



THE DATASHEET OF IRGS4056DPBF

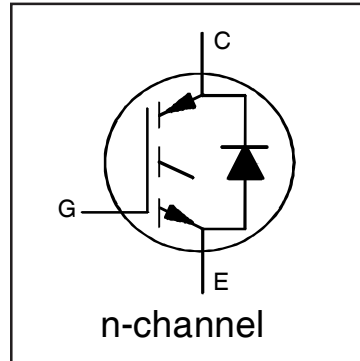


IRGS4056DPbF

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Features

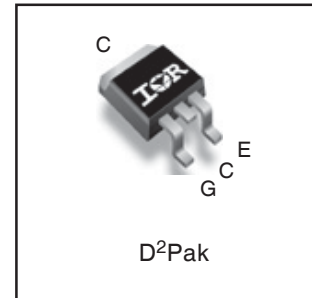
- Low $V_{CE(ON)}$ Trench IGBT Technology
- Low switching losses
- Maximum Junction temperature 175 °C
- 5 μ S short circuit SOA
- Square RBSOA
- 100% of the parts tested for 4X rated current (I_{LM})
- Positive $V_{CE(ON)}$ Temperature co-efficient
- Ultra fast soft Recovery Co-Pak Diode
- Tight parameter distribution
- Lead Free Package



| |
|--|
| $V_{CES} = 600V$ |
| $I_C = 12A, T_C = 100^\circ C$ |
| $t_{SC} \geq 5\mu s, T_{J(max)} = 175^\circ C$ |
| $V_{CE(on)} \text{ typ.} = 1.55V$ |

Benefits

- High Efficiency in a wide range of applications
- Suitable for a wide range of switching frequencies due to Low $V_{CE(ON)}$ and Low Switching losses
- Rugged transient Performance for increased reliability
- Excellent Current sharing in parallel operation
- Low EMI



| | | |
|----------|-----------|----------|
| G | C | E |
| Gate | Collector | Emitter |

Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---------------------------|------------------------------------|-----------------------------------|-------|
| V_{CES} | Collector-to-Emitter Voltage | 600 | V |
| $I_C @ T_C = 25^\circ C$ | Continuous Collector Current | 24 | A |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current | 12 | |
| I_{CM} | Pulse Collector Current | 48 | |
| I_{LM} | Clamped Inductive Load Current ① | 48 | |
| $I_F @ T_C = 25^\circ C$ | Diode Continuous Forward Current | 24 | |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current | 12 | |
| I_{FM} | Diode Maximum Forward Current ② | 48 | |
| V_{GE} | Continuous Gate-to-Emitter Voltage | ± 20 | |
| | Transient Gate-to-Emitter Voltage | ± 30 | |
| $P_D @ T_C = 25^\circ C$ | Maximum Power Dissipation | 140 | W |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation | 70 | |
| T_J | Operating Junction and | -55 to +175 | °C |
| T_{STG} | Storage Temperature Range | | |
| | Soldering Temperature, for 10 sec. | 300 (0.063 in. (1.6mm) from case) | |
| | Mounting Torque, 6-32 or M3 Screw | 10 lbf-in (1.1 N-m) | |

Thermal Resistance

| | Parameter | Min. | Typ. | Max. | Units |
|-------------------------|--|------|------|------|-------|
| $R_{\theta JC}$ (IGBT) | Thermal Resistance Junction-to-Case-(each IGBT) | — | — | 1.07 | °C/W |
| $R_{\theta JC}$ (Diode) | Thermal Resistance Junction-to-Case-(each Diode) | — | — | 3.66 | |
| $R_{\theta CS}$ | Thermal Resistance, Case-to-Sink (flat, greased surface) | — | 0.50 | — | |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient (typical socket mount) | — | 80 | — | |

Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions | Ref.Fig |
|---------------------------------|---|------|------|-----------|----------------------|--|---------|
| $V_{(BR)CES}$ | Collector-to-Emitter Breakdown Voltage | 600 | — | — | V | $V_{GE} = 0V, I_C = 100\mu A$ ④ | CT6 |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 0.30 | — | V/ $^\circ\text{C}$ | $V_{GE} = 0V, I_C = 1mA$ (25 $^\circ\text{C}$ -175 $^\circ\text{C}$) | CT6 |
| $V_{CE(on)}$ | Collector-to-Emitter Saturation Voltage | — | 1.55 | 1.85 | V | $I_C = 12A, V_{GE} = 15V, T_J = 25^\circ\text{C}$ | 5,6,7 |
| | | — | 1.90 | — | | $I_C = 12A, V_{GE} = 15V, T_J = 150^\circ\text{C}$ | 9,10,11 |
| | | — | 1.97 | — | | $I_C = 12A, V_{GE} = 15V, T_J = 175^\circ\text{C}$ | |
| $V_{GE(th)}$ | Gate Threshold Voltage | 4.0 | — | 6.5 | V | $V_{CE} = V_{GE}, I_C = 350\mu A$ | 9, 10, |
| $\Delta V_{GE(th)}/\Delta T_J$ | Threshold Voltage temp. coefficient | — | -18 | — | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 1.0mA$ (25 $^\circ\text{C}$ - 175 $^\circ\text{C}$) | 11, 12 |
| g_{fe} | Forward Transconductance | — | 7.7 | — | S | $V_{CE} = 50V, I_C = 12A, PW = 80\mu s$ | |
| I_{CES} | Collector-to-Emitter Leakage Current | — | 2.0 | 25 | μA | $V_{GE} = 0V, V_{CE} = 600V$ | |
| | | — | 475 | — | | $V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$ | |
| V_{FM} | Diode Forward Voltage Drop | — | 2.10 | 3.10 | V | $I_F = 12A$ | 8 |
| | | — | 1.61 | — | | $I_F = 12A, T_J = 175^\circ\text{C}$ | |
| I_{GES} | Gate-to-Emitter Leakage Current | — | — | ± 100 | nA | $V_{GE} = \pm 20V$ | |

Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions | Ref.Fig |
|--------------|--------------------------------------|-------------|------|------|----------|--|----------------|
| Q_g | Total Gate Charge (turn-on) | — | 25 | 38 | nC | $I_C = 12A$ $V_{GE} = 15V$ $V_{CC} = 400V$ | 24 |
| Q_{ge} | Gate-to-Emitter Charge (turn-on) | — | 7.0 | 11 | | | CT1 |
| Q_{gc} | Gate-to-Collector Charge (turn-on) | — | 11 | 16 | | | |
| E_{on} | Turn-On Switching Loss | — | 75 | 118 | μJ | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 200\mu H, L_S = 150nH, T_J = 25^\circ\text{C}$ Energy losses include tail & diode reverse recovery | CT4 |
| E_{off} | Turn-Off Switching Loss | — | 225 | 273 | | | |
| E_{total} | Total Switching Loss | — | 300 | 391 | | | |
| $t_{d(on)}$ | Turn-On delay time | — | 31 | 40 | ns | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 200\mu H, L_S = 150nH, T_J = 25^\circ\text{C}$ | CT4 |
| t_r | Rise time | — | 17 | 24 | | | |
| $t_{d(off)}$ | Turn-Off delay time | — | 83 | 94 | | | |
| t_f | Fall time | — | 24 | 31 | | | |
| E_{on} | Turn-On Switching Loss | — | 185 | — | | | μJ |
| E_{off} | Turn-Off Switching Loss | — | 355 | — | CT4 | | |
| E_{total} | Total Switching Loss | — | 540 | — | WF1, WF2 | | |
| $t_{d(on)}$ | Turn-On delay time | — | 30 | — | ns | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 200\mu H, L_S = 150nH$ $T_J = 175^\circ\text{C}$ | 14, 16 |
| t_r | Rise time | — | 18 | — | | | CT4 |
| $t_{d(off)}$ | Turn-Off delay time | — | 102 | — | | | WF1 |
| t_f | Fall time | — | 41 | — | | | WF2 |
| C_{ies} | Input Capacitance | — | 765 | — | | | pF |
| C_{oes} | Output Capacitance | — | 52 | — | | | |
| C_{res} | Reverse Transfer Capacitance | — | 23 | — | | | |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | $T_J = 175^\circ\text{C}, I_C = 48A$ $V_{CC} = 480V, V_p = 600V$ $R_G = 22\Omega, V_{GE} = +15V$ to 0V | 4 CT2 |
| SCSOA | Short Circuit Safe Operating Area | 5 | — | — | μs | $V_{CC} = 400V, V_p = 600V$ $R_G = 22\Omega, V_{GE} = +15V$ to 0V | 22, CT3 WF4 |
| E_{rec} | Reverse Recovery Energy of the Diode | — | 280 | — | μJ | $T_J = 175^\circ\text{C}$ | 17, 18, 19 |
| t_{rr} | Diode Reverse Recovery Time | — | 68 | — | ns | $V_{CC} = 400V, I_F = 12A$ | 20, 21 |
| I_{rr} | Peak Reverse Recovery Current | — | 19 | — | A | $V_{GE} = 15V, R_G = 22\Omega, L = 200\mu H, L_S = 150nH$ | WF3 |

Notes:

- ① $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 100\mu H, R_G = 22\Omega$.
- ② This is only applied to TO-220AB package.
- ③ Pulse width limited by max. junction temperature.
- ④ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.

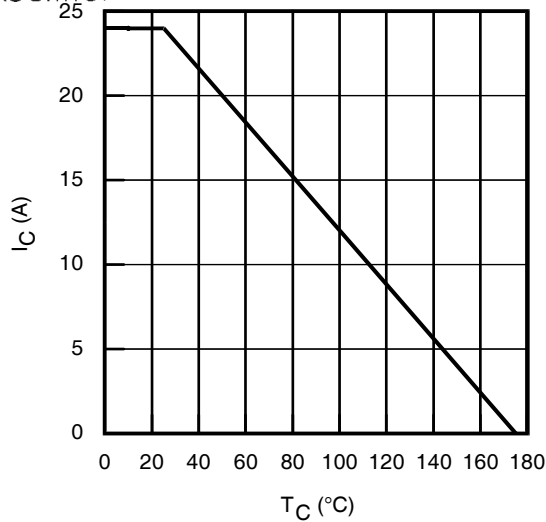


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

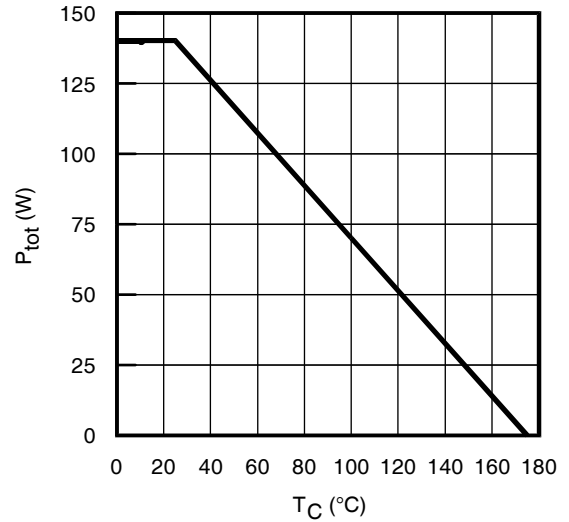


Fig. 2 - Power Dissipation vs. Case Temperature

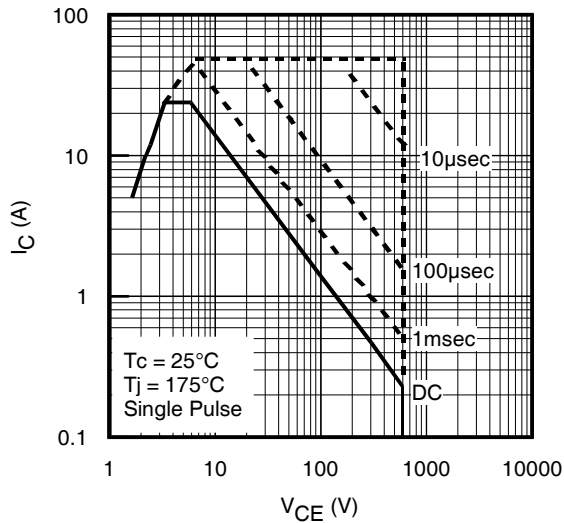


Fig. 3 - Forward SOA
 $T_C = 25^{\circ}C$, $T_J \leq 175^{\circ}C$; $V_{GE} = 15V$

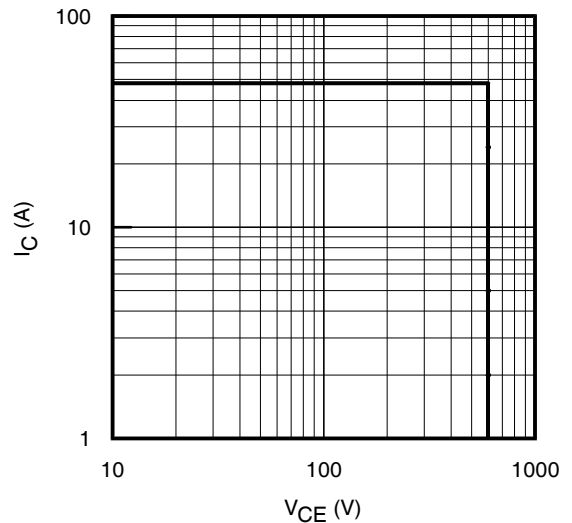


Fig. 4 - Reverse Bias SOA
 $T_J = 175^{\circ}C$; $V_{GE} = 15V$

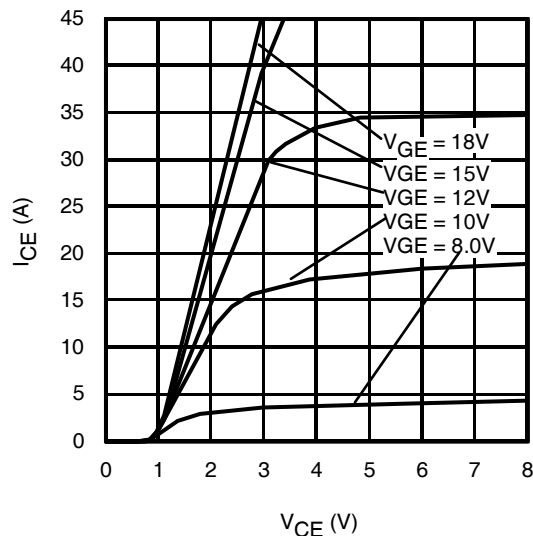


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^{\circ}C$; $t_p = 80\mu s$

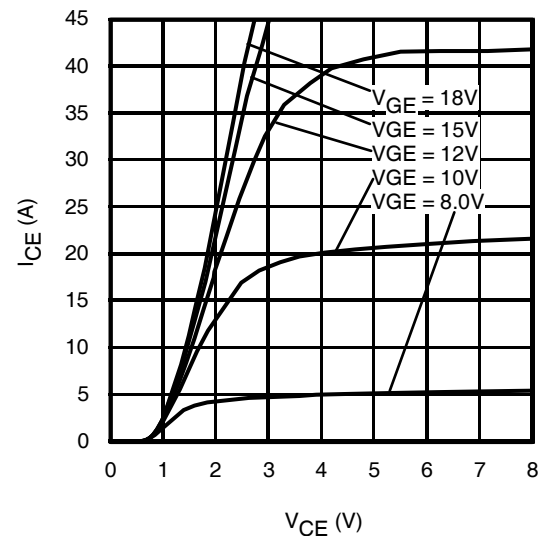


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^{\circ}C$; $t_p = 80\mu s$

IRGS4056DPbF

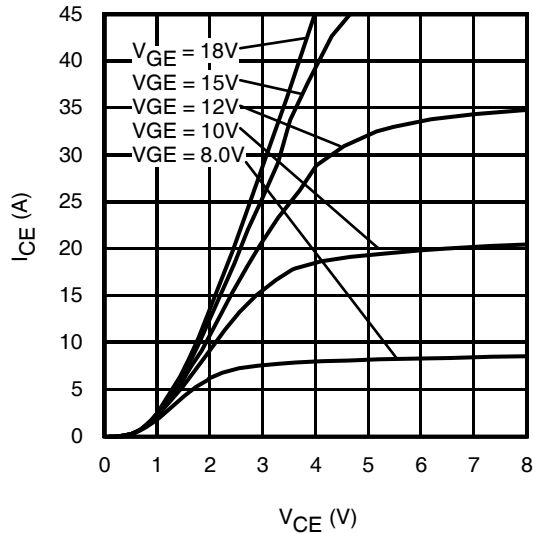


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = 80\mu\text{s}$

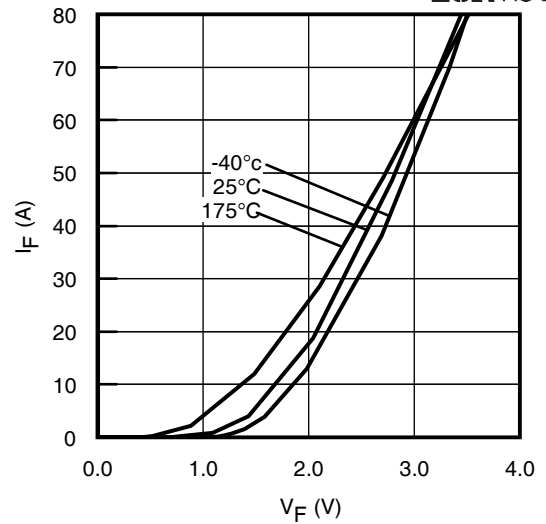


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

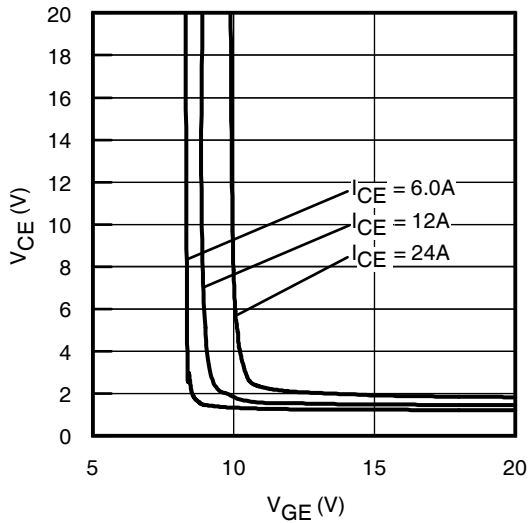


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

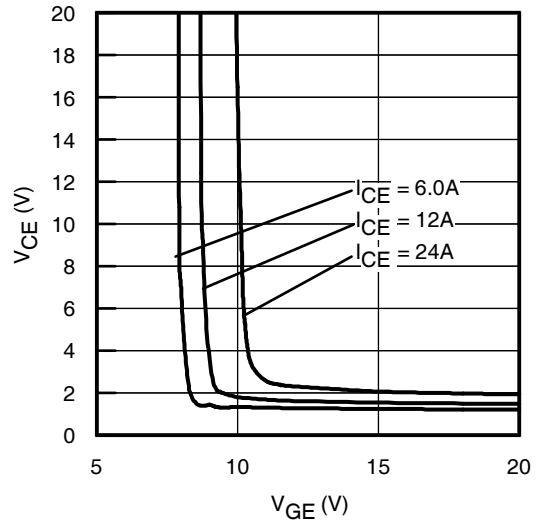


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

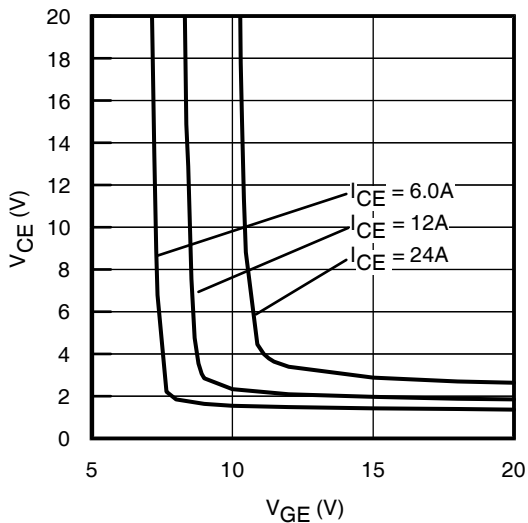


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

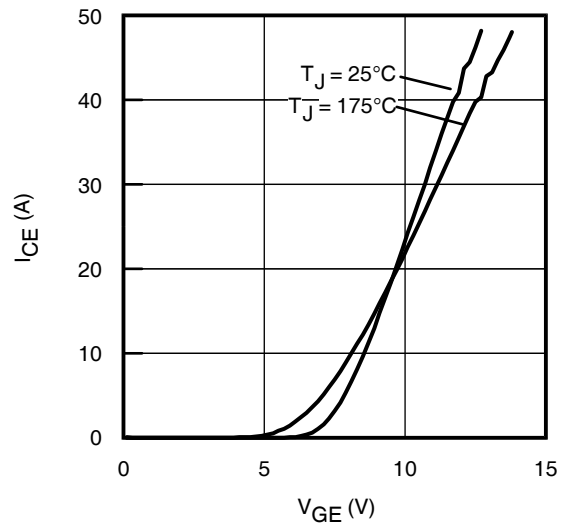


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

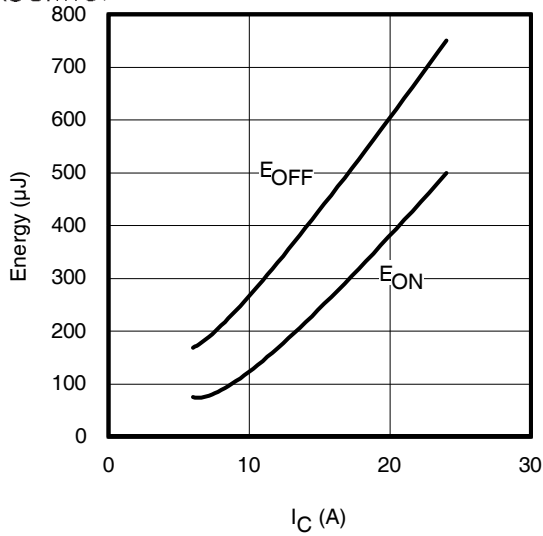


Fig. 13 - Typ. Energy Loss vs. I_C

$T_J = 175^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 400\text{V}$, $R_G = 22\Omega$; $V_{GE} = 15\text{V}$

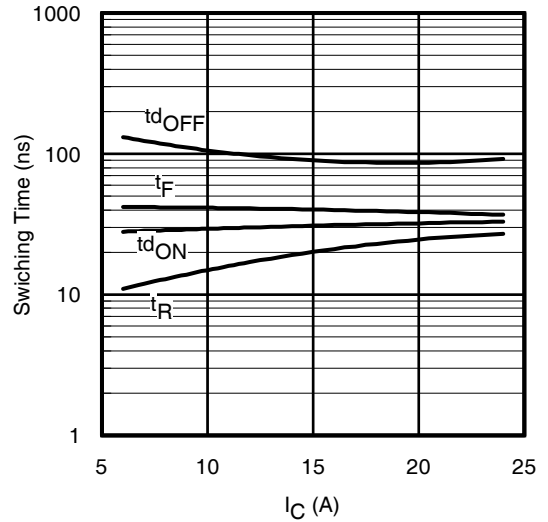


Fig. 14 - Typ. Switching Time vs. I_C

$T_J = 175^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 400\text{V}$, $R_G = 22\Omega$; $V_{GE} = 15\text{V}$

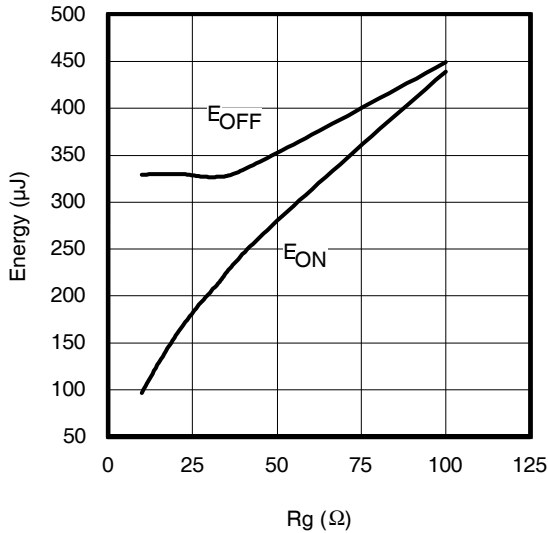


Fig. 15 - Typ. Energy Loss vs. R_G

$T_J = 175^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 400\text{V}$, $I_{CE} = 12\text{A}$; $V_{GE} = 15\text{V}$

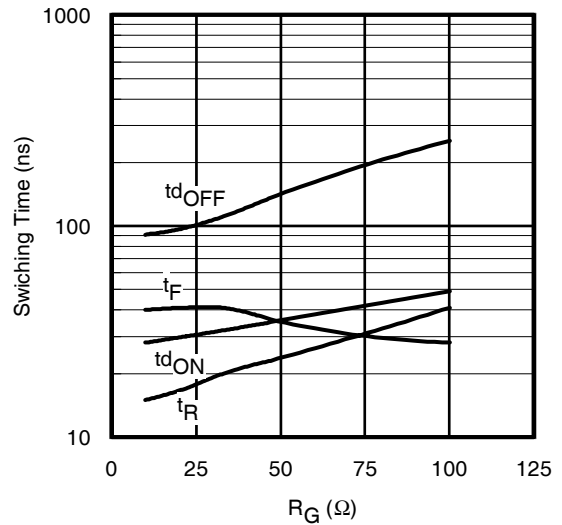


Fig. 16 - Typ. Switching Time vs. R_G

$T_J = 175^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 400\text{V}$, $I_{CE} = 12\text{A}$; $V_{GE} = 15\text{V}$

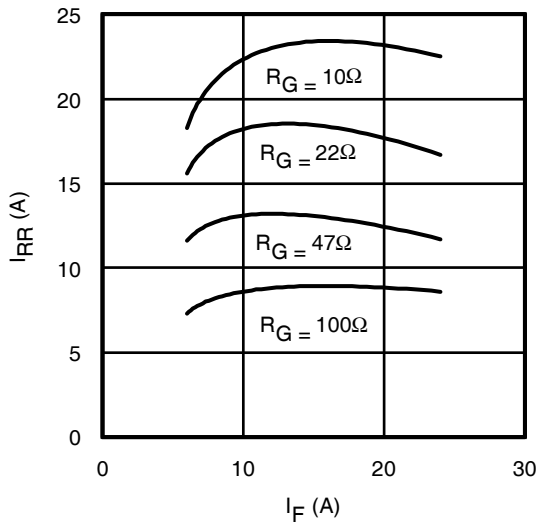


Fig. 17 - Typ. Diode I_{RR} vs. I_F

$T_J = 175^\circ\text{C}$

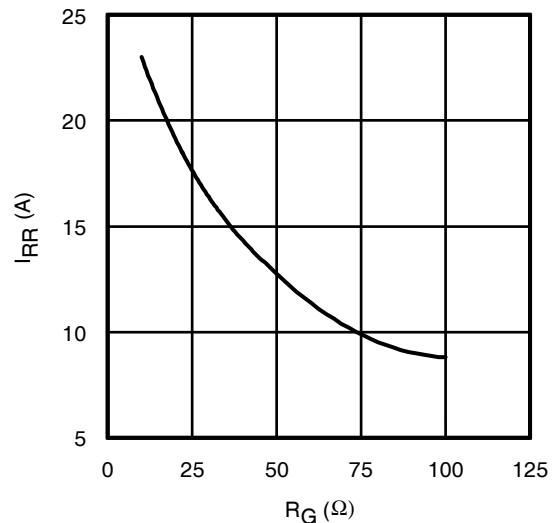


Fig. 18 - Typ. Diode I_{RR} vs. R_G

$T_J = 175^\circ\text{C}$

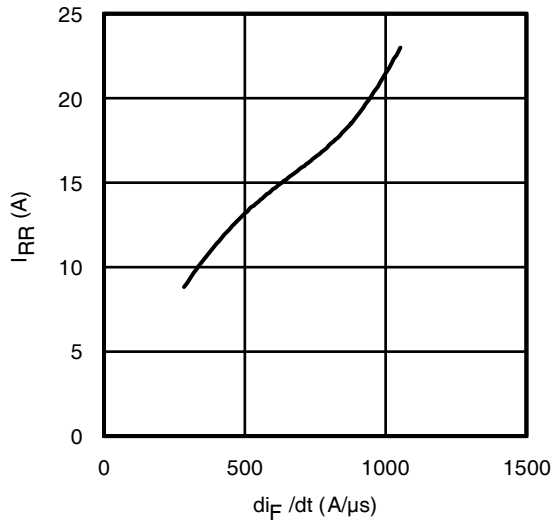


Fig. 19 - Typ. Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $I_F = 12A$; $T_J = 175^\circ C$

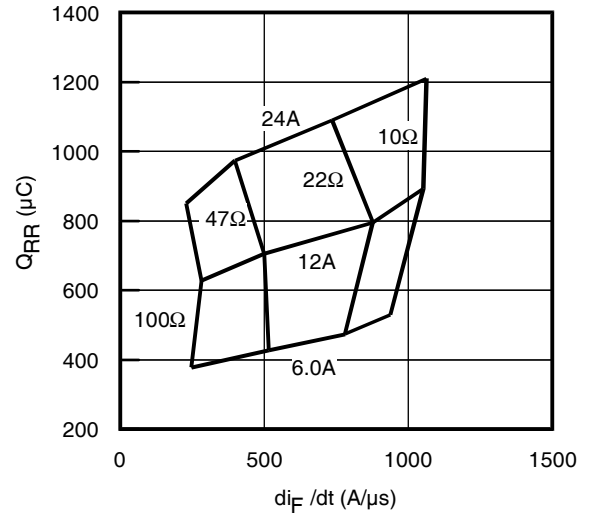


Fig. 20 - Typ. Diode Q_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 175^\circ C$

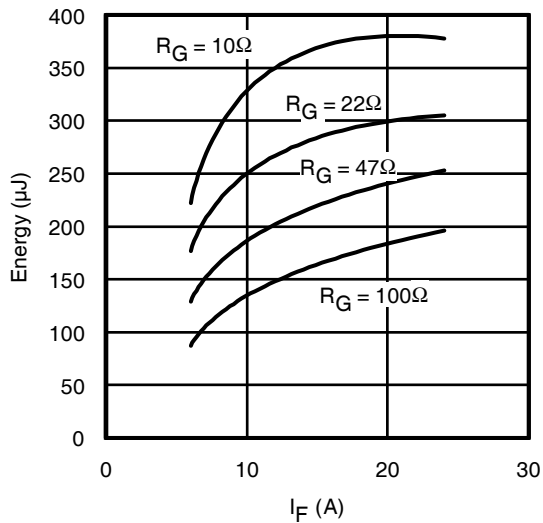


Fig. 21 - Typ. Diode E_{RR} vs. I_F
 $T_J = 175^\circ C$

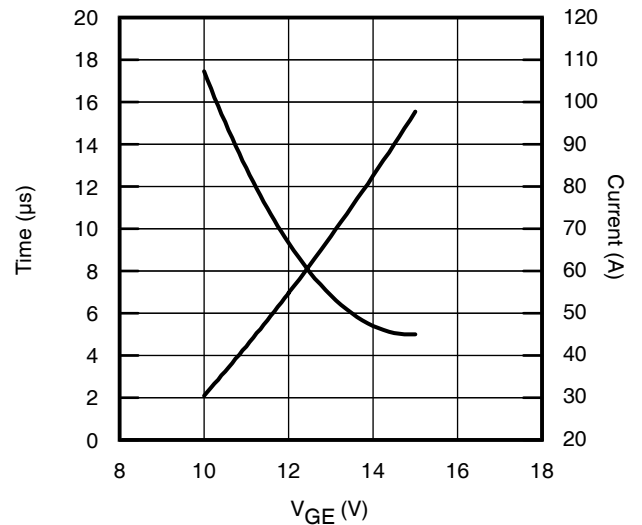


Fig. 22 - V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$; $T_C = 25^\circ C$

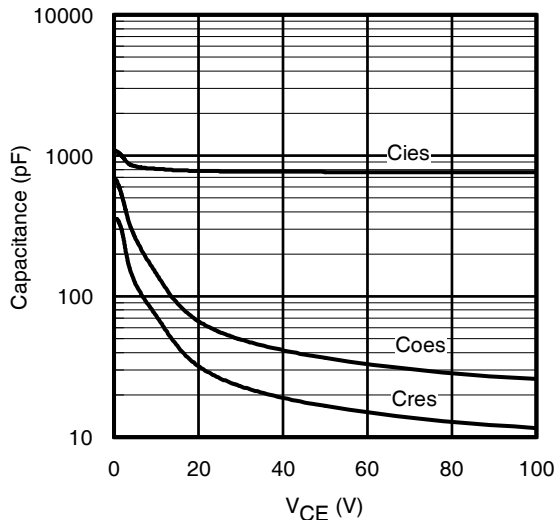


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

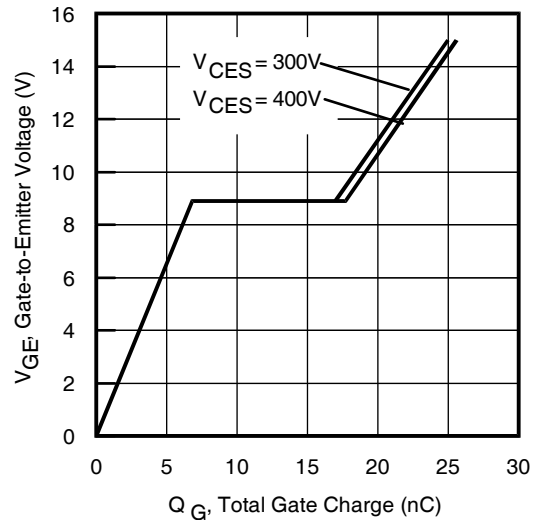


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 12A$; $L = 600\mu H$

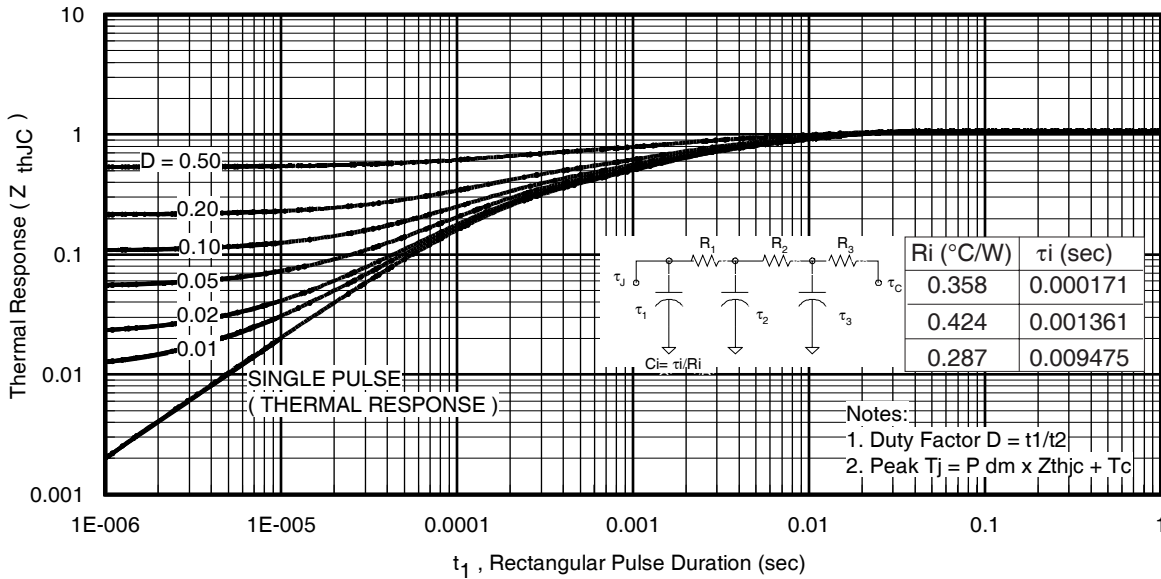


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

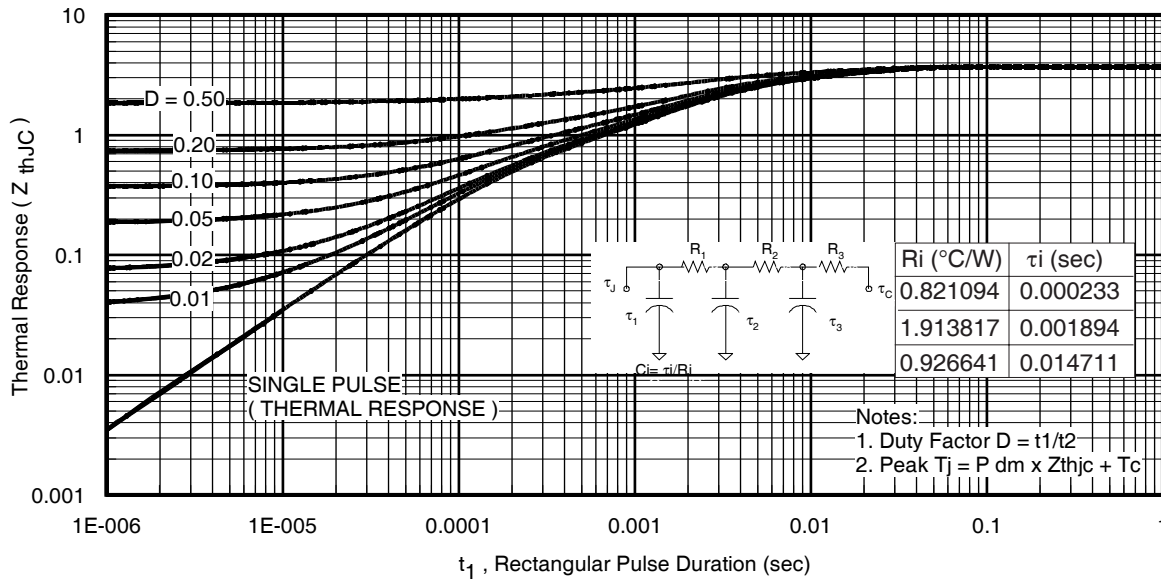


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

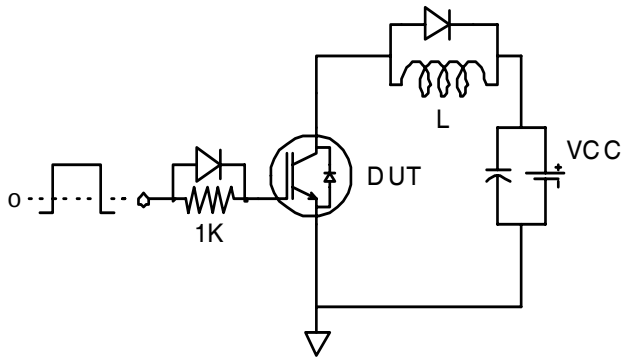


Fig.C.T.1 - Gate Charge Circuit (turn-off)

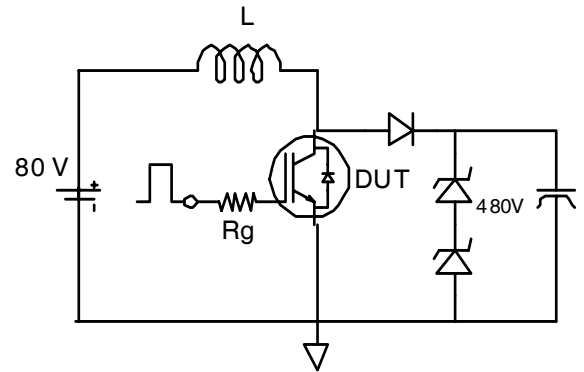


Fig.C.T.2 - RBSOA Circuit

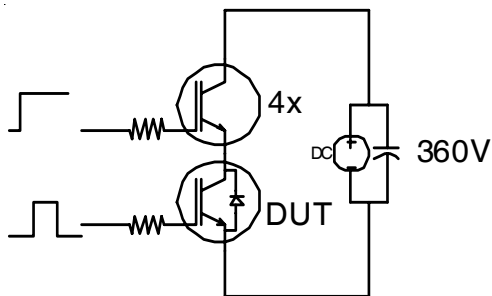


Fig.C.T.3 - S.C. SOA Circuit

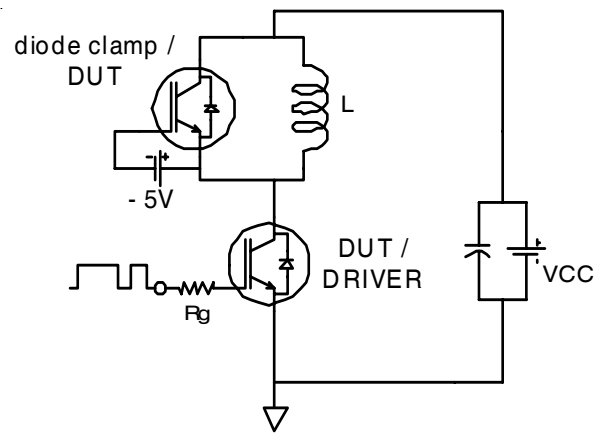


Fig.C.T.4 - Switching Loss Circuit

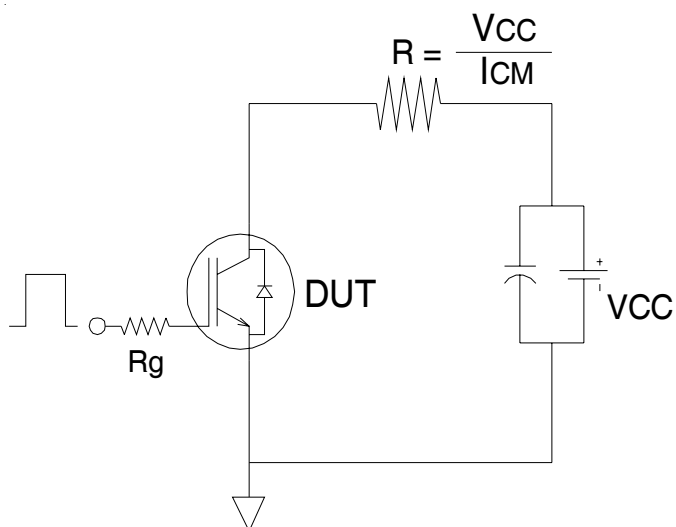


Fig.C.T.5 - Resistive Load Circuit

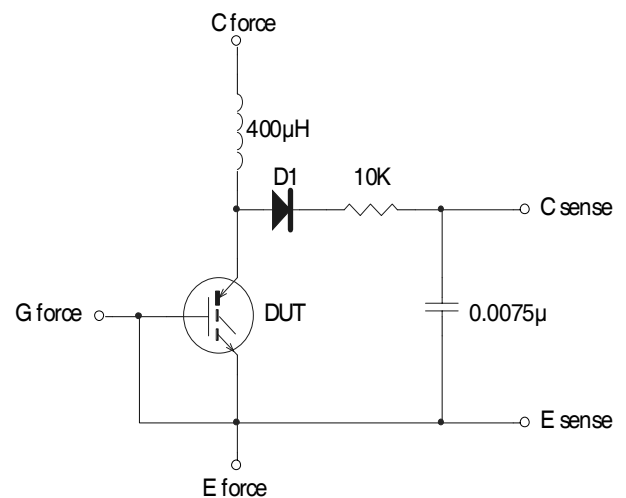


Fig.C.T.6 - BVCES Filter Circuit

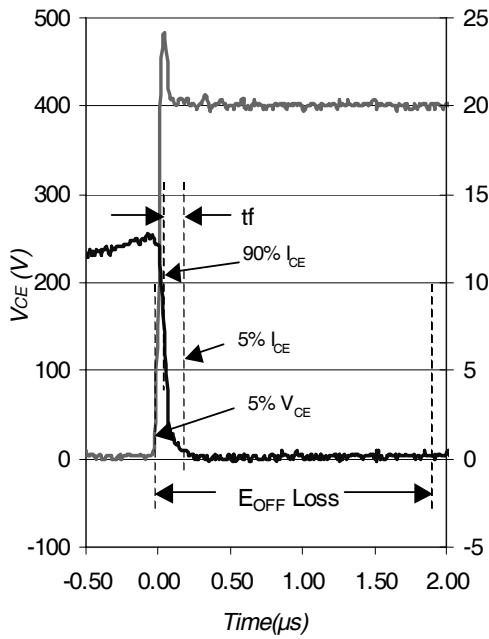


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

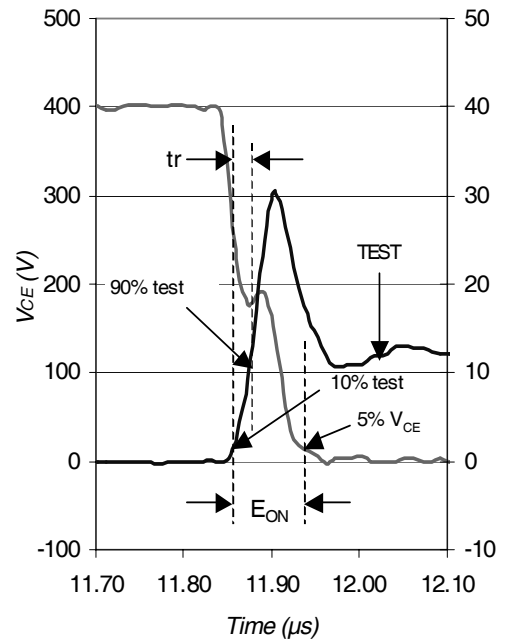


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

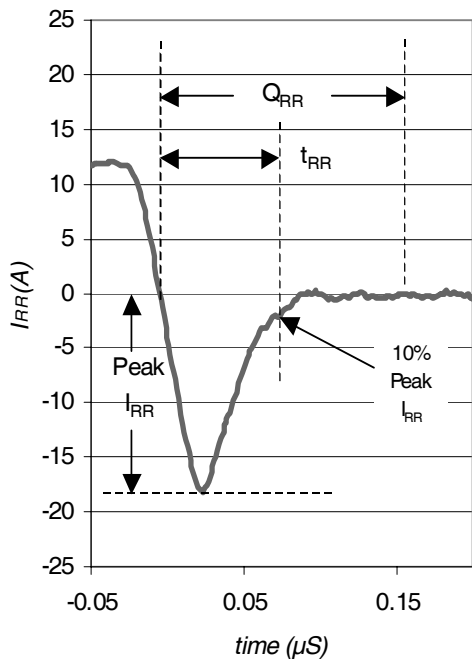


Fig. WF3 - Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

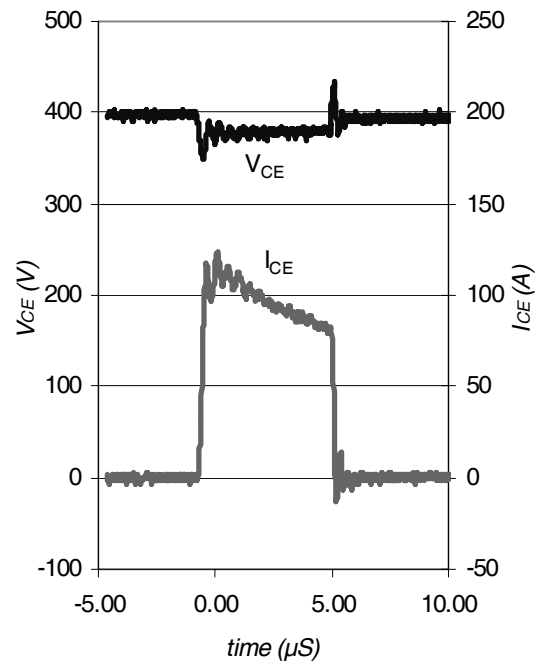
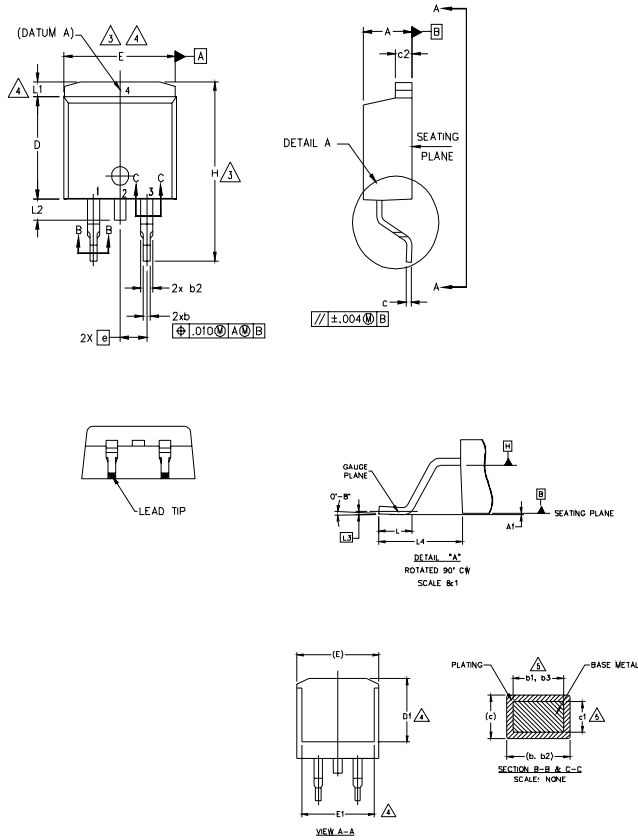


Fig. WF4 - Typ. S.C. Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

D²Pak (TO-263AB) Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263AB.

| SYMBOL | DIMENSIONS | | | | NOTES |
|--------|-------------|-------|----------|------|-------|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 0.00 | 0.254 | .000 | .010 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 5 |
| b2 | 1.14 | 1.78 | .045 | .070 | |
| b3 | 1.14 | 1.73 | .045 | .068 | 5 |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.38 | 0.58 | .015 | .023 | 5 |
| c2 | 1.14 | 1.65 | .045 | .065 | |
| D | 8.38 | 9.65 | .330 | .380 | 3 |
| D1 | 6.86 | - | .270 | - | 4 |
| E | 9.65 | 10.67 | .380 | .420 | 3,4 |
| E1 | 6.22 | - | .245 | - | 4 |
| e | 2.54 BSC | | .100 BSC | | |
| H | 14.61 | 15.88 | .575 | .625 | |
| L | 1.78 | 2.79 | .070 | .110 | |
| L1 | - | 1.65 | - | .066 | 4 |
| L2 | 1.27 | 1.78 | - | .070 | |
| L3 | 0.25 BSC | | .010 BSC | | |
| L4 | 4.78 | 5.28 | .188 | .208 | |

LEAD ASSIGNMENTS

HEXFET

- 1.- GATE
- 2, 4.- DRAIN
- 3.- SOURCE

IGBTs, CoPACK

- 1.- GATE
- 2, 4.- COLLECTOR
- 3.- EMITTER

DIODES

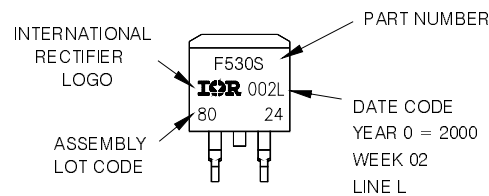
- 1.- ANODE *
- 2, 4.- CATHODE
- 3.- ANODE

* PART DEPENDENT.

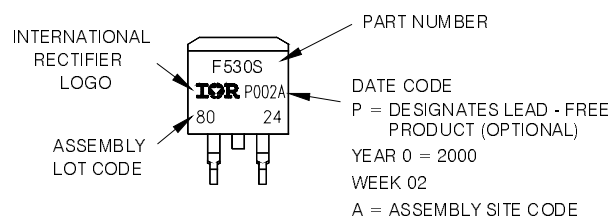
D²Pak (TO-263AB) Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW 02, 2000
IN THE ASSEMBLY LINE "L"

Note: "P" in assembly line position
indicates "Lead - Free"



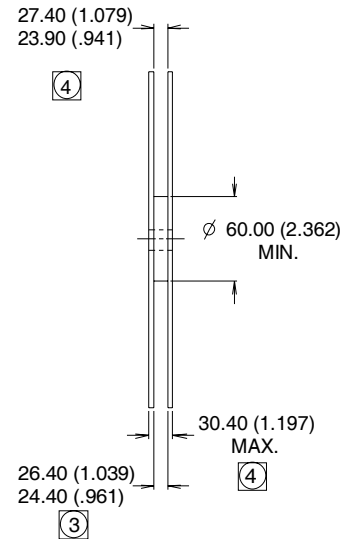
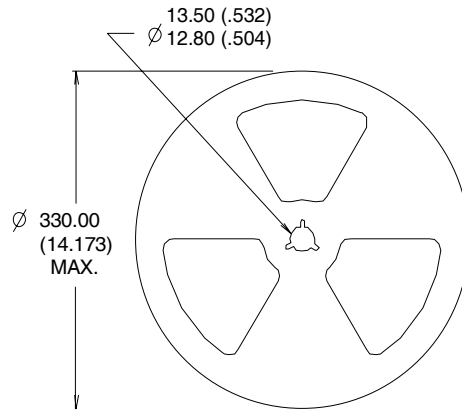
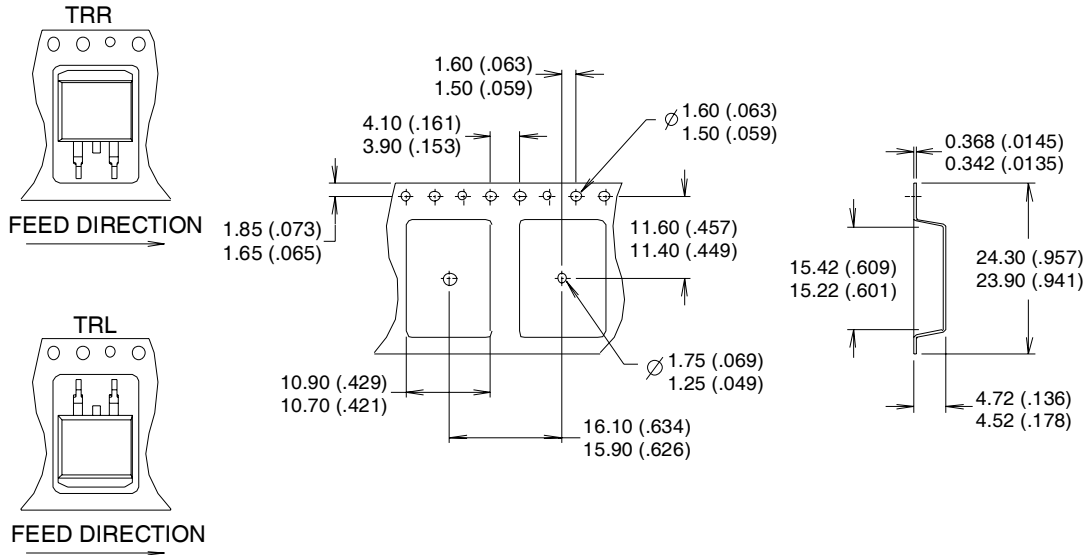
OR



Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

D²Pak (TO-263AB) Tape & Reel Information

Dimensions are shown in millimeters (inches)



NOTES :

1. COMFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
- ③ DIMENSION MEASURED @ HUB.
- ④ INCLUDES FLANGE DISTORTION @ OUTER EDGE.

Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

Data and specifications subject to change without notice.
 This product has been designed and qualified for Industrial market.
 Qualification Standards can be found on IR's Web site.

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