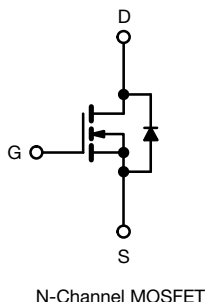
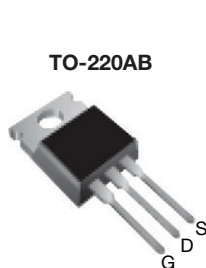


## EF Series Power MOSFET with Fast Body Diode

### PRODUCT SUMMARY

|                                         |                 |       |
|-----------------------------------------|-----------------|-------|
| $V_{DS}$ (V) at $T_J$ max.              | 700             |       |
| $R_{DS(on)}$ typ. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.102 |
| $Q_g$ max. (nC)                         | 146             |       |
| $Q_{gs}$ (nC)                           | 21              |       |
| $Q_{gd}$ (nC)                           | 43              |       |
| Configuration                           | Single          |       |



### FEATURES

- Fast body diode MOSFET using E series technology
- 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)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
FREE

### APPLICATIONS

- Telecommunications
  - Server and telecom power supplies
- Lighting
  - High intensity discharge (HID)
  - Light emitting diodes (LEDs)
- Consumer and computing
  - ATX power supplies
- Industrial
  - Welding
  - Battery chargers
- Renewable energy
  - Solar (PV inverters)
- Switch mode power supplies (SMPS)
- Applications using the following topologies
  - LLC
  - Phase shifted bridge (ZVS)
  - 3-level inverter
  - AC/DC bridge

### ORDERING INFORMATION

|                                 |                 |
|---------------------------------|-----------------|
| Package                         | TO-220AB        |
| Lead (Pb)-free and Halogen-free | SiHP28N65EF-GE3 |

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted)

| PARAMETER                                                 | SYMBOL           | LIMIT          | UNIT |
|-----------------------------------------------------------|------------------|----------------|------|
| Drain-Source Voltage                                      | $V_{DS}$         | 650            | V    |
| Gate-Source Voltage                                       | $V_{GS}$         | $\pm 30$       |      |
| Continuous Drain Current ( $T_J = 150$ °C)                | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A    |
|                                                           |                  | $T_C = 100$ °C |      |
| Pulsed Drain Current <sup>a</sup>                         | $I_{DM}$         | 87             |      |
| Linear Derating Factor                                    |                  | 2              | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>                | $E_{AS}$         | 427            | mJ   |
| Maximum Power Dissipation                                 | $P_D$            | 250            | W    |
| Operating Junction and Storage Temperature Range          | $T_J, T_{stg}$   | -55 to +150    | °C   |
| Drain-Source Voltage Slope                                | $dV/dt$          | 70             | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                        |                  | 11             |      |
| Soldering Recommendations (Peak Temperature) <sup>c</sup> | for 10 s         | 300            | °C   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DD} = 140$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 5.5$  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**

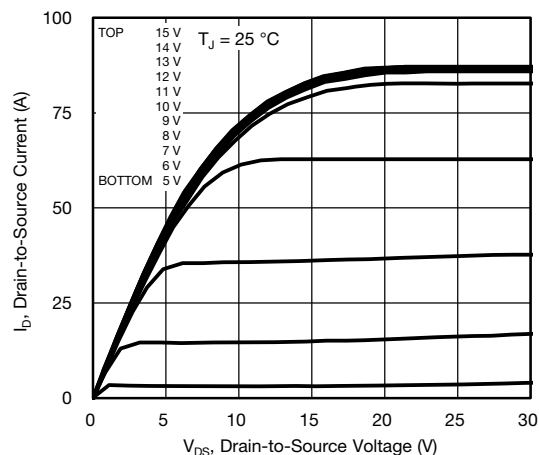
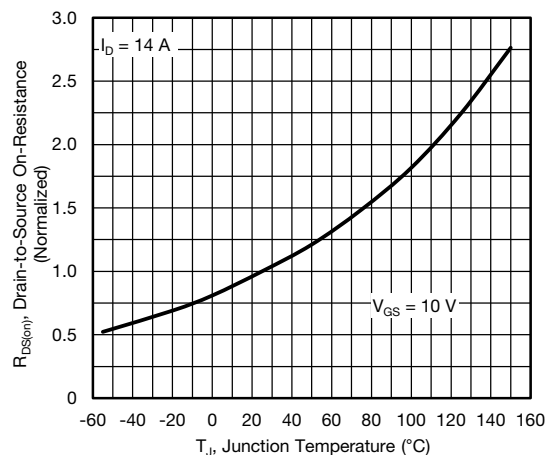
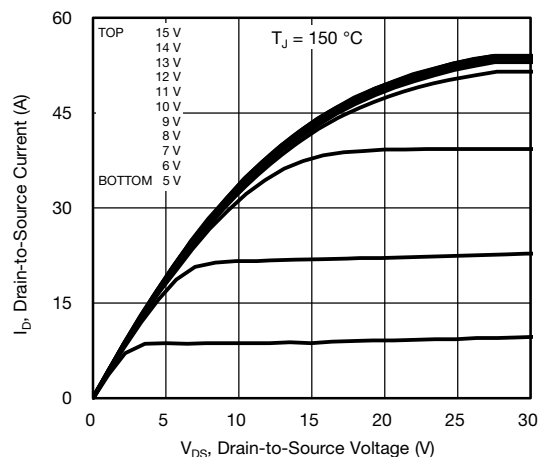
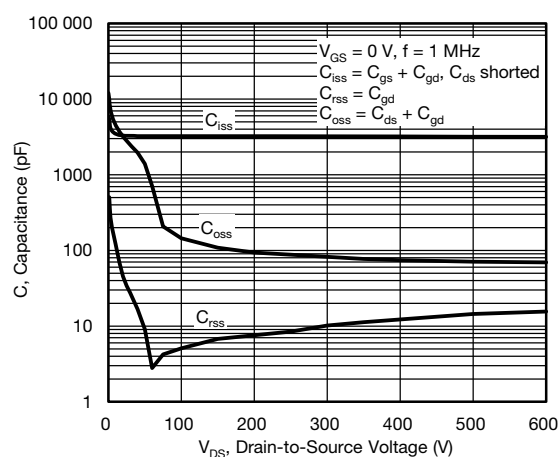
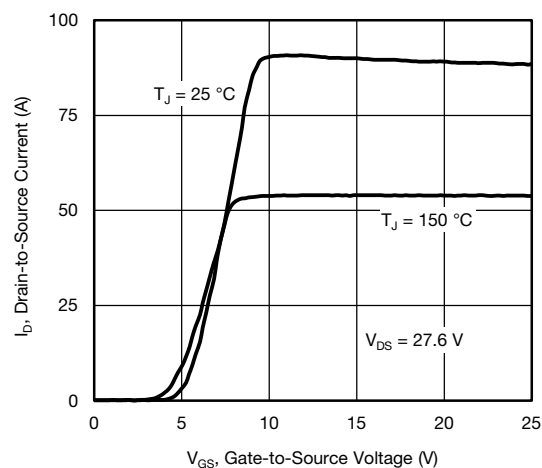
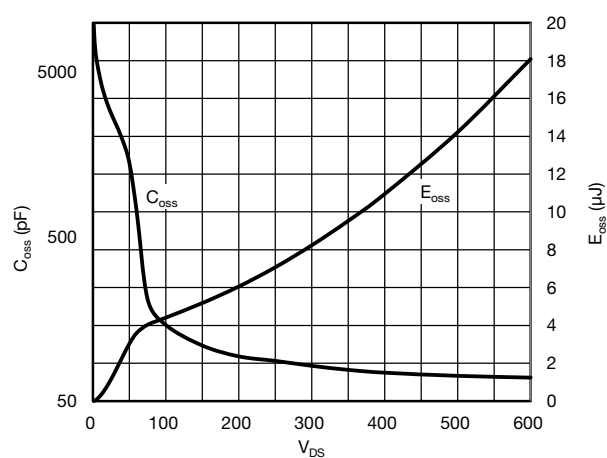
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.5  |      |

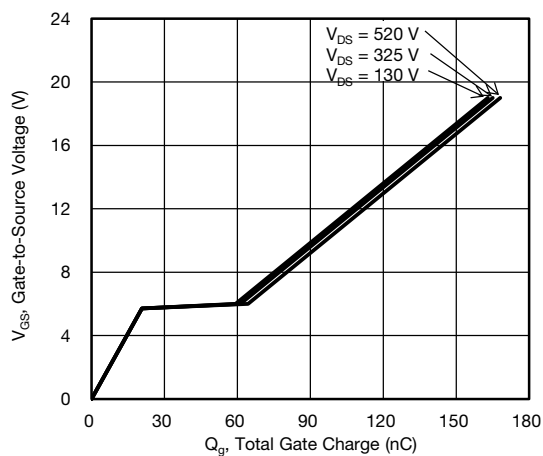
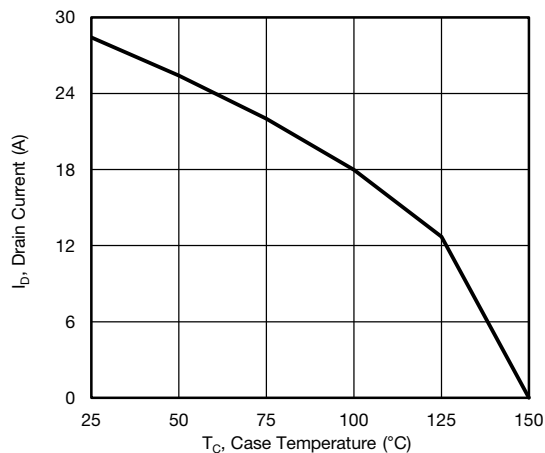
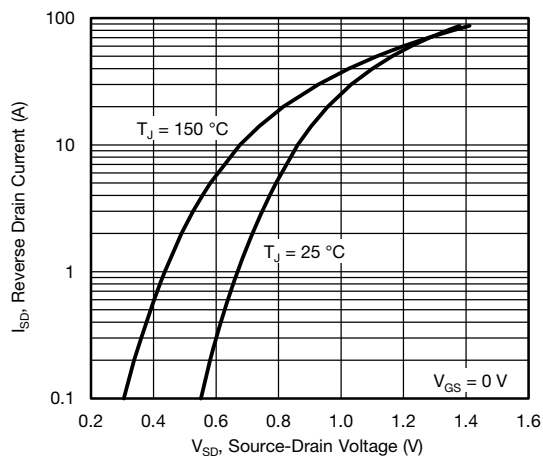
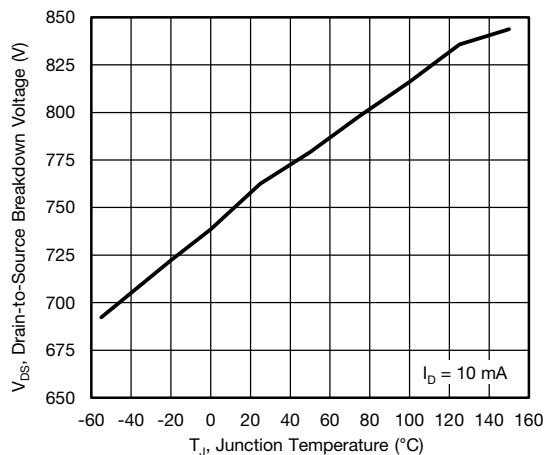
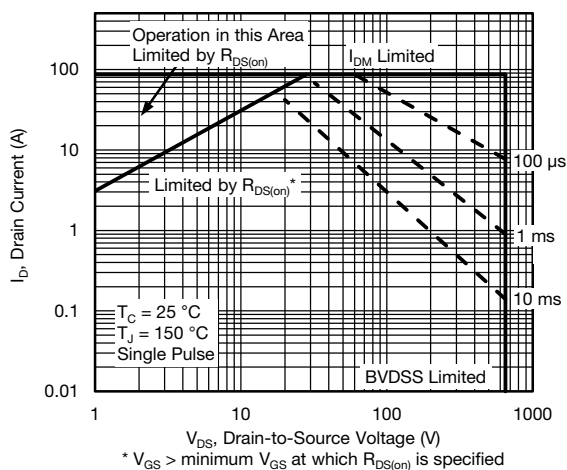
**SPECIFICATIONS** ( $T_J = 25\text{ °C}$ , unless otherwise noted)

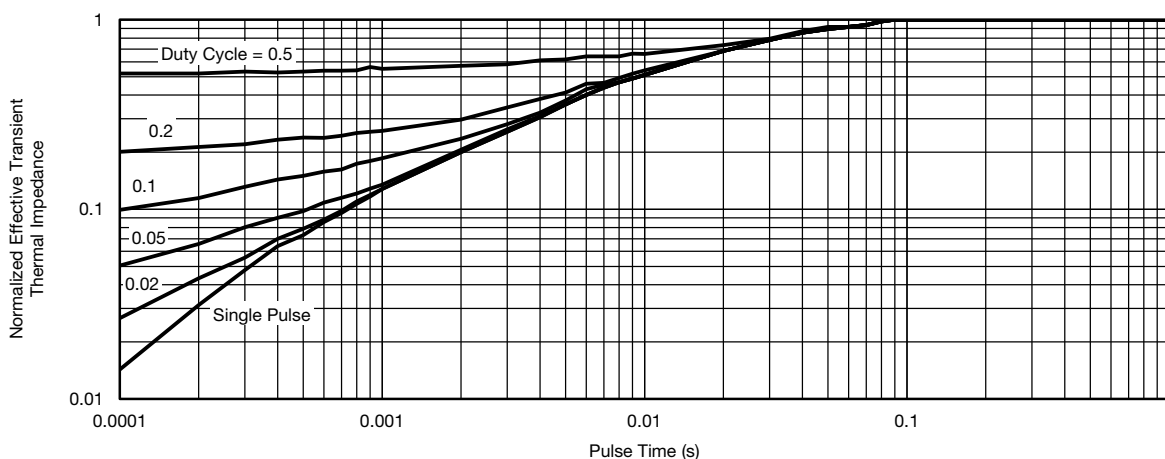
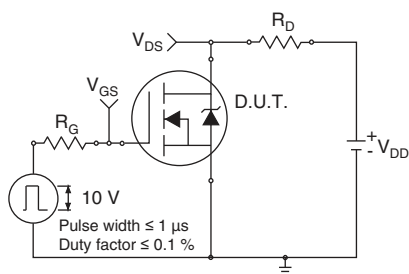
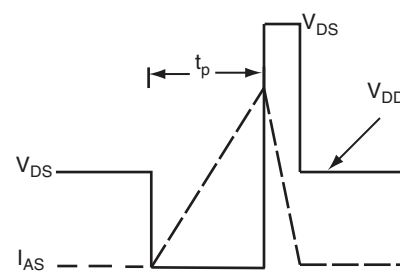
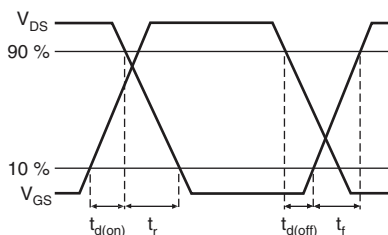
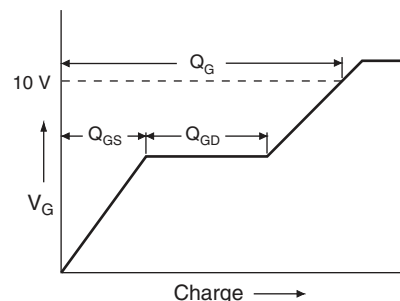
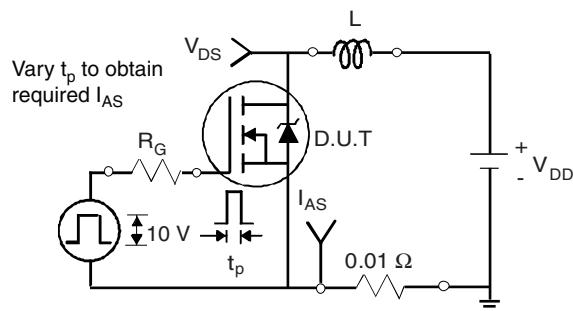
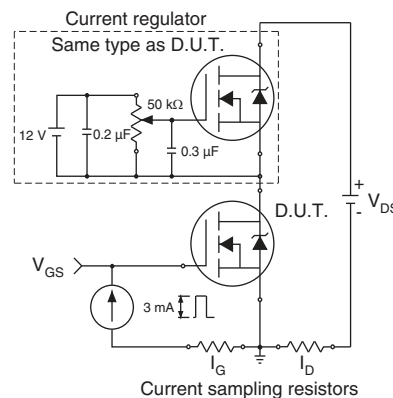
| PARAMETER                                                 | SYMBOL              | TEST CONDITIONS                                                                                                                                          | MIN. | TYP.  | MAX.      | UNIT          |
|-----------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|-----------|---------------|
| <b>Static</b>                                             |                     |                                                                                                                                                          |      |       |           |               |
| 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 $25\text{ °C}$ , $I_D = 10\text{ mA}$                                                                                                       | -    | 0.74  | -         | V/°C          |
| Gate-Source Threshold Voltage (N)                         | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                       | 2.0  | -     | 4.0       | V             |
| Gate-Source Leakage                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                               | -    | -     | $\pm 100$ | nA            |
|                                                           |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                               | -    | -     | $\pm 1$   | $\mu\text{A}$ |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                          | -    | -     | 1         | $\mu\text{A}$ |
|                                                           |                     | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ °C}$                                                                                  | -    | -     | 500       |               |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$ , $I_D = 14\text{ A}$                                                                                                             | -    | 0.102 | 0.117     | $\Omega$      |
| Forward Transconductance <sup>a</sup>                     | $g_{fs}$            | $V_{DS} = 30\text{ V}$ , $I_D = 14\text{ A}$                                                                                                             | -    | 11    | -         | S             |
| <b>Dynamic</b>                                            |                     |                                                                                                                                                          |      |       |           |               |
| Input Capacitance                                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$                                                                               | -    | 3249  | -         | pF            |
| Output Capacitance                                        | $C_{oss}$           |                                                                                                                                                          | -    | 145   | -         |               |
| Reverse Transfer Capacitance                              | $C_{rss}$           |                                                                                                                                                          | -    | 5     | -         |               |
| Effective Output Capacitance, Energy related <sup>a</sup> | $C_{o(er)}$         | $V_{GS} = 0\text{ V}$ , $V_{DS} = 0\text{ V to } 520\text{ V}$                                                                                           | -    | 105   | -         |               |
| Effective Output Capacitance, Time Related <sup>b</sup>   | $C_{o(tr)}$         |                                                                                                                                                          | -    | 441   | -         |               |
| Total Gate Charge                                         | $Q_g$               | $V_{GS} = 10\text{ V}$ ,<br>$I_D = 14\text{ A}$ , $V_{DS} = 520\text{ V}$                                                                                | -    | 97    | 146       | nC            |
| Gate-Source Charge                                        | $Q_{gs}$            |                                                                                                                                                          | -    | 21    | -         |               |
| Gate-Drain Charge                                         | $Q_{gd}$            |                                                                                                                                                          | -    | 43    | -         |               |
| Turn-On Delay Time                                        | $t_{d(on)}$         | $V_{DD} = 520\text{ V}$ , $I_D = 14\text{ A}$<br>$R_g = 9.1\text{ }\Omega$ , $V_{GS} = 10\text{ V}$                                                      | -    | 29    | 58        | ns            |
| Rise Time                                                 | $t_r$               |                                                                                                                                                          | -    | 44    | 88        |               |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |                                                                                                                                                          | -    | 93    | 140       |               |
| Fall Time                                                 | $t_f$               |                                                                                                                                                          | -    | 51    | 102       |               |
| Gate Input Resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                          | 0.25 | 0.5   | 1.0       | $\Omega$      |
| <b>Drain-Source Body Diode Characteristics</b>            |                     |                                                                                                                                                          |      |       |           |               |
| Continuous Source-Drain Diode Current                     | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode<br> | -    | -     | 28        | A             |
| Pulsed Diode Forward Current                              | $I_{SM}$            |                                                                                                                                                          | -    | -     | 87        |               |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25\text{ °C}$ , $I_S = 11\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                                       | -    | 0.9   | 1.2       | V             |
| Reverse Recovery Time                                     | $t_{rr}$            | $T_J = 25\text{ °C}$ , $I_F = I_S = 14\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 25\text{ V}$                                           | -    | 174   | -         | ns            |
| Reverse Recovery Charge                                   | $Q_{rr}$            |                                                                                                                                                          | -    | 1.1   | -         | $\mu\text{C}$ |
| Reverse Recovery Current                                  | $I_{RRM}$           |                                                                                                                                                          | -    | 12    | -         | A             |

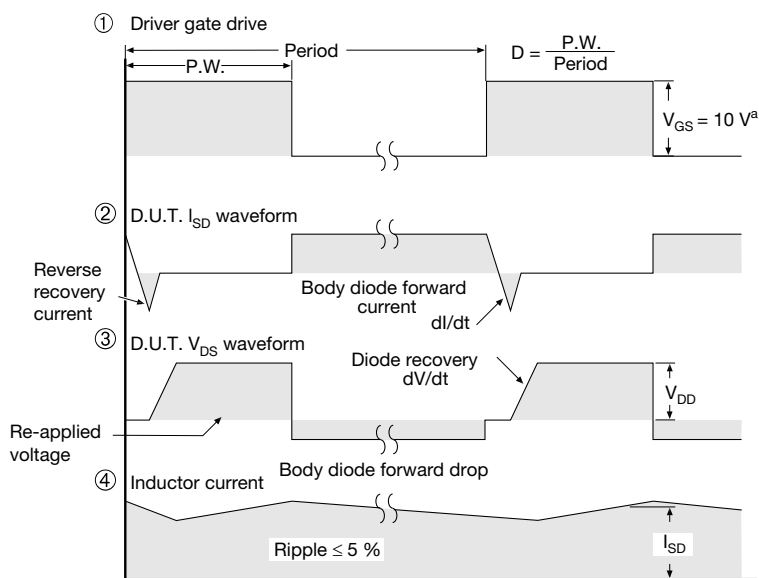
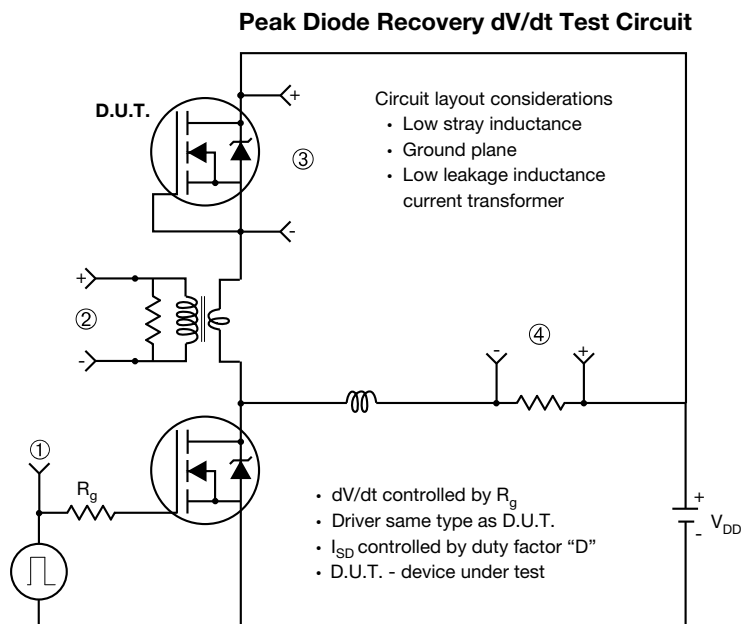
**Notes**

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

**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 - Typical Drain-to-Source Voltage vs. Temperature**

**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**

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**Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.**

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### Офис по работе с юридическими лицами:

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