# IGBT SIP Module (Fast IGBT)

IMS-2

| PRIMARY CHARACTERISTICS | |
|---|---|
| **OUTPUT CURRENT IN A TYPICAL 5.0 kHz MOTOR DRIVE** | |
| $V_{CES}$ | 600 V |
| $I_{RMS}$ per phase (3.1 kW total) with $T_C$ = 90 °C | 11 $A_{RMS}$ |
| $T_J$ | 125 °C |
| Supply voltage | 360 $V_{DC}$ |
| Power factor | 0.8 |
| Modulation depth (see fig. 1) | 115 % |
| $V_{CE(on)}$ (typical) at $I_C$ = 8.7 A, 25 °C | 1.37 V |
| Speed | 1 kHz to 10 kHz |
| Package | SIP |
| Circuit configuration | Three phase inverter |

## FEATURES

- Fully isolated printed circuit board mount package
- Switching-loss rating includes all "tail" losses
- HEXFRED® soft ultrafast diodes
- Optimized for medium speed 1 kHz to 10 kHz, see fig. 1 for current vs. frequency curve
- Designed and qualified for industrial level
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

## DESCRIPTION

The IGBT technology is the key to Vishay's Semiconductors advanced line of IMS (insulated metal substrate) power modules. These modules are more efficient than comparable bipolar transistor modules, while at the same time having the simpler gate-drive requirements of the familiar power MOSFET. This superior technology has now been coupled to a state of the art materials system that maximizes power throughput with low thermal resistance. This package is highly suited to motor drive applications and where space is at a premium.

**ABSOLUTE MAXIMUM RATINGS**

| PARAMETER | SYMBOL | TEST CONDITIONS | MAX. | UNITS |
|---|---|---|---|---|
| Collector to emitter voltage | $V_{CES}$ | | 600 | V |
| Continuous collector current, each IGBT | $I_C$ | $T_C$ = 25 °C | 16 | A |
| | | $T_C$ = 100 °C | 8.7 | |
| Pulsed collector current | $I_{CM}$ (1) | | 50 | |
| Clamped inductive load current | $I_{LM}$ (2) | | 50 | |
| Diode continuous forward current | $I_F$ | $T_C$ = 100 °C | 6.1 | |
| Diode maximum forward current | $I_{FM}$ | | 50 | |
| Gate to emitter voltage | $V_{GE}$ | | ± 20 | V |
| Isolation voltage | $V_{ISOL}$ | Any terminal to case, t = 1 min | 2500 | $V_{RMS}$ |
| Maximum power dissipation, each IGBT | $P_D$ | $T_C$ = 25 °C | 36 | W |
| | | $T_C$ = 100 °C | 14 | |
| Operating junction and storage temperature range | $T_J$, $T_{Stg}$ | | -40 to +150 | °C |
| Soldering temperature | | For 10 s, (0.063" (1.6 mm) from case) | 300 | |
| Mounting torque | | 6-32 or M3 screw | 5 to 7 (0.55 to 0.8) | lbf · in (N · m) |

**Notes**

(1) Repetitive rating; $V_{GE}$ = 20 V, pulse width limited by maximum junction temperature (see fig. 20)

(2) $V_{CC}$ = 80 % ($V_{CES}$), $V_{GE}$ = 20 V, L = 10 μH, $R_g$ = 22 Ω (see fig. 19)



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| THERMAL AND MECHANICAL SPECIFICATIONS | | | | |
|---|---|---|---|---|
| PARAMETER | SYMBOL | TYP. | MAX. | UNITS |
| Junction to case, each IGBT, one IGBT in conduction | $R_{thJC}$ | - | 3.5 | °C/W |
| Junction to case, each DIODE, one DIODE in conduction | $R_{thJC}$ | - | 5.5 | |
| Case to sink, flat, greased surface | $R_{thCS}$ | 0.10 | - | |
| Weight of module | | 20 | - | g |
| | | 0.7 | - | oz. |

| ELECTRICAL SPECIFICATIONS ($T_J$ = 25 °C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNITS |
| Collector to emitter breakdown voltage | $V_{(BR)CES}$ (1) | $V_{GE}$ = 0 V, $I_C$ = 250 µA | 600 | - | - | V |
| Temperature coefficient of breakdown voltage | $\Delta V_{(BR)CES}/\Delta T_J$ | $V_{GE}$ = 0 V, $I_C$ = 1.0 mA | - | 0.69 | - | V/°C |
| Collector to emitter saturation voltage | $V_{CE(on)}$ | $I_C$ = 8.7 A; $V_{GE}$ = 15 V, see fig. 2, 5 | - | 1.37 | 1.5 | V |
| | | $I_C$ = 16 A; $V_{GE}$ = 15 V, see fig. 2, 5 | - | 1.63 | - | |
| | | $I_C$ = 8.7 A, $T_J$ = 150 °C; $V_{GE}$ = 15 V, see fig. 2, 5 | - | 1.37 | - | |
| Gate threshold voltage | $V_{GE(th)}$ | $V_{CE}$ = $V_{GE}$, $I_C$ = 250 µA | 3.0 | - | 6.0 | |
| Temperature coefficient of threshold voltage | $\Delta V_{GE(th)}/\Delta T_J$ | | - | - 11 | - | mV/°C |
| Forward transconductance | $g_{fe}$ (2) | $V_{CE}$ = 100 V, $I_C$ = 8.7 A | 6.0 | 8.0 | - | S |
| Zero gate voltage collector current | $I_{CES}$ | $V_{GE}$ = 0 V, $V_{CE}$ = 600 V | - | - | 250 | µA |
| | | $V_{GE}$ = 0 V, $V_{CE}$ = 600 V, $T_J$ = 150 °C | - | - | 2500 | µA |
| Diode forward voltage drop | $V_{FM}$ | $I_C$ = 12 A; see fig. 13 | - | 1.3 | 1.7 | V |
| | | $I_C$ = 12 A, $T_J$ = 150 °C; see fig. 13 | - | 1.2 | 1.6 | V |
| Gate to emitter leakage current | $I_{GES}$ | $V_{GE}$ = ± 20 V | - | - | ± 100 | nA |

**Notes**

(1) Pulse width ≤ 80 µs, duty factor ≤ 0.1 %

(2) Pulse width 5.0 µs; single shot


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| **SWITCHING CHARACTERISTICS** ($T_J$ = 25 °C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| Total gate charge (turn-on) | $Q_g$ | $I_C$ = 8.7 A<br>$V_{CC}$ = 400 V<br>$V_{GE}$ = 15 V<br>see fig. 8 | - | 54 | 82 | nC |
| Gate to emitter charge (turn-on) | $Q_{ge}$ | | - | 8.1 | 12 | |
| Gate to collector charge (turn-on) | $Q_{gc}$ | | - | 21 | 32 | |
| Turn-on delay time | $t_{d(on)}$ | $T_J$ = 25 °C<br>$I_C$ = 8.7 A, $V_{CC}$ = 480 V<br>$V_{GE}$ = 15 V, $R_G$ = 22 Ω<br>Energy losses include “tail” and diode reverse recovery.<br>see fig. 9, 10, 11, 18 | - | 39 | - | ns |
| Rise time | $t_r$ | | - | 16 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 220 | 330 | |
| Fall time | $t_f$ | | - | 160 | 240 | |
| Turn-on switching loss | $E_{on}$ | | - | 0.30 | - | mJ |
| Turn-off switching loss | $E_{off}$ | | - | 0.55 | - | |
| Total switching loss | $E_{ts}$ | | - | 0.85 | 1.3 | |
| Turn-on delay time | $t_{d(on)}$ | $T_J$ = 150 °C,<br>$I_C$ = 8.7 A, $V_{CC}$ = 480 V<br>$V_{GE}$ = 15 V, $R_G$ = 22 Ω<br>Energy losses include “tail” and diode reverse recovery<br>see fig. 9, 10, 11, 18 | - | 37 | - | ns |
| Rise time | $t_r$ | | - | 16 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 400 | - | |
| Fall time | $t_f$ | | - | 290 | - | |
| Total switching loss | $E_{ts}$ | | - | 1.57 | - | mJ |
| Input capacitance | $C_{ies}$ | $V_{GE}$ = 0 V<br>$V_{CC}$ = 30 V<br>$f$ = 1.0 MHz<br>see fig. 7 | - | 1100 | - | pF |
| Output capacitance | $C_{oes}$ | | - | 74 | - | |
| Reverse transfer capacitance | $C_{res}$ | | - | 14 | - | |
| Diode reverse recovery time | $t_{rr}$ | $T_J$ = 25 °C, see fig. 14, $I_F$ = 12 A, $V_R$ = 200 V, dI/dt = 200 A/μs | - | 42 | 60 | ns |
| | | $T_J$ = 125 °C, see fig. 14 | - | 80 | 120 | |
| Diode peak reverse recovery charge | $I_{rr}$ | $T_J$ = 25 °C, see fig. 15 | - | 3.5 | 6.0 | A |
| | | $T_J$ = 125 °C, see fig. 15 | - | 5.6 | 10 | |
| Diode reverse recovery charge | $Q_{rr}$ | $T_J$ = 25 °C, see fig. 16 | - | 80 | 180 | nC |
| | | $T_J$ = 125 °C, see fig. 16 | - | 220 | 600 | |
| Diode peak rate of fall of recovery during $t_b$ | $dI_{(rec)M}/dt$ | $T_J$ = 25 °C, see fig. 17 | - | 180 | - | A/μs |
| | | $T_J$ = 125 °C, see fig. 17 | - | 116 | - | |

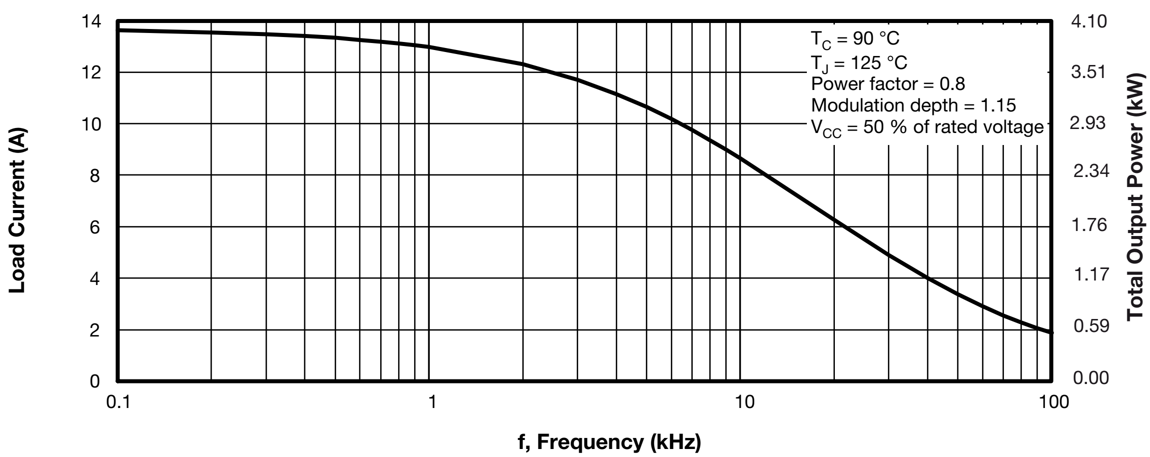


Fig. 1 - Typical Load Current vs. Frequency
(Load Current = $I_{RMS}$ of Fundamental)


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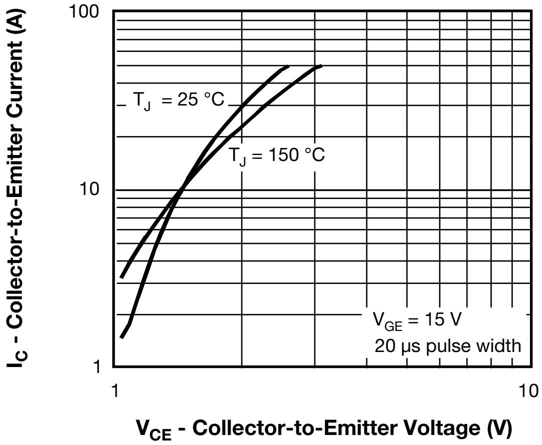


Fig. 2 - Typical Output Characteristics

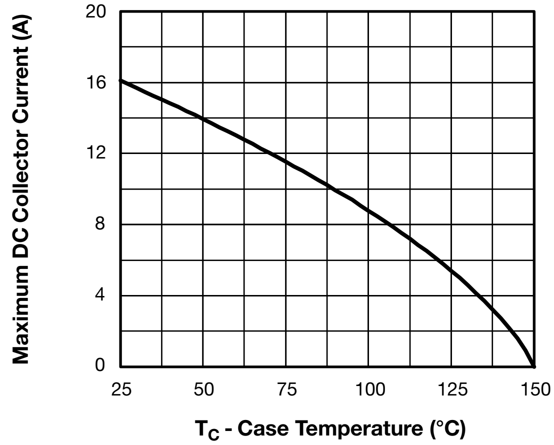


Fig. 4 - Maximum Collector Current vs. Case Temperature

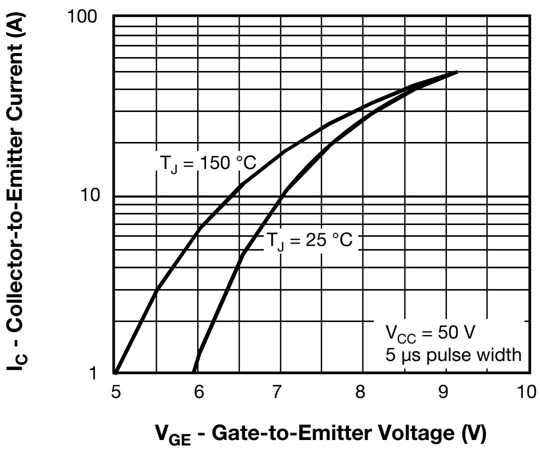


Fig. 3 - Typical Transfer Characteristics

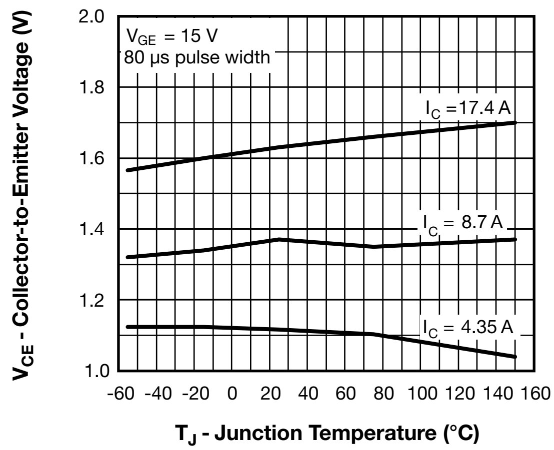


Fig. 5 - Typical Collector to Emitter Voltage vs. Junction Temperature

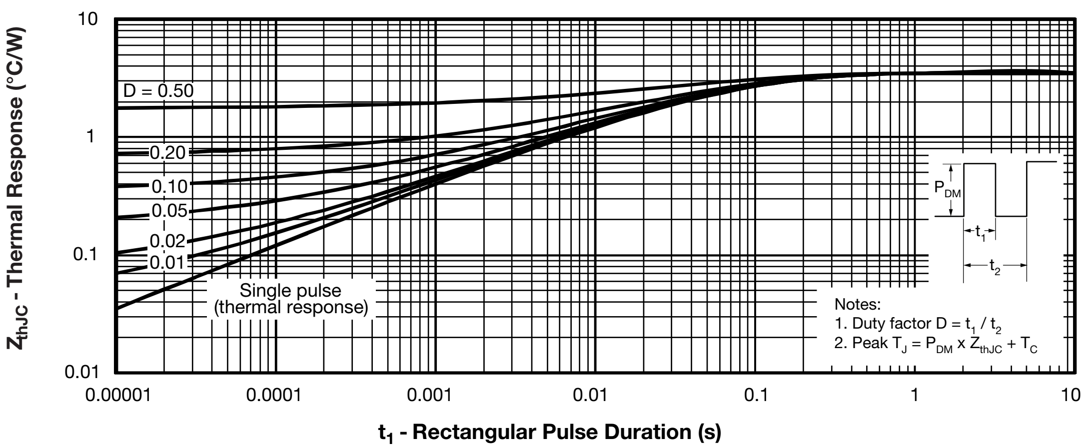


Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction to Case


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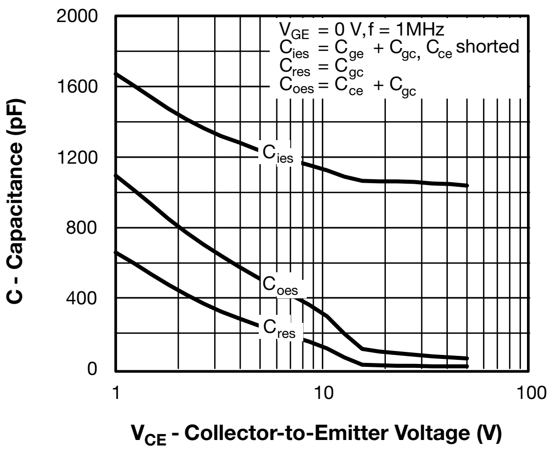


Fig. 7 - Typical Capacitance vs. Collector to Emitter Voltage

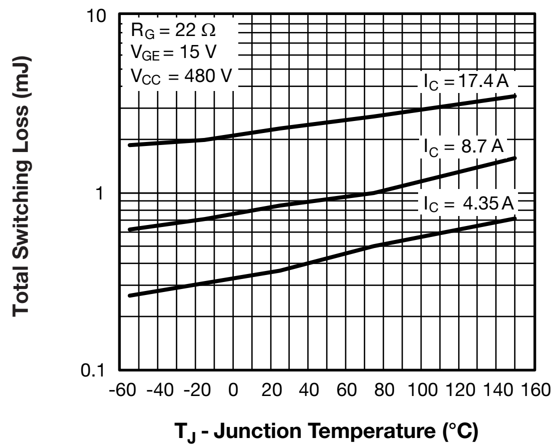


Fig. 10 - Typical Switching Losses vs. Junction Temperature

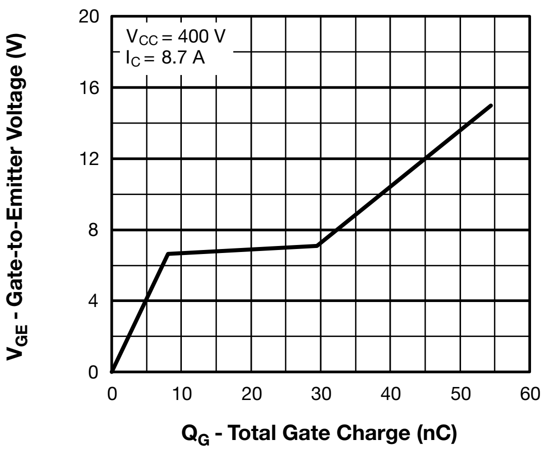


Fig. 8 - Typical Gate Charge vs. Gate to Emitter Voltage

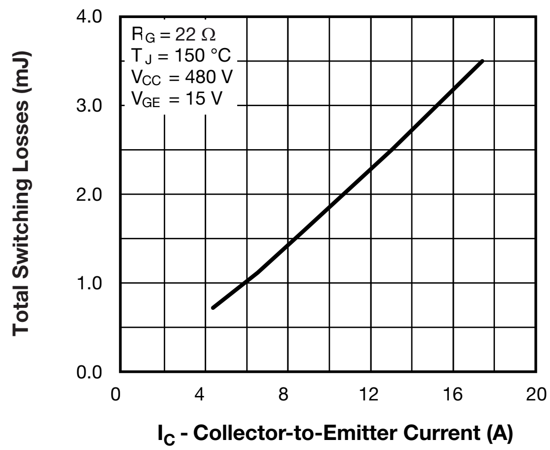


Fig. 11 - Typical Switching Losses vs. Collector to Emitter Current

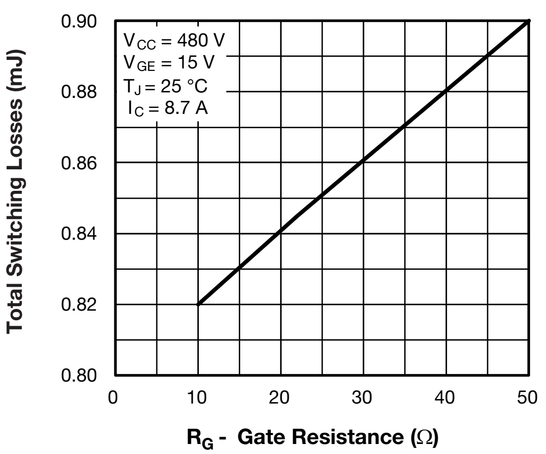


Fig. 9 - Typical Switching Losses vs. Gate Resistance

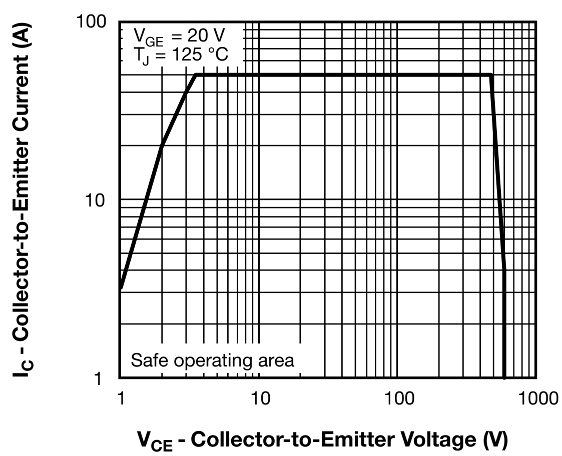


Fig. 12 - Turn-Off SOA


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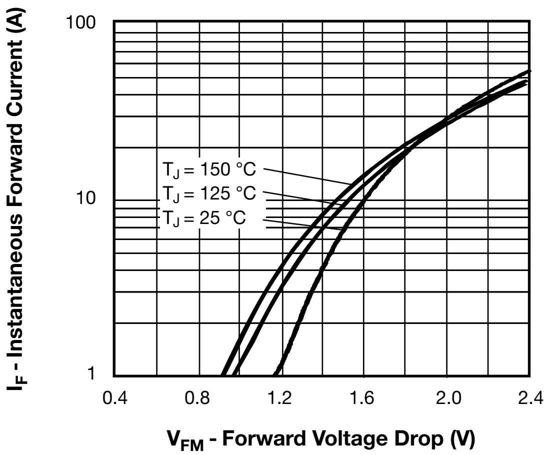


Fig. 13 - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

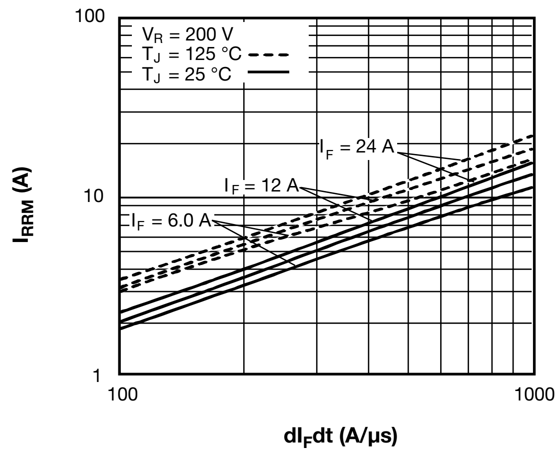


Fig. 15 - Typical Recovery Current vs. $dI_F/dt$

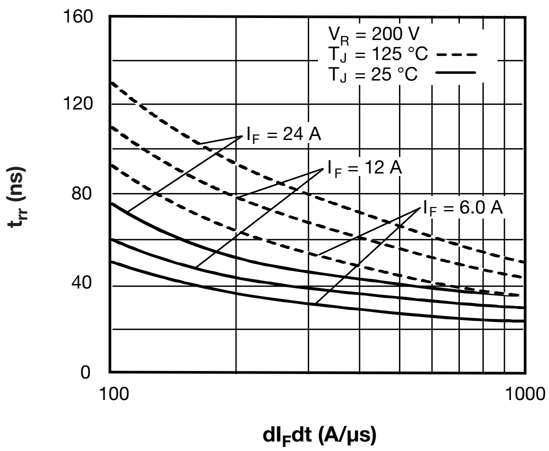


Fig. 14 - Typical Reverse Recovery Time vs. $dI_F/dt$

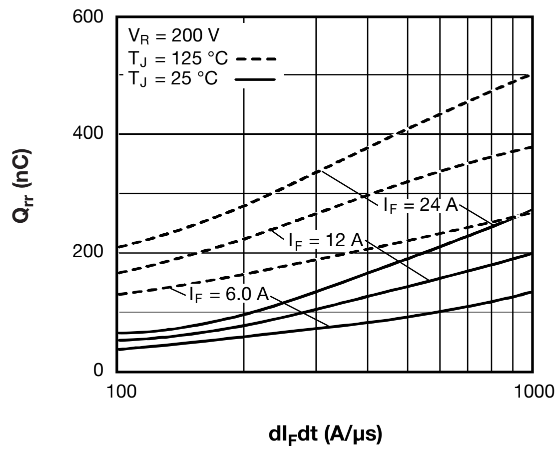


Fig. 16 - Typical Stored Charge vs. $dI_F/dt$

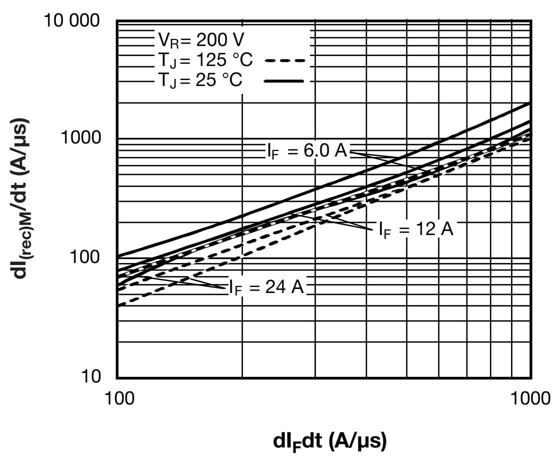


Fig. 17 - Typical $dI_{(rec)M}/dt$ vs $dI_F/dt$


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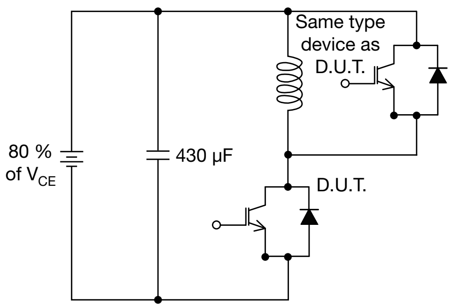


Fig.18a - Test Circuit for Measurements of $I_{LM}$, $E_{on}$, $E_{off(diode)}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$, $t_{d(on)}$, $t_r$, $t_{d(off)}$, $t_f$

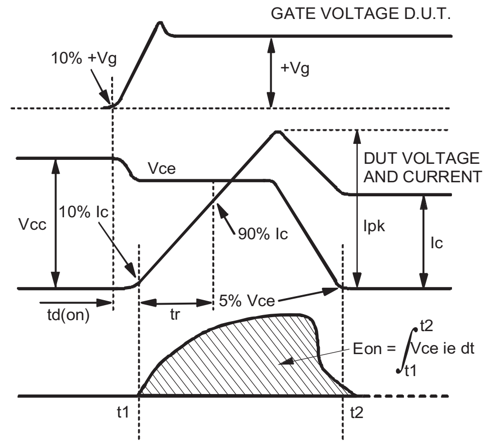


Fig.18b - Test Waveforms for Circuit of Fig. 18a, Defining $E_{on}$, $t_{d(on)}$, $t_r$

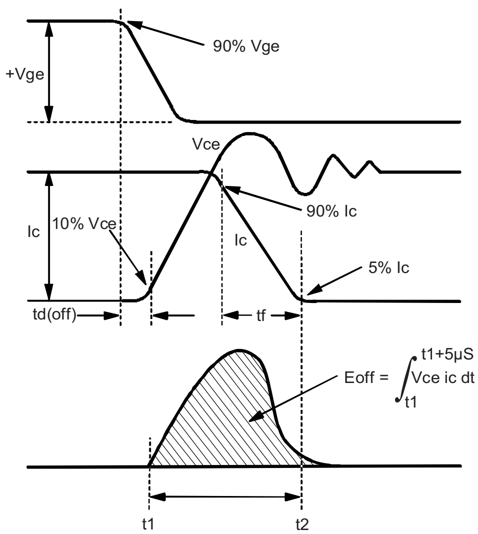


Fig.18c - Test Waveforms for Circuit of Fig. 18a, Defining $E_{off}$, $t_{d(off)}$, $t_f$

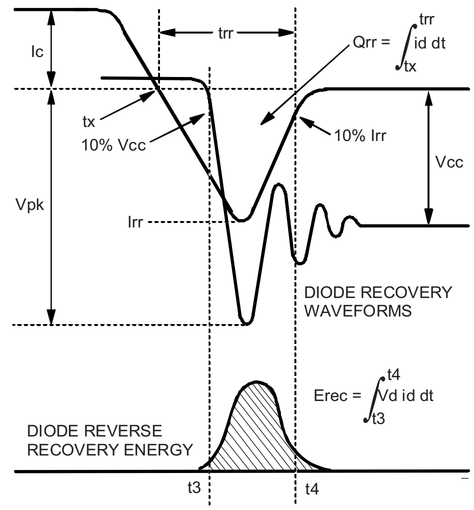


Fig.18d - Test Waveforms for Circuit of Fig. 18a, Defining $E_{rec}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$

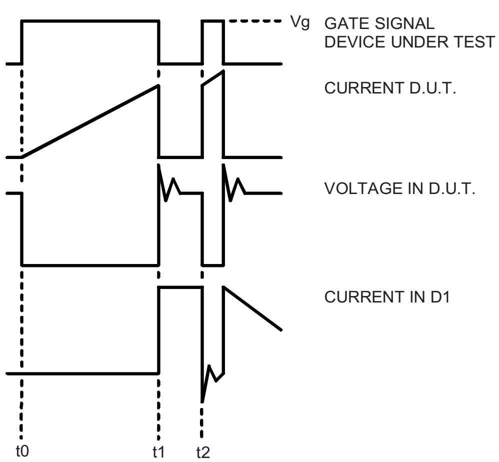


Fig.18e - Macro Waveforms for Figure 18a's Test Circuit


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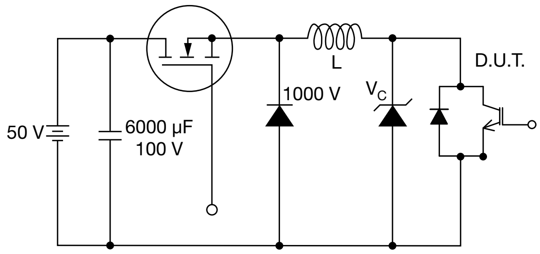



Fig.19 - Clamped Inductive Load Test Circuit

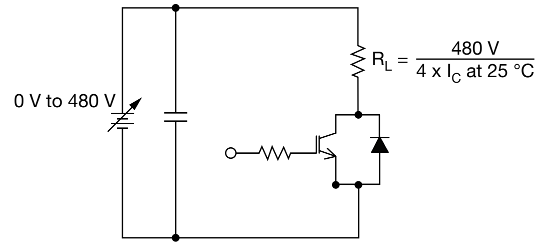
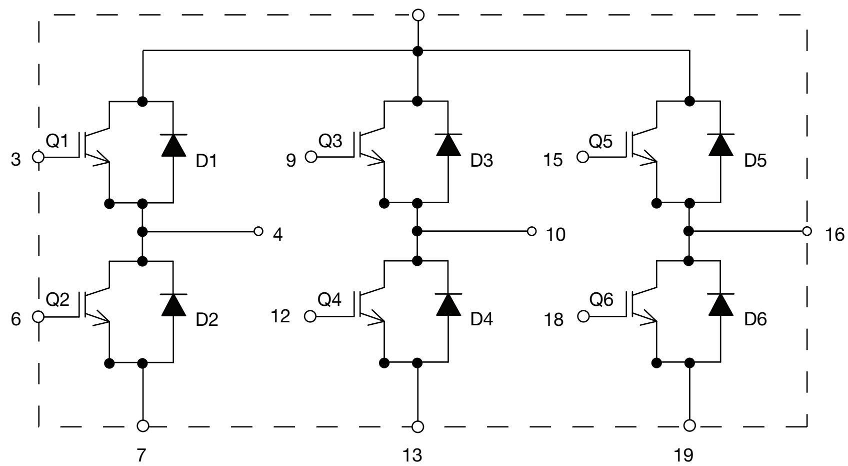



Fig. 20 - Pulsed Collector Current Test Circuit

## CIRCUIT CONFIGURATION

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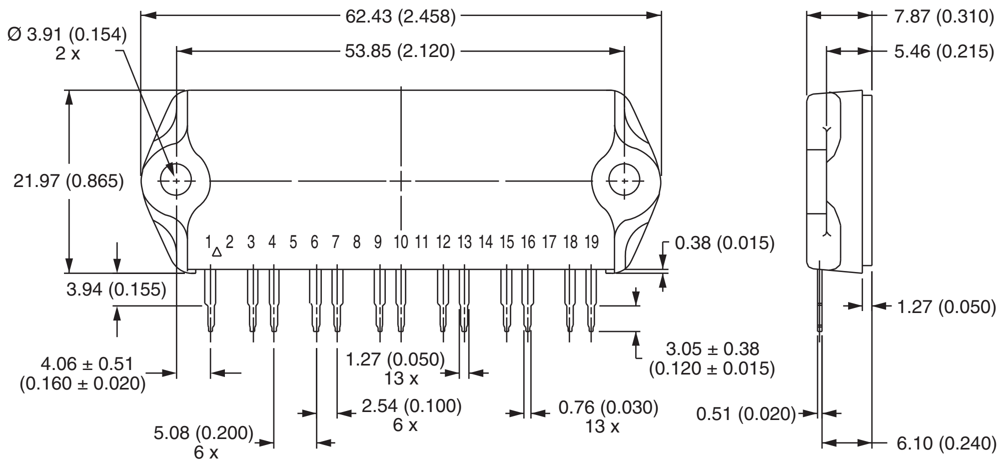
# IMS-2 (SIP)

**DIMENSIONS** in millimeters (inches)




IMS-2 Package Outline (13 Pins)

**Notes**

(1) Tolerance uless otherwise specified ± 0.254 mm (0.010")

(2) Controlling dimension: inch

(3) Terminal numbers are shown for reference only

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