

## N-Channel 650 V (D-S) MOSFET

| PRODUCT SUMMARY                         |                 |      |
|-----------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |      |
| $R_{DS(on)}$ max. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.36 |
| $Q_g$ max. (nC)                         | 106             |      |
| $Q_{gs}$ (nC)                           | 14              |      |
| $Q_{gd}$ (nC)                           | 33              |      |
| Configuration                           | Single          |      |

### FEATURES

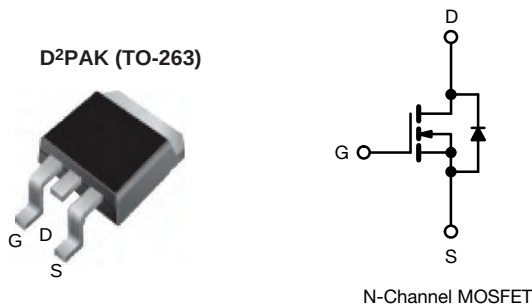
- Reduced  $t_{rr}$ ,  $Q_{rr}$ , and  $I_{RRM}$
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Low switching losses due to reduced  $Q_{rr}$
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)

### APPLICATIONS

- Telecommunications
  - Server and telecom power supplies
- Lighting
  - High-intensity discharge (HID)
  - Fluorescent ballast lighting
- Consumer and computing
  - ATX power supplies
- Industrial
  - Welding
  - Battery chargers
- Renewable energy
  - Solar (PV inverters)
- Switch mode power supplies (SMPS)



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| ABSOLUTE MAXIMUM RATINGS (T <sub>C</sub> = 25 °C, unless otherwise noted) |                         |                         |                                   |             |      |
|---------------------------------------------------------------------------|-------------------------|-------------------------|-----------------------------------|-------------|------|
| PARAMETER                                                                 |                         |                         | SYMBOL                            | LIMIT       | UNIT |
| Drain-Source Voltage                                                      |                         |                         | V <sub>DS</sub>                   | 650         | V    |
| Gate-Source Voltage                                                       |                         |                         | V <sub>GS</sub>                   | ± 30        |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C)                        | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 18          | A    |
|                                                                           |                         | T <sub>C</sub> = 100 °C |                                   | 16          |      |
| Pulsed Drain Current <sup>a</sup>                                         |                         |                         | I <sub>DM</sub>                   | 53          |      |
| Linear Derating Factor                                                    |                         |                         |                                   | 1.7         | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>                                |                         |                         | E <sub>AS</sub>                   | 367         | mJ   |
| Maximum Power Dissipation                                                 |                         |                         | P <sub>D</sub>                    | 208         | W    |
| Operating Junction and Storage Temperature Range                          |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | -55 to +150 | °C   |
| Drain-Source Voltage Slope                                                | T <sub>J</sub> = 125 °C |                         | dV/dt                             | 37          | V/ns |
| Reverse Diode dV/dt <sup>d</sup>                                          |                         | 31                      |                                   |             |      |
| Soldering Recommendations (Peak Temperature) <sup>c</sup>                 | for 10 s                |                         |                                   | 300         | °C   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DD} = 50$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 5.1$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ ,  $dI/dt = 100$  A/ $\mu$ s, starting  $T_J = 25$  °C.

**THERMAL RESISTANCE RATINGS**

| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.5  |      |

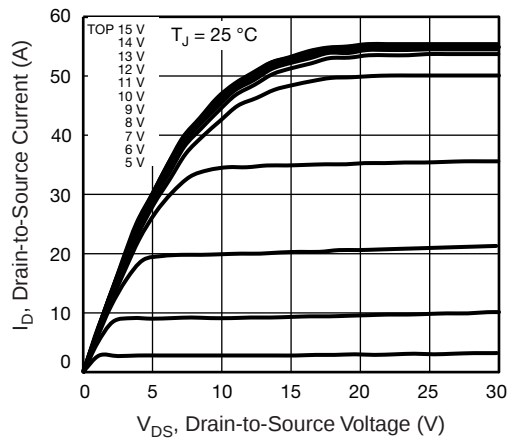
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

| PARAMETER                                                 | SYMBOL              | TEST CONDITIONS                                                                                                                                          |                                               | MIN. | TYP. | MAX.      | UNIT                  |
|-----------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|------|-----------|-----------------------|
| Static                                                    |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Drain-Source Breakdown Voltage                            | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                   |                                               | 650  | -    | -         | V                     |
| $V_{DS}$ Temperature Coefficient                          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^{\circ}\text{C}$ , $I_D = 1\text{ mA}$                                                                                          |                                               | -    | 0.67 | -         | V/ $^{\circ}\text{C}$ |
| Gate-Source Threshold Voltage (N)                         | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                       |                                               | 2    | -    | 4         | V                     |
| Gate-Source Leakage                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                               |                                               | -    | -    | $\pm 100$ | nA                    |
|                                                           |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                               |                                               | -    | -    | $\pm 1$   | $\mu\text{A}$         |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                          |                                               | -    | -    | 1         | $\mu\text{A}$         |
|                                                           |                     | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$                                                                    |                                               | -    | -    | 500       |                       |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 11\text{ A}$                           | -    | -    | 0.36      | $\Omega$              |
| Forward Transconductance                                  | $g_{fs}$            | $V_{DS} = 30\text{ V}$ , $I_D = 11\text{ A}$                                                                                                             |                                               | -    | 7.0  | -         | S                     |
| Dynamic                                                   |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Input Capacitance                                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$                                                                               |                                               | -    | 2322 | -         | pF                    |
| Output Capacitance                                        | $C_{oss}$           |                                                                                                                                                          |                                               | -    | 105  | -         |                       |
| Reverse Transfer Capacitance                              | $C_{rss}$           |                                                                                                                                                          |                                               | -    | 4    | -         |                       |
| Effective Output Capacitance, Energy Related <sup>a</sup> | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 520\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                           |                                               | -    | 84   | -         |                       |
| Effective Output Capacitance, Time Related <sup>b</sup>   | $C_{o(tr)}$         |                                                                                                                                                          |                                               | -    | 293  | -         |                       |
| Total Gate Charge                                         | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 11\text{ A}$ , $V_{DS} = 520\text{ V}$ | -    | 71   | 106       | nC                    |
| Gate-Source Charge                                        | $Q_{gs}$            |                                                                                                                                                          |                                               | -    | 14   | -         |                       |
| Gate-Drain Charge                                         | $Q_{gd}$            |                                                                                                                                                          |                                               | -    | 33   | -         |                       |
| Turn-On Delay Time                                        | $t_{d(on)}$         | $V_{DD} = 520\text{ V}$ , $I_D = 11\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ , $R_g = 9.1\text{ }\Omega$                                                    |                                               | -    | 22   | 44        | ns                    |
| Rise Time                                                 | $t_r$               |                                                                                                                                                          |                                               | -    | 34   | 68        |                       |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |                                                                                                                                                          |                                               | -    | 68   | 102       |                       |
| Fall Time                                                 | $t_f$               |                                                                                                                                                          |                                               | -    | 42   | 84        |                       |
| Gate Input Resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                          |                                               | -    | 0.78 | -         | $\Omega$              |
| Drain-Source Body Diode Characteristics                   |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Continuous Source-Drain Diode Current                     | $I_S$               | MOSFET symbol showing the integral reverse<br>p - n junction diode  |                                               | -    | -    | 21        | A                     |
| Pulsed Diode Forward Current                              | $I_{SM}$            |                                                                                                                                                          |                                               | -    | -    | 53        |                       |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 11\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                         |                                               | -    | 0.9  | 1.2       | V                     |
| Reverse Recovery Time                                     | $t_{rr}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = I_S = 11\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 25\text{ V}$                             |                                               | -    | 160  | -         | ns                    |
| Reverse Recovery Charge                                   | $Q_{rr}$            |                                                                                                                                                          |                                               | -    | 1.2  | -         | $\mu\text{C}$         |
| Reverse Recovery Current                                  | $I_{RRM}$           |                                                                                                                                                          |                                               | -    | 14   | -         | A                     |

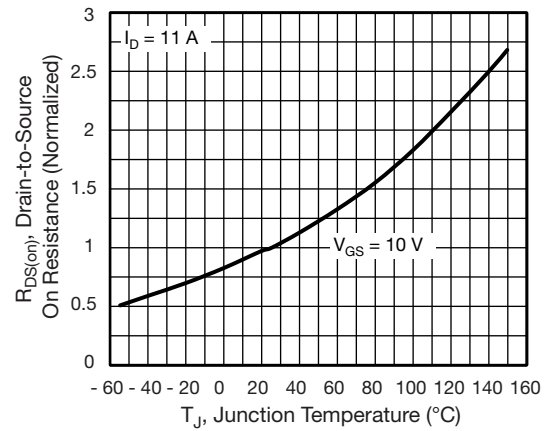
**Notes**

- a.  $C_{oss(er)}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .  
 b.  $C_{oss(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .

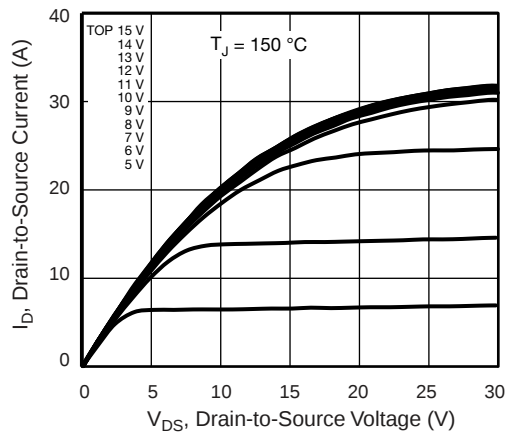
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



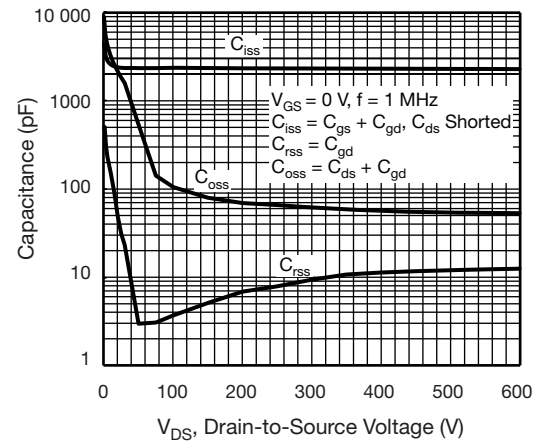
**Fig. 1 - Typical Output Characteristics**



**Fig. 4 - Normalized On-Resistance vs. Temperature**



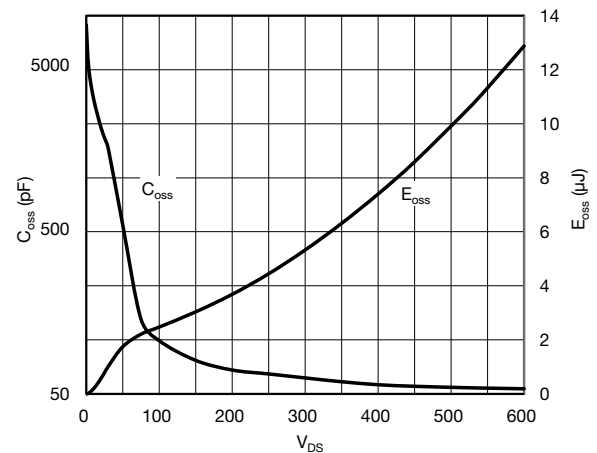
**Fig. 2 - Typical Output Characteristics**



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



**Fig. 3 - Typical Transfer Characteristics**



**Fig. 6 -  $C_{oss}$  and  $E_{oss}$  vs.  $V_{DS}$**

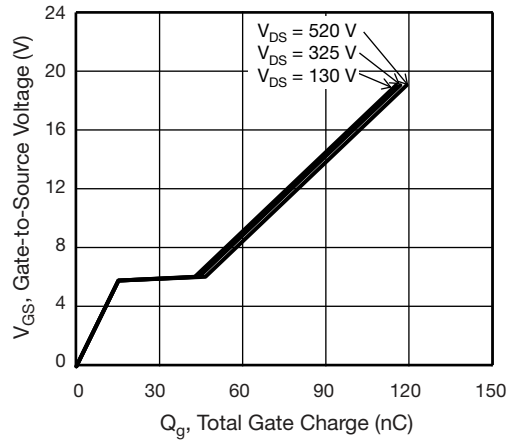


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

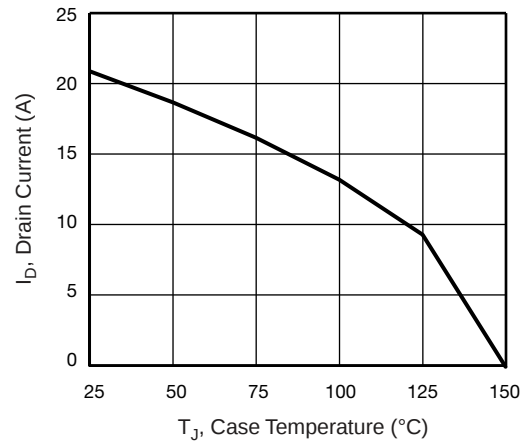


Fig. 10 - Maximum Drain Current vs. Case Temperature

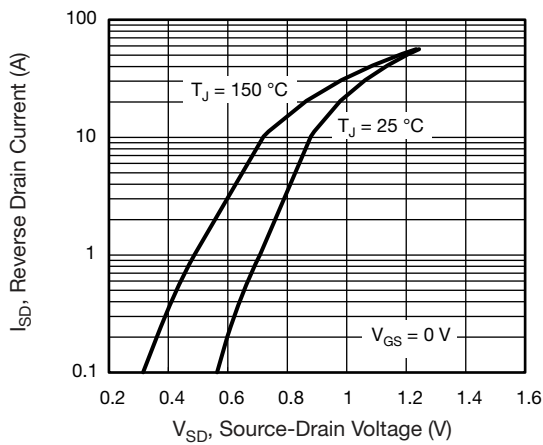


Fig. 8 - Typical Source-Drain Diode Forward Voltage

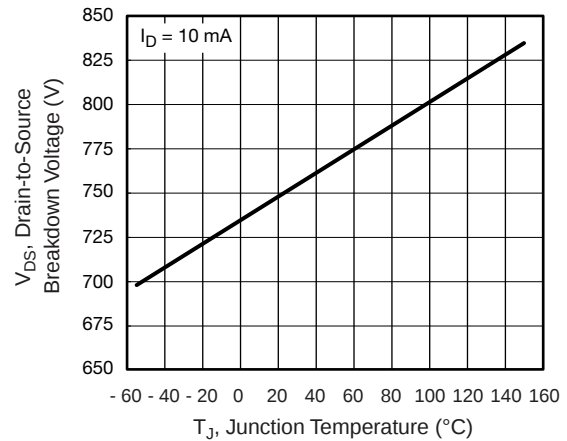


Fig. 11 - Temperature vs. Drain-to-Source Voltage

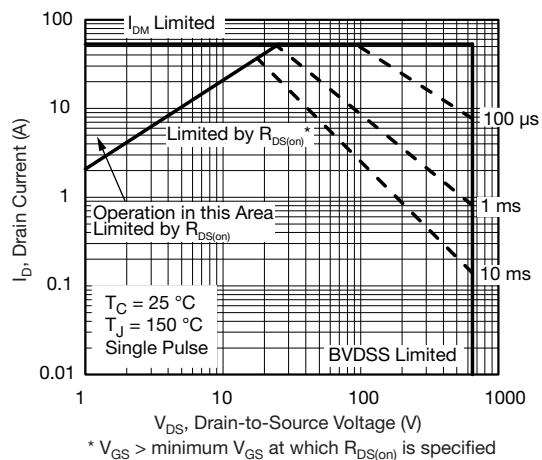


Fig. 9 - Maximum Safe Operating Area

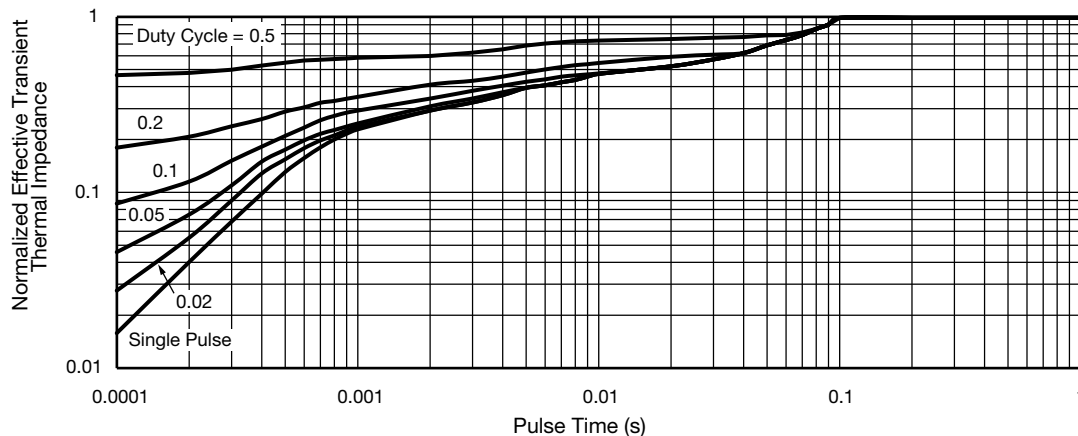


Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case



Fig. 13 - Switching Time Test Circuit

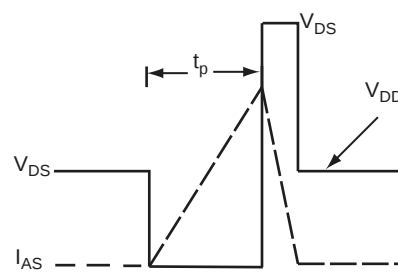


Fig. 16 - Unclamped Inductive Waveforms

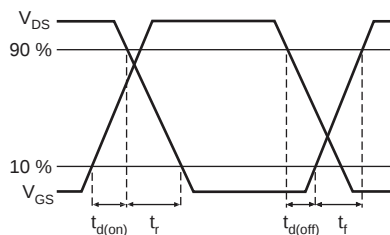


Fig. 14 - Switching Time Waveforms

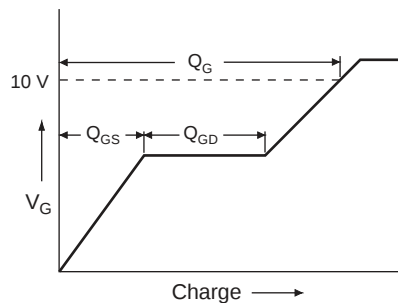


Fig. 17 - Basic Gate Charge Waveform

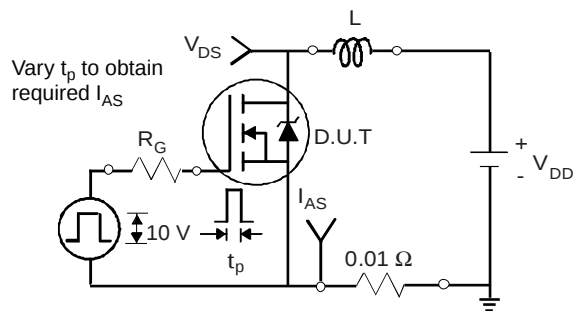


Fig. 15 - Unclamped Inductive Test Circuit

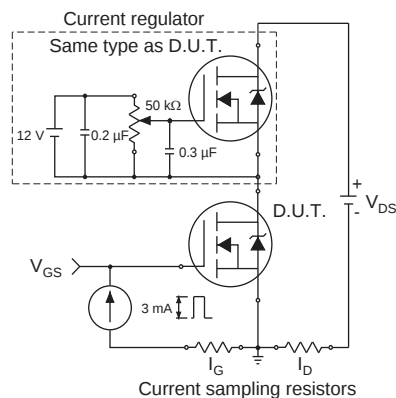
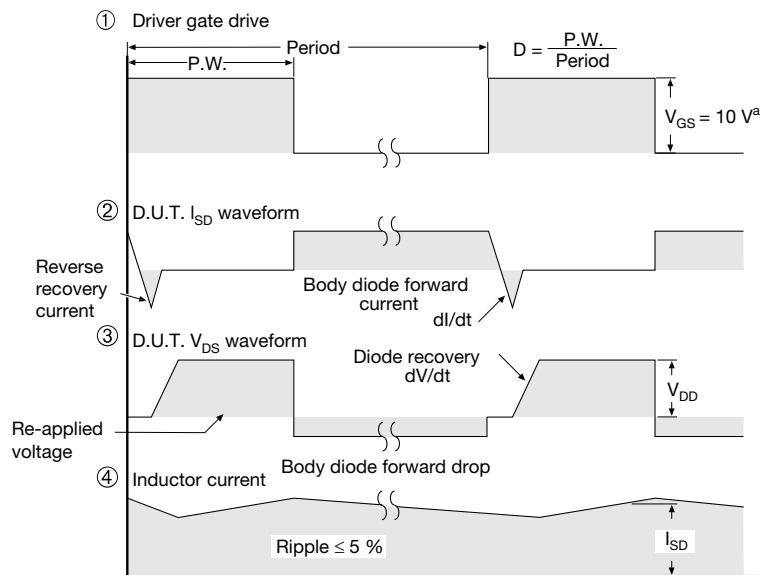
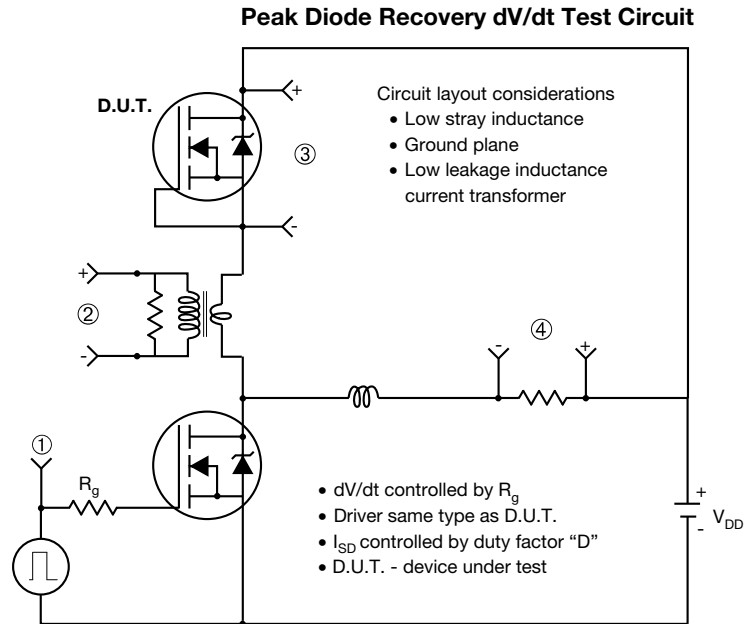


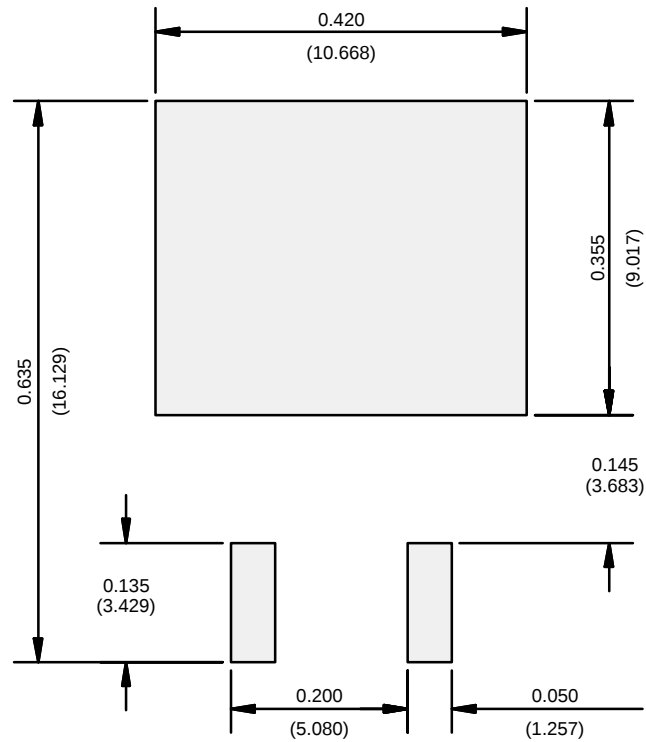
Fig. 18 - Gate Charge Test Circuit



**Note**

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

**Fig. 19 - For N-Channel**

**RECOMMENDED MINIMUM PADS FOR D<sup>2</sup>PAK: 3-Lead**

Recommended Minimum Pads  
Dimensions in Inches/(mm)

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