

## EMIPAK 1B PressFit Power Module 600 V Double PFC MOSFET, 25 A



**EMIPAK 1B**  
(package example)



**RoHS**  
COMPLIANT

### FEATURES

- E series Power MOSFET
- MOAT and SiC diode technology
- Exposed Al<sub>2</sub>O<sub>3</sub> substrate with low thermal resistance
- Low input capacitance
- Low switching and conduction losses
- Ultra low gate charge Q<sub>g</sub>
- Low internal inductances
- Qualified using AQG324 guideline as reference
- PressFit pins locking technology  
PATENT(S): [www.vishay.com/patents](http://www.vishay.com/patents)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?999912](http://www.vishay.com/doc?999912)

### DESCRIPTION

The EMIPAK 1B package is easy to use thanks to the PressFit pins. The exposed substrate provides improved thermal performance.

The optimized layout also helps to minimize stray parameters, allowing for better EMI performance.

| PRIMARY CHARACTERISTICS                              |   |
|--|---|
| <b>Q1 - Q4 MOSFET</b>                                |   |
| V <sub>DSS</sub>                                     | 600 V   |
| R <sub>DS(on)</sub> typical at I <sub>C</sub> = 25 A | 59 mΩ   |
| I <sub>D</sub> at T <sub>SINK</sub> = 37 °C          | 25 A  |
| <b>Da1 - Da2 DIODE</b>                               |   |
| V <sub>RRM</sub>                                     | 1200 V  |
| V <sub>FM</sub> typical at 20 A                      | 1.29 V  |
| I <sub>F</sub> at T <sub>SINK</sub> = 83 °C          | 20 A  |
| <b>D1 - D4 SILICON CARBIDE CLAMP DIODE</b>           |   |
| V <sub>RRM</sub>                                     | 600 V   |
| V <sub>FM</sub> typical at 10 A                      | 1.72 V  |
| I <sub>F</sub> at T <sub>SINK</sub> = 62 °C          | 10 A  |
| Package  | EMIPAK 1B   |
| Circuit configuration                                | Double interleaved bridgless PFC (4 x channels) with individual return diodes |
| Type   | Modules - MOSFET  |

| ABSOLUTE MAXIMUM RATINGS (T <sub>J</sub> = 25 °C unless otherwise noted) |                   |   |             |       |
|--|-------------------|---|-------------|-------|
| PARAMETER  | SYMBOL            | TEST CONDITIONS   | MAX.        | UNITS |
| Operating junction temperature   | T <sub>J</sub>    |   | 150         | °C    |
| Storage temperature range  | T <sub>Stg</sub>  |   | -40 to +150 |       |
| RMS isolation voltage  | V <sub>ISOL</sub> | T <sub>J</sub> = 25 °C, all terminals shorted, f = 50 Hz, t = 1 s | 3500        | V     |
| <b>Q1 - Q4 MOSFET</b>  |                   |   |             |       |
| Drain to source voltage  | V <sub>DSS</sub>  |   | 600         | V     |
| Gate to source voltage   | V <sub>GS</sub>   |   | ± 20        |       |
| Pulsed drain current   | I <sub>DM</sub>   | V <sub>GS</sub> = 10 V  | 85          | A     |
| Continuous drain current   | I <sub>D</sub>    | T <sub>SINK</sub> = 25 °C   | 26          | A     |
|  |                   | T <sub>SINK</sub> = 80 °C   | 20          |       |
| Power dissipation  | P <sub>D</sub>    | T <sub>SINK</sub> = 25 °C   | 104         | W     |
|  |                   | T <sub>SINK</sub> = 80 °C   | 58          |       |
| Single pulse avalanche energy  | E <sub>AS</sub>   | L = 10 mH, I <sub>AS</sub> = 19 A, T <sub>J</sub> = 25 °C         | 1800        | mJ    |
| Pulsed source current (body diode)                                       | I <sub>SM</sub>   |   | 85          | A     |

**PATENT(S):** [www.vishay.com/patents](http://www.vishay.com/patents)

**This Vishay product is protected by one or more United States and international patents.**



| <b>ABSOLUTE MAXIMUM RATINGS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise noted) |           |  |      |   |
|--|-----------|--|------|---|
| <b>DA1 - DA2 DIODE</b>   |           |  |      |   |
| Cathode to anode voltage   | $V_{RRM}$ |  | 1200 | V |
| Single pulse forward current   | $I_{FSM}$ |  | 230  | A |
| Diode continuous forward current   | $I_F$     | $T_{SINK} = 25\text{ }^\circ\text{C}$                                  | 29   | A |
|  |           | $T_{SINK} = 80\text{ }^\circ\text{C}$                                  | 21   |   |
| Power dissipation  | $P_D$     | $T_{SINK} = 25\text{ }^\circ\text{C}$                                  | 70   | W |
|  |           | $T_{SINK} = 80\text{ }^\circ\text{C}$                                  | 39   |   |
| <b>D1 - D4 SILICON CARBIDE CLAMP DIODE</b>   |           |  |      |   |
| Cathode to anode voltage   | $V_{RRM}$ |  | 600  | V |
| Single pulse forward current   | $I_{FSM}$ | 10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ }^\circ\text{C}$ | 80   | A |
| Diode continuous forward current   | $I_F$     | $T_{SINK} = 25\text{ }^\circ\text{C}$                                  | 12   | A |
|  |           | $T_{SINK} = 80\text{ }^\circ\text{C}$                                  | 9    |   |
| Power dissipation  | $P_D$     | $T_{SINK} = 25\text{ }^\circ\text{C}$                                  | 38   | W |
|  |           | $T_{SINK} = 80\text{ }^\circ\text{C}$                                  | 21   |   |

| <b>ELECTRICAL SPECIFICATIONS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise noted) |                                |  |      |      |           |                      |
|---|--------------------------------|--|------|------|-----------|----------------------|
| PARAMETER   | SYMBOL                         | TEST CONDITIONS  | MIN. | TYP. | MAX.      | UNITS                |
| <b>Q1 - Q4 MOSFET</b>   |                                |  |      |      |           |                      |
| Drain to source breakdown voltage   | $BV_{DSS}$                     | $V_{GS} = 0\text{ V}, I_D = 500\text{ }\mu\text{A}$  | 600  | -    | -         | m $\Omega$           |
| Drain to source on resistance   | $R_{DS(on)}$                   | $V_{GS} = 10\text{ V}, I_D = 25\text{ A}$  | -    | 59   | 71        |                      |
|   |                                | $V_{GS} = 10\text{ V}, I_D = 25\text{ A}, T_J = 150\text{ }^\circ\text{C}$                     | -    | 140  | -         |                      |
| Gate threshold voltage  | $V_{GS(th)}$                   | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$  | 1.8  | 2.6  | 4.4       | V                    |
| Temperature coefficient of threshold voltage  | $\Delta V_{GS(th)}/\Delta T_J$ | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ (25 $^\circ\text{C}$ to 125 $^\circ\text{C}$ ) | -    | -9.7 | -         | mV/ $^\circ\text{C}$ |
| Forward transconductance  | $g_{fs}$                       | $V_{DS} = 20\text{ V}, I_D = 25\text{ A}$  | -    | 29   | -         | S                    |
| Transfer characteristics  | $V_{GS}$                       | $V_{DS} = 20\text{ V}, I_D = 25\text{ A}$  | -    | 5.1  | -         | V                    |
| Zero gate voltage drain current   | $I_{DSS}$                      | $V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}$   | -    | 0.3  | 5         | $\mu\text{A}$        |
|   |                                | $V_{GS} = 0\text{ V}, V_{DS} = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$                  | -    | 19   | -         |                      |
| Gate to source leakage current  | $I_{GSS}$                      | $V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$  | -    | -    | $\pm 150$ | nA                   |
| <b>Q1 - Q4 BODY DIODE</b>   |                                |  |      |      |           |                      |
| Source-to-drain voltage drop  | $V_{SD}$                       | $I_{SD} = 25\text{ A}, V_{GS} = 0\text{ V}$  | -    | 0.9  | 1.32      | V                    |
| <b>Da1 - Da2 DIODE</b>  |                                |  |      |      |           |                      |
| Forward voltage drop  | $V_{FM}$                       | $I_F = 20\text{ A}$  | -    | 1.29 | 1.90      | V                    |
|   |                                | $I_F = 20\text{ A}, T_J = 150\text{ }^\circ\text{C}$   | -    | 1.26 | -         |                      |
| Breakdown voltage   | $V_{BR}$                       | $I_R = 500\text{ }\mu\text{A}$   | 1200 | -    | -         | V                    |
| Reverse leakage current   | $I_{RM}$                       | $V_R = 1200\text{ V}$  | -    | 1.0  | 100       | $\mu\text{A}$        |
|   |                                | $V_R = 1200\text{ V}, T_J = 150\text{ }^\circ\text{C}$   | -    | 900  | -         |                      |
| <b>D1 - D4 SILICON CARBIDE CLAMP DIODE</b>  |                                |  |      |      |           |                      |
| Forward voltage drop  | $V_{FM}$                       | $I_F = 10\text{ A}$  | -    | 1.72 | 1.98      | V                    |
|   |                                | $I_F = 10\text{ A}, T_J = 150\text{ }^\circ\text{C}$   | -    | 2.21 | -         |                      |
| Breakdown voltage   | $V_{BR}$                       | $I_R = 500\text{ }\mu\text{A}$   | 600  | -    | -         | V                    |
| Reverse leakage current   | $I_{RM}$                       | $V_R = 600\text{ V}$   | -    | 0.2  | 100       | $\mu\text{A}$        |
|   |                                | $V_R = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$  | -    | 1.4  | -         |                      |



| <b>SWITCHING CHARACTERISTICS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise noted) |              |  |      |      |      |               |
|---|--------------|--|------|------|------|---------------|
| PARAMETER   | SYMBOL       | TEST CONDITIONS  | MIN. | TYP. | MAX. | UNITS         |
| <b>Q1 - Q4 MOSFET WITH D1 - D4 CLAMP DIODE</b>  |              |  |      |      |      |               |
| Total gate charge (turn-on)   | $Q_g$        | $I_D = 24\text{ A}$<br>$V_{DS} = 480\text{ V}$<br>$V_{GS} = 10\text{ V}$   | -    | 147  | -    | nC            |
| Gate to source charge (turn-on)   | $Q_{gs}$     |  | -    | 36   | -    |               |
| Gate to drain charge (turn-on)  | $Q_{gd}$     |  | -    | 60   | -    |               |
| Turn-on delay time  | $t_{d(on)}$  | $I_D = 25\text{ A}$<br>$V_{DD} = 300\text{ V}$<br>$V_{GS} = 10\text{ V}$<br>$R_g = 4.7\text{ }\Omega, L = 500\text{ }\mu\text{H}$                                  | -    | 82   | -    | ns            |
| Rise time   | $t_r$        |  | -    | 23   | -    |               |
| Turn-off delay time   | $t_{d(off)}$ |  | -    | 109  | -    |               |
| Fall time   | $t_f$        |  | -    | 9    | -    |               |
| Turn-on delay time  | $t_{d(on)}$  | $I_D = 25\text{ A}$<br>$V_{DD} = 300\text{ V}$<br>$V_{GS} = 10\text{ V}$<br>$R_g = 4.7\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$ | -    | 83   | -    | ns            |
| Rise time   | $t_r$        |  | -    | 26   | -    |               |
| Turn-off delay time   | $t_{d(off)}$ |  | -    | 111  | -    |               |
| Fall time   | $t_f$        |  | -    | 22   | -    |               |
| Input capacitance   | $C_{iss}$    | $V_{GS} = 0\text{ V}$<br>$V_{DS} = 100\text{ V}$<br>$f = 1\text{ MHz}$   | -    | 4810 | -    | pF            |
| Output capacitance  | $C_{oss}$    |  | -    | 230  | -    |               |
| Reverse transfer capacitance  | $C_{rss}$    |  | -    | 5    | -    |               |
| Reverse bias safe operating area  | RBSOA        | $T_J = 150\text{ }^\circ\text{C}, I_D = 50\text{ A}, V_{DD} = 400\text{ V},$<br>$V_P = 600\text{ V}, R_g = 4.7\text{ }\Omega, V_{GS} = +10 / 0\text{ V}$           |      |      |      |               |
| <b>Q1 - Q4 BODY DIODE</b>   |              |  |      |      |      |               |
| Diode reverse recovery time   | $t_{rr}$     | $V_R = 30\text{ V}, T_J = 25\text{ }^\circ\text{C}$<br>$I_S = 30\text{ A}$<br>$di/dt = 100\text{ A}/\mu\text{s}$   | -    | 500  | -    | ns            |
| Diode reverse recovery current  | $I_{rr}$     |  | -    | 41   | -    | A             |
| Diode reverse recovery charge   | $Q_{rr}$     |  | -    | 10.5 | -    | $\mu\text{C}$ |
| <b>D1 - D4 SILICON CARBIDE CLAMP DIODE</b>  |              |  |      |      |      |               |
| Total capacitive charge   | $Q_C$        | $V_R = 600\text{ V}$<br>$I_F = 10\text{ A}$<br>$di/dt = 500\text{ A}/\mu\text{s}$  | -    | 30   | -    | nC            |

| <b>INTERNAL NTC - THERMISTOR SPECIFICATIONS</b> |             |  |                |                            |
|---|-------------|--|----------------|----------------------------|
| PARAMETER                                       | SYMBOL      | TEST CONDITIONS  | VALUE          | UNITS                      |
| Resistance                                      | $R_{25}$    | $T_C = 25\text{ }^\circ\text{C}$                             | 5000           | $\Omega$                   |
|   | $R_{100}$   | $T_C = 100\text{ }^\circ\text{C}$                            | $493 \pm 5\%$  |                            |
| B-value   | $B_{25/50}$ | $R_2 = R_{25} \exp. [B_{25/50}(1/T_2 - 1/(298.15\text{K}))]$ | $3375 \pm 5\%$ | K                          |
| Maximum operating temperature                   |             |  | 220            | $^\circ\text{C}$           |
| Dissipation constant                            |             |  | 2              | $\text{mW}/^\circ\text{C}$ |
| Thermal time constant                           |             |  | 8              | s                          |

| <b>THERMAL AND MECHANICAL SPECIFICATIONS</b>   |            |      |      |      |                           |
|--|------------|------|------|------|---------------------------|
| PARAMETER  | SYMBOL     | MIN. | TYP. | MAX. | UNITS                     |
| Q1 - Q4 MOSFET - Junction to sink thermal resistance (per switch) <sup>(1)</sup>               | $R_{thJS}$ | -    | 1.00 | -    | $^\circ\text{C}/\text{W}$ |
| Da1 - Da2 DIODE - Junction to sink thermal resistance (per diode) <sup>(1)</sup>               |            | -    | 1.48 | -    |                           |
| D1 - D4 SILICON CARBIDE DIODE - Junction to sink thermal resistance (per diode) <sup>(1)</sup> |            | -    | 2.76 | -    |                           |
| Case to sink thermal resistance (per module) <sup>(1)</sup>                                    |            | -    | 0.1  | -    |                           |
| Mounting torque (M4)   |            | 2    | -    | 3    | Nm                        |
| Weight   |            | -    | 28   | -    | g                         |

**Note**

<sup>(1)</sup> Mounting surface flat, smooth, and greased,  $\lambda_{grease} = 0.67\text{ W}/\text{mK}$

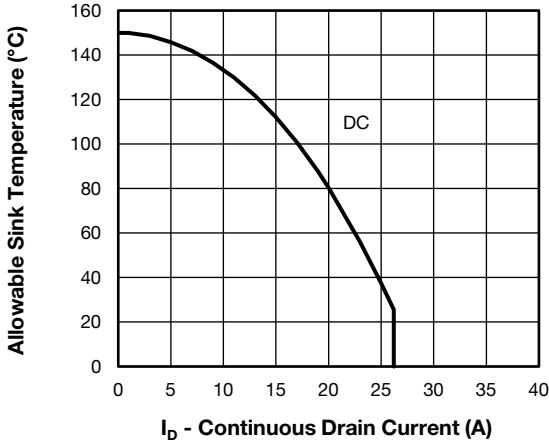


Fig. 1 - Maximum Continuous Drain Current vs. Sink Temperature

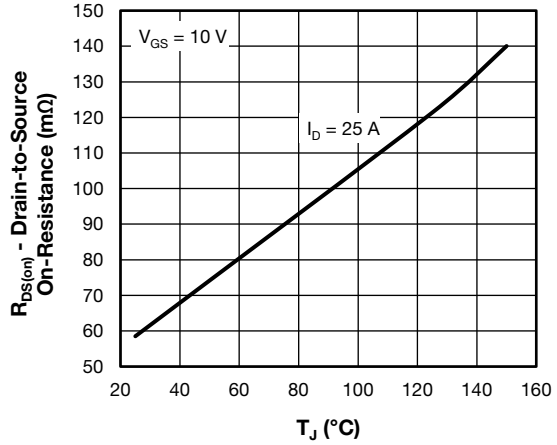


Fig. 4 - Typical Drain-to-Source On-Resistance vs. Temperature

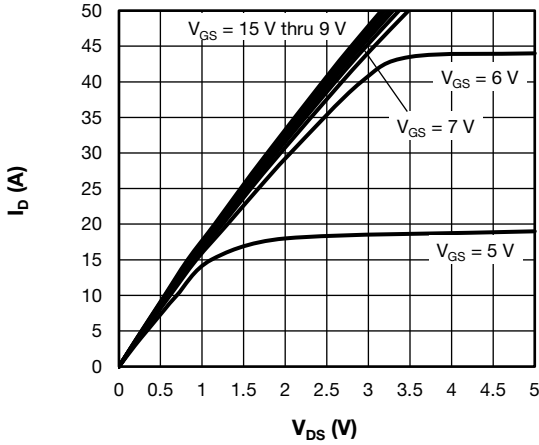


Fig. 2 - Typical Drain to Source Current Output Characteristics at  $T_J = 25\text{ }^\circ\text{C}$

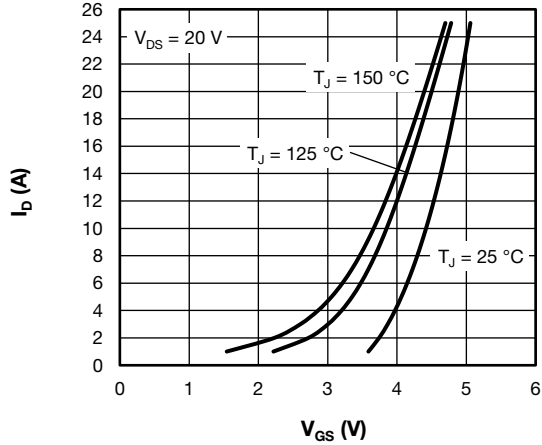


Fig. 5 - Typical Transfer Characteristics

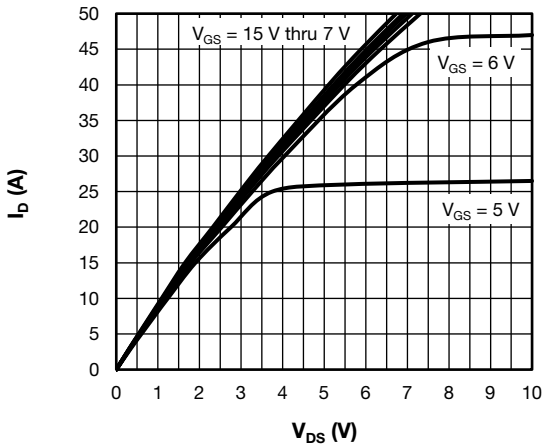


Fig. 3 - Typical Drain to Source Current Output Characteristics at  $T_J = 125\text{ }^\circ\text{C}$

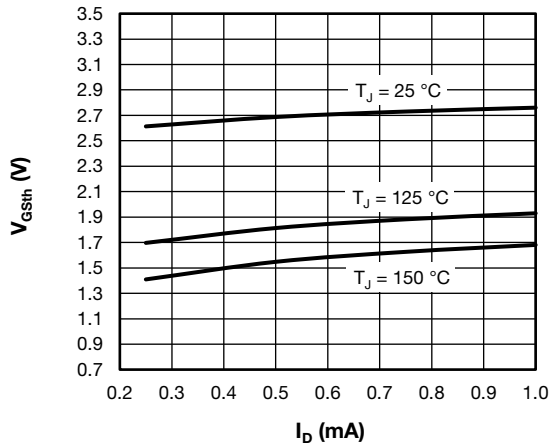


Fig. 6 - Typical Gate Threshold Voltage Characteristics

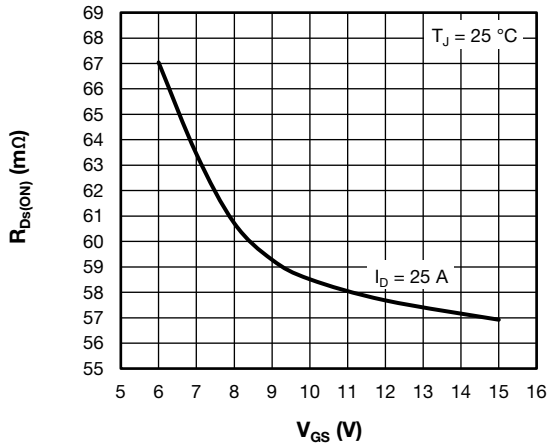


Fig. 7 - Typical Drain-State Resistance vs. Gate-to-Source Voltage

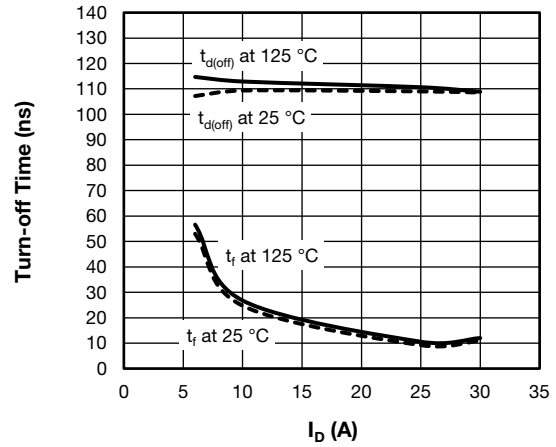


Fig. 10 - Typical Turn-off Switching Time vs.  $I_D$   
 $V_{DD} = 300\text{ V}$ ,  $R_g = 4.7\ \Omega$ ,  $V_{GS} = \pm 10\text{ V}$ ,  $L = 500\ \mu\text{H}$

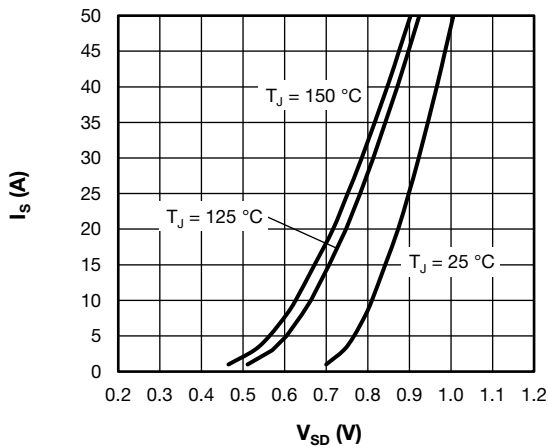


Fig. 8 - Typical Body Diode Source-to-Drain Current Characteristics

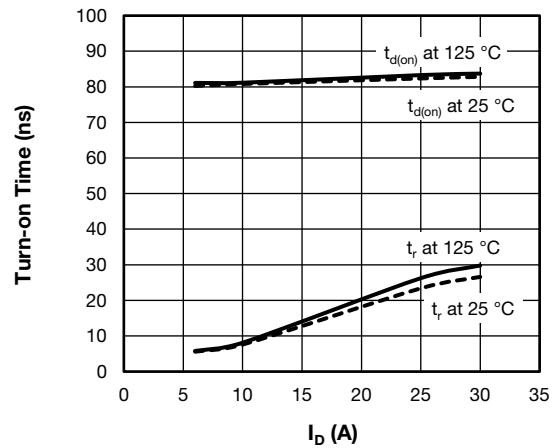


Fig. 11 - Typical Turn-on Switching Time vs.  $I_D$   
 $V_{DD} = 300\text{ V}$ ,  $R_g = 4.7\ \Omega$ ,  $V_{GS} = \pm 10\text{ V}$ ,  $L = 500\ \mu\text{H}$

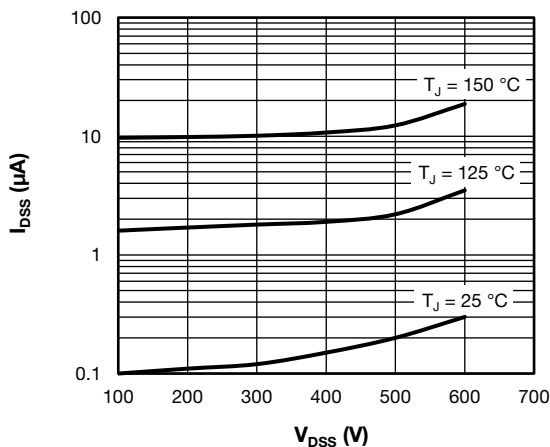


Fig. 9 - Typical Zero Gate Voltage Drain Current

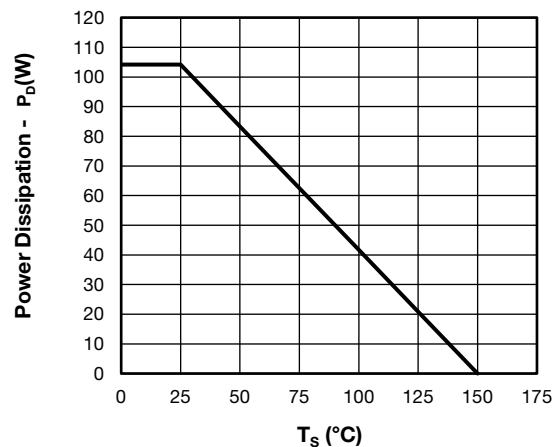


Fig. 12 - Power Dissipation Curve

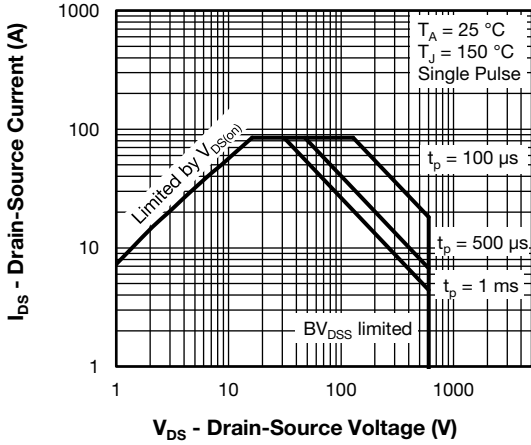


Fig. 13 - Safe Operating Area

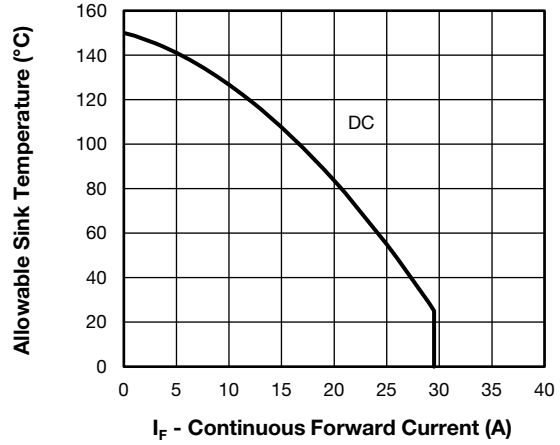


Fig. 16 - Maximum Da1-Da2 Diode Continuous Forward Current vs. Sink Temperature

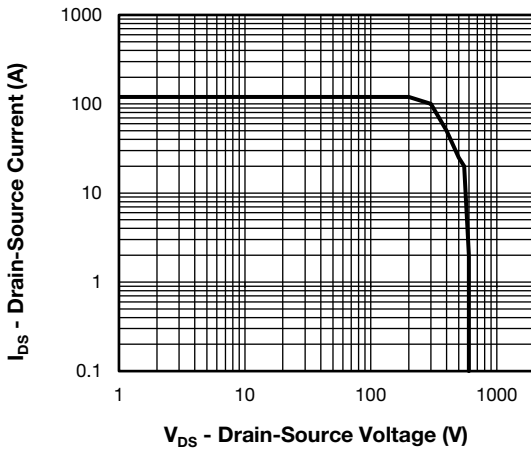


Fig. 14 - Reverse BIAS SOA

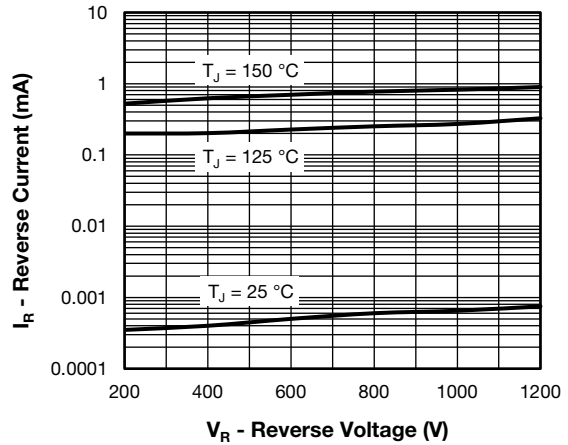


Fig. 17 - Typical Da1-Da2 Diode Reverse Leakage Current

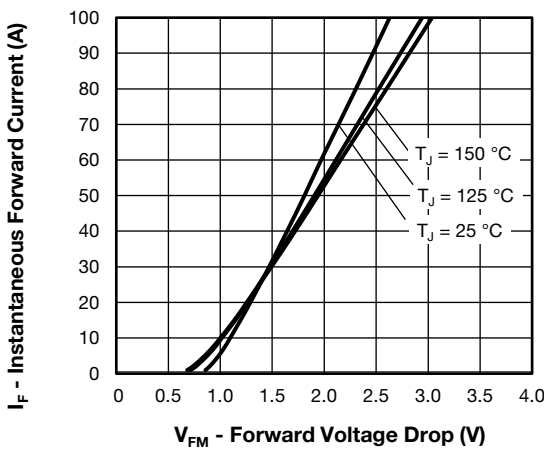


Fig. 15 - Typical Da1-Da2 Diode Forward Characteristics

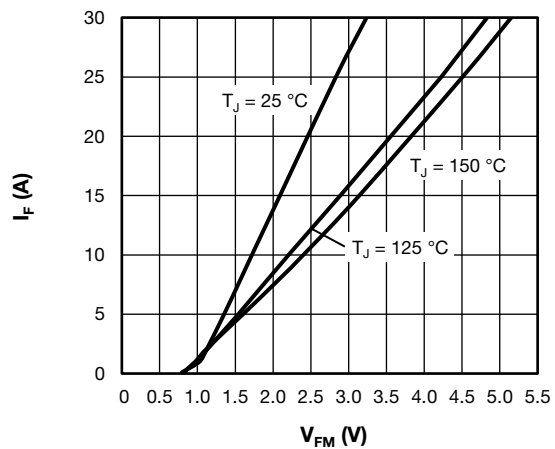


Fig. 18 - Typical D1-D4 Clamp Diode Forward Characteristics

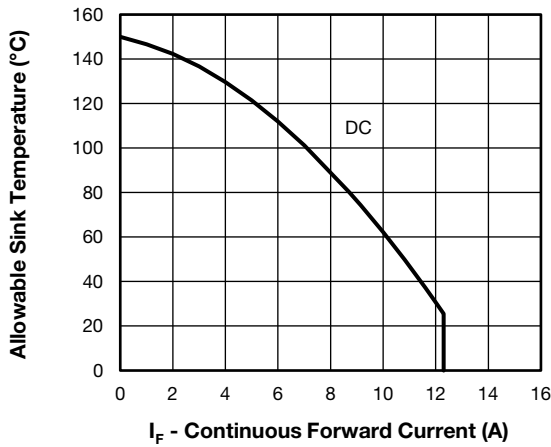


Fig. 19 - Maximum D1-D4 Clamp Diode Continuous Forward Current vs. Sink Temperature

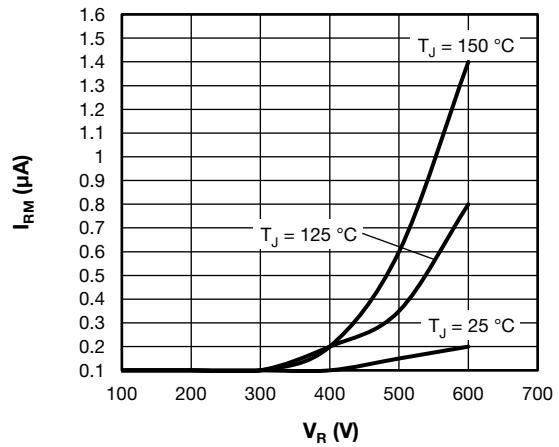


Fig. 20 - Typical D1-D4 Clamp Diode Reverse Leakage Current

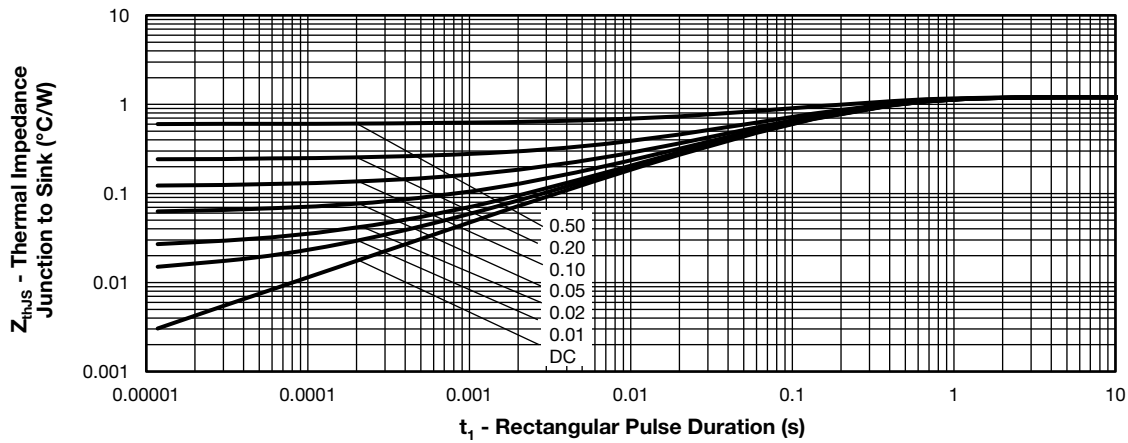


Fig. 21 - Maximum Thermal Impedance  $Z_{thJS}$  Characteristics - (Q1-Q4 MOSFET)

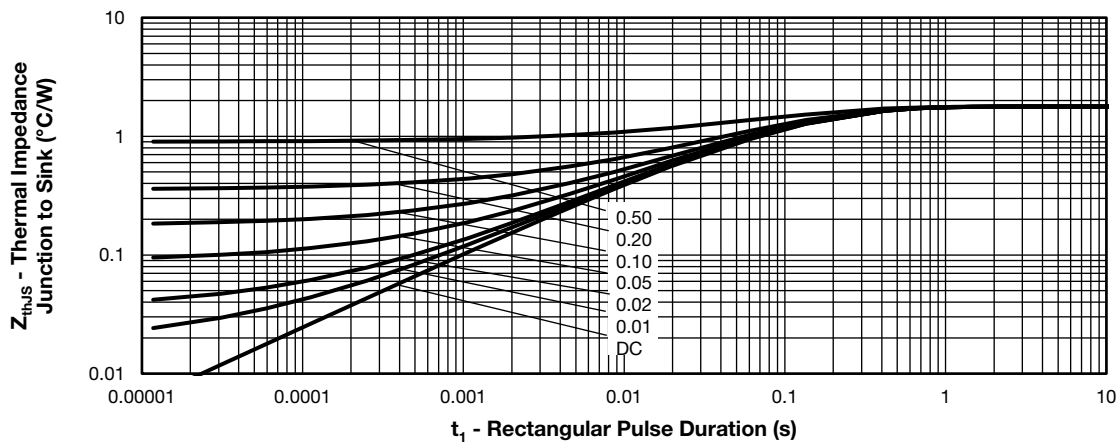


Fig. 22 - Maximum Thermal Impedance  $Z_{thJS}$  Characteristics - (Da1-Da2 Diode)

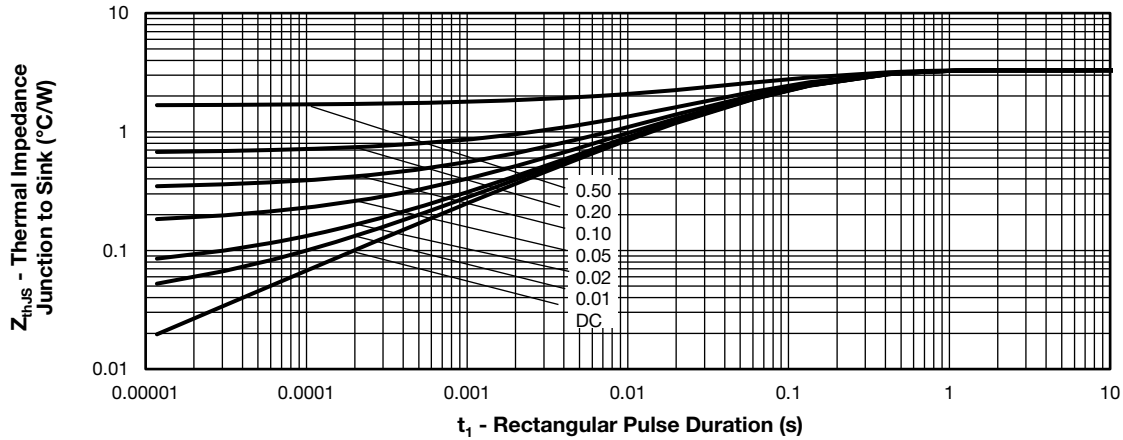


Fig. 23 - Maximum Thermal Impedance  $Z_{thJS}$  Characteristics - (D1-D4 Clamp Diode)

**ORDERING INFORMATION TABLE**

|             |            |           |          |            |          |           |          |
|-------------|------------|-----------|----------|------------|----------|-----------|----------|
| Device code | <b>VS-</b> | <b>EN</b> | <b>Z</b> | <b>025</b> | <b>C</b> | <b>60</b> | <b>N</b> |
|             | ①          | ②         | ③        | ④          | ⑤        | ⑥         | ⑦        |

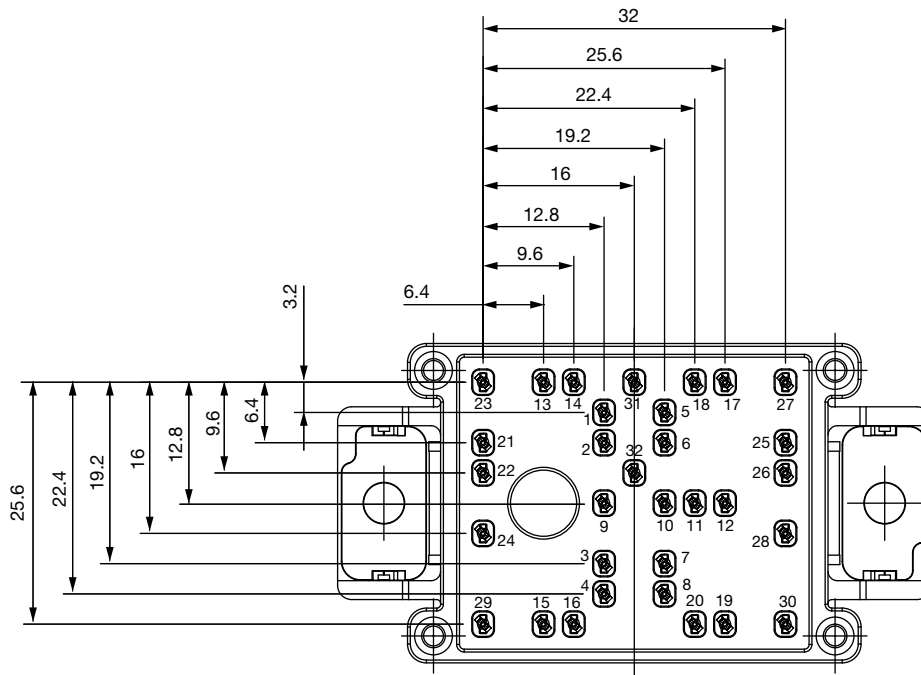
- 1** - Vishay Semiconductors product
- 2** - Package indicator (EN = EMIPAK 1B)
- 3** - Circuit configuration (Z = Double interleaved bridgless PFC (4 x channels) with individual return diodes)
- 4** - Current rating (025 = 25 A)
- 5** - Switch die technology (C = PowerMOS)
- 6** - Voltage rating (60 = 600 V)
- 7** - Diode die technology





| CIRCUIT CONFIGURATION   |                            |                 |
|---|----------------------------|-----------------|
| CIRCUIT   | CIRCUIT CONFIGURATION CODE | CIRCUIT DRAWING |
| Double interleaved<br>bridgless PFC (4 x channels)<br>with individual return diodes | Z                          |                 |

**PACKAGE**

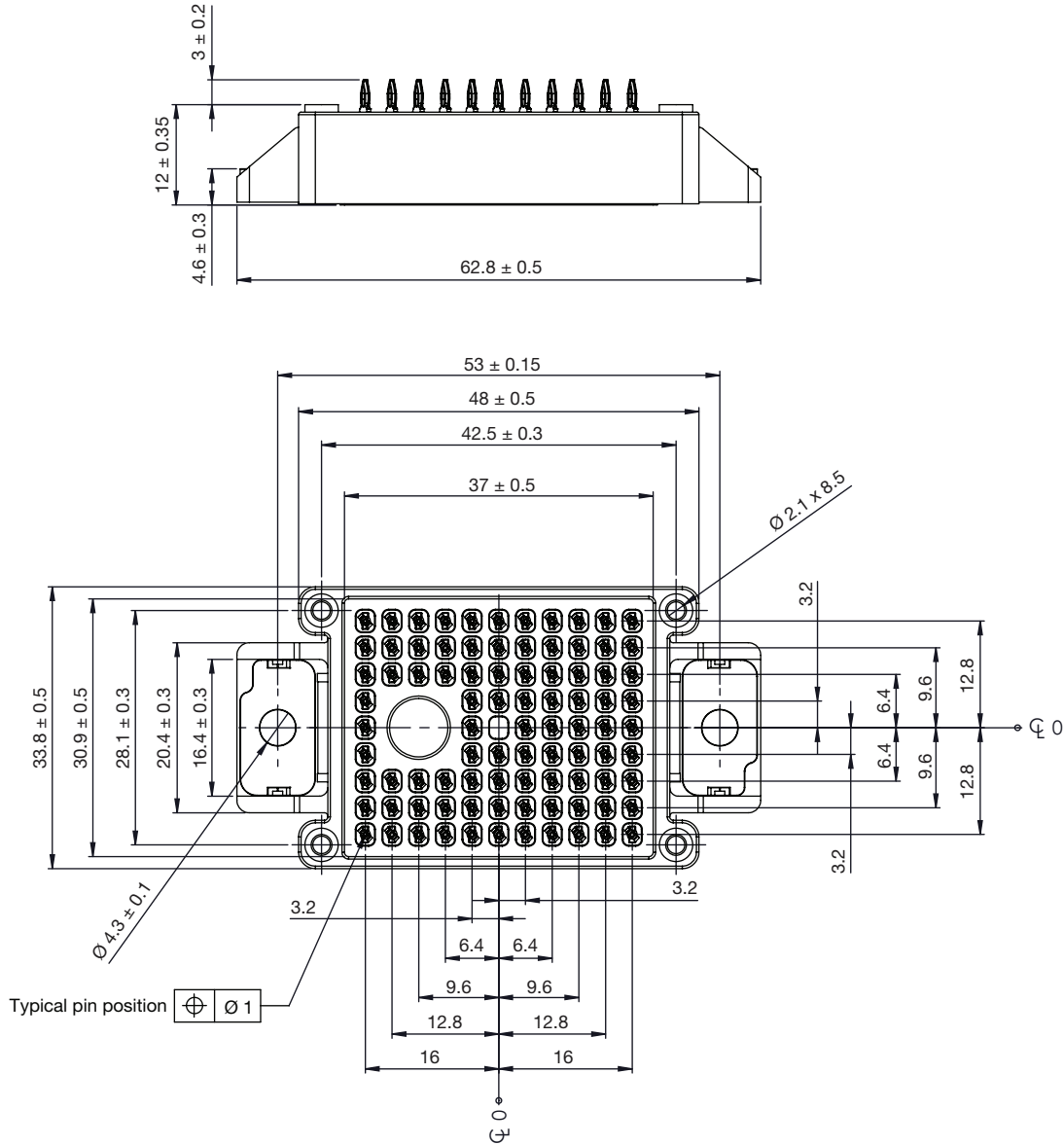


| LINKS TO RELATED DOCUMENTS |  |
|----------------------------|--|
| Dimensions                 | <a href="http://www.vishay.com/doc?95558">www.vishay.com/doc?95558</a> |
| Application Note           | <a href="http://www.vishay.com/doc?95580">www.vishay.com/doc?95580</a> |



## EMIPAK-1B PressFit

**DIMENSIONS** in millimeters





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