

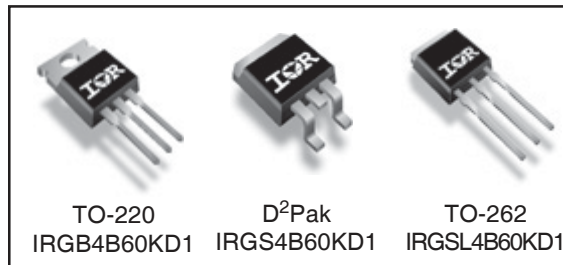
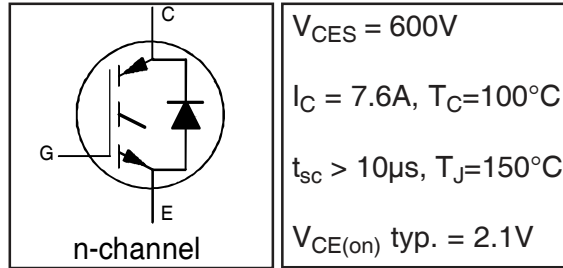
INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE

Features

- Low VCE (on) Non Punch Through IGBT Technology.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Positive VCE (on) Temperature Coefficient.
- Maximum Junction Temperature rated at 175°C.
- Lead-Free

Benefits

- Benchmark Efficiency for Motor Control.
- Rugged Transient Performance.
- Low EMI.
- Excellent Current Sharing in Parallel Operation.



Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---------------------------|---|-----------------------------------|-------|
| V_{CES} | Collector-to-Emitter Voltage | 600 | V |
| $I_C @ T_C = 25^\circ C$ | Continuous Collector Current | 11 | A |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current | 7.6 | |
| I_{CM} | Pulse Collector Current (Ref.Fig.C.T.5) | 22 | |
| I_{LM} | Clamped Inductive Load current ① | 22 | |
| $I_F @ T_C = 25^\circ C$ | Diode Continuous Forward Current | 11 | |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current | 6.7 | |
| I_{FM} | Diode Maximum Forward Current | 22 | V |
| V_{GE} | Gate-to-Emitter Voltage | ±20 | |
| $P_D @ T_C = 25^\circ C$ | Maximum Power Dissipation | 63 | W |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation | 31 | |
| T_J | Operating Junction and | -55 to +175 | °C |
| T_{STG} | Storage Temperature Range | | |
| | Storage Temperature Range, for 10 sec. | 300 (0.063 in. (1.6mm) from case) | |

Thermal / Mechanical Characteristics

| | Parameter | Min. | Typ. | Max. | Units |
|-----------------|--|------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case- IGBT | — | — | 2.4 | °C/W |
| $R_{\theta JC}$ | Junction-to-Case- Diode | — | — | 6.1 | |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface | — | 0.50 | — | |
| $R_{\theta JA}$ | Junction-to-Ambient | — | — | 62 | |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount, steady state)② | — | — | 40 | |
| Wt | Weight | — | 1.44 | — | g |

IRGB/S/SL4B60KD1PbF

International
IR Rectifier

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 | $V_{GE} = 0V, I_C = 500\mu A$ | |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 0.28 | — | V/ $^\circ\text{C}$ | $V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$ | |
| $V_{CE(on)}$ | Collector-to-Emitter Voltage | — | 2.1 | 2.5 | V | $I_C = 4.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$ | 5,6,7 |
| | | — | 2.5 | 2.8 | | $I_C = 4.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$ | 9,10,11 |
| | | — | 2.6 | 2.9 | | $I_C = 4.0A, V_{GE} = 15V, T_J = 175^\circ\text{C}$ | |
| $V_{GE(th)}$ | Gate Threshold Voltage | 3.5 | 4.5 | 5.5 | V | $V_{CE} = V_{GE}, I_C = 250\mu A$ | 9,10,11 |
| $\Delta V_{GE(th)}/\Delta T_J$ | Threshold Voltage temp. coefficient | — | -8.1 | — | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$ | 12 |
| g_{fe} | Forward Transconductance | — | 1.7 | — | S | $V_{CE} = 50V, I_C = 4.0A, PW = 80\mu s$ | |
| I_{CES} | Zero Gate Voltage Collector Current | — | 1.0 | 150 | μA | $V_{GE} = 0V, V_{CE} = 600V$ | |
| | | — | 136 | 600 | | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$ | |
| | | — | 722 | 2400 | | $V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$ | |
| V_{FM} | Diode Forward Voltage Drop | — | 1.4 | 2.0 | V | $I_F = 4.0A$ | 8 |
| | | — | 1.3 | 1.8 | | $I_F = 4.0A, T_J = 150^\circ\text{C}$ | |
| | | — | 1.2 | 1.7 | | $I_F = 4.0A, T_J = 175^\circ\text{C}$ | |
| 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) | — | 12 | — | nC | $I_C = 4.0A$ | 23 | |
| Q_{ge} | Gate-to-Emitter Charge (turn-on) | — | 1.7 | — | | $V_{CC} = 400V$ | CT1 | |
| Q_{gc} | Gate-to-Collector Charge (turn-on) | — | 6.5 | — | | $V_{GE} = 15V$ | | |
| E_{on} | Turn-On Switching Loss | — | 73 | 80 | μJ | $I_C = 4.0A, V_{CC} = 400V$ | CT4 | |
| E_{off} | Turn-Off Switching Loss | — | 47 | 53 | | $V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$ | | |
| E_{tot} | Total Switching Loss | — | 120 | 130 | | $T_J = 25^\circ\text{C}$ ③ | | |
| $t_{d(on)}$ | Turn-On delay time | — | 22 | 28 | ns | $I_C = 4.0A, V_{CC} = 400V$ | CT4 | |
| t_r | Rise time | — | 18 | 23 | | $V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$ | | |
| $t_{d(off)}$ | Turn-Off delay time | — | 100 | 110 | | $T_J = 25^\circ\text{C}$ | | |
| t_f | Fall time | — | 66 | 80 | | | | |
| E_{on} | Turn-On Switching Loss | — | 130 | 150 | μJ | $I_C = 4.0A, V_{CC} = 400V$ | CT4 | |
| E_{off} | Turn-Off Switching Loss | — | 83 | 140 | | $V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$ | | 13,15 |
| E_{tot} | Total Switching Loss | — | 220 | 280 | | $T_J = 150^\circ\text{C}$ ③ | | WF1,WF2 |
| $t_{d(on)}$ | Turn-On delay time | — | 22 | 27 | ns | $I_C = 4.0A, V_{CC} = 400V$ | 14,16 | |
| t_r | Rise time | — | 18 | 22 | | $V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$ | | CT4 |
| $t_{d(off)}$ | Turn-Off delay time | — | 120 | 130 | | $T_J = 150^\circ\text{C}$ | | WF1 |
| t_f | Fall time | — | 79 | 89 | | | | WF2 |
| C_{ies} | Input Capacitance | — | 190 | — | pF | $V_{GE} = 0V$ | 22 | |
| C_{oes} | Output Capacitance | — | 25 | — | | $V_{CC} = 30V$ | | |
| C_{res} | Reverse Transfer Capacitance | — | 6.2 | — | | $f = 1.0MHz$ | | |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | $T_J = 150^\circ\text{C}, I_C = 22A, V_p = 600V$ $V_{CC}=500V, V_{GE} = +15V \text{ to } 0V, R_G = 100\Omega$ | 4 CT2 | |
| SCSOA | Short Circuit Safe Operating Area | 10 | — | — | μs | $T_J = 150^\circ\text{C}, V_p = 600V, R_G = 100\Omega$ $V_{CC}=360V, V_{GE} = +15V \text{ to } 0V$ | CT3 WF4 | |
| E_{rec} | Reverse Recovery Energy of the Diode | — | 81 | 100 | μJ | $T_J = 150^\circ\text{C}$ | 17,18,19 | |
| t_{rr} | Diode Reverse Recovery Time | — | 93 | — | ns | $V_{CC} = 400V, I_F = 4.0A, L = 2.5mH$ | 20,21 | |
| I_{rr} | Peak Reverse Recovery Current | — | 6.3 | 7.9 | A | $V_{GE} = 15V, R_G = 100\Omega$ | CT4,WF3 | |

Note ① to ③ are on page 16

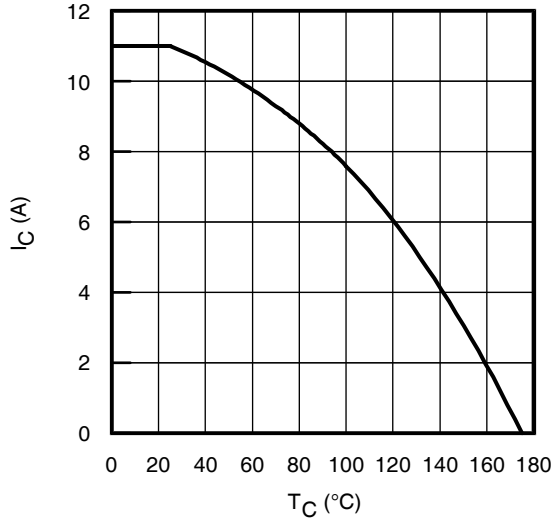


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

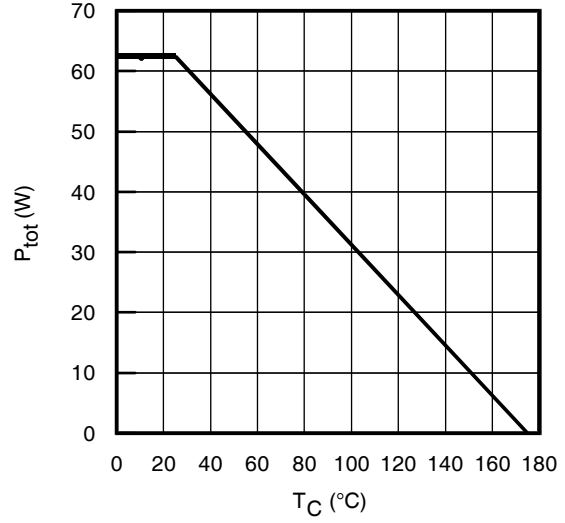


Fig. 2 - Power Dissipation vs. Case Temperature

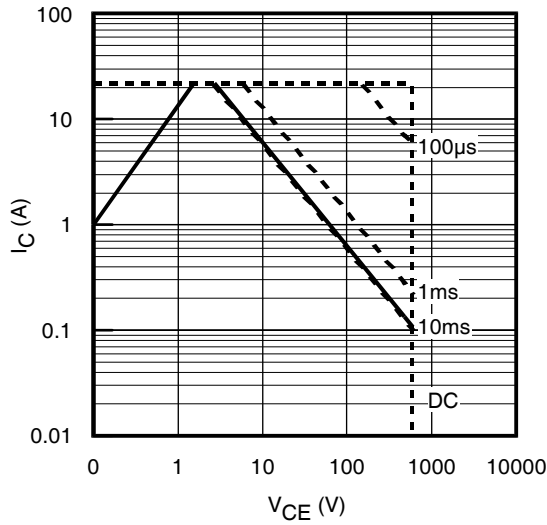


Fig. 3 - Forward SOA
 $T_C = 25^{\circ}C$; $T_J \leq 150^{\circ}C$

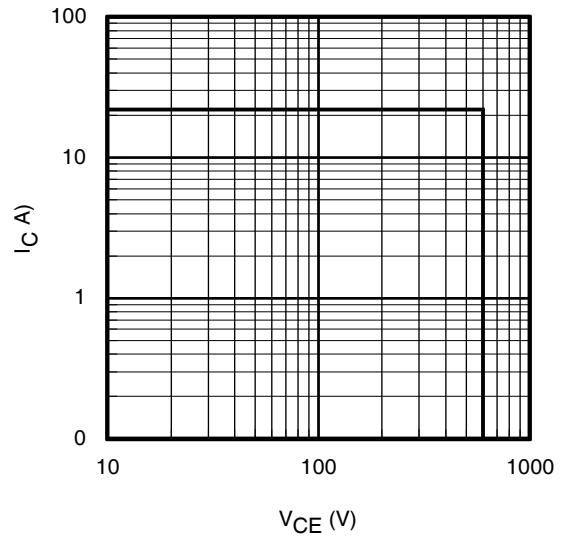


Fig. 4 - Reverse Bias SOA
 $T_J = 150^{\circ}C$; $V_{GE} = 15V$

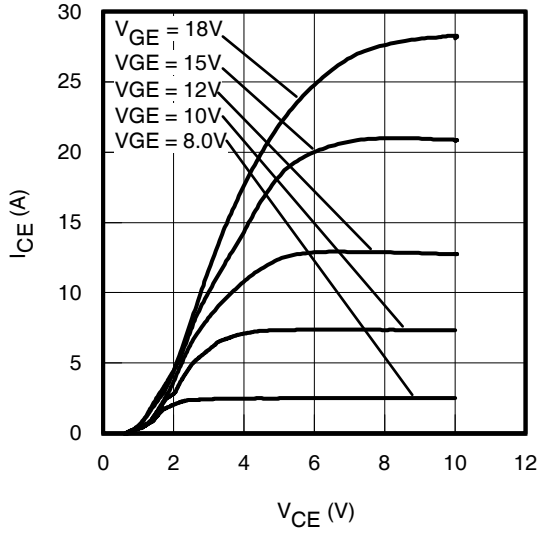


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

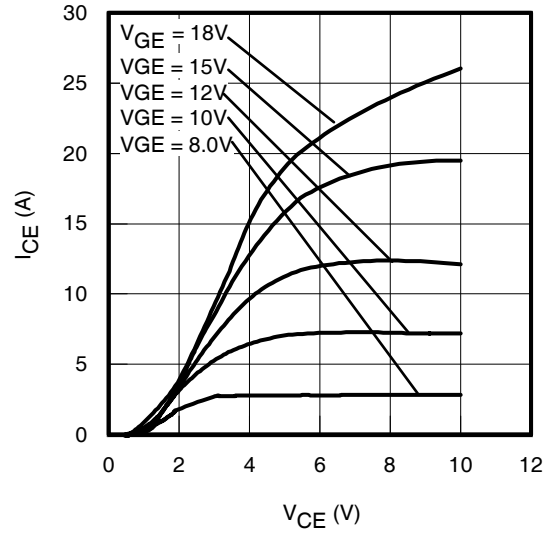


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

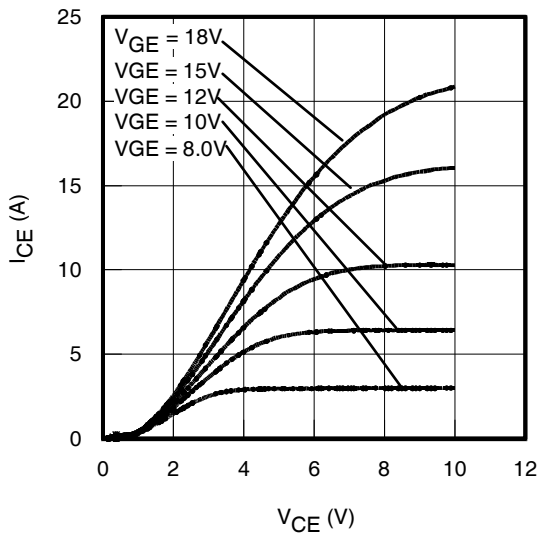


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^\circ\text{C}$; $t_p = 80\mu\text{s}$

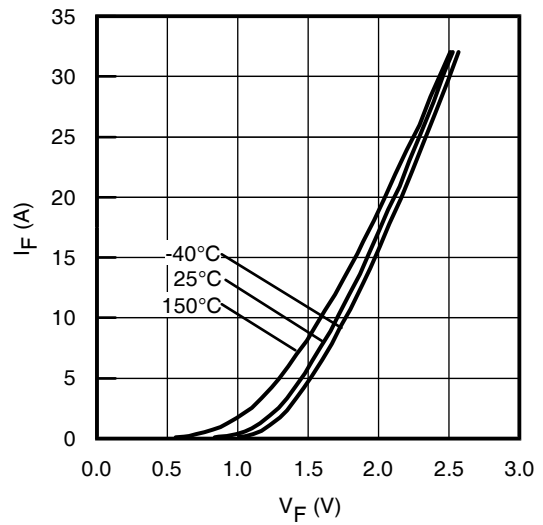


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

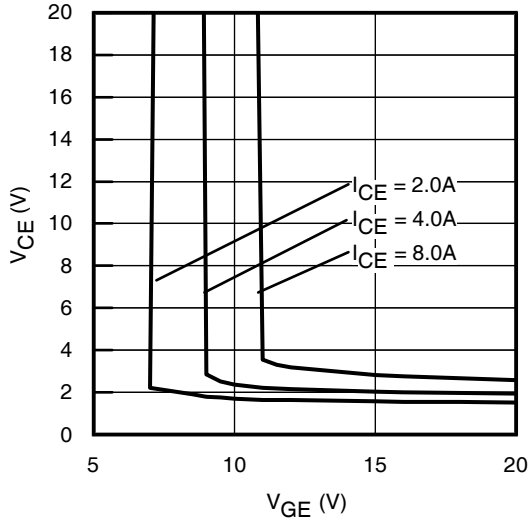


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

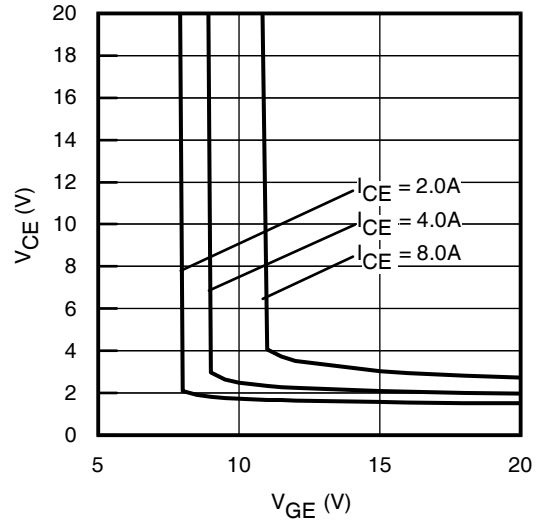


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

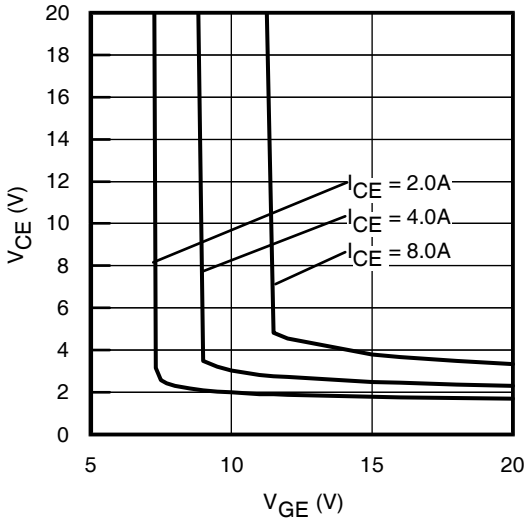


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ\text{C}$

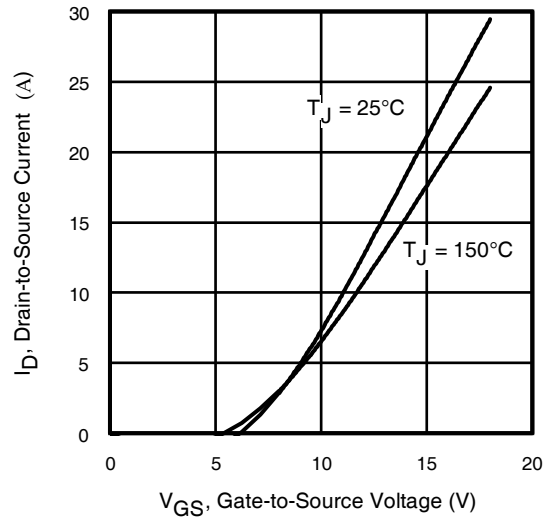


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 360\text{V}$; $t_p = 10\mu\text{s}$

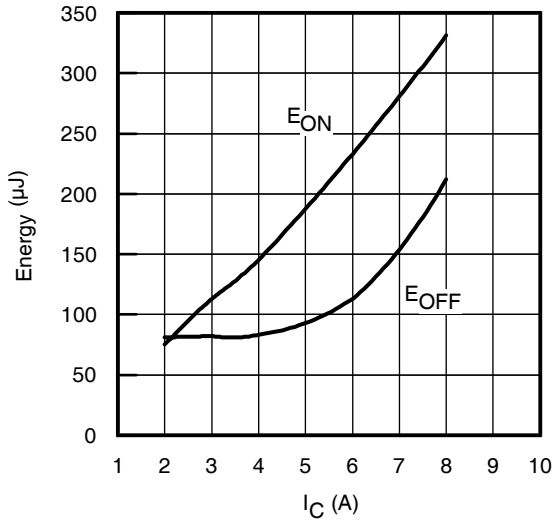


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$,
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

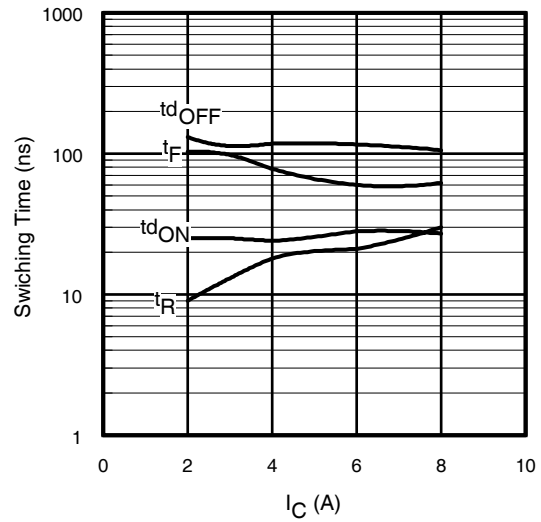


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

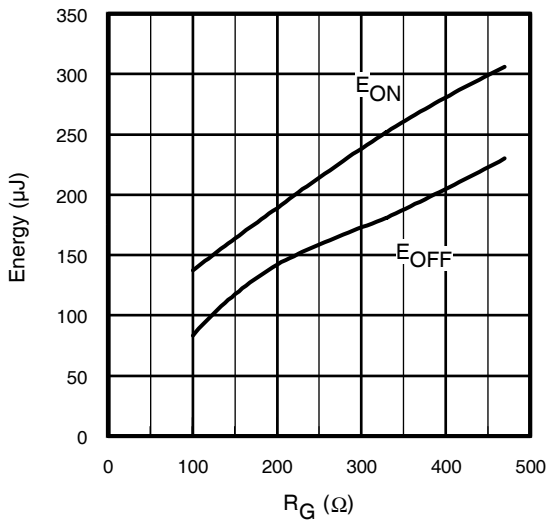


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 4.0\text{A}$; $V_{GE}= 15\text{V}$

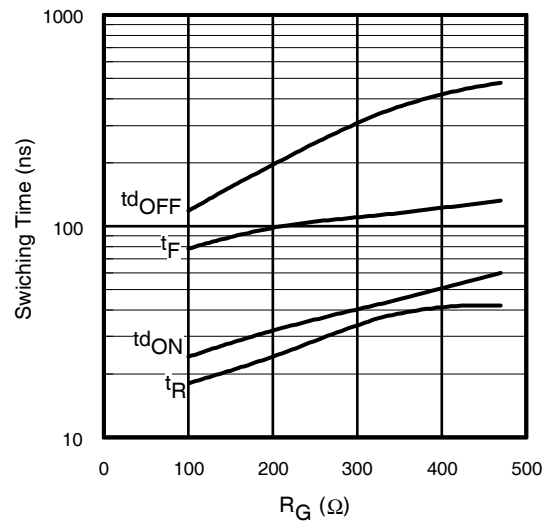


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 4.0\text{A}$; $V_{GE}= 15\text{V}$

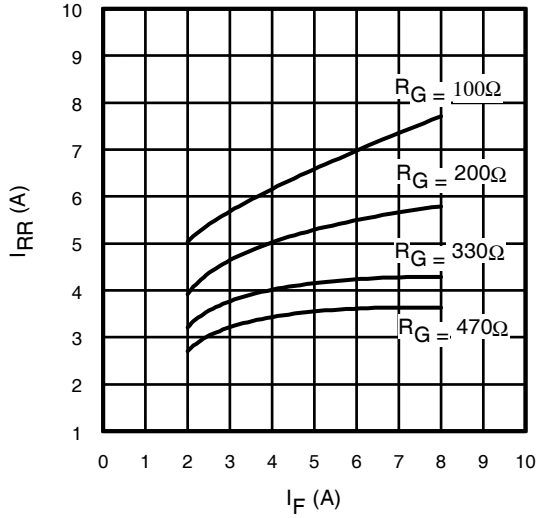


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

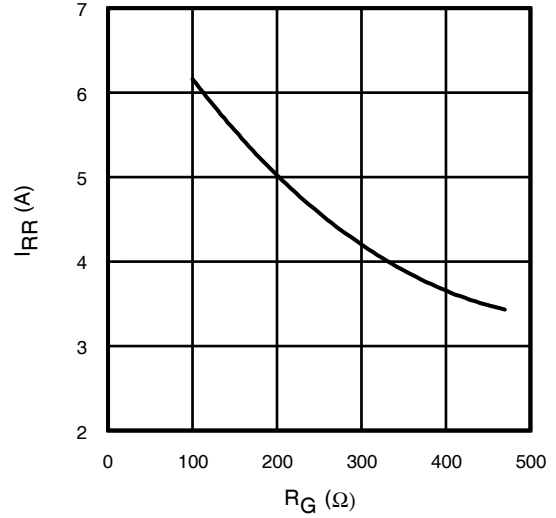


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}$; $I_F = 4.0\text{A}$

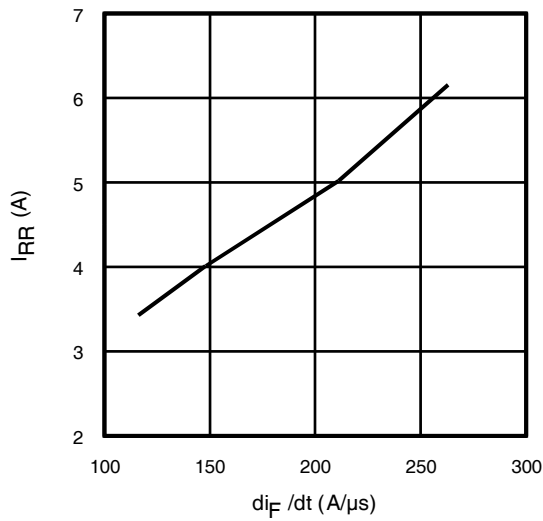


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$;
 $I_F = 4.0\text{A}$; $T_J = 150^\circ\text{C}$

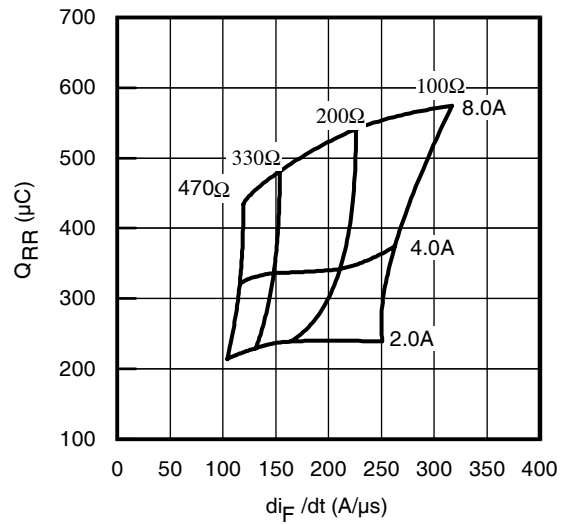


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $T_J = 150^\circ\text{C}$

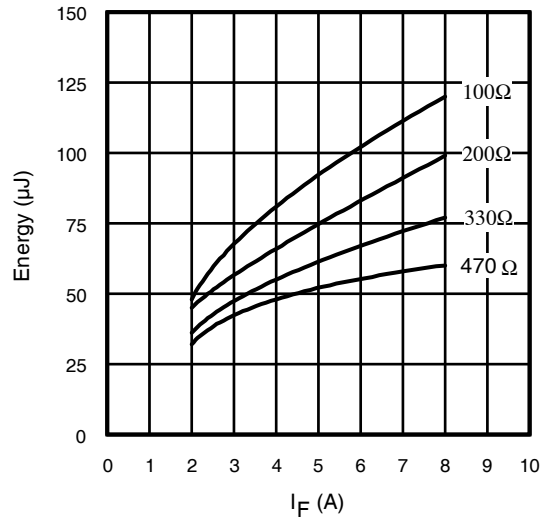


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

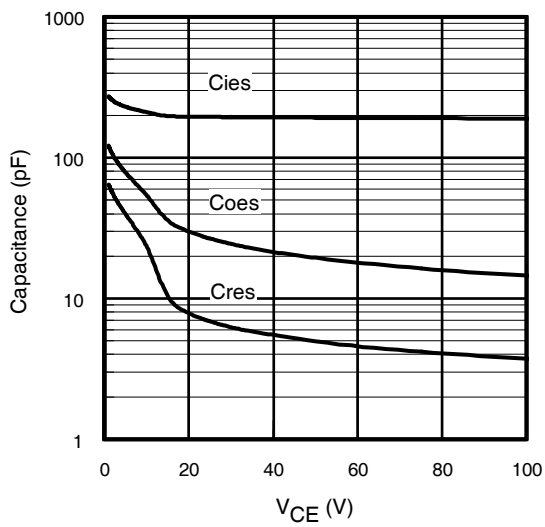


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

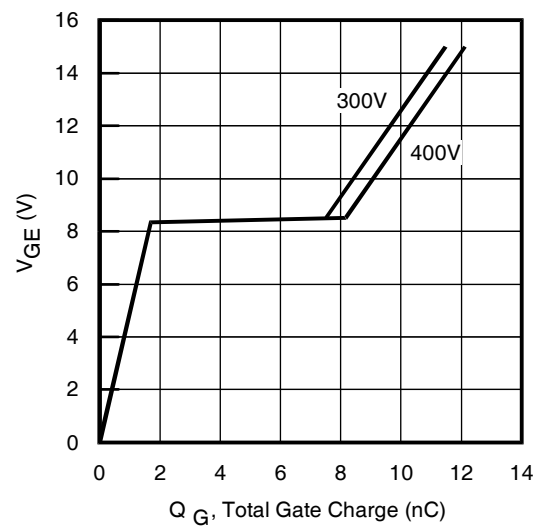


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 4.0\text{A}$; $L = 3150\mu\text{H}$

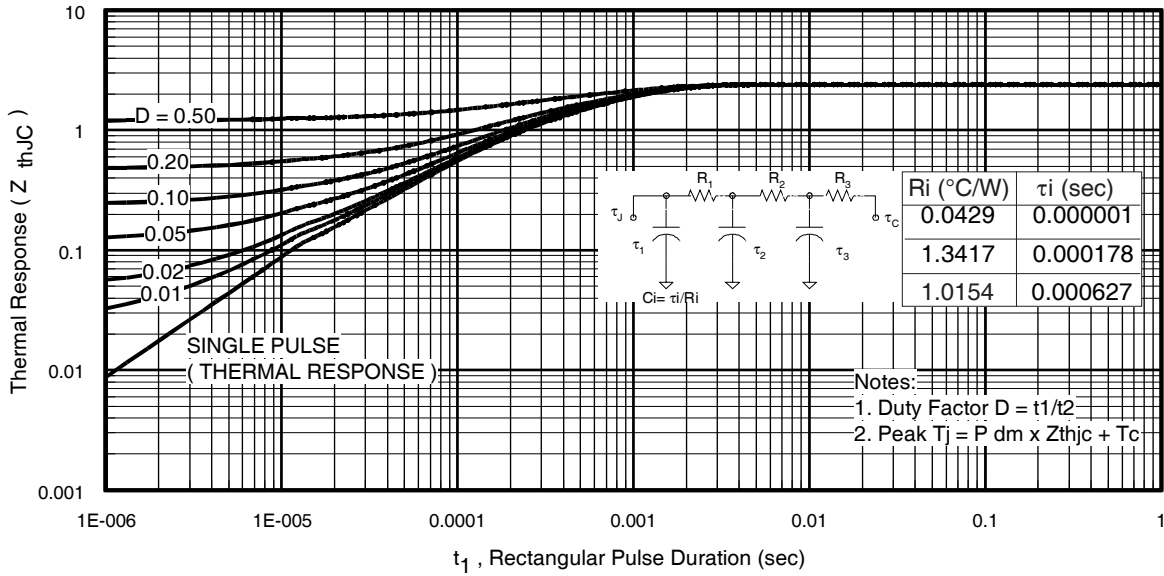


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

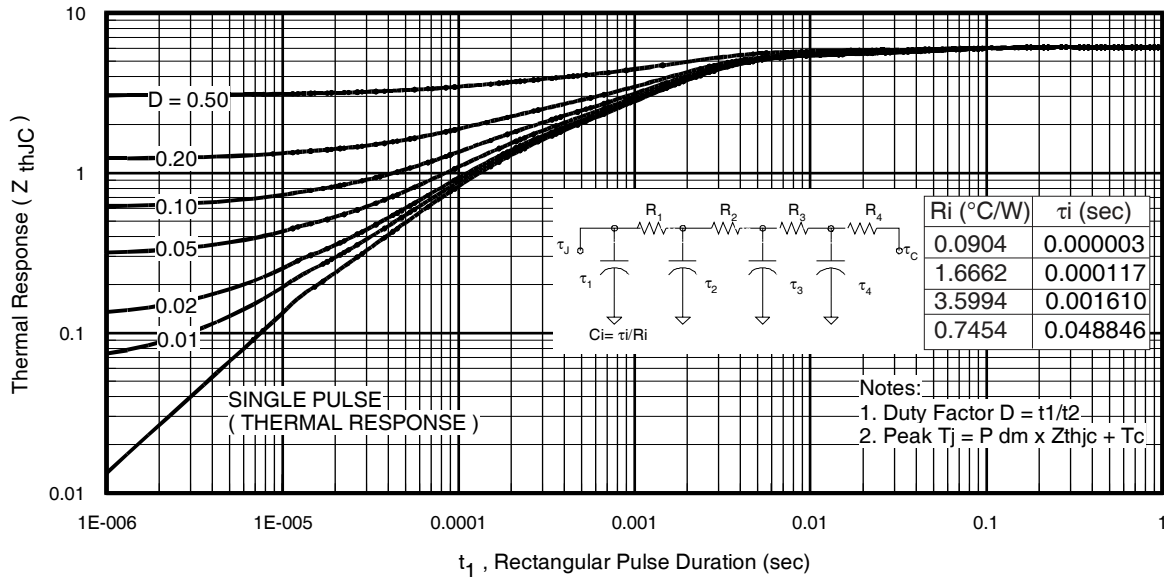


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

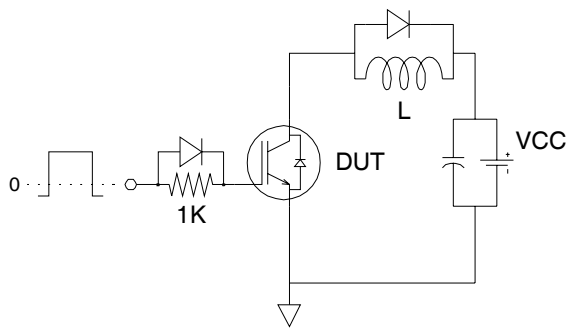


Fig.C.T.1 - Gate Charge Circuit (turn-off)

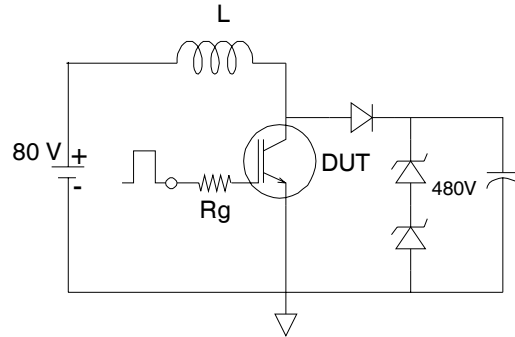


Fig.C.T.2 - RBSOA Circuit

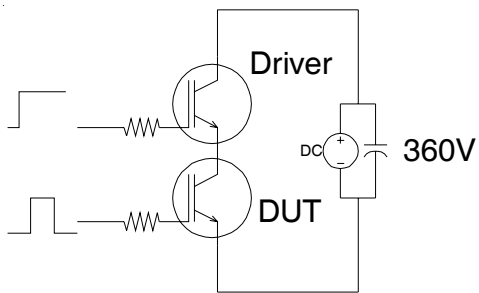


Fig.C.T.3 - S.C.SOA Circuit

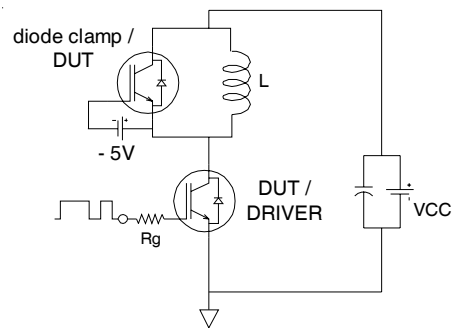


Fig.C.T.4 - Switching Loss Circuit

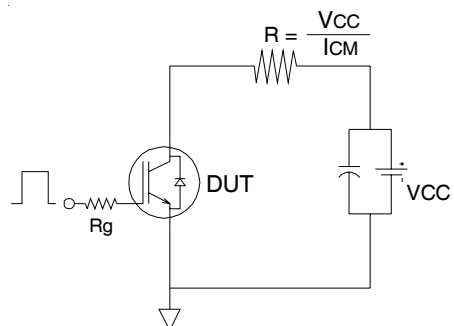


Fig.C.T.5 - Resistive Load Circuit

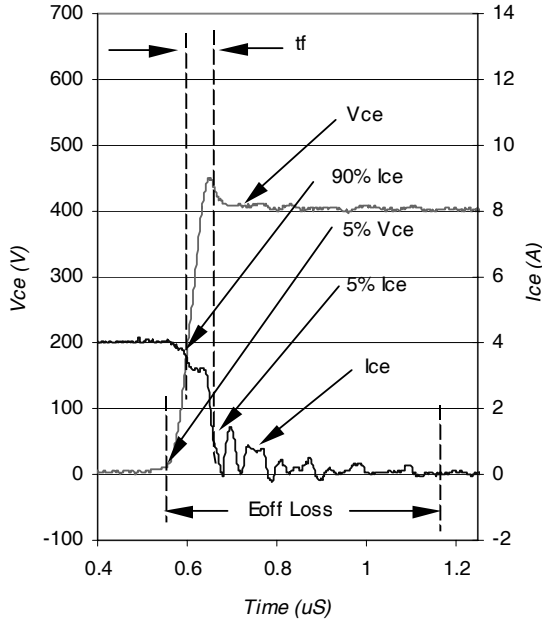


Fig. WF1- Typ. Turn-off Loss Waveform
@ T_J = 150°C using Fig. CT.4

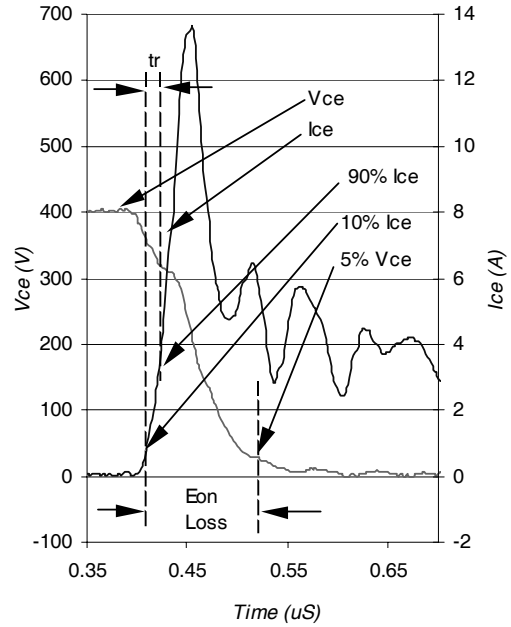


Fig. WF2- Typ. Turn-on Loss Waveform
@ T_J = 150°C using Fig. CT.4

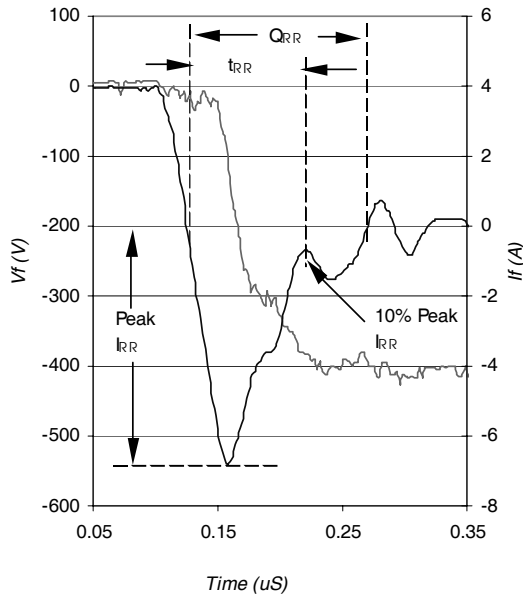


Fig. WF3- Typ. Diode Recovery Waveform
@ T_J = 150°C using Fig. CT.4

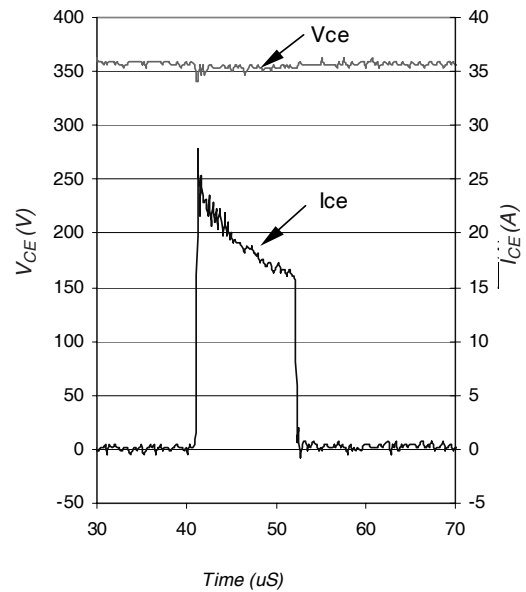
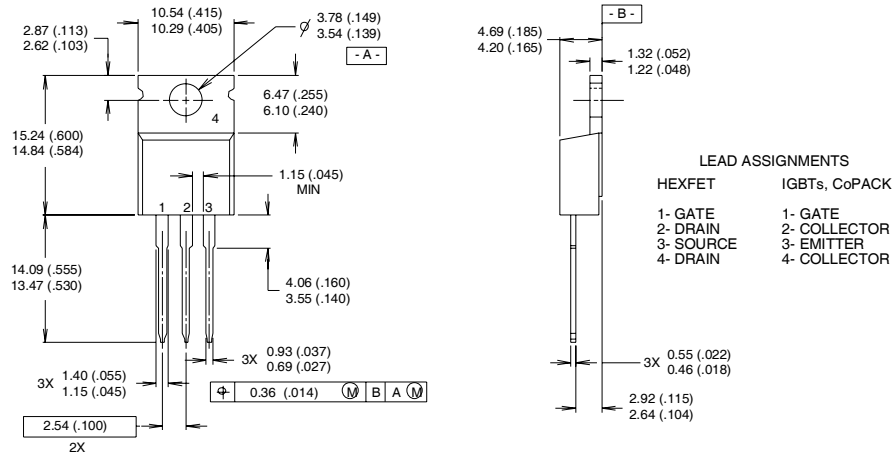


Fig. WF4- Typ. S.C Waveform
@ T_C = 150°C using Fig. CT.3

IRGB/S/SL4B60KD1PbF

TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



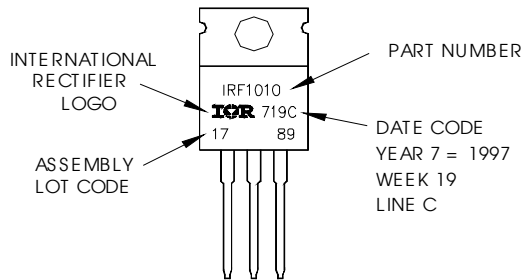
NOTES:

- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH

- 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
- 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

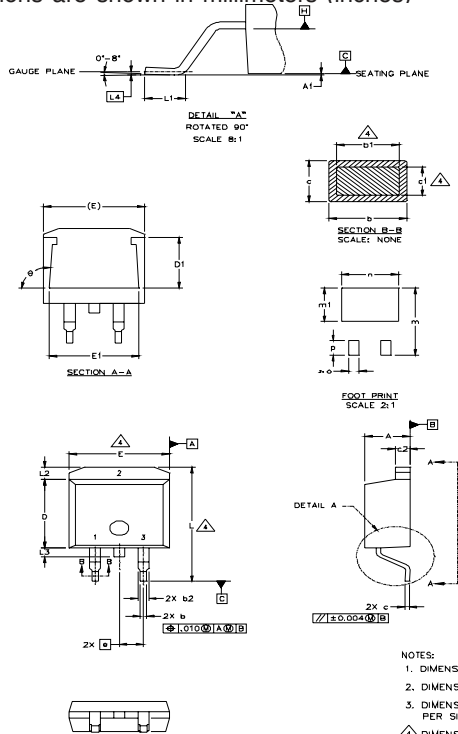
TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
 LOT CODE 1789
 ASSEMBLED ON WW 19, 1997
 IN THE ASSEMBLY LINE "C"
Note: "P" in assembly line position indicates "Lead-Free"



D²Pak Package Outline

Dimensions are shown in millimeters (inches)



| SYMBOL | DIMENSIONS | | | | NOTES |
|--------|-------------|-------|----------|------|-------|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | 4 |
| A1 | | 0.127 | | .005 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | |
| b2 | 1.14 | 1.40 | .045 | .055 | 4 |
| c | 0.43 | 0.63 | .017 | .025 | |
| c1 | 0.38 | 0.74 | .015 | .029 | |
| c2 | 1.14 | 1.40 | .045 | .055 | 3 |
| D | 8.51 | 9.65 | .335 | .380 | |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 14.61 | 15.88 | .575 | .625 | |
| L1 | 1.78 | 2.79 | .070 | .110 | |
| L2 | | 1.65 | | .065 | |
| L3 | 1.27 | 1.78 | .050 | .070 | |
| L4 | 0.25 BSC | | .010 BSC | | |
| m | 17.78 | | .700 | | |
| m1 | 8.89 | | .350 | | |
| n | 11.43 | | .450 | | |
| o | 2.08 | | .082 | | |
| p | 3.81 | | .150 | | |
| θ | 90° | 93° | 90° | 93° | |

LEAD ASSIGNMENTS

| | | |
|---------------|-----------------------|---------------|
| HEXFET | IGBTs - CoPACK | DIODES |
| 1 - GATE | 1 - GATE | 1 - ANODE + |
| 2 - DRAIN | 2 - COLLECTOR | 2 - CATHODE |
| 3 - SOURCE | 3 - EMITTER | 3 - ANODE |

* PART DEPENDENT.

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 [0.005] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

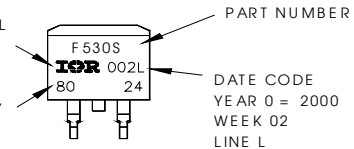
D²Pak Part Marking Information (Lead-Free)

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"

INTERNATIONAL
RECTIFIER
LOGO

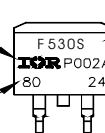
ASSEMBLY
LOT CODE



OR

INTERNATIONAL
RECTIFIER
LOGO

ASSEMBLY
LOT CODE

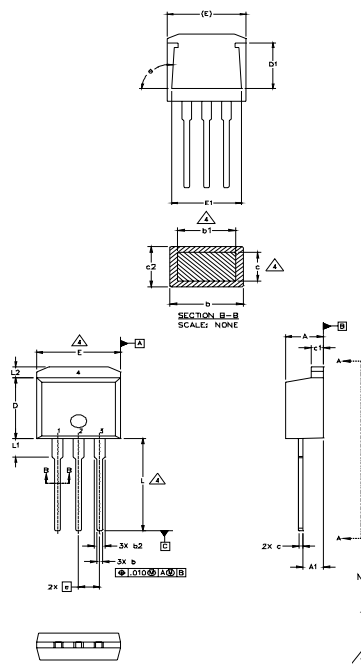


PART NUMBER

DATE CODE
YEAR 0 = 2000
WEEK 02
A = ASSEMBLY SITE CODE

IRGB/S/SL4B60KD1PbF

TO-262 Package Outline



| SYMBOL | DIMENSIONS | | | | NOTES |
|--------|-------------|-------|----------|------|-------|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 2.03 | 2.92 | .080 | .115 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.40 | .045 | .055 | |
| c | 0.38 | 0.63 | .015 | .025 | 4 |
| c1 | 1.14 | 1.40 | .045 | .055 | |
| c2 | 0.43 | .063 | .017 | .029 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 13.46 | 14.09 | .530 | .555 | |
| L1 | 3.56 | 3.71 | .140 | .146 | |
| L2 | | 1.65 | | .065 | |

LEAD ASSIGNMENTS

HEXFET

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

IGBT

- 1 - GATE
- 2 - COLLECTOR
- 3 - EMITTER

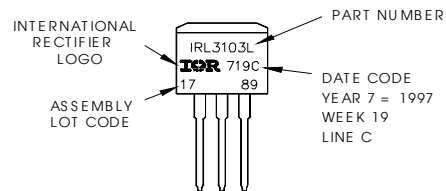
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES]
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4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

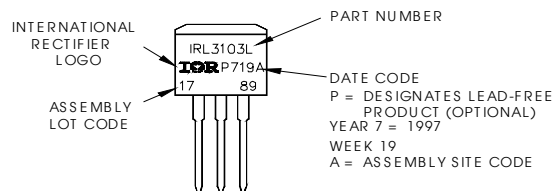
TO-262 Part Marking Information

EXAMPLE: THIS IS AN IRL3103L
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"

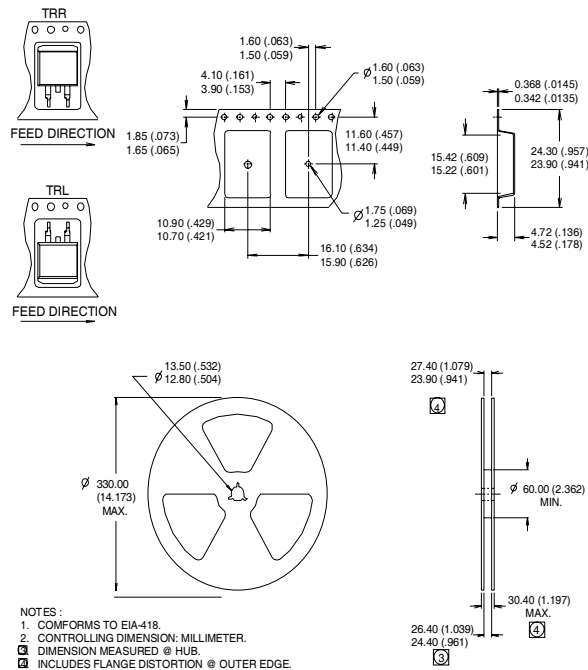
Note: "P" in assembly line position indicates "Lead-Free"



OR



D²Pak Tape & Reel Infomation



Notes:

- ① $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 15V$, $L = 100\mu H$, $R_G = 100\Omega$.
- ② When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ③ Energy losses include "tail" and diode reverse recovery, using Diode FD059H06A5.

TO-220AB package is not recommended for Surface Mount Application.

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.

International
IR Rectifier

IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
 TAC Fax: (310) 252-7903

Visit us at www.irf.com for sales contact information. 08/04

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