

## K1416-VB Datasheet

### N-Channel 60 V (D-S) MOSFET

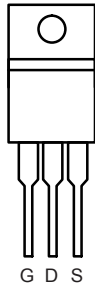
| PRODUCT SUMMARY |                           |                        |
|-----------------|---------------------------|------------------------|
| $V_{DS}$ (V)    | $R_{DS(on)}$ ( $\Omega$ ) | $I_D$ (A) <sup>a</sup> |
| 60              | 0.024 at $V_{GS} = 10$ V  | 50                     |
|                 | 0.028 at $V_{GS} = 4.5$ V | 40                     |

**FEATURES**

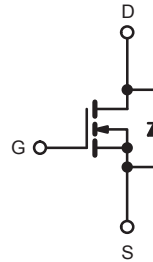
- Halogen-free According to IEC 61249-2-21 Definition
- Surface Mount
- Available in Tape and Reel
- Dynamic  $dV/dt$  Rating
- Logic-Level Gate Drive
- Fast Switching
- Compliant to RoHS Directive 2002/95/EC


**RoHS\***  
 COMPLIANT

TO-220AB



Top View



N-Channel MOSFET

| ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted) |                  |                |                  |      |
|---|------------------|----------------|------------------|------|
| PARAMETER   |                  | SYMBOL         | LIMIT            | UNIT |
| Drain-Source Voltage  |                  | $V_{DS}$       | 60               | V    |
| Gate-Source Voltage   |                  | $V_{GS}$       | $\pm 20$         |      |
| Continuous Drain Current <sup>f</sup>                             | $V_{GS}$ at 10 V | $I_D$          | $T_C = 25$ °C    | A    |
| Continuous Drain Current  |                  |                | $T_C = 100$ °C   |      |
| Pulsed Drain Current <sup>a</sup>                                 |                  | $I_{DM}$       | 200              |      |
| Linear Derating Factor  |                  |                | 1.0              | W/°C |
| Linear Derating Factor (PCB Mount) <sup>e</sup>                   |                  |                | 0.025            |      |
| Single Pulse Avalanche Energy <sup>b</sup>                        |                  | $E_{AS}$       | 400              | mJ   |
| Maximum Power Dissipation   | $T_C = 25$ °C    | $P_D$          | 150              | W    |
| Maximum Power Dissipation (PCB Mount) <sup>e</sup>                | $T_A = 25$ °C    |                | 3.7              |      |
| Peak Diode Recovery $dV/dt^c$                                     |                  | $dV/dt$        | 4.5              | V/ns |
| Operating Junction and Storage Temperature Range                  |                  | $T_J, T_{stg}$ | - 55 to + 175    | °C   |
| Soldering Recommendations (Peak Temperature) <sup>d</sup>         | for 10 s         |                | 300 <sup>d</sup> |      |

**Notes**

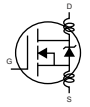

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = 25$  V, starting  $T_J = 25$  °C,  $L = 179$   $\mu$ H,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 51$  A (see fig. 12).
- $I_{SD} \leq 51$  A,  $di/dt \leq 250$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 175$  °C.
- 1.6 mm from case.
- When mounted on 1" square PCB (FR-4 or G-10 material).
- Current limited by the package, (die current = 51 A).

| THERMAL RESISTANCE RATINGS                           |            |      |      |      |
|--|------------|------|------|------|
| PARAMETER  | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient                          | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Ambient (PCB Mount) <sup>a</sup> | $R_{thJA}$ | -    | 40   |      |
| Maximum Junction-to-Case (Drain)                     | $R_{thJC}$ | -    | 1.0  |      |

**Note**

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

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| SPECIFICATIONS ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                     |  |  |       |           |               |          |
|---|---------------------|--|--|-------|-----------|---------------|----------|
| PARAMETER   | SYMBOL              | TEST CONDITIONS  | MIN.   | TYP.  | MAX.      | UNIT          |          |
| <b>Static</b>   |                     |  |  |       |           |               |          |
| Drain-Source Breakdown Voltage  | $V_{DS}$            | $V_{GS} = 0, I_D = 250\ \mu\text{A}$   | 60   | -     | -         | V             |          |
| $V_{DS}$ Temperature Coefficient  | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\ \text{mA}$   | -  | 0.070 | -         | V/°C          |          |
| Gate-Source Threshold Voltage   | $V_{GS(th)}$        | $V_{DS} = V_{GS}, I_D = 250\ \mu\text{A}$  | 1.0  | -     | 2.5       |               |          |
| Gate-Source Leakage   | $I_{GSS}$           | $V_{GS} = \pm 10\ \text{V}$  | -  | -     | $\pm 100$ | nA            |          |
| Zero Gate Voltage Drain Current   | $I_{DSS}$           | $V_{DS} = 60\ \text{V}, V_{GS} = 0\ \text{V}$  | -  | -     | 25        | $\mu\text{A}$ |          |
|   |                     | $V_{DS} = 48\ \text{V}, V_{GS} = 0\ \text{V}, T_J = 150\text{ }^\circ\text{C}$                                     | -  | -     | 250       |               |          |
| Drain-Source On-State Resistance  | $R_{DS(on)}$        | $V_{GS} = 10\ \text{V}$  | $I_D = 21\ \text{A}^b$   | -     | 0.024     | -             | $\Omega$ |
|   |                     | $V_{GS} = 4.5\ \text{V}$   | $I_D = 15\ \text{A}^b$   | -     | 0.028     | -             |          |
| Forward Transconductance  | $g_{fs}$            | $V_{DS} = 25\ \text{V}, I_D = 21\ \text{A}^b$  | 23   | -     | -         | S             |          |
| <b>Dynamic</b>  |                     |  |  |       |           |               |          |
| Input Capacitance   | $C_{iss}$           | $V_{GS} = 0\ \text{V},$<br>$V_{DS} = 25\ \text{V},$<br>$f = 1.0\ \text{MHz}$ , see fig. 5                          | -  | 190   | -         | pF            |          |
| Output Capacitance  | $C_{oss}$           |  | -  | 920   | -         |               |          |
| Reverse Transfer Capacitance  | $C_{rss}$           |  | -  | 170   | -         |               |          |
| Total Gate Charge   | $Q_g$               | $V_{GS} = 5.0\ \text{V}$   | $I_D = 51\ \text{A}, V_{DS} = 48\ \text{V},$<br>see fig. 6 and 13 <sup>b</sup>       | -     | -         | 66            | nC       |
| Gate-Source Charge  | $Q_{gs}$            |  |  | -     | -         | 12            |          |
| Gate-Drain Charge   | $Q_{gd}$            |  |  | -     | -         | 43            |          |
| Turn-On Delay Time  | $t_{d(on)}$         | $V_{DD} = 30\ \text{V}, I_D = 51\ \text{A},$<br>$R_g = 4.6\ \Omega, R_D = 0.56\ \Omega$ , see fig. 10 <sup>b</sup> | -  | 17    | -         | ns            |          |
| Rise Time   | $t_r$               |  | -  | 230   | -         |               |          |
| Turn-Off Delay Time   | $t_{d(off)}$        |  | -  | 2     | -         |               |          |
| Fall Time   | $t_f$               |  | -  | 110   | -         |               |          |
| 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       | -             |          |
| <b>Drain-Source Body Diode Characteristics</b>                              |                     |  |  |       |           |               |          |
| Continuous Source-Drain Diode Current                                       | $I_S$               | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode   |  | -     | -         | 50°           | A        |
| Pulsed Diode Forward Current <sup>a</sup>                                   | $I_{SM}$            |  |  | -     | -         | 200           |          |
| Body Diode Voltage  | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = 51\ \text{A}, V_{GS} = 0\ \text{V}^b$                                       | -  | -     | 2.5       | V             |          |
| Body Diode Reverse Recovery Time  | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = 51\ \text{A}, di/dt = 100\ \text{A}/\mu\text{s}^b$                          | -  | 130   | 180       | ns            |          |
| Body Diode Reverse Recovery Charge  | $Q_{rr}$            |  | -  | 0.84  | 1.3       | $\mu\text{C}$ |          |
| 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  $\leq 300\ \mu\text{s}$ ; duty cycle  $\leq 2\%$ .  
 c. Current limited by the package, (Die Current = 51 A).

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



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



Fig. 3 - Typical Transfer Characteristics



Fig. 2 - Typical Output Characteristics,  $T_C = 150\text{ }^\circ\text{C}$



Fig. 4 - Normalized On-Resistance vs. Temperature



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

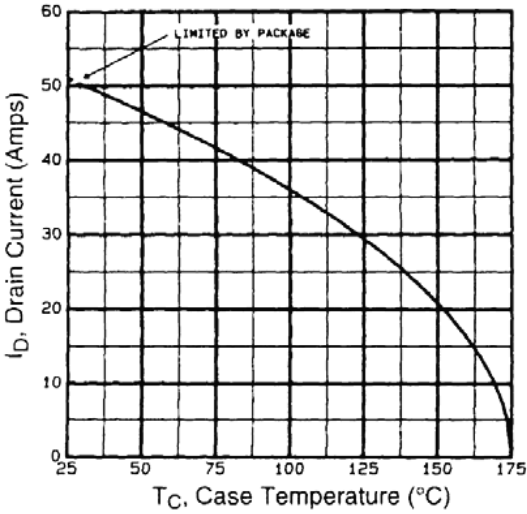


Fig. 9 - Maximum Drain Current vs. Case Temperature

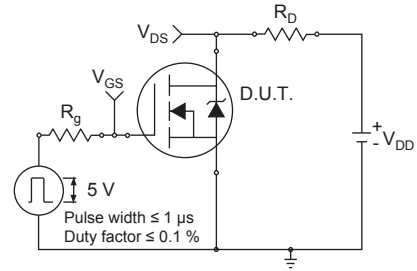


Fig. 10a - Switching Time Test Circuit

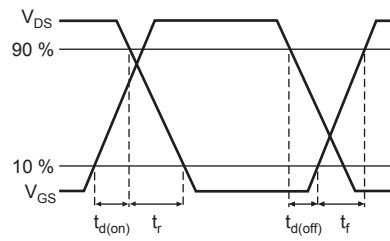


Fig. 10b - Switching Time Waveforms

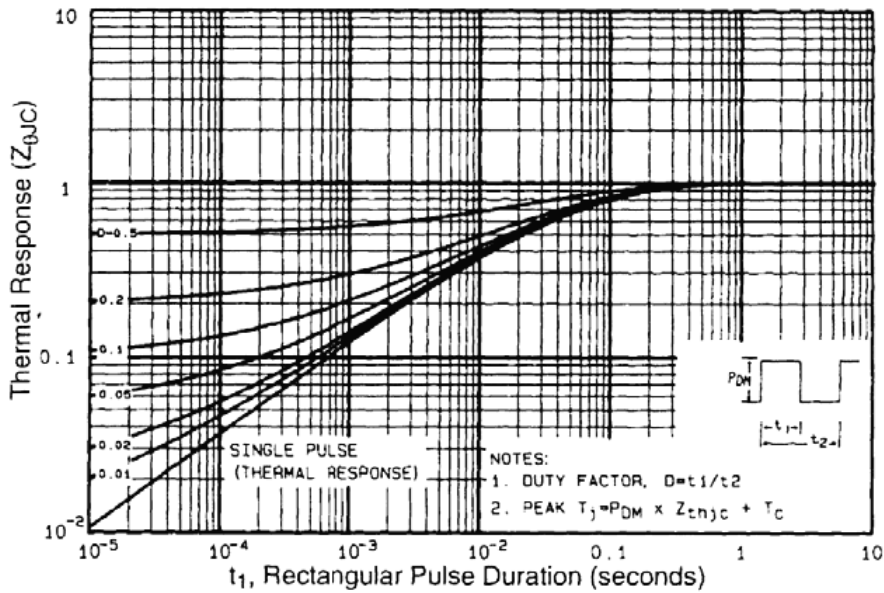


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

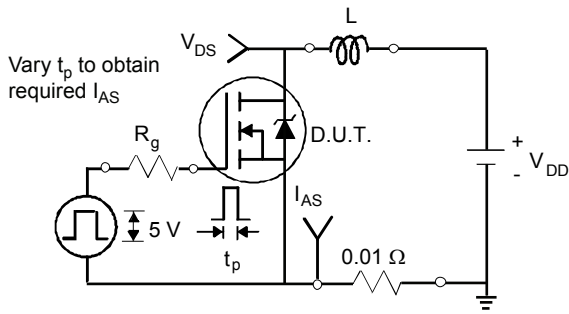


Fig. 12a - Unclamped Inductive Test Circuit

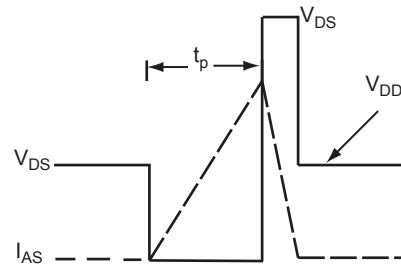


Fig. 12b - Unclamped Inductive Waveforms



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



Fig. 13a - Basic Gate Charge Waveform

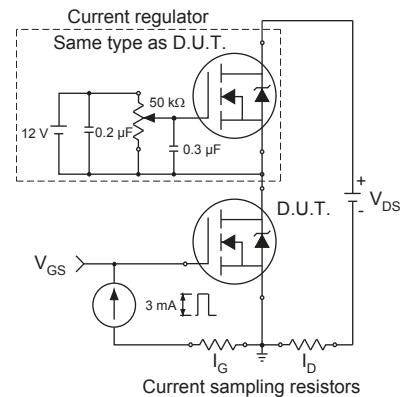


Fig. 13b - Gate Charge Test Circuit

**Peak Diode Recovery dV/dt Test Circuit**



**Note**

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

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

### TO-220AB



| DIM. | MILLIMETERS |       | INCHES |       |
|------|-------------|-------|--------|-------|
|      | MIN.        | MAX.  | MIN.   | MAX.  |
| A    | 4.25        | 4.65  | 0.167  | 0.183 |
| b    | 0.69        | 1.01  | 0.027  | 0.040 |
| b(1) | 1.20        | 1.73  | 0.047  | 0.068 |
| c    | 0.36        | 0.61  | 0.014  | 0.024 |
| D    | 14.85       | 15.49 | 0.585  | 0.610 |
| E    | 10.04       | 10.51 | 0.395  | 0.414 |
| e    | 2.41        | 2.67  | 0.095  | 0.105 |
| e(1) | 4.88        | 5.28  | 0.192  | 0.208 |
| F    | 1.14        | 1.40  | 0.045  | 0.055 |
| H(1) | 6.09        | 6.48  | 0.240  | 0.255 |
| J(1) | 2.41        | 2.92  | 0.095  | 0.115 |
| L    | 13.35       | 14.02 | 0.526  | 0.552 |
| L(1) | 3.32        | 3.82  | 0.131  | 0.150 |
| Ø P  | 3.54        | 3.94  | 0.139  | 0.155 |
| Q    | 2.60        | 3.00  | 0.102  | 0.118 |

ECN: X12-0208-Rev. N, 08-Oct-12  
DWG: 5471

**Notes**

\* M = 1.32 mm to 1.62 mm (dimension including protrusion)  
Heatsink hole for HVM



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