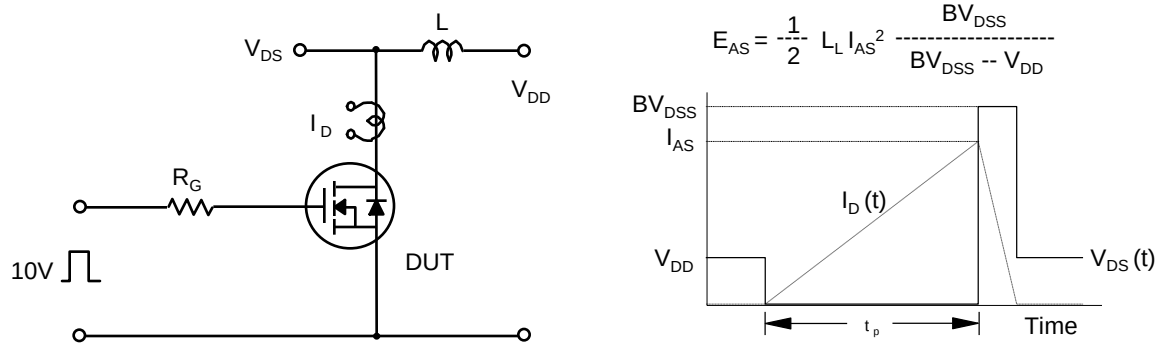
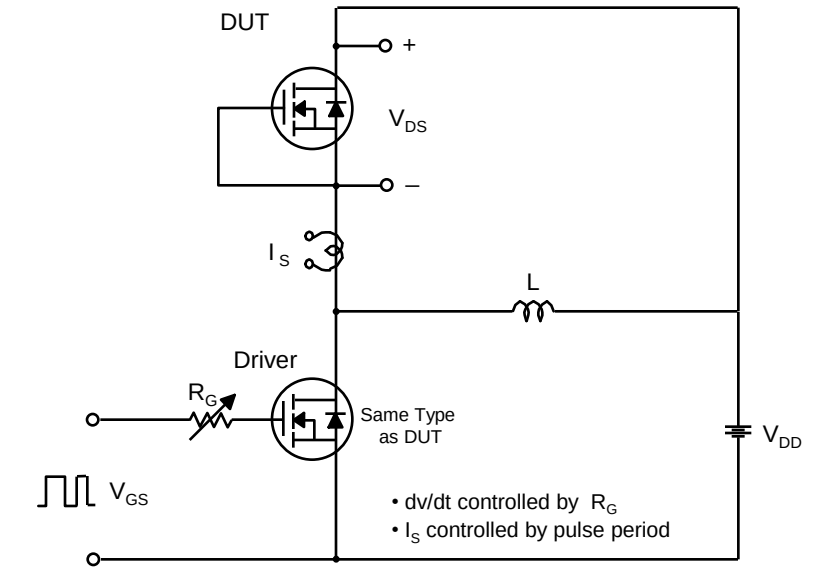



**Fig 16. Unclamped Inductive Switching Test Circuit & Waveforms**

## Characteristics Test Circuit & Waveform (continued)



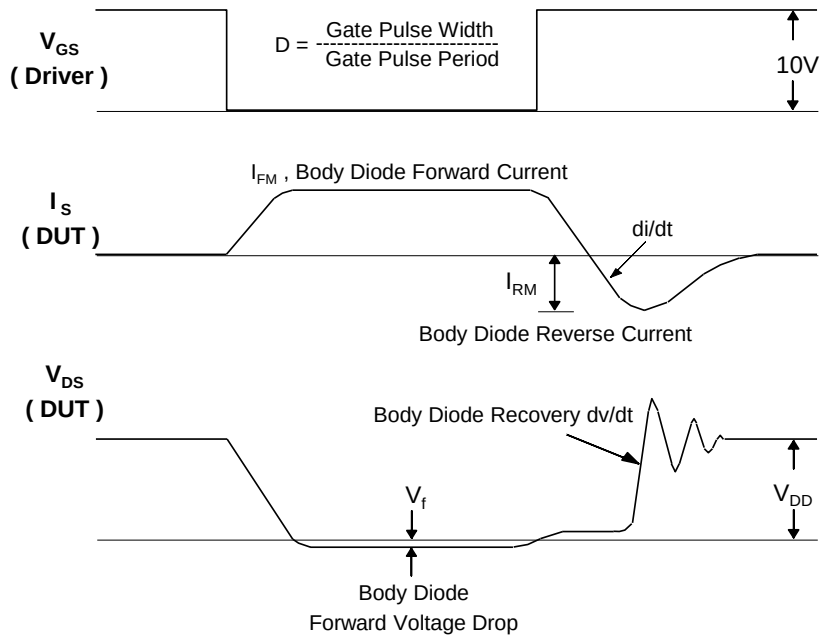
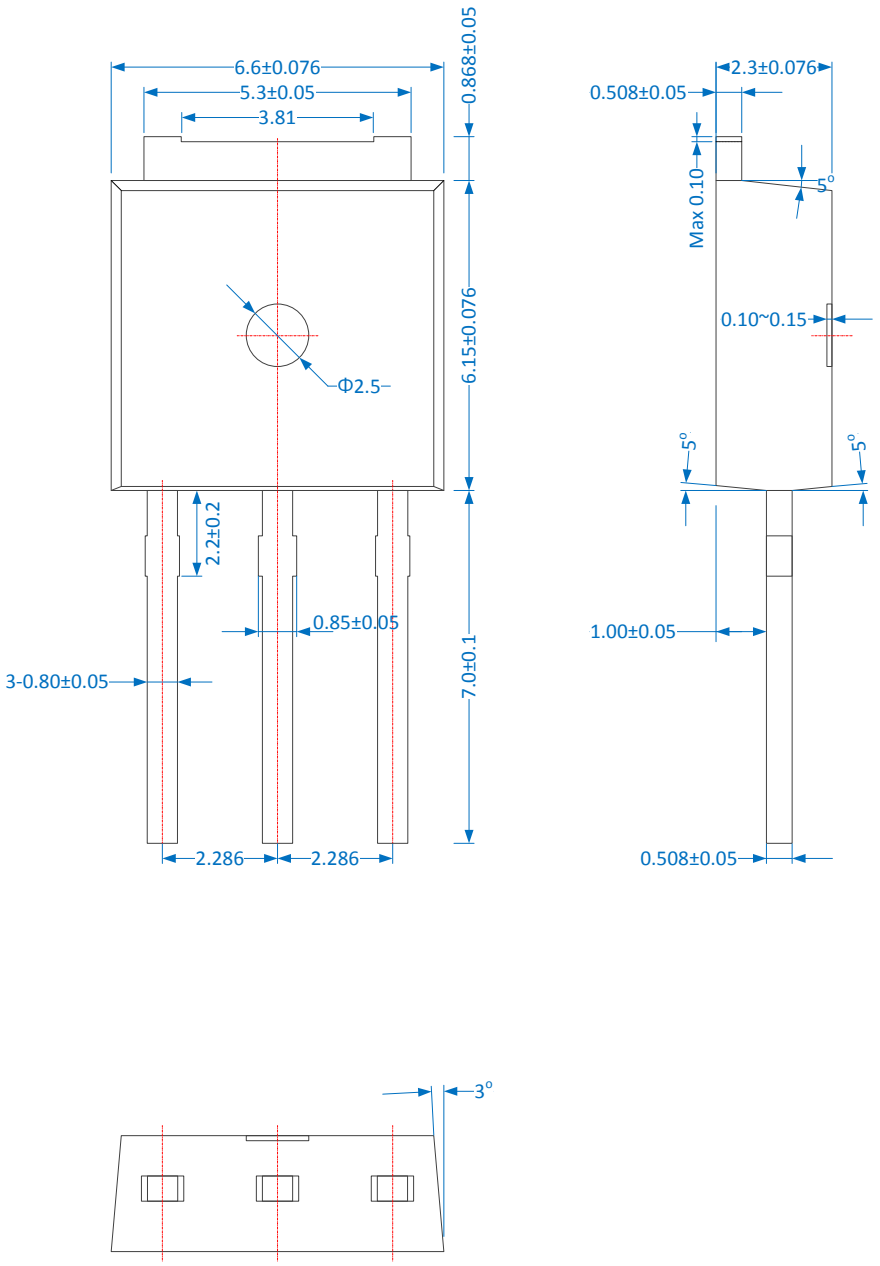




**Fig 17. Peak Diode Recovery dv/dt Test Circuit & Waveforms**

## Package Dimension

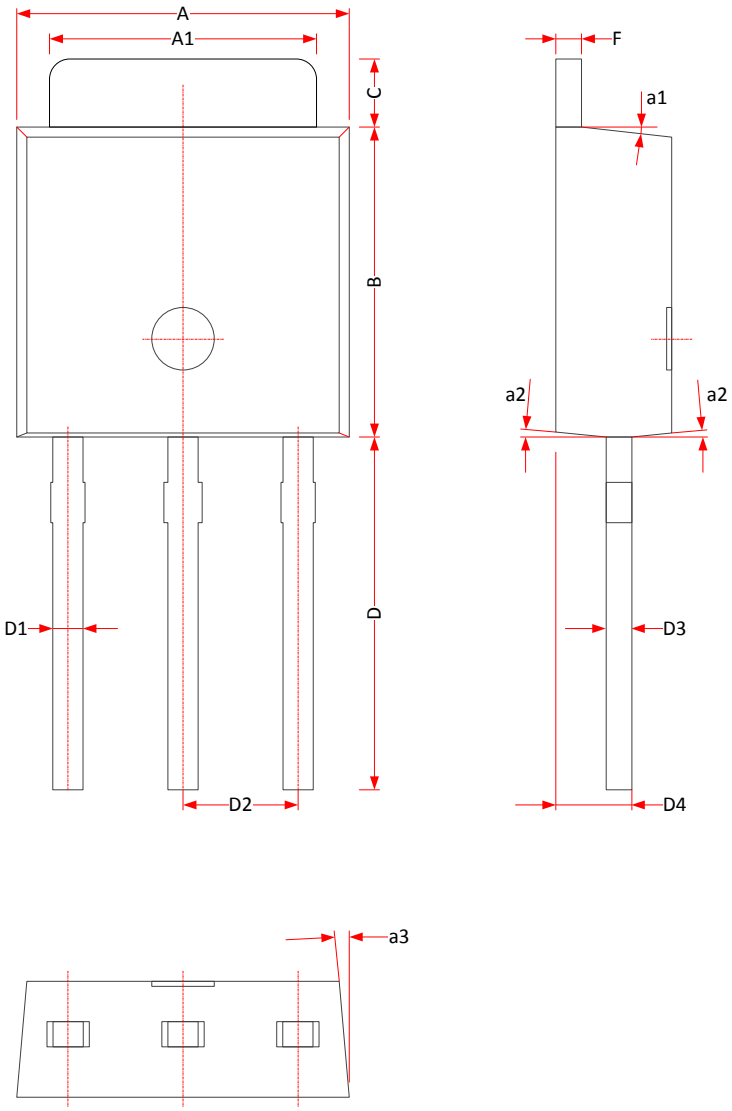
# I-PAK(TO-251) ⓩ



## Package Dimension

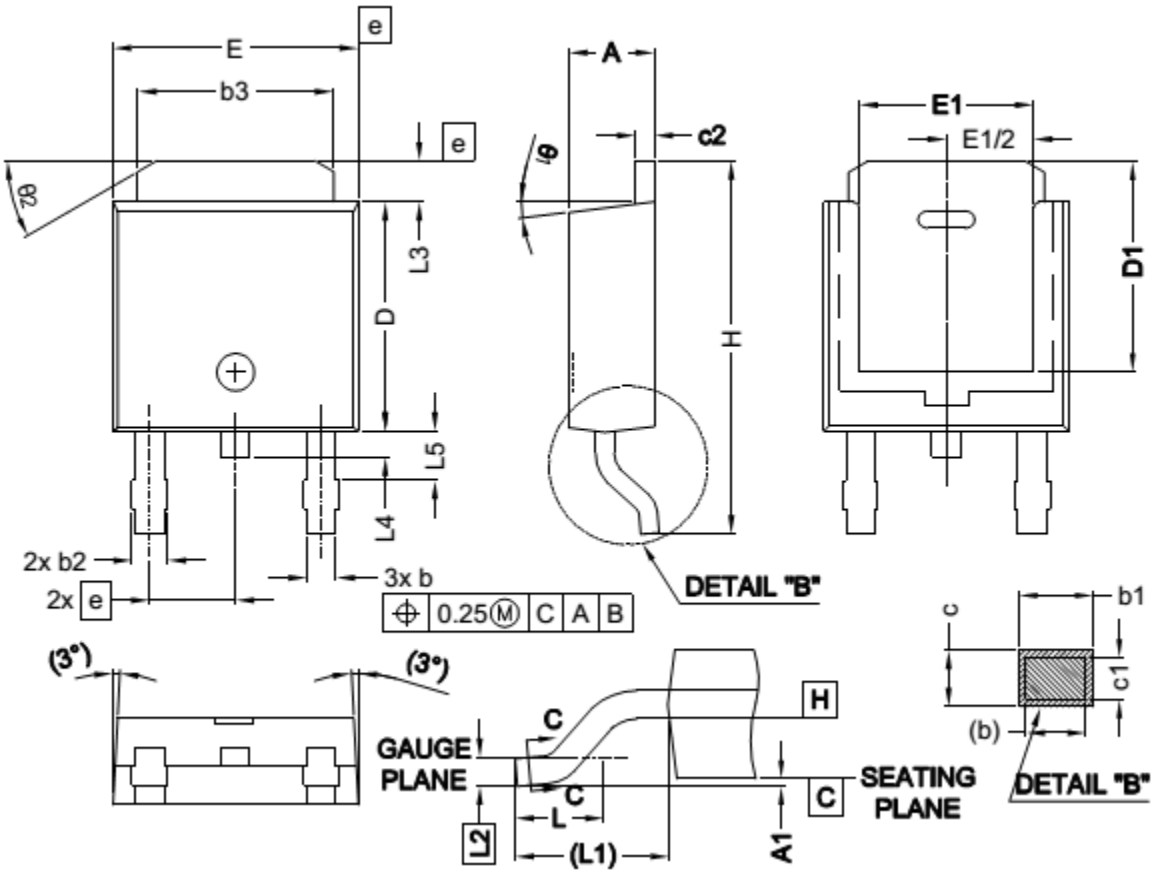
# I-PAK(TO-251) ⓗ

| Symbol | Millimeters |
|---|---|
| A | 6.40 ~ 6.60 |
| A1 | 5.30 ~ 5.50 |
| B | 5.40 ~ 5.70 |
| C | 1.35 ~ 1.65 |
| D | 7.40 ~ 8.00 |
| D1 | 0.60 ~ 0.75 |
| D2 | 2.30 |
| D3 | 0.49 ~ 0.59 |
| D4 | 1.72 ~ 1.82 |
| E | 2.20 ~ 2.40 |
| F | 0.55 ~ 0.65 |
| a1 | 5 deg |
| a2 | 5 deg |
| a3 | 2 deg |



## Package Dimension

# D-PAK(TO-252) ⓐ




| SYMBOL | MIN. | MAX. | SYMBOL | MIN. | MAX. | SYMBOL | MIN. | MAX. |
|---|---|---|---|---|---|---|---|---|
| A | 2.18 | 2.39 | E | 6.35 | 6.73 | ϕ1 | 0° | 15° |
| A1 | - | 0.13 | E1 | 4.32 | - | ϕ2 | 25° | 35° |
| b | 0.640 | 0.884 | e | 2.29 BSC | | | | |
| b1 | 0.65 | 0.79 | H | 9.94 | 10.34 | | | |
| b2 | 0.760 | 1.124 | L | 1.50 | 1.78 | | | |
| b3 | 4.95 | 5.46 | L1 | 2.74 REF | | | | |
| c | 0.46 | 0.61 | L2 | 0.51 BSC | | | | |
| c1 | 0.41 | 0.56 | L3 | 0.89 | 1.27 | | | |
| c2 | 0.40 | 0.60 | L4 | - | 1.02 | | | |
| D | 5.97 | 6.22 | L5 | 1.140 | 1.492 | | | |
| D1 | 5.21 | - | ϕ | 0° | 10° | | | |

## Package Dimension

# D-PAK(TO-252) ⓩ