# EMIPAK-2B PressFit Power Module Double Interleaved Boost Converter, 15 A

**EMIPAK-2B (package example)**

| PRODUCT SUMMARY | |
|---|---|
| **RECTIFIER BYPASS DIODE** | |
| $V_{RRM}$ | 1200 V |
| $V_{FM}$ typical at $I_F$ = 20 A | 1.04 V |
| $I_F$ at $T_C$ = 80 °C | 62 A |
| **PFC IGBT** | |
| $V_{CES}$ | 1200 V |
| $V_{CE(ON)}$ typical at $I_C$ = 15 A | 2.61 V |
| $I_C$ at $T_C$ = 80 °C | 15 A |
| Speed (max.) | 20 kHz |
| Speed | 8 kHz to 30 kHz |
| Package | EMIPAK-2B |
| Circuit | Double interleaved boost converter |

## FEATURES

RoHS COMPLIANT

- Trench IGBT technology
- HEXFRED clamping diode technology
- Rectifier bypass diode
- PressFit pins technology
- Exposed $Al_2O_3$ substrate with low thermal resistance
- Integrated thermistor
- 10 μs short circuit capability
- Square RBSOA
- Low internal inductances
- Low switching loss
- PressFit pins locking technology. Patent # US.263.820 B2
- UL approved file E78996
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

## DESCRIPTION

VS-ETL015Y120H is an integrated solution for a double interleaved boost converter. The EMIPAK-2B package is easy to use thanks to the PressFit pins and the exposed substrate provides improved thermal performance. The optimized layout also helps to minimize stray parameters, allowing for better EMI performance.

| ABSOLUTE MAXIMUM RATINGS | | | | |
|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MAX.** | **UNITS** |
| Operating junction temperature | $T_J$ | | 150 | °C |
| Storage temperature range | $T_{Stg}$ | | -40 to +150 | |
| RMS isolation voltage | $V_{ISOL}$ | $T_J$ = 25 °C, all terminals shorted, f = 50 Hz, t = 1 s | 3500 | V |
| **DbpA - DbpB BYPASS DIODE** | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | 1200 | V |
| Continuous output current | $I_F$ | $T_C$ = 25 °C | 94 | A |
| | | $T_C$ = 80 °C | 62 | |
| | | $T_{SINK}$ = 80 °C | 39 | |
| Surge current (non- repetitive) | $I_{FSM}$ | Rated $V_{RRM}$ applied | 250 | |
| Power dissipation | $P_D$ | $T_C$ = 25 °C | 167 | W |
| | | $T_C$ = 80 °C | 93 | |

**PATENT(S): www.vishay.com/patents**
**This Vishay product is protected by one or more United States and International patents.**

## ABSOLUTE MAXIMUM RATINGS

| PARAMETER | SYMBOL | TEST CONDITIONS | MAX. | UNITS |
|---|---|---|---|---|
| **Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT** | | | | |
| Collector to emitter voltage | $V_{CES}$ | | 1200 | V |
| Gate to emitter voltage | $V_{GES}$ | | 20 | |
| Pulsed collector current | $I_{CM}$ | | 40 | A |
| Clamped inductive load current | $I_{LM}$ (1) | | 40 | |
| Continuous collector current | $I_C$ | $T_C$ = 25 °C | 22 | A |
| | | $T_C$ = 80 °C | 15 | |
| | | $T_{SINK}$ = 80 °C | 11 | |
| Power dissipation | $P_D$ | $T_C$ = 25 °C | 89 | W |
| | | $T_C$ = 80 °C | 50 | |
| **Da1 - Da2 - Db1 - Db2 CLAMPING DIODE** | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | 1200 | V |
| Single pulse forward current | $I_{FSM}$ | 10 ms sine or 6 ms rectangular pulse, $T_J$ = 25 °C | 95 | A |
| Diode continuous forward current | $I_F$ | $T_C$ = 25 °C | 22 | |
| | | $T_C$ = 80 °C | 14 | |
| | | $T_{SINK}$ = 80 °C | 10 | |
| Power dissipation | $P_D$ | $T_C$ = 25 °C | 80 | W |
| | | $T_C$ = 80 °C | 45 | |
| **DTa1 - DTa2 - DTb1 - DTb2 AP DIODE** | | | | |
| Single pulse forward current | $I_{FSM}$ | 10 ms sine or 6 ms rectangular pulse, $T_J$ = 25 °C | 95 | A |
| Diode continuous forward current | $I_F$ | $T_C$ = 25 °C | 22 | |
| | | $T_C$ = 80 °C | 14 | |
| | | $T_{SINK}$ = 80 °C | 10 | |
| Power dissipation | $P_D$ | $T_C$ = 25 °C | 80 | W |
| | | $T_C$ = 80 °C | 45 | |

**Notes**

- Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur.

(1) $V_{CC}$ = 600 V, $V_{GE}$ = 15 V, L = 500 μH, $R_g$ = 4.7 Ω, $T_J$ = 150 °C

## ELECTRICAL SPECIFICATIONS ($T_J$ = 25 °C unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|---|
| **DbpA - DbpB BYPASS DIODE** | | | | | | |
| Reverse leakage current | $I_{RRM}$ | $V_{RRM}$ = 1200 V | - | - | 0.14 | mA |
| | | $V_{RRM}$ = 1200 V, $T_J$ = 150 °C | - | - | 3.0 | |
| Forward voltage drop | $V_{FM}$ | $I_F$ = 20 A | - | 1.04 | 1.23 | V |
| | | $I_F$ = 20 A, $T_J$ = 150 °C | - | 0.95 | - | |
| Forward slope resistance | rt | $T_J$ = 150 °C | - | - | 6.6 | mΩ |
| Conduction threshold voltage | $V_T$ | | - | - | 0.73 | V |
| **Ta1 - Ta2 -Tb1 - Tb2 PFC IGBT** | | | | | | |
| Collector to emitter breakdown voltage | $BV_{CES}$ | $V_{GE}$ = 0 V, $I_C$ = 250 μA | 1200 | - | - | V |
| Collector to emitter voltage | $V_{CE(ON)}$ | $V_{GE}$ = 15 V, $I_C$ = 15 A | - | 2.61 | 3.03 | |
| | | $V_{GE}$ = 15 V, $I_C$ = 15 A, $T_J$ = 125 °C | - | 3.05 | - | |
| Gate threshold voltage | $V_{GE(th)}$ | $V_{CE}$ = $V_{GE}$, $I_C$ = 400 μA | 4.5 | 5.8 | 8.1 | |
| Temperature coefficient of threshold voltage | $\Delta V_{GE(th)}/\Delta T_J$ | $V_{CE}$ = $V_{GE}$, $I_C$ = 1.0 mA (25 °C to 125 °C) | - | -14 | - | mV/°C |
| Forward transconductance | $g_{fe}$ | $V_{CE}$ = 20 V, $I_C$ = 15 A | - | 8 | - | S |
| Transfer characteristics | $V_{GE}$ | $V_{CE}$ = 20 V, $I_C$ = 15 A | - | 10 | - | V |
| Zero gate voltage collector current | $I_{CES}$ | $V_{GE}$ = 0 V, $V_{CE}$ = 1200 V | - | 0.0003 | 0.075 | mA |
| | | $V_{GE}$ = 0 V, $V_{CE}$ = 1200 V, $T_J$ = 125 °C | - | 0.24 | - | |
| Gate to emitter leakage current | $I_{GES}$ | $V_{GE}$ = ± 20 V, $V_{CE}$ = 0 V | - | - | ± 200 | nA |

| ELECTRICAL SPECIFICATIONS ($T_J$ = 25 °C unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **Da1 - Da2 - Db1 - Db2 CLAMPING DIODE** | | | | | | |
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| Cathode to anode blocking voltage | $V_{BR}$ | $I_R$ = 100 μA | 1200 | - | - | V |
| Forward voltage drop | $V_{FM}$ | $I_F$ = 10 A | - | 2.09 | 2.77 | V |
| | | $I_F$ = 10 A, $T_J$ = 125 °C | - | 2.16 | - | |
| Reverse leakage current | $I_{RM}$ | $V_R$ = 1200 V | - | 0.0004 | 0.075 | mA |
| | | $V_R$ = 1200 V, $T_J$ = 125 °C | - | 0.25 | - | |
| **DTa1 - DTa2 - DTb1 - DTb2 AP DIODE** | | | | | | |
| Forward voltage drop | $V_{FM}$ | $I_F$ = 20 A | - | 2.59 | 3.25 | V |
| | | $I_F$ = 20 A $T_J$ = 125 °C | - | 2.86 | - | |

| SWITCHING CHARACTERISTICS ($T_J$ = 25 °C unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| **PFC IGBT (WITH FREEWHEELING CLAMPING DIODE)** | | | | | | |
| Total gate charge (turn-on) | $Q_g$ | $I_C$ = 9 A<br>$V_{CC}$ = 600 V<br>$V_{GE}$ = 15 V | - | 45 | - | nC |
| Gate to emitter charge (turn-on) | $Q_{ge}$ | | - | 8.7 | - | |
| Gate to collector charge (turn-on) | $Q_{gc}$ | | - | 20 | - | |
| Turn-on switching loss | $E_{ON}$ | $I_C$ = 15 A<br>$V_{CC}$ = 600 V<br>$V_{GE}$ = 15 V<br>$R_g$ = 4.7 Ω<br>L = 500 μH (1) | - | 0.95 | - | mJ |
| Turn-off switching loss | $E_{OFF}$ | | - | 0.47 | - | |
| Total switching loss | $E_{TOT}$ | | - | 1.42 | - | |
| Turn-on delay time | $t_{d(on)}$ | | - | 23 | - | ns |
| Rise time | $t_r$ | | - | 22 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 58 | - | |
| Fall time | $t_f$ | | - | 178 | - | |
| Turn-on switching loss | $E_{ON}$ | $I_C$ = 15 A<br>$V_{CC}$ = 600 V<br>$V_{GE}$ = 15 V<br>$R_g$ = 4.7 Ω<br>L = 500 μH<br>$T_J$ = 125 °C (1) | - | 1.18 | - | mJ |
| Turn-off switching loss | $E_{OFF}$ | | - | 0.72 | - | |
| Total switching loss | $E_{TOT}$ | | - | 1.89 | - | |
| Turn-on delay time | $t_{d(on)}$ | | - | 24 | - | ns |
| Rise time | $t_r$ | | - | 23 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 60 | - | |
| Fall time | $t_f$ | | - | 219 | - | |
| Input capacitance | $C_{ies}$ | $V_{GE}$ = 0 V<br>$V_{CC}$ = 30 V<br>f = 1 MHz | - | 1070 | | pF |
| Output capacitance | $C_{oes}$ | | - | 63 | | |
| Reverse transfer capacitance | $C_{res}$ | | - | 26 | | |
| Reverse bias safe operating area | RBSOA | $T_J$ = 150 °C, $I_C$ = 40 A, $V_{CC}$ = 600 V,<br>$V_P$ = 1200 V, $R_g$ = 4.7 Ω, $V_{GE}$ = 15 V to 0 V | | Fullsquare | | |
| Short circuit safe operating area | SCSOA | $R_g$ = 22 Ω, $V_{CC}$ = 900 V, $V_P$ = 1200 V<br>$V_{GE}$ = 15 V to 0 | - | - | 10 | μs |
| **Da1 - Da2 - Db1 - Db2 CLAMPING DIODE** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $V_R$ = 400 V<br>$I_F$ = 10 A<br>dI/dt = 500 A/μs | - | 103 | - | ns |
| Diode peak reverse current | $I_{rr}$ | | - | 14 | - | A |
| Diode recovery charge | $Q_{rr}$ | | - | 711 | - | nC |
| Diode reverse recovery time | $t_{rr}$ | $V_R$ = 400 V<br>$I_F$ = 10 A<br>dI/dt = 500 A/μs, $T_J$ = 125 °C | - | 126 | - | ns |
| Diode peak reverse current | $I_{rr}$ | | - | 17 | - | A |
| Diode recovery charge | $Q_{rr}$ | | - | 1047 | - | nC |

| SWITCHING CHARACTERISTICS ($T_J$ = 25 °C unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| **DTa1 - DTa2 - DTb1 - DTb2 AP DIODE** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $V_R$ = 400 V<br>$I_F$ = 20 A<br>dI/dt = 500 A/μs | - | 127 | - | ns |
| Diode peak reverse current | $I_{rr}$ | | - | 16 | - | A |
| Diode recovery charge | $Q_{rr}$ | | - | 1020 | - | nC |
| Diode reverse recovery time | $t_{rr}$ | $V_R$ = 400 V<br>$I_F$ = 20 A<br>dI/dt = 500 A/μs, $T_J$ = 125 °C | - | 153 | - | ns |
| Diode peak reverse current | $I_{rr}$ | | - | 19 | - | A |
| Diode recovery charge | $Q_{rr}$ | | - | 1464 | - | nC |

**Note**

(1) Energy losses include "tail" and diode reverse recovery.

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

| THERMAL AND MECHANICAL SPECIFICATIONS | | | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| DbpA - DbpB Bypass diode - Junction to case thermal resistance (per diode) | $R_{thJC}$ | - | - | 0.75 | °C/W |
| Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT - Junction to case thermal resistance (per switch) | | - | - | 1.4 | |
| Da1 - Da2 - Db1 - Db2 Clamping diode - Junction to case thermal resistance (per diode) | | - | - | 1.56 | |
| DTa1 - DTa2 - DTb1 - DTb2 AP diode - Junction to case thermal resistance (per diode) | | - | - | 1.56 | |
| DbpA - DbpB Bypass diode - Case to sink thermal resistance (per diode) | $R_{thCS}$ (1) | - | 0.63 | - | |
| Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT - Case to sink thermal resistance (per switch) | | - | 0.96 | - | |
| Da1 - Da2 - Db1 - Db2 Clamping diode - Case to sink thermal resistance (per diode) | | - | 1.1 | - | |
| DTa1 - DTa2 - DTb1 - DTb2 AP diode - Case to sink thermal resistance (per diode) | | - | 1.1 | - | |
| Case to sink thermal resistance per module | | - | 0.1 | - | |
| Mounting torque (M4) | | 2 | - | 3 | Nm |
| Weight | | - | 45 | - | g |

**Note**

(1) Mounting surface flat, smooth, and greased

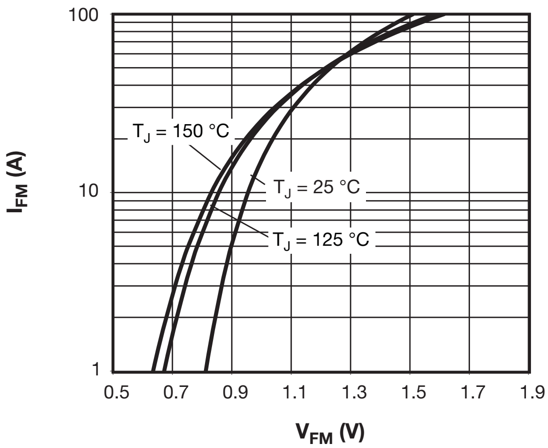



Fig. 1 - Typical DbpA -DbpB Bypass Diode Forward Characteristics

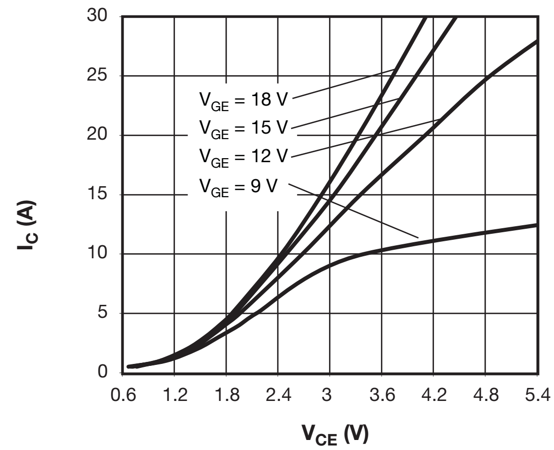



Fig. 4 - Typical Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT Output Characteristics, $T_J$ = 125 °C

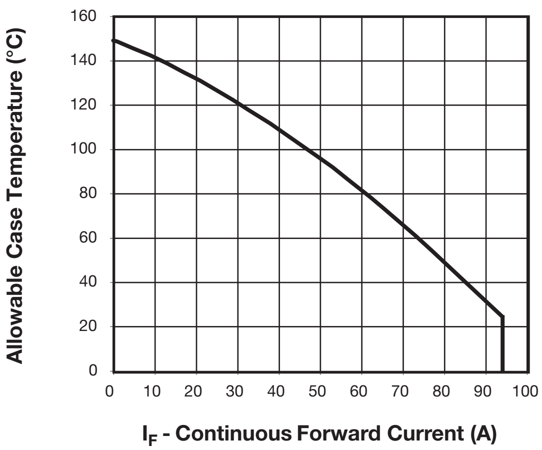



Fig. 2 - Maximum DbpA -DbpB Bypass Diode Forward Current vs. Case Temperature

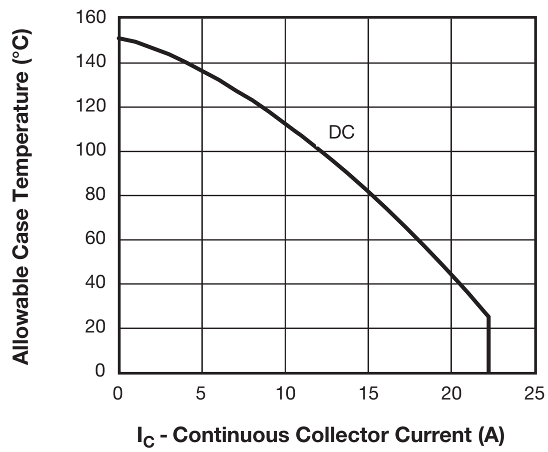



Fig. 5 - Maximum Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT Continuous Collector Current vs. Case Temperature

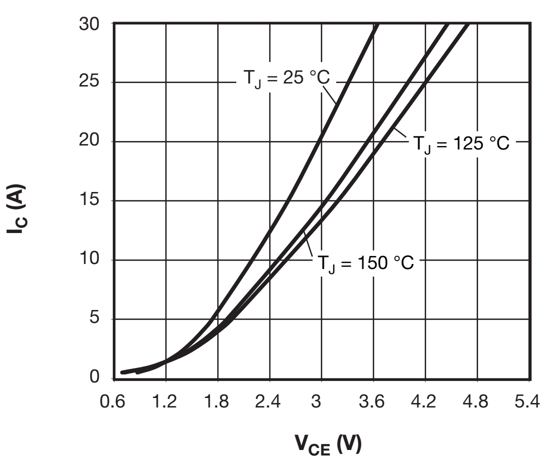



Fig. 3 - Typical Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT Output Characteristics, $V_{GE}$ = 15 V

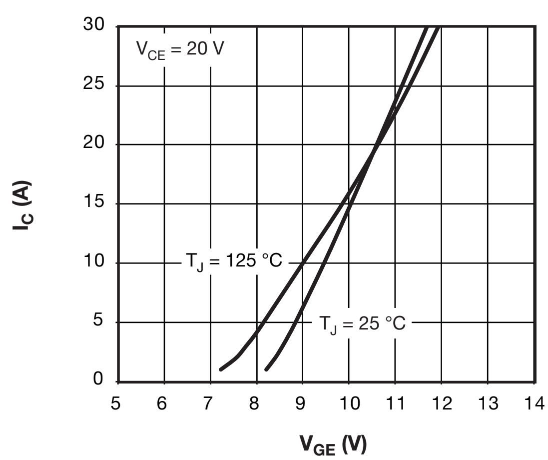



Fig. 6 - Typical Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT Transfer Characteristics

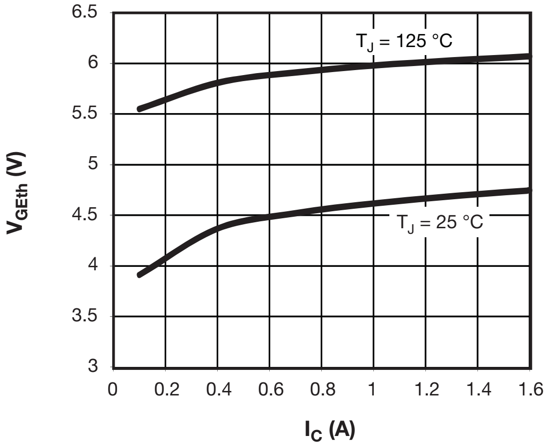



Fig. 7 - Typical Q1 - Q4 Trench IGBT Energy Loss vs. $I_C$
(with D5 - D6 Clamping Diode)
$T_J$ = 125 °C, $V_{CC}$ = 300 V, $R_g$ = 4.7 Ω, $V_{GE}$ = 15 V, L = 500 µH

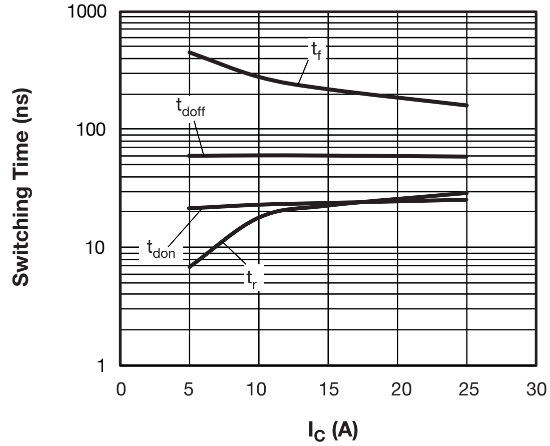



Fig. 10 - Typical PFC IGBT Switching Time vs. $I_C$
(with Freewheeling Clamping Diode)
$T_J$ = 125 °C, $V_{CC}$ = 600 V, $R_g$ = 4.7 Ω, $V_{GE}$ = 15 V, L = 500 µH

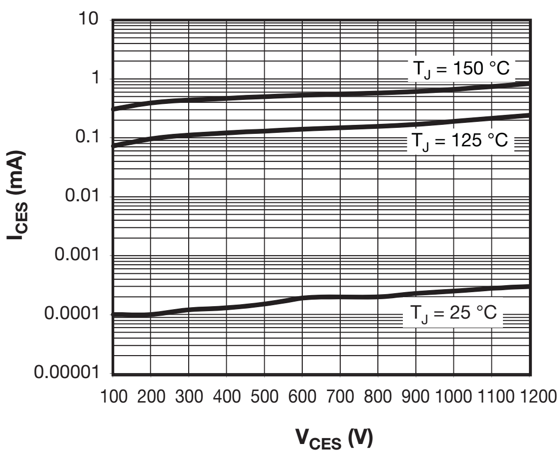



Fig. 8 - Typical Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT
Zero Gate Voltage Collector Current

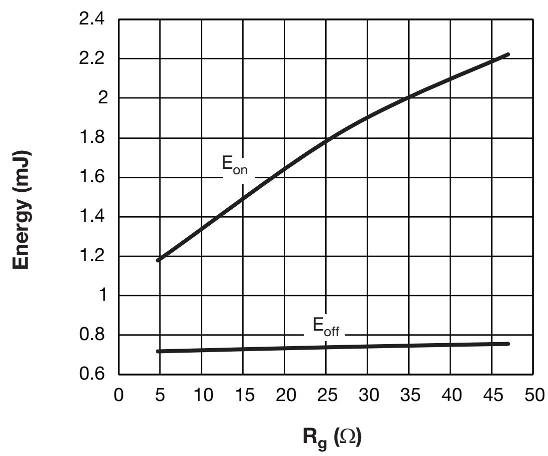



Fig. 11 - Typical PFC IGBT Energy Loss vs. $R_g$
(with Freewheeling Clamping Diode)
$T_J$ = 125 °C, $V_{CC}$ = 600 V, $I_C$ = 15 A, $V_{GE}$ = 15 V, L = 500 µH

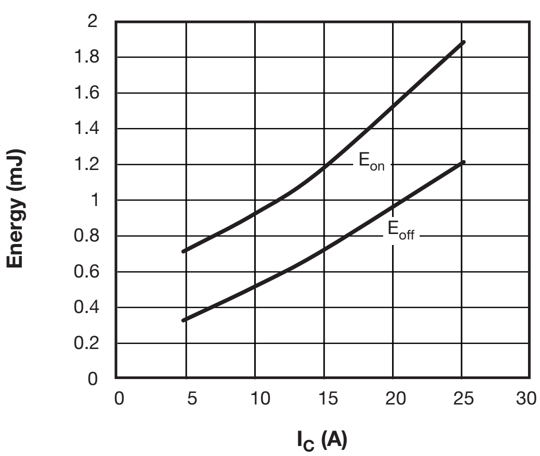



Fig. 9 - Typical PFC IGBT Energy Loss vs. $I_C$
(with Freewheeling Clamping Diode)
$T_J$ = 125 °C, $V_{CC}$ = 600 V, $R_g$ = 4.7 Ω, $V_{GE}$ = 15 V, L = 500 µH

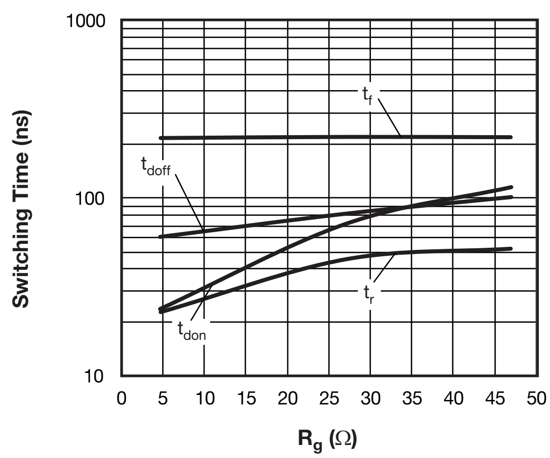



Fig. 12 - Typical PFC IGBT Switching Time vs. $R_g$
(with Freewheeling Clamping Diode)
$T_J$ = 125 °C, $V_{CC}$ = 600 V, $I_C$ = 15 A, $V_{GE}$ = 15 V, L = 500 µH

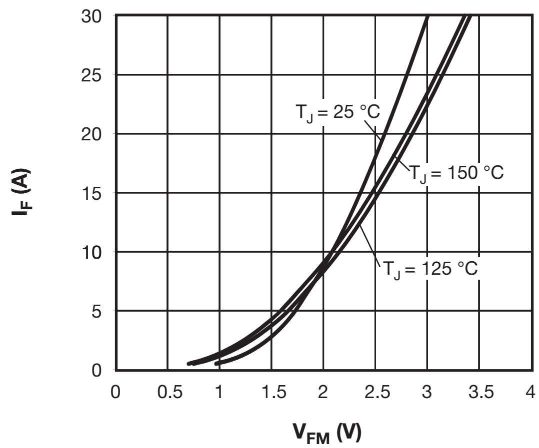



Fig. 13 - Typical Da1 - Da2 - Db1 - Db2 Clamping Diode Forward Characteristics

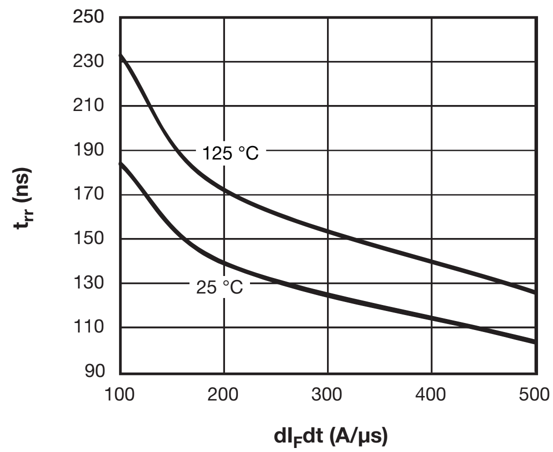



Fig. 16 - Typical Da1 - Da2 - Db1 - Db2 Clamping Diode Reverse Recovery Time vs. $dI_F/dt$, $V_{rr}$ = 400 V, $I_F$ = 10 A

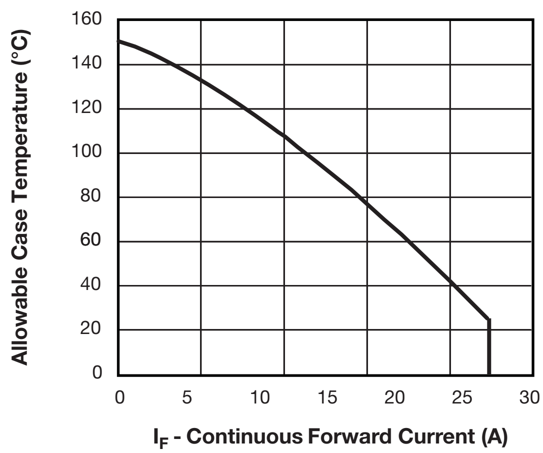



Fig. 14 - Maximum Da1 - Da2 - Db1 - Db2 Clamping Diode Forward Current vs. Case Temperature

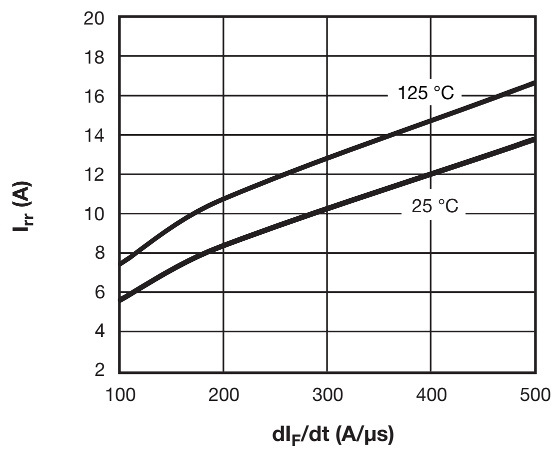



Fig. 17 - Typical Da1 - Da2 - Db1 - Db2 Clamping Diode Reverse Recovery Current vs. $dI_F/dt$, $V_{rr}$ = 400 V, $I_F$ = 10 A

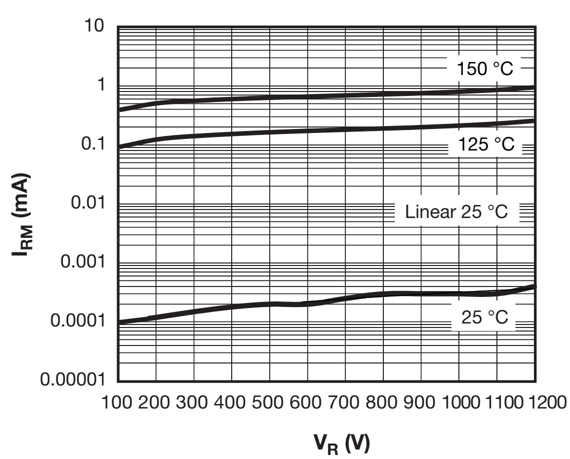



Fig. 15 - Typical Da1 - Da2 - Db1 - Db2 Clamping Diode Reverse Leakage Current

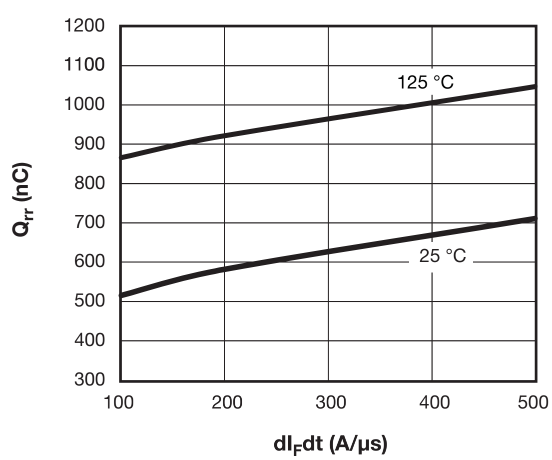



Fig. 18 - Typical Da1 - Da2 - Db1 - Db2 Clamping Diode Reverse Recovery Charge vs. $dI_F/dt$, $V_{rr}$ = 400 V, $I_F$ = 10 A

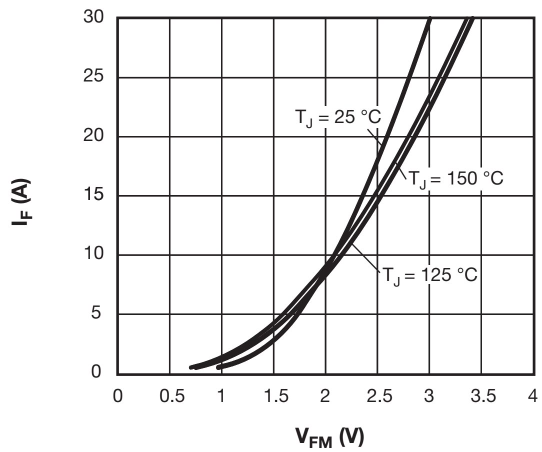



Fig. 19 - Typical DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode Forward Characteristics

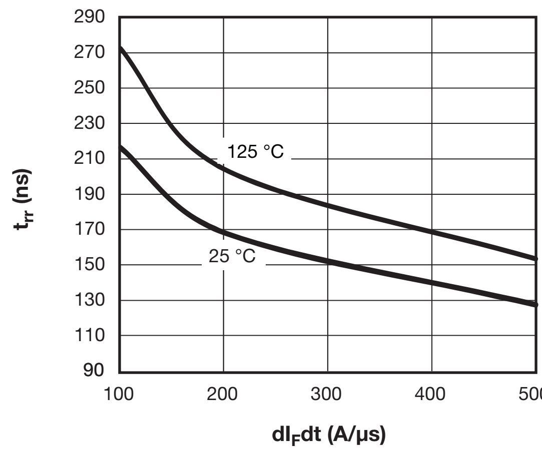



Fig. 21 - Typical DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode Reverse Recovery Time vs. $dI_F/dt$
$V_{rr}$ = 400 V, $I_F$ = 20 A

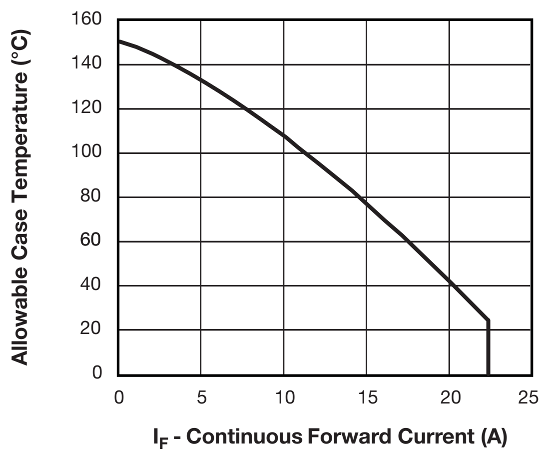



Fig. 20 - Maximum DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode Forward Current vs. Case Temperature

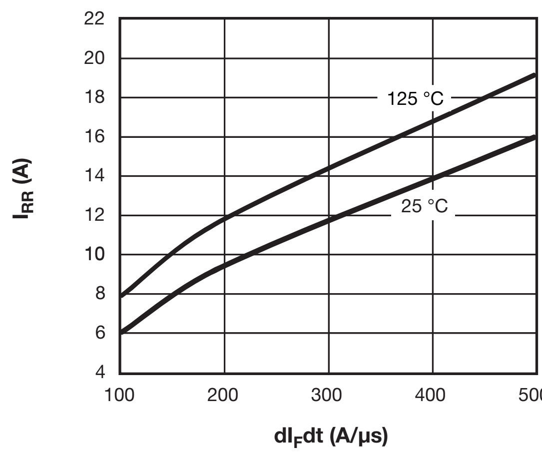



Fig. 22 - Typical DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode Reverse Recovery Current vs. $dI_F/dt$
$V_{rr}$ = 400 V, $I_F$ = 10 A

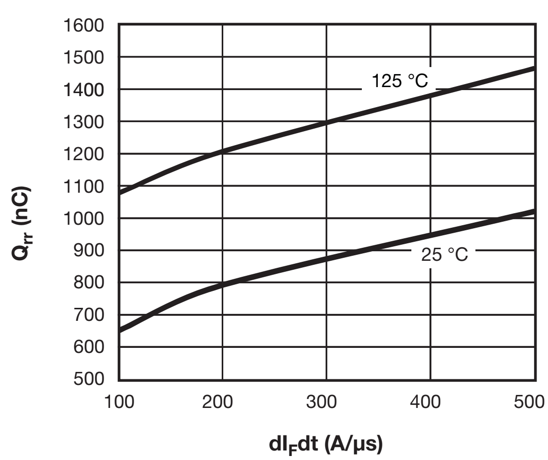



Fig. 23 - Typical DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode Reverse Recovery Charge vs. $dI_F/dt$
$V_{rr}$ = 400 V, $I_F$ = 20 A

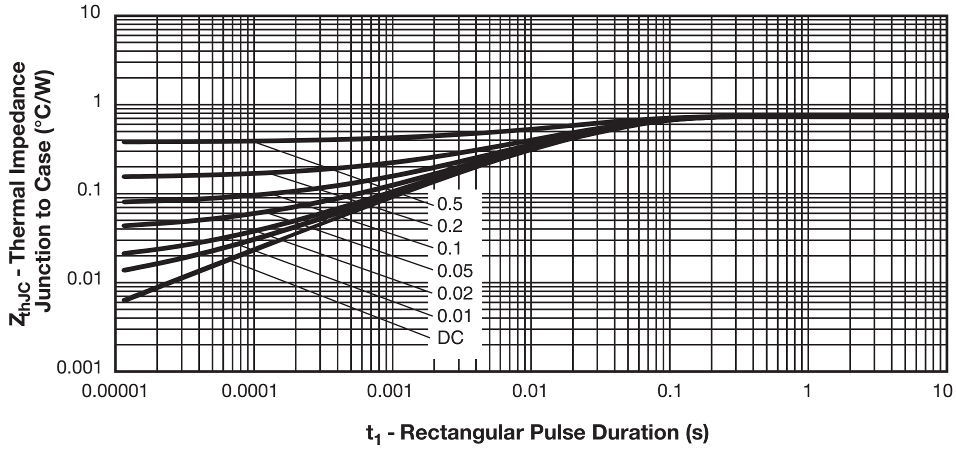



Fig. 24 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (DbPa - DbpB Bypass Diode)

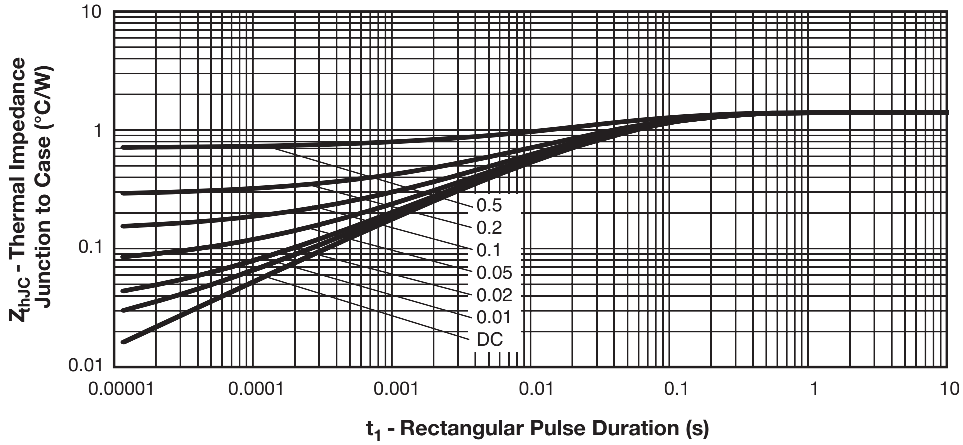



Fig. 25 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (Ta1 - Ta2 - Tb1 - Tb2 PFC IGBT)

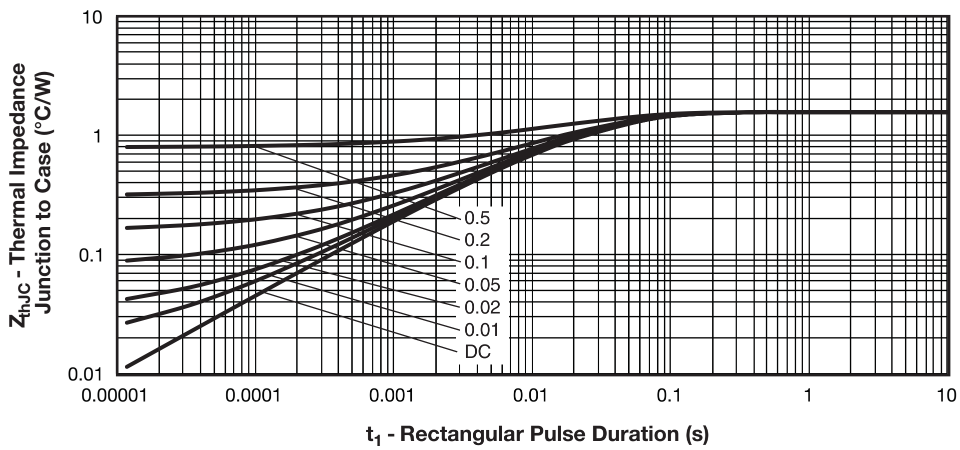



Fig. 26 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (Da1 - Da2 - Db1 - Db2 Clamping diode)

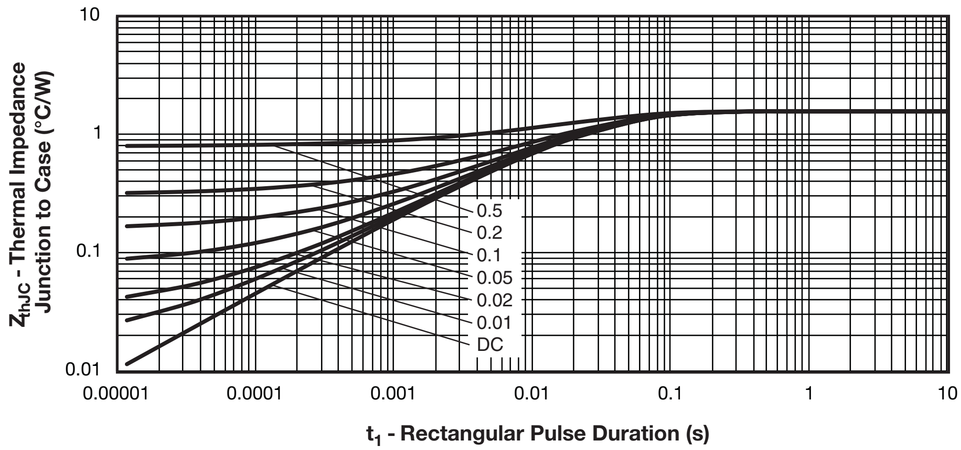


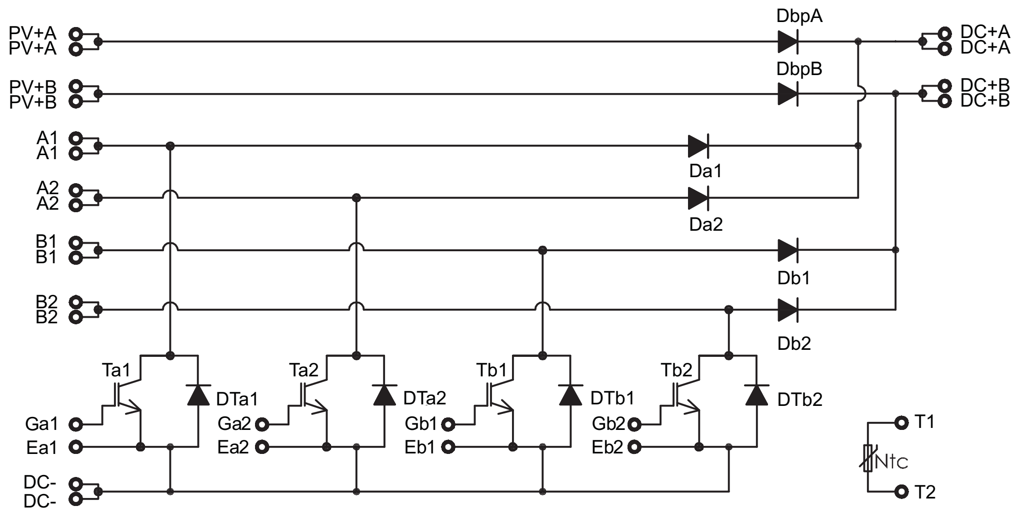

Fig. 27 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (DTa1 - DTa2 - DTb1 - DTb2 Antiparallel Diode)

## ORDERING INFORMATION TABLE

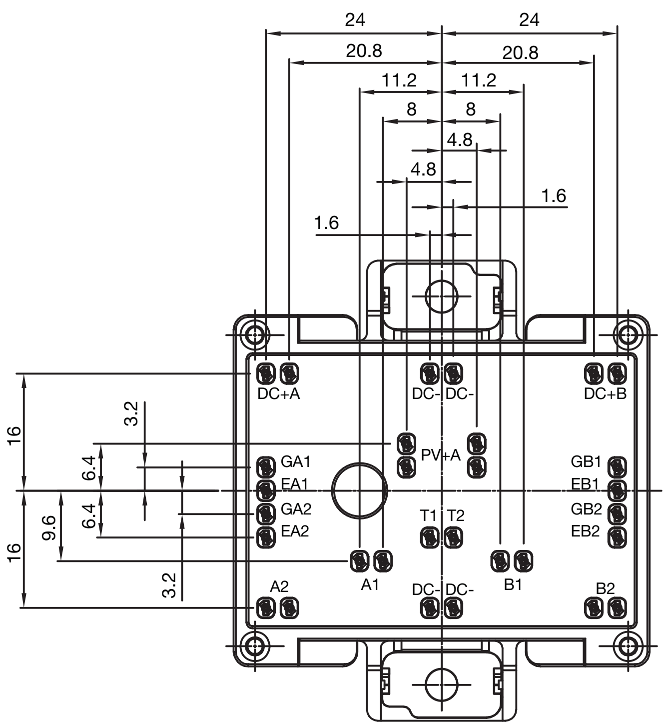
| Device code | VS- | ET | L | 015 | Y | 120 | H |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

1 - Vishay Semiconductors product
2 - Package indicator (ET = EMIPAK-2B)
3 - Circuit configuration (L = double interleaved boost converter)
4 - Current rating (015 = 15 A)
5 - Switch die technology (Y = trench IGBT)
6 - Voltage rating (120 = 1200 V)
7 - Diode die technology (H = HEXFRED diode)

## CIRCUIT CONFIGURATION



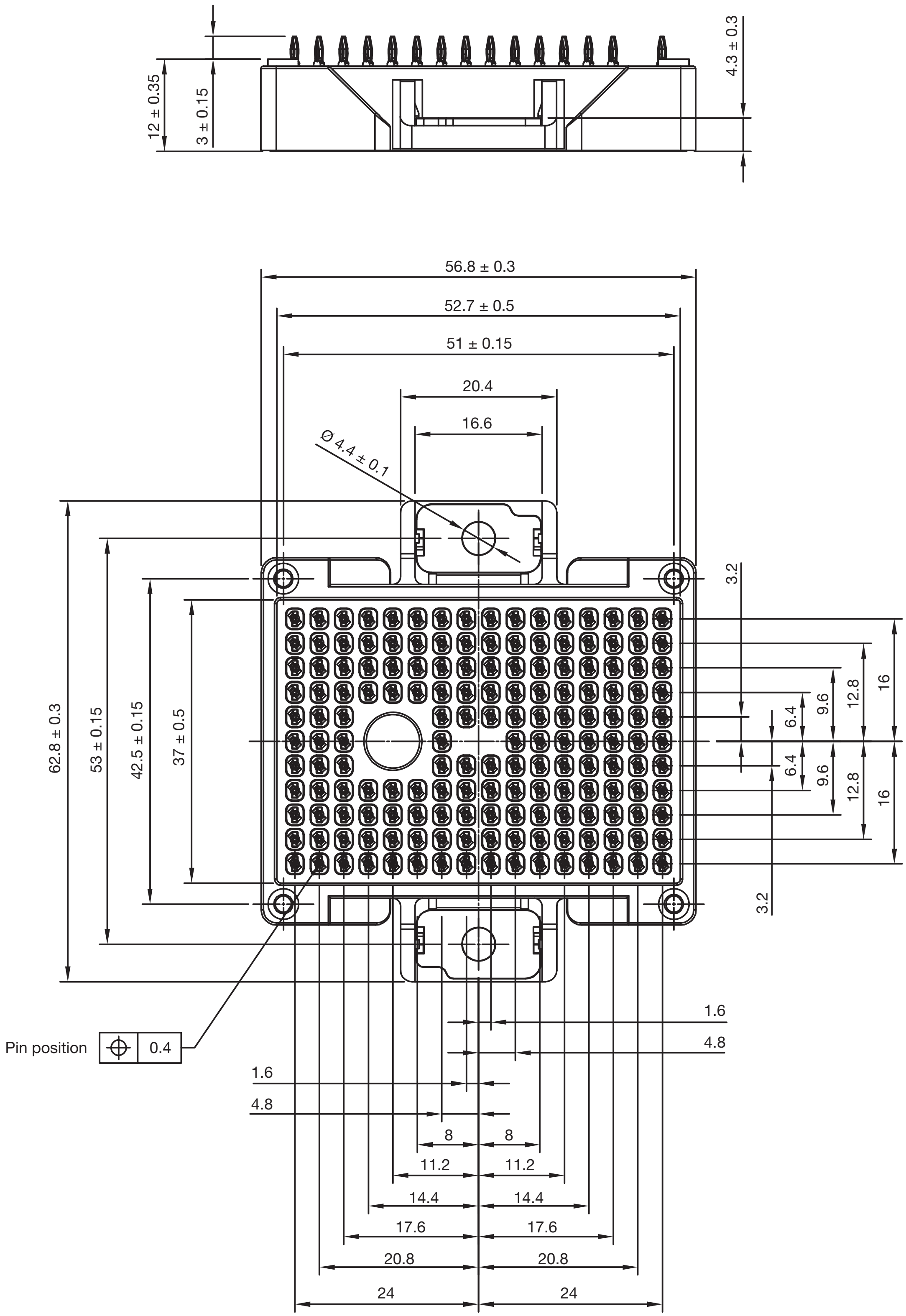

## PACKAGE




| LINKS TO RELATED DOCUMENTS | |
|---|---|
| Dimensions | www.vishay.com/doc?95559 |

# EMIPAK-2B PressFit

**DIMENSIONS** in millimeters



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