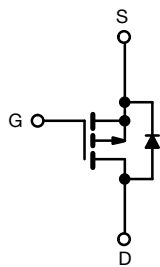


# Power MOSFET

**TO-220AB**


P-Channel MOSFET

## FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- P-channel
- 175 °C operating temperature
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS\***  
Available

## Note

\* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

## DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

## PRODUCT SUMMARY

|                          |                         |      |
|--------------------------|-------------------------|------|
| V <sub>DS</sub> (V)      | -60                     |      |
| R <sub>DS(on)</sub> (Ω)  | V <sub>GS</sub> = -10 V | 0.28 |
| Q <sub>g</sub> max. (nC) | 19                      |      |
| Q <sub>gs</sub> (nC)     | 5.4                     |      |
| Q <sub>gd</sub> (nC)     | 11                      |      |
| Configuration            | Single                  |      |

## ORDERING INFORMATION

|                                 |                |
|---------------------------------|----------------|
| Package                         | TO-220AB       |
| Lead (Pb)-free                  | IRF9Z24PbF     |
| Lead (Pb)-free and halogen-free | IRF9Z24PbF-BE3 |

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25 °C, unless otherwise noted)

| PARAMETER                                                 | SYMBOL                            | LIMIT                   | UNIT     |
|-----------------------------------------------------------|-----------------------------------|-------------------------|----------|
| Drain-source voltage                                      | V <sub>DS</sub>                   | -60                     | 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  | A        |
|                                                           |                                   | T <sub>C</sub> = 100 °C |          |
| Pulsed drain current <sup>a</sup>                         | I <sub>DM</sub>                   | -44                     |          |
| Linear derating factor                                    |                                   | 0.40                    | W/°C     |
| Single pulse avalanche energy <sup>b</sup>                | E <sub>AS</sub>                   | 240                     | mJ       |
| Repetitive avalanche current <sup>a</sup>                 | I <sub>AR</sub>                   | -11                     | A        |
| Repetitive avalanche energy <sup>a</sup>                  | E <sub>AR</sub>                   | 6.0                     | mJ       |
| Maximum power dissipation                                 | P <sub>D</sub>                    | 60                      | W        |
| Peak diode recovery dV/dt <sup>c</sup>                    | dV/dt                             | -4.5                    | V/ns     |
| Operating junction and storage temperature range          | T <sub>J</sub> , T <sub>stg</sub> | -55 to +175             | °C       |
| Soldering recommendations (peak temperature) <sup>d</sup> | For 10 s                          | 300                     |          |
| Mounting torque                                           | 6-32 or M3 screw                  | 10                      | lbf · in |
|                                                           |                                   | 1.1                     | N · m    |

## Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- V<sub>DD</sub> = -25 V, starting T<sub>J</sub> = 25 °C, L = 2.3 mH, R<sub>g</sub> = 25 Ω, I<sub>AS</sub> = -11 A (see fig. 12)
- I<sub>SD</sub> ≤ -11 A, di/dt ≤ 140 A/μs, V<sub>DD</sub> ≤ V<sub>DS</sub>, T<sub>J</sub> ≤ 175 °C
- 1.6 mm from case

**THERMAL RESISTANCE RATINGS**

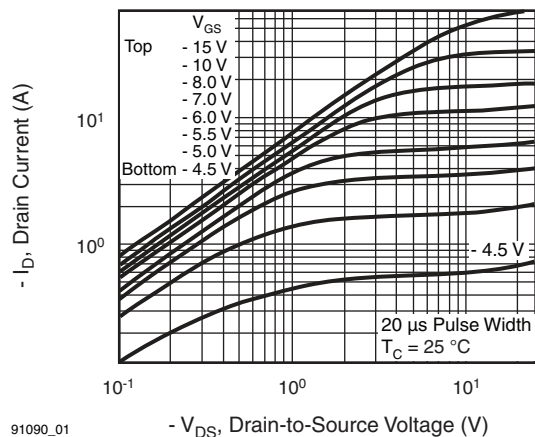
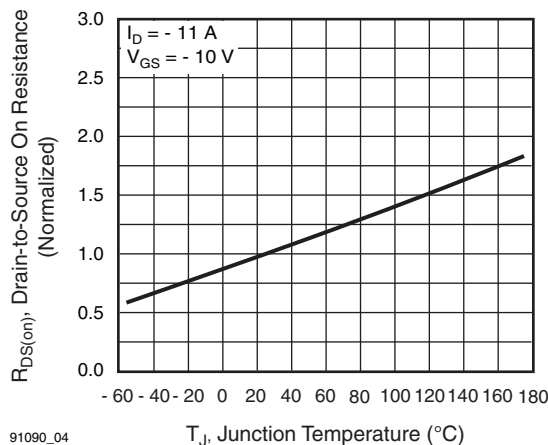
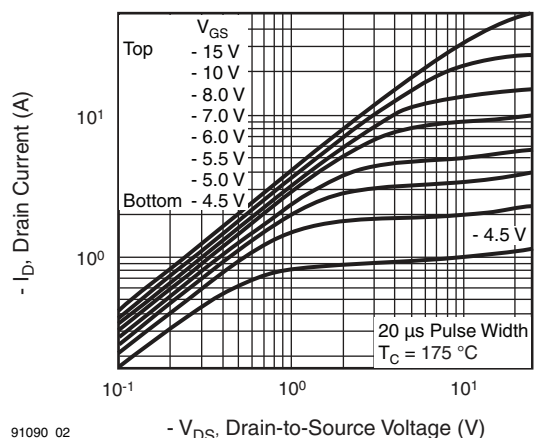
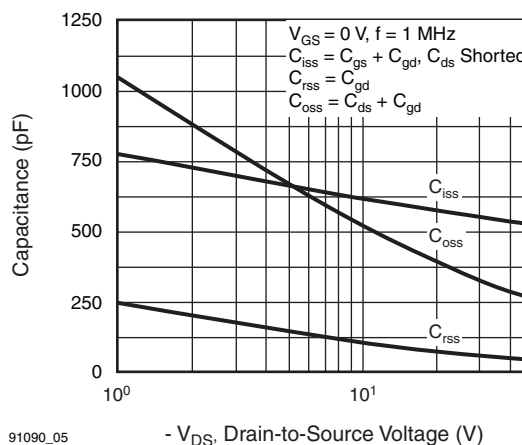
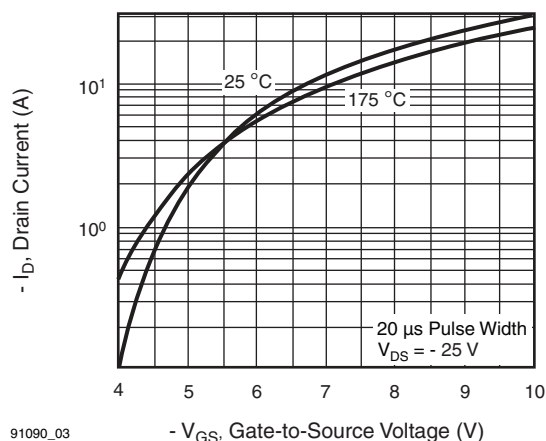
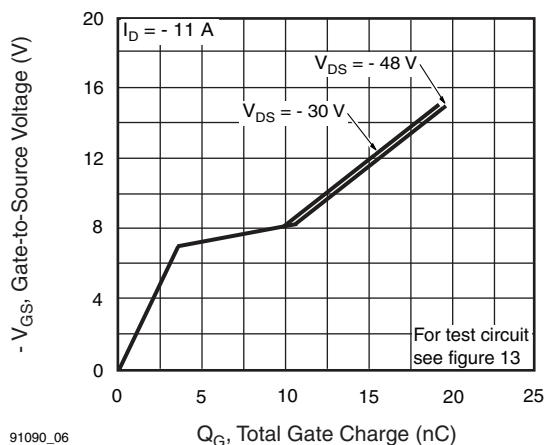
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
|-------------------------------------|------------|------|------|------|
| Maximum junction-to-ambient         | $R_{thJA}$ | -    | 62   | °C/W |
| Case-to-sink, flat, greased surface | $R_{thCS}$ | 0.50 | -    |      |
| Maximum junction-to-case (drain)    | $R_{thJC}$ | -    | 2.5  |      |

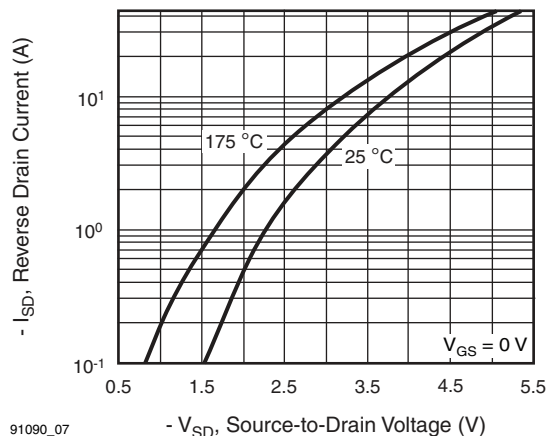
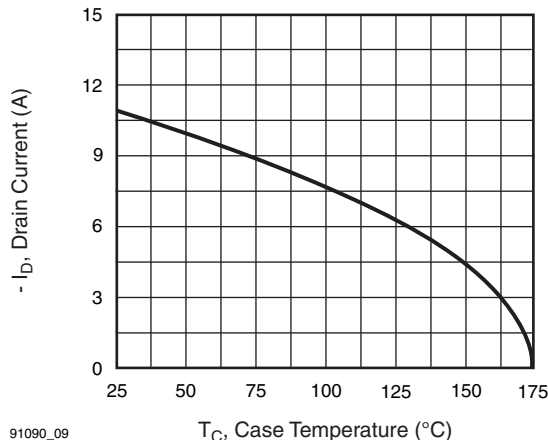
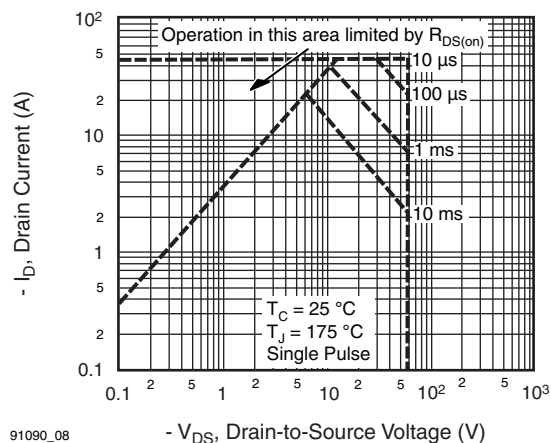
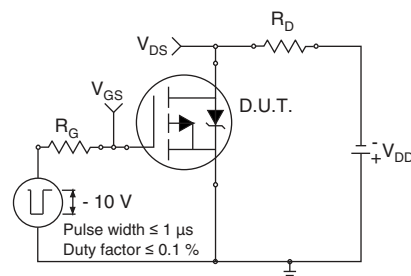
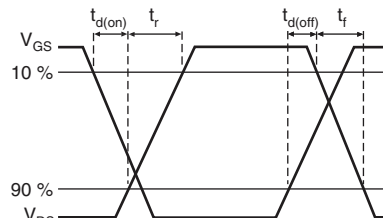
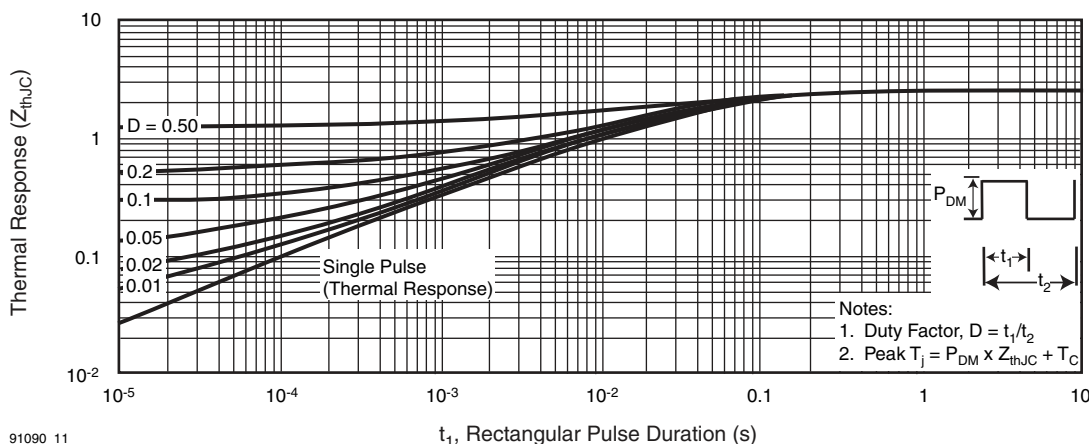
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

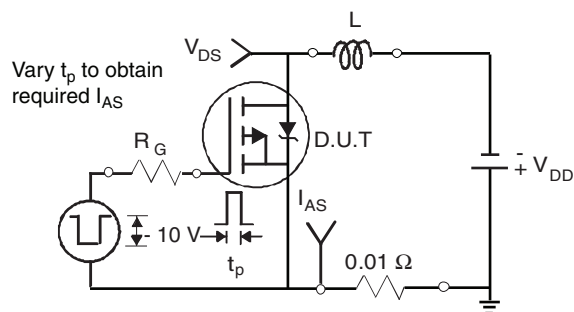
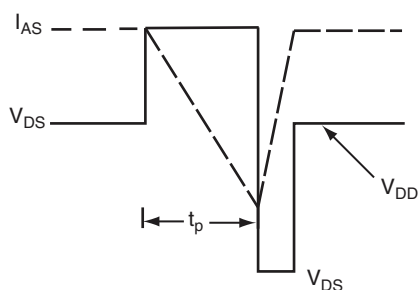
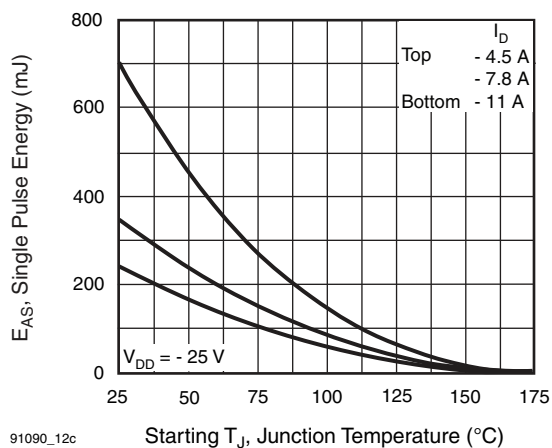
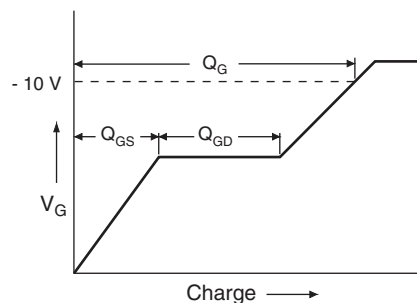
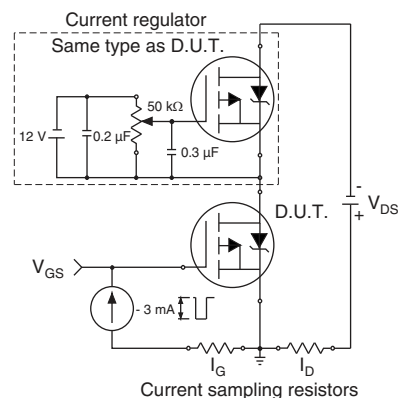
| PARAMETER                                 | SYMBOL              | TEST CONDITIONS                                                                                                                                                  |                                                                                    | MIN. | TYP.   | MAX.      | UNIT                |
|-------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------|--------|-----------|---------------------|
| Static                                    |                     |                                                                                                                                                                  |                                                                                    |      |        |           |                     |
| Drain-source breakdown voltage            | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = -250\text{ }\mu\text{A}$                                                                                                          |                                                                                    | -60  | -      | -         | V                   |
| $V_{DS}$ temperature coefficient          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = -1\text{ mA}$                                                                                                   |                                                                                    | -    | -0.056 | -         | V/ $^\circ\text{C}$ |
| Gate-source threshold voltage             | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = -250\text{ }\mu\text{A}$                                                                                                              |                                                                                    | -2.0 | -      | -4.0      | V                   |
| Gate-source leakage                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                                       |                                                                                    | -    | -      | $\pm 100$ | nA                  |
| Zero gate voltage drain current           | $I_{DSS}$           | $V_{DS} = -60\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                                  |                                                                                    | -    | -      | -100      | $\mu\text{A}$       |
|                                           |                     | $V_{DS} = -48\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$                                                                              |                                                                                    | -    | -      | -500      |                     |
| Drain-source on-state resistance          | $R_{DS(on)}$        | $V_{GS} = -10\text{ V}$                                                                                                                                          | $I_D = -6.6\text{ A}^b$                                                            | -    | -      | 0.28      | $\Omega$            |
| Forward transconductance                  | $g_{fs}$            | $V_{DS} = -25\text{ V}$ , $I_D = -6.6\text{ A}^b$                                                                                                                |                                                                                    | 1.4  | -      | -         | S                   |
| Dynamic                                   |                     |                                                                                                                                                                  |                                                                                    |      |        |           |                     |
| Input capacitance                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = -25\text{ V}$ ,<br>$f = 1.0\text{ MHz}$ , see fig. 5                                                                        |                                                                                    | -    | 570    | -         | pF                  |
| Output capacitance                        | $C_{oss}$           |                                                                                                                                                                  |                                                                                    | -    | 360    | -         |                     |
| Reverse transfer capacitance              | $C_{rss}$           |                                                                                                                                                                  |                                                                                    | -    | 65     | -         |                     |
| Total gate charge                         | $Q_g$               | $V_{GS} = -10\text{ V}$                                                                                                                                          | $I_D = -11\text{ A}$ , $V_{DS} = -48\text{ V}$ ,<br>see fig. 6 and 13 <sup>b</sup> | -    | -      | 19        | nC                  |
| Gate-source charge                        | $Q_{gs}$            |                                                                                                                                                                  |                                                                                    | -    | -      | 5.4       |                     |
| Gate-drain charge                         | $Q_{gd}$            |                                                                                                                                                                  |                                                                                    | -    | -      | 11        |                     |
| Turn-on delay time                        | $t_{d(on)}$         | $V_{DD} = -30\text{ V}$ , $I_D = -11\text{ A}$ ,<br>$R_g = 18\text{ }\Omega$ , $R_D = 2.5\text{ }\Omega$ , see fig. 10 <sup>b</sup>                              |                                                                                    | -    | 13     | -         | ns                  |
| Rise time                                 | $t_r$               |                                                                                                                                                                  |                                                                                    | -    | 68     | -         |                     |
| Turn-off delay time                       | $t_{d(off)}$        |                                                                                                                                                                  |                                                                                    | -    | 15     | -         |                     |
| Fall time                                 | $t_f$               |                                                                                                                                                                  |                                                                                    | -    | 29     | -         |                     |
| Gate input resistance                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                                  |                                                                                    | 0.5  | -      | 3.5       | $\Omega$            |
| Internal drain inductance                 | $L_D$               | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact  |                                                                                    | -    | 4.5    | -         | nH                  |
| Internal source inductance                | $L_S$               |                                                                                                                                                                  |                                                                                    | -    | 7.5    | -         |                     |
| Drain-Source Body Diode Characteristics   |                     |                                                                                                                                                                  |                                                                                    |      |        |           |                     |
| Continuous source-drain diode current     | $I_S$               | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode    |                                                                                    | -    | -      | -11       | A                   |
| Pulsed diode forward current <sup>a</sup> | $I_{SM}$            |                                                                                                                                                                  |                                                                                    | -    | -      | -44       |                     |
| Body diode voltage                        | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_S = -11\text{ A}$ , $V_{GS} = 0\text{ V}^b$                                                                                |                                                                                    | -    | -      | -6.3      | V                   |
| Body diode reverse recovery time          | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_F = -11\text{ A}$ , $dI/dt = 100\text{ A}/\mu\text{s}^b$                                                                   |                                                                                    | -    | 100    | 200       | ns                  |
| Body diode reverse recovery charge        | $Q_{rr}$            |                                                                                                                                                                  |                                                                                    | -    | 0.32   | 0.64      | $\mu\text{C}$       |
| Forward turn-on time                      | $t_{on}$            | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$ )                                                                                  |                                                                                    |      |        |           |                     |

**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  $\leq 2\%$

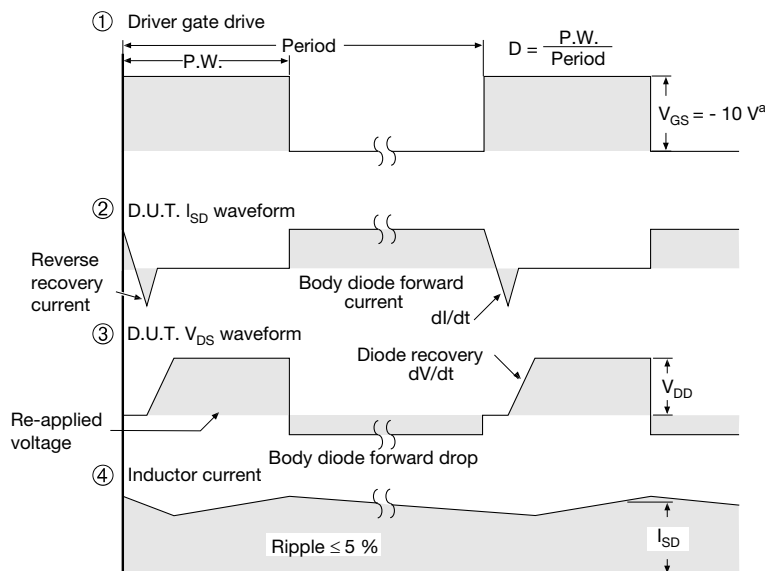
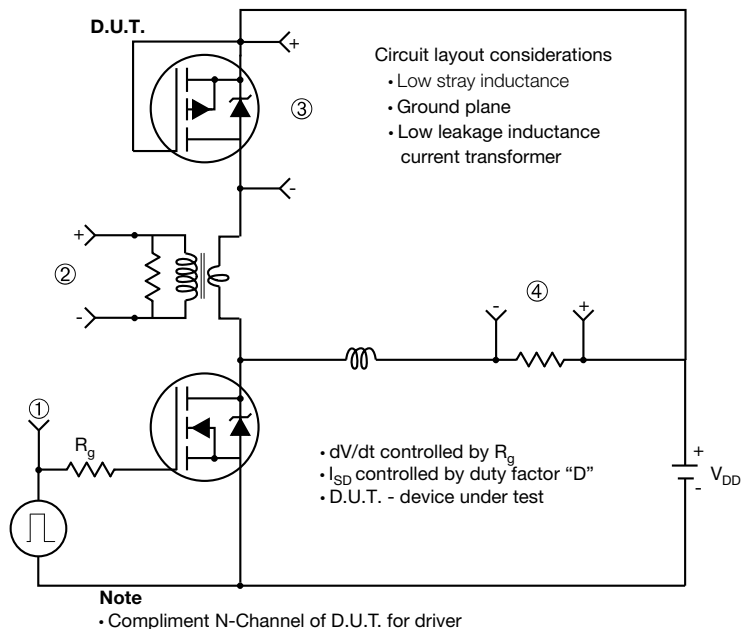
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$** 

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

**Fig. 2 - Typical Output Characteristics,  $T_C = 175^\circ\text{C}$** 

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

**Fig. 3 - Typical Transfer Characteristics**

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


**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

**Fig. 9 - Maximum Drain Current vs. Case Temperature**

**Fig. 8 - Maximum Safe Operating Area**

**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**

91090\_12c

### Peak Diode Recovery dV/dt Test Circuit



**Note**  
a.  $V_{GS} = -5\text{ V}$  for logic level and  $-3\text{ V}$  drive devices

**Fig. 14 - For P-Channel**

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