

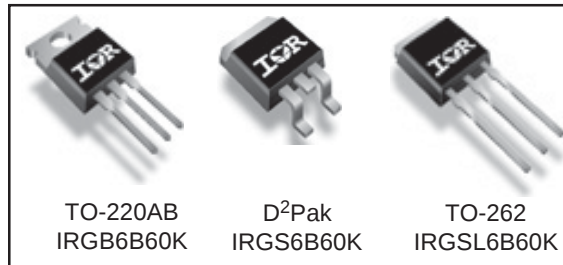
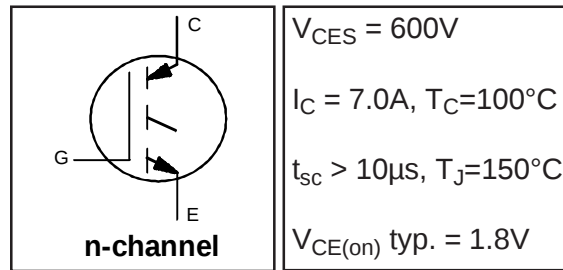
IRGB6B60KPbF  
IRGS6B60KPbF  
IRGSL6B60KPbF

### Features

- Low VCE (on) Non Punch Through IGBT Technology.
- 10μs Short Circuit Capability.
- Square RBSOA.
- Positive VCE (on) Temperature Coefficient.
- 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 <sub>CES</sub>                        | Collector-to-Emitter Voltage       | 600                               | V     |
| I <sub>C</sub> @ T <sub>C</sub> = 25°C  | Continuous Collector Current       | 13                                | A     |
| I <sub>C</sub> @ T <sub>C</sub> = 100°C | Continuous Collector Current       | 7.0                               |       |
| I <sub>CM</sub>                         | Pulsed Collector Current           | 26                                |       |
| I <sub>LM</sub>                         | Clamped Inductive Load Current ①   | 26                                |       |
| V <sub>GE</sub>                         | Gate-to-Emitter Voltage            | ± 20                              | V     |
| P <sub>D</sub> @ T <sub>C</sub> = 25°C  | Maximum Power Dissipation          | 90                                | W     |
| P <sub>D</sub> @ T <sub>C</sub> = 100°C | Maximum Power Dissipation          | 36                                |       |
| T <sub>J</sub>                          | Operating Junction and             | -55 to +150                       | °C    |
| T <sub>STG</sub>                        | Storage Temperature Range          |                                   |       |
|                                         | Soldering Temperature, for 10 sec. | 300 (0.063 in. (1.6mm) from case) |       |

### Thermal Resistance

|                  | Parameter                                      | Min. | Typ. | Max. | Units |
|------------------|------------------------------------------------|------|------|------|-------|
| R <sub>θJC</sub> | Junction-to-Case - IGBT                        | —    | —    | 1.4  | °C/W  |
| R <sub>θCS</sub> | Case-to-Sink, flat, greased surface            | —    | 0.50 | —    |       |
| R <sub>θJA</sub> | Junction-to-Ambient, typical socket mount②     | —    | —    | 62   |       |
| R <sub>θJA</sub> | Junction-to-Ambient (PCB Mount, steady state)③ | —    | —    | 40   |       |
| Wt               | Weight                                         | —    | 1.44 | —    | g     |

# IRGB/S/SL6B60KPbF

International  
**IR** Rectifier

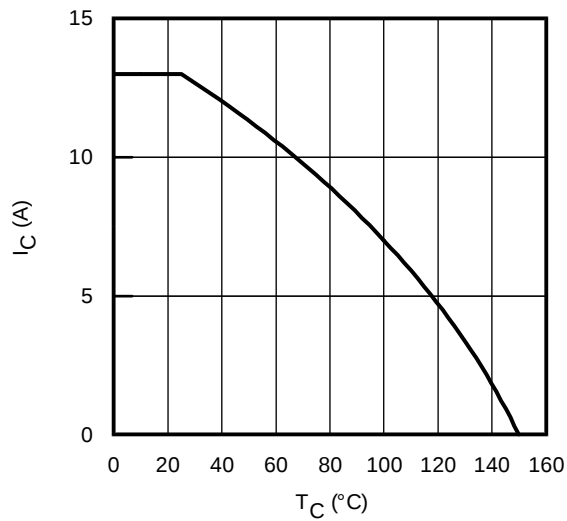
## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

|                                 | 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 | —    | 0.3  | —         | V/°C    | $V_{GE} = 0V, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$     |          |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage | 1.5  | 1.80 | 2.20      | V       | $I_C = 5.0A, V_{GE} = 15V$                                           | 5, 6, 7  |
|                                 |                                         | —    | 2.20 | 2.50      |         | $I_C = 5.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$                  | 8, 9, 10 |
| $V_{GE(th)}$                    | Gate Threshold Voltage                  | 3.5  | 4.5  | 5.5       | V       | $V_{CE} = V_{GE}, I_C = 250\mu A$                                    | 8, 9, 10 |
| $\Delta V_{GE(th)}/\Delta T_J$  | Temperature Coeff. of Threshold Voltage | —    | -10  | —         | mV/°C   | $V_{CE} = V_{GE}, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$ | 11       |
| $g_{fe}$                        | Forward Transconductance                | —    | 3.0  | —         | S       | $V_{CE} = 50V, I_C = 5.0A, PW=80\mu s$                               |          |
| $I_{CES}$                       | Zero Gate Voltage Collector Current     | —    | 1.0  | 150       | $\mu A$ | $V_{GE} = 0V, V_{CE} = 600V$                                         |          |
|                                 |                                         | —    | 200  | 500       |         | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$                |          |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current         | —    | —    | $\pm 100$ | nA      | $V_{GE} = \pm 20V$                                                   |          |

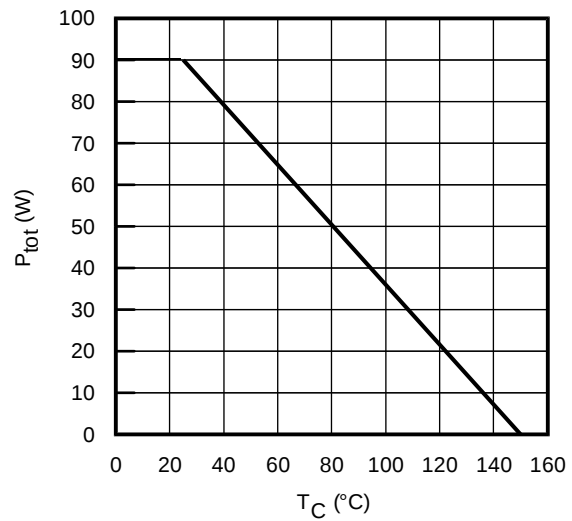
## Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

|              | Parameter                         | Min.        | Typ. | Max. | Units   | Conditions                                                                                                         | Ref.Fig.   |
|--------------|-----------------------------------|-------------|------|------|---------|--------------------------------------------------------------------------------------------------------------------|------------|
| $Q_g$        | Total Gate Charge (turn-on)       | —           | 18.2 | —    | nC      | $I_C = 5.0A$                                                                                                       | 17         |
| $Q_{ge}$     | Gate - Emitter Charge (turn-on)   | —           | 1.9  | —    |         | $V_{CC} = 400V$                                                                                                    | CT1        |
| $Q_{gc}$     | Gate - Collector Charge (turn-on) | —           | 9.2  | —    |         | $V_{GE} = 15V$                                                                                                     |            |
| $E_{on}$     | Turn-On Switching Loss            | —           | 110  | 210  | $\mu J$ | $I_C = 5.0A, V_{CC} = 400V$                                                                                        | CT4        |
| $E_{off}$    | Turn-Off Switching Loss           | —           | 135  | 245  |         | $V_{GE} = 15V, R_G = 100\Omega, L = 1.4mH$                                                                         |            |
| $E_{tot}$    | Total Switching Loss              | —           | 245  | 455  |         | $L_s = 150nH, T_J = 25^\circ\text{C} \text{ ④}$                                                                    |            |
| $t_{d(on)}$  | Turn-On Delay Time                | —           | 25   | 34   | ns      | $I_C = 5.0A, V_{CC} = 400V$                                                                                        | CT4        |
| $t_r$        | Rise Time                         | —           | 17   | 26   |         | $V_{GE} = 15V, R_G = 100\Omega, L = 1.4mH$                                                                         |            |
| $t_{d(off)}$ | Turn-Off Delay Time               | —           | 215  | 230  |         | $L_s = 150nH, T_J = 25^\circ\text{C}$                                                                              |            |
| $t_f$        | Fall Time                         | —           | 13.2 | 22   |         |                                                                                                                    |            |
| $E_{on}$     | Turn-On Switching Loss            | —           | 150  | 260  | $\mu J$ | $I_C = 5.0A, V_{CC} = 400V$                                                                                        | CT4        |
| $E_{off}$    | Turn-Off Switching Loss           | —           | 190  | 300  |         | $V_{GE} = 15V, R_G = 100\Omega, L = 1.4mH$                                                                         | 12, 14     |
| $E_{tot}$    | Total Switching Loss              | —           | 340  | 560  |         | $L_s = 150nH, T_J = 150^\circ\text{C} \text{ ④}$                                                                   | WF1, WF2   |
| $t_{d(on)}$  | Turn-On Delay Time                | —           | 28   | 37   | ns      | $I_C = 5.0A, V_{CC} = 400V$                                                                                        | 13, 15     |
| $t_r$        | Rise Time                         | —           | 17   | 26   |         | $V_{GE} = 15V, R_G = 100\Omega, L = 1.4mH$                                                                         | CT4        |
| $t_{d(off)}$ | Turn-Off Delay Time               | —           | 240  | 255  |         | $L_s = 150nH, T_J = 150^\circ\text{C}$                                                                             | WF1        |
| $t_f$        | Fall Time                         | —           | 18   | 27   |         |                                                                                                                    | WF2        |
| $C_{ies}$    | Input Capacitance                 | —           | 290  | —    | pF      | $V_{GE} = 0V$                                                                                                      | 16         |
| $C_{oes}$    | Output Capacitance                | —           | 34   | —    |         | $V_{CC} = 30V$                                                                                                     |            |
| $C_{res}$    | Reverse Transfer Capacitance      | —           | 10   | —    |         | $f = 1.0MHz$                                                                                                       |            |
| RBSOA        | Reverse Bias Safe Operating Area  | FULL SQUARE |      |      |         | $T_J = 150^\circ\text{C}, I_C = 26A, V_p = 600V$<br>$V_{CC} = 500V, V_{GE} = +15V \text{ to } 0V, R_G = 100\Omega$ | 4<br>CT2   |
| SCSOA        | Short Circuit Safe Operating Area | 10          | —    | —    | $\mu s$ | $T_J = 150^\circ\text{C}, V_p = 600V, R_G = 100\Omega$<br>$V_{CC} = 360V, V_{GE} = +15V \text{ to } 0V$            | CT3<br>WF3 |

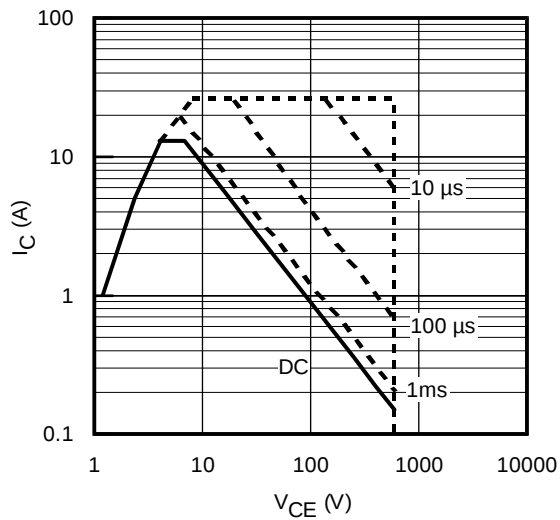
Note ① to ④ are on page 13



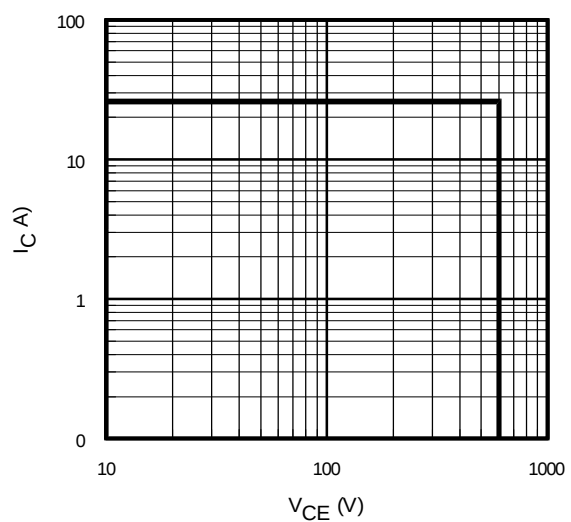
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



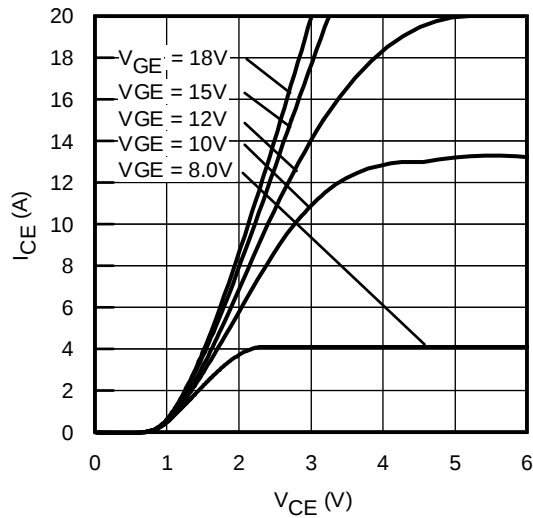
**Fig. 2** - Power Dissipation vs. Case Temperature



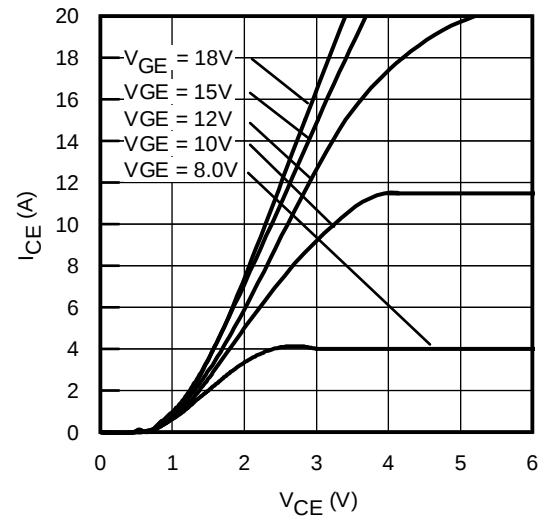
**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$



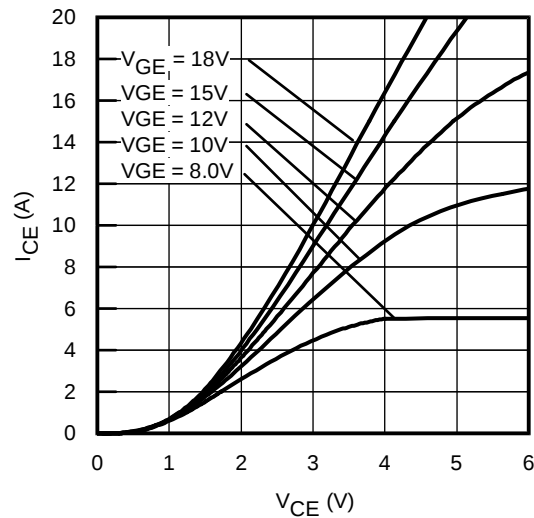
**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$



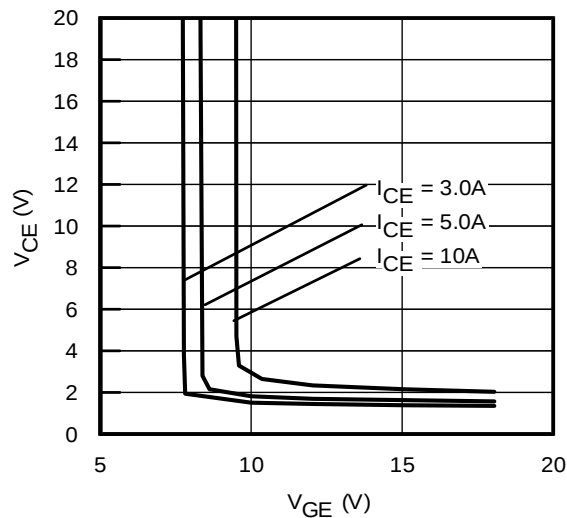
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



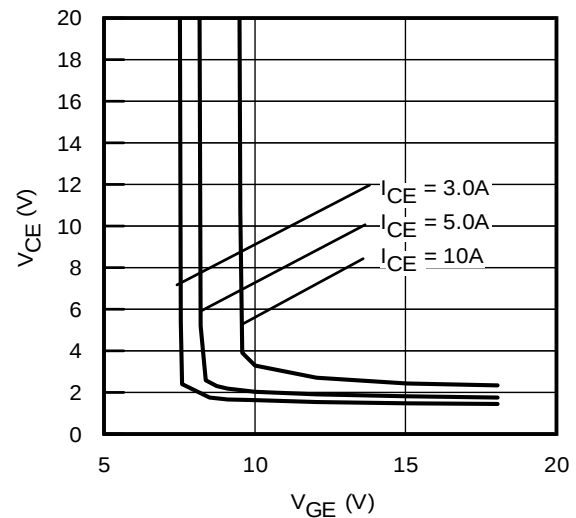
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



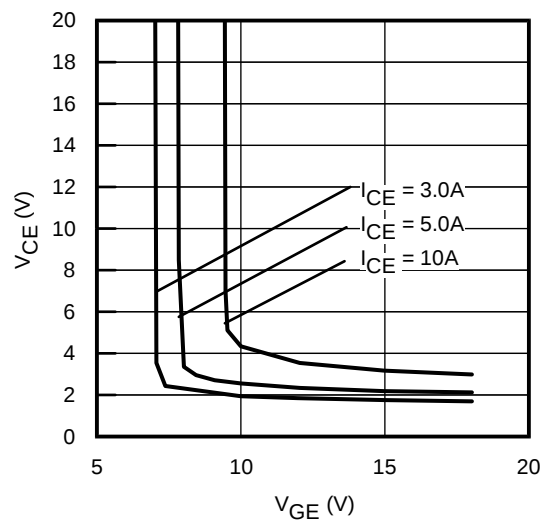
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 150^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



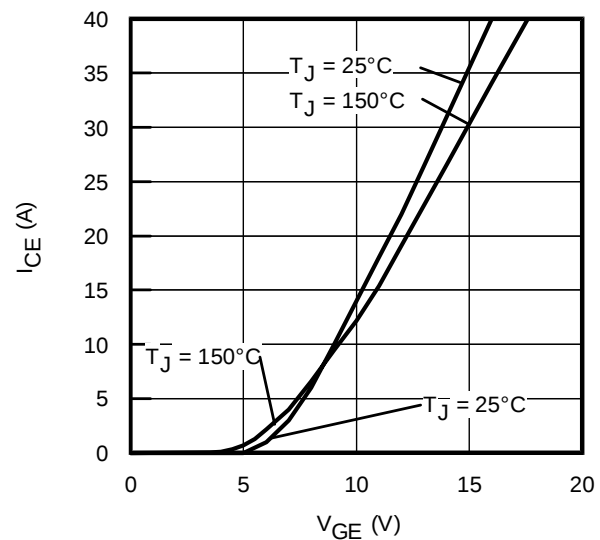
**Fig. 8** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



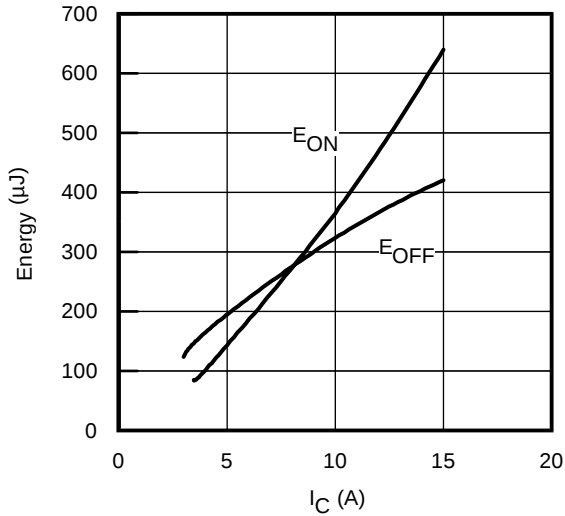
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



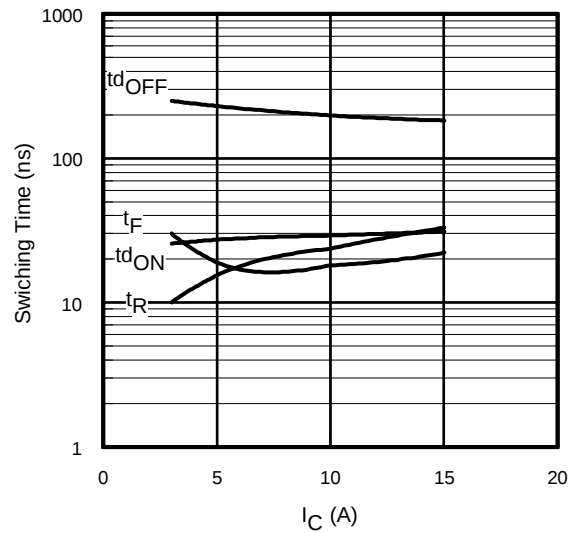
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 150^\circ\text{C}$



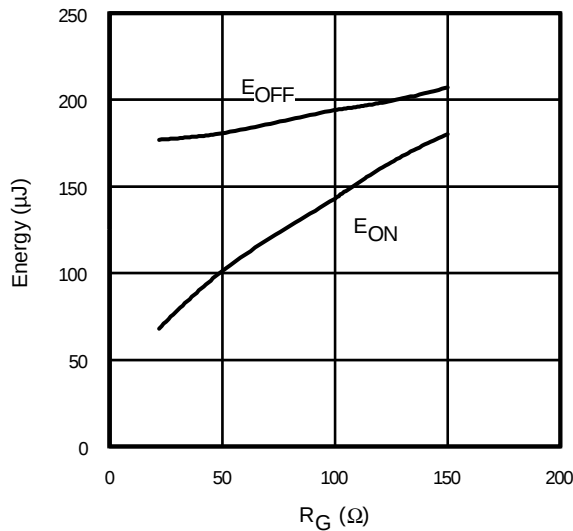
**Fig. 11** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$



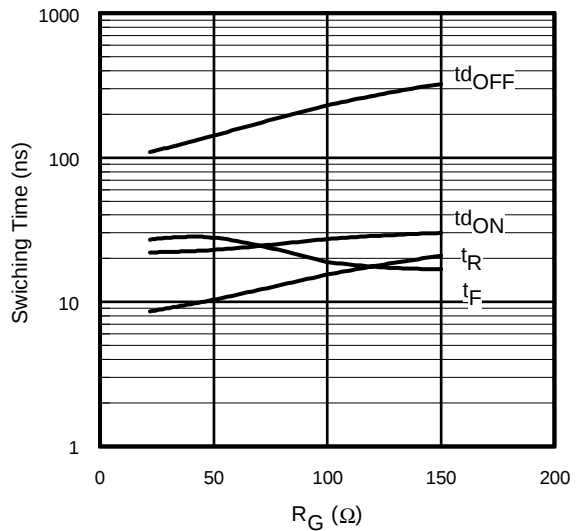
**Fig. 12** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 100\Omega$ ;  $V_{GE} = 15\text{V}$



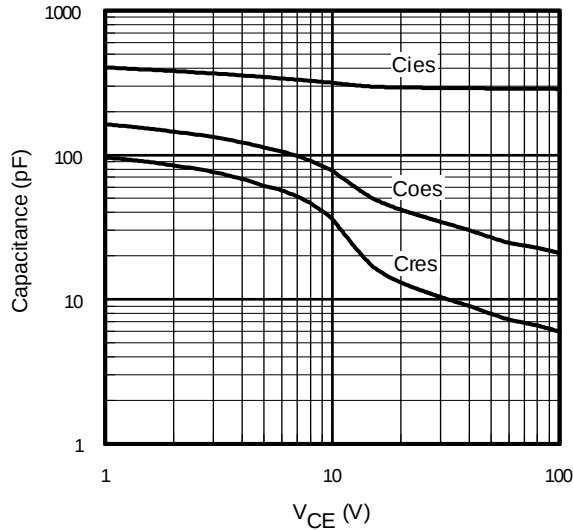
**Fig. 13** - Typ. Switching Time vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 100\Omega$ ;  $V_{GE} = 15\text{V}$



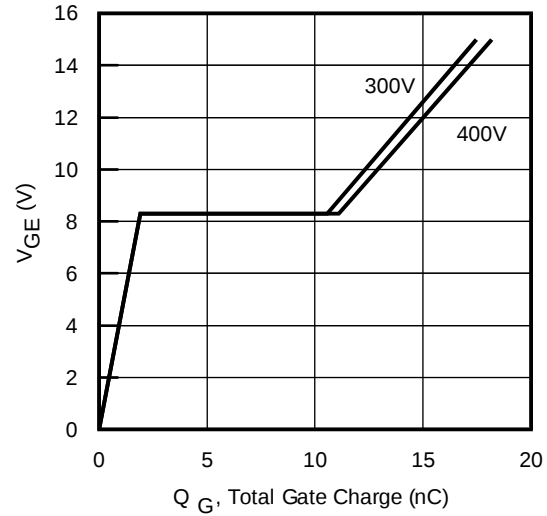
**Fig. 14** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 5.0\text{A}$ ;  $V_{GE} = 15\text{V}$



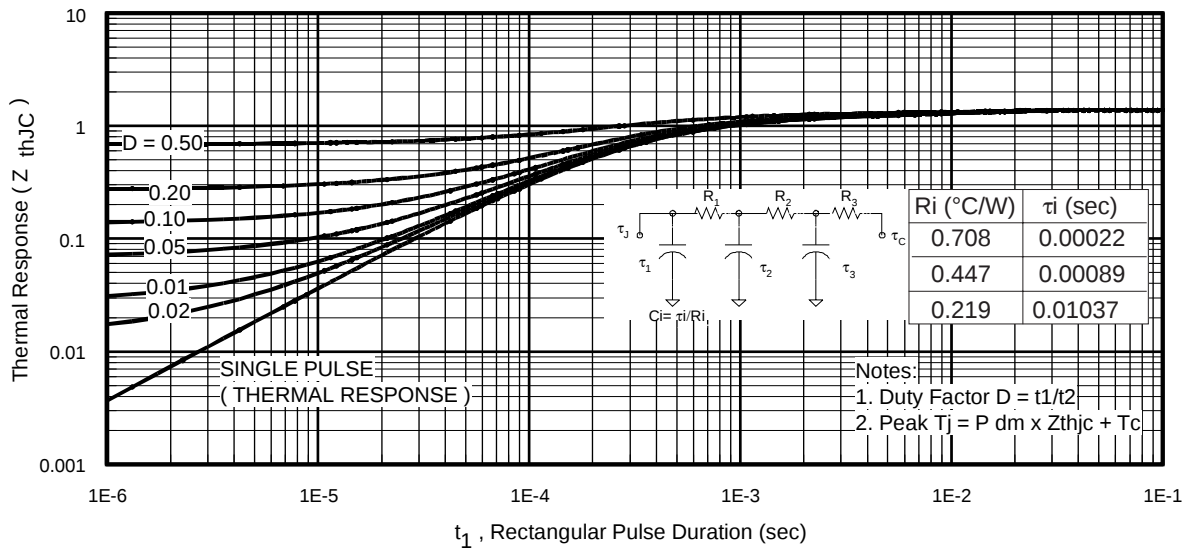
**Fig. 15** - Typ. Switching Time vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 5.0\text{A}$ ;  $V_{GE} = 15\text{V}$



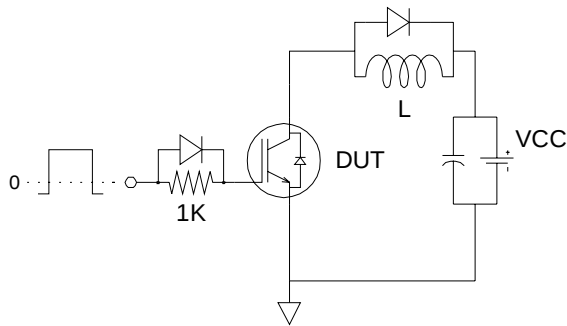
**Fig. 16-** Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0V$ ;  $f = 1MHz$



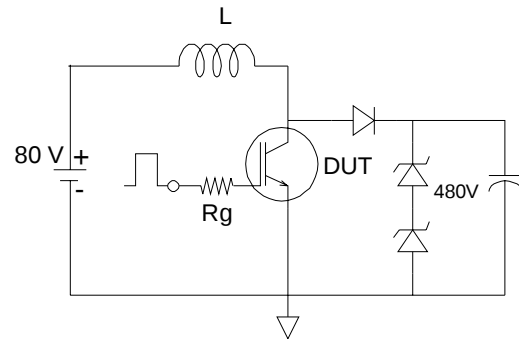
**Fig. 17 -** Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 5.0A$ ;  $L = 600\mu H$



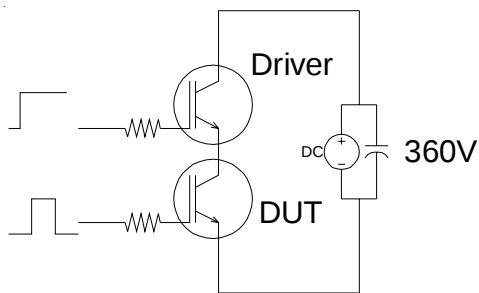
**Fig 18.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)



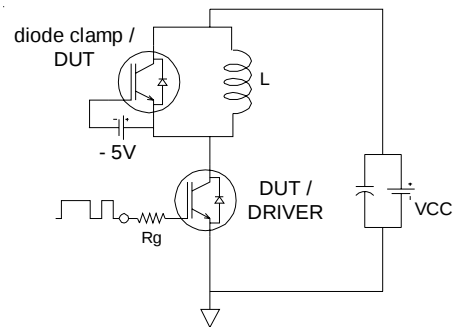
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



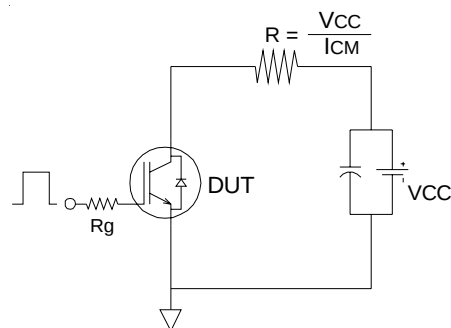
**Fig.C.T.2** - RBSOA Circuit



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



**Fig.C.T.4** - Switching Loss Circuit



**Fig.C.T.5** - Resistive Load Circuit

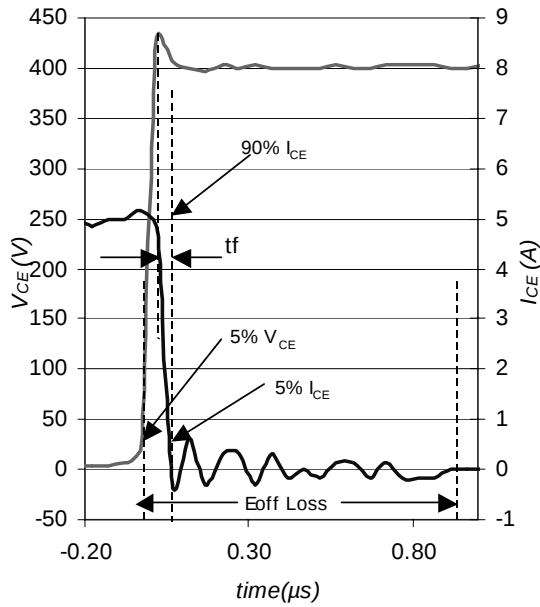


Fig. WF1- Typ. Turn-off Loss Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4

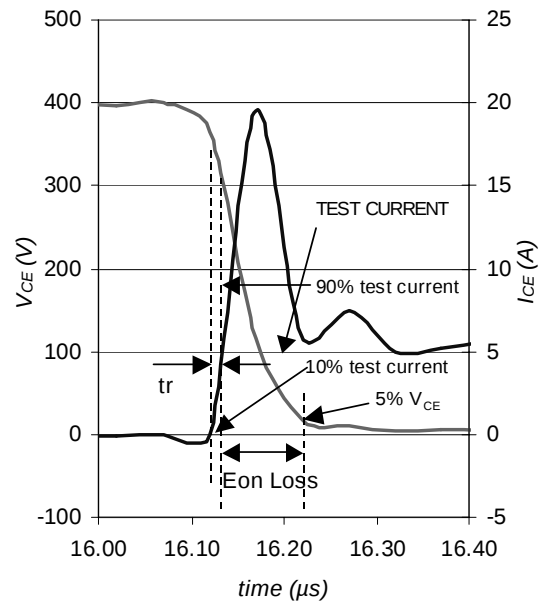


Fig. WF2- Typ. Turn-on Loss Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4

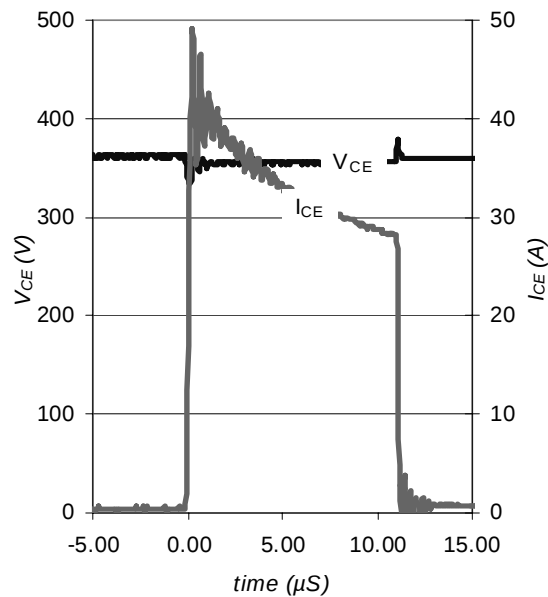


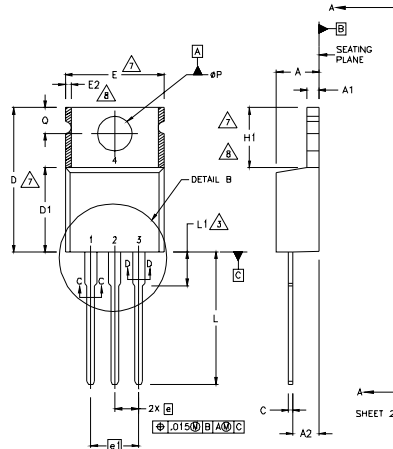
Fig. WF3- Typ. S.C Waveform  
@  $T_C = 150^\circ\text{C}$  using Fig. CT.3

# IRGB/S/SL6B60KPbF

International  
**IR** Rectifier

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



### NOTES:

- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5 DIMENSION b1 & c1 APPLY TO BASE METAL ONLY.
- 6 CONTROLLING DIMENSION : INCHES.
- 7 THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
- 8 DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.

### LEAD ASSIGNMENTS

#### DIODET

- 1 - GATE
- 2 - DRAIN
- 3 - SOURCE

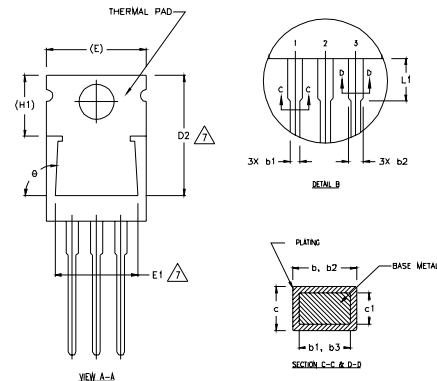
#### IGBTs, COPACK

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

#### DIODES

- 1 - ANODE/OPEN
- 2 - CATHODE
- 3 - ANODE

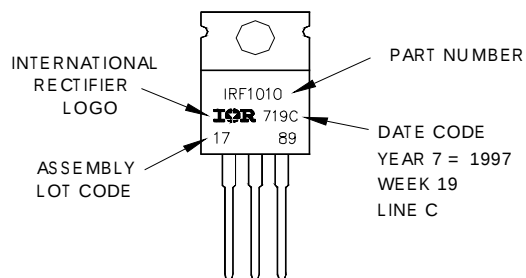
| SYMBOL | DIMENSIONS  |       |          |      | NOTES |   |
|--------|-------------|-------|----------|------|-------|---|
|        | MILLIMETERS |       | INCHES   |      |       |   |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |   |
| A      | 3.56        | 4.82  | .140     | .190 | 5     |   |
| A1     | 0.51        | 1.40  | .020     | .055 |       |   |
| A2     | 2.04        | 2.92  | .080     | .115 |       |   |
| b      | 0.38        | 1.01  | .015     | .040 |       |   |
| b1     | 0.38        | 0.96  | .015     | .038 |       |   |
| b2     | 1.15        | 1.77  | .045     | .070 |       |   |
| b3     | 1.15        | 1.73  | .045     | .068 |       |   |
| c      | 0.36        | 0.61  | .014     | .024 |       | 5 |
| c1     | 0.36        | 0.56  | .014     | .022 |       |   |
| D      | 14.22       | 16.51 | .560     | .650 | 4     |   |
| D1     | 8.38        | 9.02  | .330     | .355 |       |   |
| D2     | 12.19       | 12.88 | .480     | .507 | 7     |   |
| E      | 9.66        | 10.66 | .380     | .420 | 4,7   |   |
| E1     | 8.38        | 8.89  | .330     | .350 | 7     |   |
| e      | 2.54 BSC    |       | .100 BSC |      |       |   |
| e1     | 5.08        |       | .200 BSC |      |       |   |
| H1     | 5.85        | 6.55  | .230     | .270 | 7,8   |   |
| L      | 12.70       | 14.73 | .500     | .580 |       |   |
| L1     | —           | 6.35  | —        | .250 | 3     |   |
| øP     | 3.54        | 4.08  | .139     | .161 |       |   |
| Q      | 2.54        | 3.42  | .100     | .135 |       |   |
| ø      | 90°-93°     |       | 90°-93°  |      |       |   |



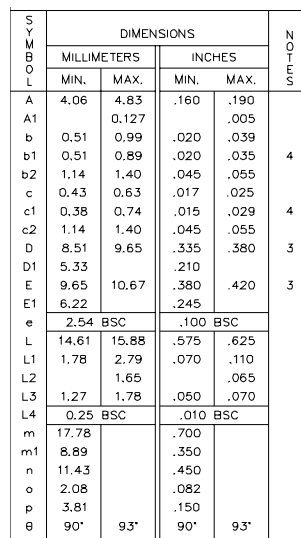
## TO-220AB Part Marking Information

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"



Dimensions are shown in millimeters (inches)



| 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.

## D<sup>2</sup>Pak Part Marking Information

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

Diagram of a 2-pin connector with labels:

- PART NUMBER: F530S
- DATE CODE: 002L
- YEAR 0 = 2000
- WEEK 02
- LINE L

OR

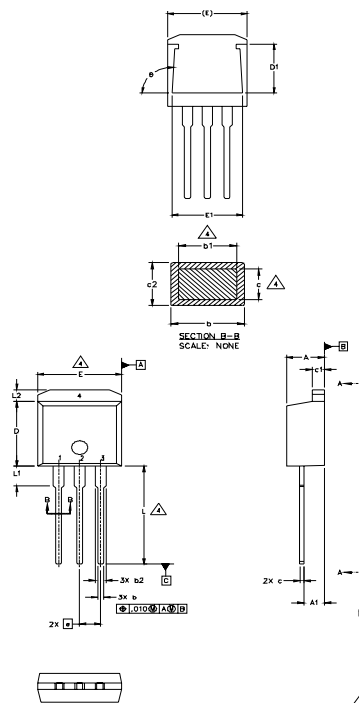
PART NUMBER  
 DATE CODE  
 P = DESIGNATES LEAD-FREE  
 PRODUCT (OPTIONAL)  
 YEAR 0 = 2000  
 WEEK 02  
 A = ASSEMBLY SITE CODE

# IRGB/S/SL6B60KPbF

International  
**IR** Rectifier

## TO-262 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     | 2.03        | 2.92  | .080     | .115 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 |       |
| b2     | 1.14        | 1.40  | .045     | .055 | 4     |
| c      | 0.38        | 0.63  | .015     | .025 |       |
| 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

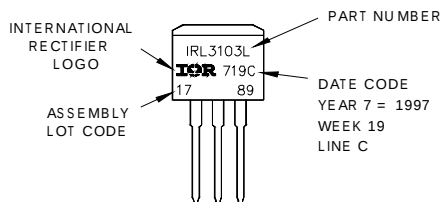
- 1 - GATE
- 2 - COLLECTOR
- 3 - EMITTER

- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
  2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
  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.

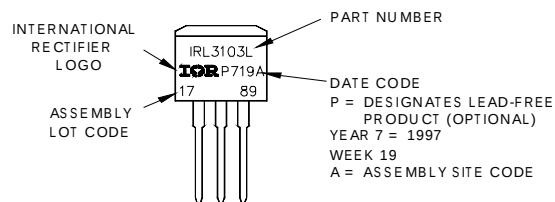
## TO-262 Part Marking Information

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"

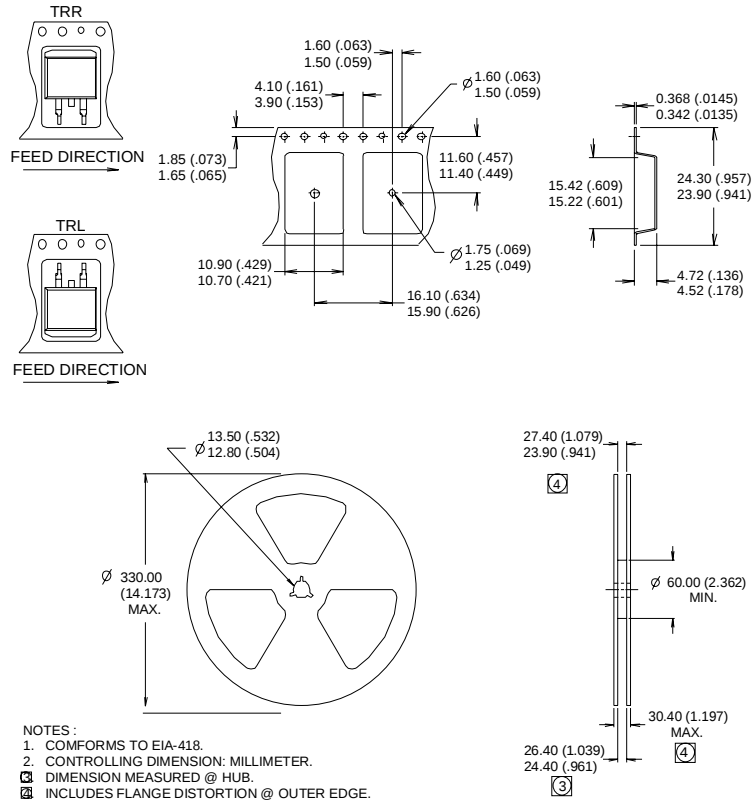


OR



## D<sup>2</sup>Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)



Notes:

- ①  $V_{CC}=80\% (V_{CES})$ ,  $V_{GE}=15V$ ,  $L=28\mu H$ ,  $R_G=22\Omega$
- ② This is only applied to TO-220AB package
- ③ This is applied to D<sup>2</sup>Pak, when mounted on 1" square PCB ( FR-4 or G-10 Material ).  
For recommended footprint and soldering techniques refer to application note #AN-994.
- ④ Energy losses include "tail" and diode reverse recovery, using Diode HF03D060ACE.

TO-220 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  
**IOR** Rectifier

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TAC Fax: (310) 252-7903

Visit us at [www.irf.com](http://www.irf.com) for sales contact information. 11/04

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