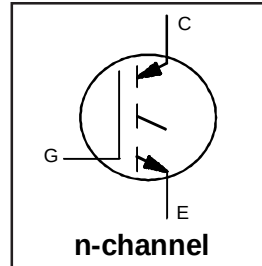


### Features

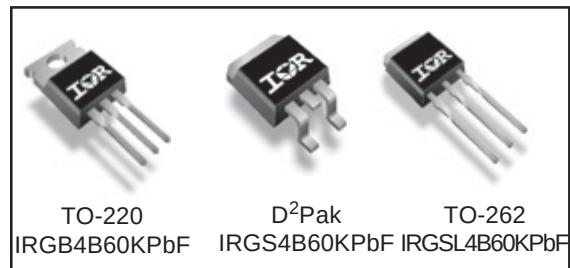
- Low VCE (on) Non Punch Through IGBT Technology.
- 10μs Short Circuit Capability.
- Square RBSOA.
- Positive VCE (on) Temperature Coefficient.
- Maximum Junction Temperature rated at 175°C.
- Lead-Free.

### Benefits

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



$V_{CES} = 600V$   
 $I_C = 6.8A, T_C = 100^\circ C$   
 $t_{sc} > 10\mu s, T_J = 150^\circ C$   
 $V_{CE(on)} \text{ typ.} = 2.1V$



### Absolute Maximum Ratings

|                           | Parameter                               | Max.        | Units      |
|---------------------------|-----------------------------------------|-------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage            | 600         | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current            | 12          | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current            | 6.8         |            |
| $I_{CM}$                  | Pulse Collector Current (Ref.Fig.C.T.5) | 24          |            |
| $I_{LM}$                  | Clamped Inductive Load current ①        | 24          |            |
| $V_{GE}$                  | Gate-to-Emitter Voltage                 | $\pm 20$    | V          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation               | 63          | W          |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation               | 31          |            |
| $T_J$                     | Operating Junction and                  | -55 to +175 | $^\circ C$ |
| $T_{STG}$                 | Storage Temperature Range               |             |            |
|                           | Soldering Temperature, for 10 sec.      |             |            |

### Thermal / Mechanical Characteristics

|                 | Parameter                                      | Min. | Typ. | Max. | Units        |
|-----------------|------------------------------------------------|------|------|------|--------------|
| $R_{\theta JC}$ | Junction-to-Case- IGBT                         | —    | —    | 2.4  | $^\circ C/W$ |
| $R_{\theta CS}$ | 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/SL4B60KPbF

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

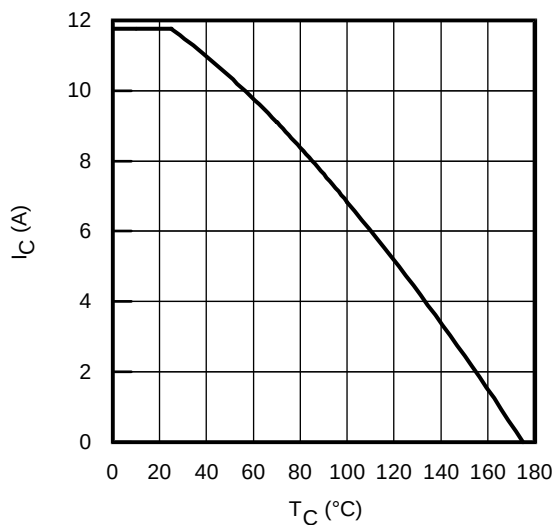
|                                        | Parameter                               | Min. | Typ. | Max. | Units | Conditions                                                            | Ref.Fig. |
|----------------------------------------|-----------------------------------------|------|------|------|-------|-----------------------------------------------------------------------|----------|
| V <sub>(BR)CES</sub>                   | Collector-to-Emitter Breakdown Voltage  | 600  | —    | —    | V     | V <sub>GE</sub> = 0V, I <sub>C</sub> = 500μA                          |          |
| ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub> | Temperature Coeff. of Breakdown Voltage | —    | 0.28 | —    | V/°C  | V <sub>GE</sub> = 0V, I <sub>C</sub> = 1mA (25°C-150°C)               |          |
| V <sub>CE(on)</sub>                    | Collector-to-Emitter Voltage            | —    | 2.1  | 2.5  | V     | I <sub>C</sub> = 4.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C   | 5,6,7    |
|                                        |                                         | —    | 2.5  | 2.8  |       | I <sub>C</sub> = 4.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C  | 9,10,11  |
|                                        |                                         | —    | 2.6  | 2.8  |       | I <sub>C</sub> = 4.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 175°C  |          |
| V <sub>GE(th)</sub>                    | Gate Threshold Voltage                  | 3.5  | 4.5  | 5.5  | V     | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA            | 9,10,11  |
| ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>  | Threshold Voltage temp. coefficient     | —    | -8.1 | —    | mV/°C | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1mA (25°C-150°C) | 12       |
| g <sub>fe</sub>                        | Forward Transconductance                | —    | 1.7  | —    | S     | V <sub>CE</sub> = 50V, I <sub>C</sub> = 4.0A, PW = 80μs               |          |
| I <sub>CES</sub>                       | Zero Gate Voltage Collector Current     | —    | 1.0  | 150  | μA    | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V                          |          |
|                                        |                                         | —    | 54   | 300  |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C  |          |
|                                        |                                         | —    | 300  | 800  |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 175°C  |          |
| I <sub>GES</sub>                       | Gate-to-Emitter Leakage Current         | —    | —    | ±100 | nA    | V <sub>GE</sub> = ±20V                                                |          |

## Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

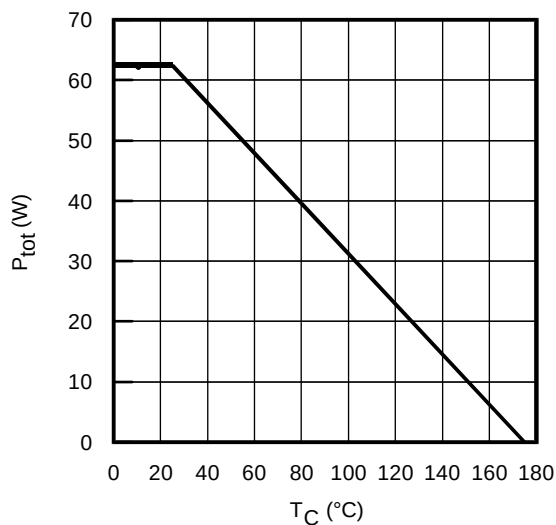
|                     | Parameter                          | Min.        | Typ. | Max. | Units | Conditions                                                                                                                                        | Ref.Fig.   |
|---------------------|------------------------------------|-------------|------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Q <sub>g</sub>      | Total Gate Charge (turn-on)        | —           | 12   | —    | nC    | I <sub>C</sub> = 4.0A                                                                                                                             | 23         |
| Q <sub>ge</sub>     | Gate-to-Emitter Charge (turn-on)   | —           | 1.7  | —    |       | V <sub>CC</sub> = 400V                                                                                                                            | CT1        |
| Q <sub>gc</sub>     | Gate-to-Collector Charge (turn-on) | —           | 6.5  | —    |       | V <sub>GE</sub> = 15V                                                                                                                             |            |
| E <sub>on</sub>     | Turn-On Switching Loss             | —           | 73   | 80   | μJ    | I <sub>C</sub> = 4.0A, V <sub>CC</sub> = 400V                                                                                                     | CT4        |
| E <sub>off</sub>    | Turn-Off Switching Loss            | —           | 47   | 53   |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 2.5mH                                                                                           |            |
| E <sub>tot</sub>    | Total Switching Loss               | —           | 120  | 130  |       | T <sub>J</sub> = 25°C ③                                                                                                                           |            |
| t <sub>d(on)</sub>  | Turn-On delay time                 | —           | 22   | 28   | ns    | I <sub>C</sub> = 4.0A, V <sub>CC</sub> = 400V                                                                                                     | CT4        |
| t <sub>r</sub>      | Rise time                          | —           | 18   | 23   |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 2.5mH                                                                                           |            |
| t <sub>d(off)</sub> | Turn-Off delay time                | —           | 100  | 110  |       | T <sub>J</sub> = 25°C                                                                                                                             |            |
| t <sub>f</sub>      | Fall time                          | —           | 66   | 80   |       |                                                                                                                                                   |            |
| E <sub>on</sub>     | Turn-On Switching Loss             | —           | 130  | 150  | μJ    | I <sub>C</sub> = 4.0A, V <sub>CC</sub> = 400V                                                                                                     | CT4        |
| E <sub>off</sub>    | Turn-Off Switching Loss            | —           | 83   | 140  |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 2.5mH                                                                                           | 13,15      |
| E <sub>tot</sub>    | Total Switching Loss               | —           | 220  | 280  |       | T <sub>J</sub> = 150°C ③                                                                                                                          | WF1,WF2    |
| t <sub>d(on)</sub>  | Turn-On delay time                 | —           | 22   | 27   | ns    | I <sub>C</sub> = 4.0A, V <sub>CC</sub> = 400V                                                                                                     | 14,16      |
| t <sub>r</sub>      | Rise time                          | —           | 18   | 22   |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 2.5mH                                                                                           | CT4        |
| t <sub>d(off)</sub> | Turn-Off delay time                | —           | 120  | 130  |       | T <sub>J</sub> = 150°C                                                                                                                            | WF1        |
| t <sub>f</sub>      | Fall time                          | —           | 79   | 89   |       |                                                                                                                                                   | WF2        |
| C <sub>ies</sub>    | Input Capacitance                  | —           | 190  | —    | pF    | V <sub>GE</sub> = 0V                                                                                                                              | 22         |
| C <sub>oes</sub>    | Output Capacitance                 | —           | 25   | —    |       | V <sub>CC</sub> = 30V                                                                                                                             |            |
| C <sub>res</sub>    | Reverse Transfer Capacitance       | —           | 6.2  | —    |       | f = 1.0MHz                                                                                                                                        |            |
| RBSOA               | Reverse Bias Safe Operating Area   | FULL SQUARE |      |      |       | T <sub>J</sub> = 150°C, I <sub>C</sub> = 24A, V <sub>p</sub> = 600V<br>V <sub>CC</sub> =500V, V <sub>GE</sub> = +15V to 0V, R <sub>G</sub> = 100Ω | 4<br>CT2   |
| SCSOA               | Short Circuit Safe Operating Area  | 10          | —    | —    | μs    | T <sub>J</sub> = 150°C, V <sub>p</sub> = 600V, R <sub>G</sub> = 100Ω<br>V <sub>CC</sub> =360V, V <sub>GE</sub> = +15V to 0V                       | CT3<br>WF3 |

Note ① to ③ are on page 16

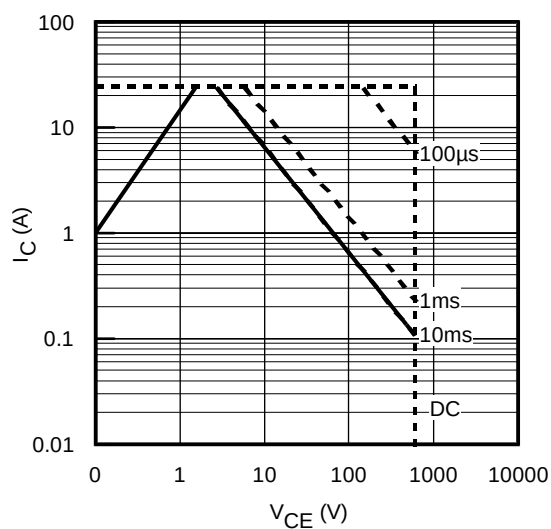
## IRGB/S/SL4B60KPbF



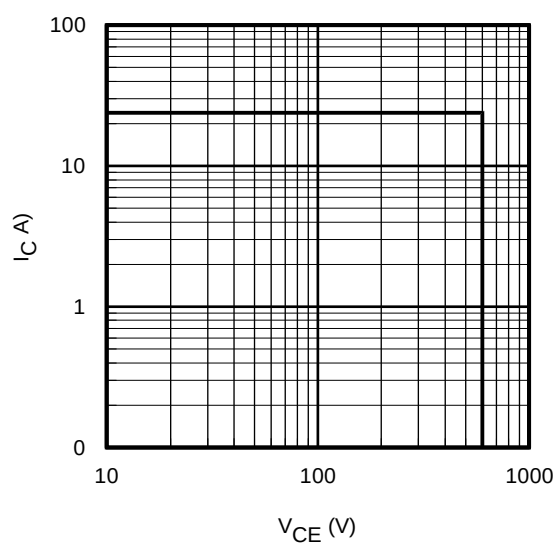
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



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

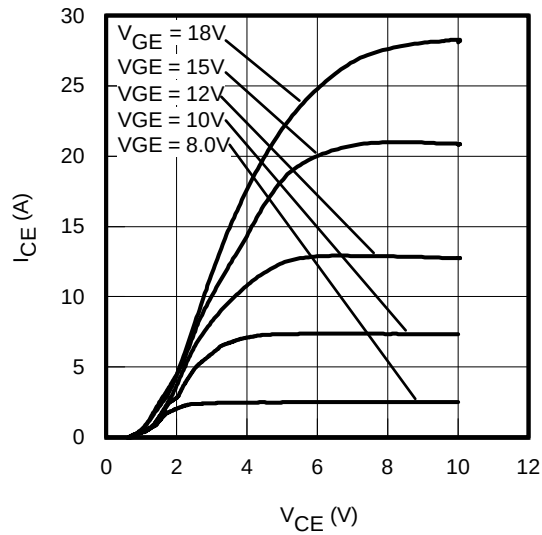


**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$

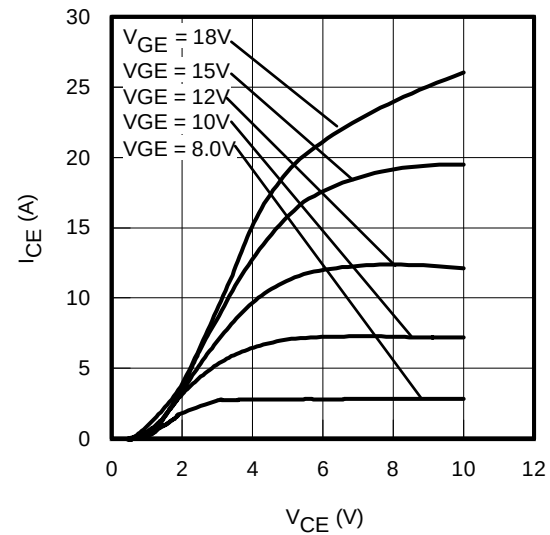


**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$

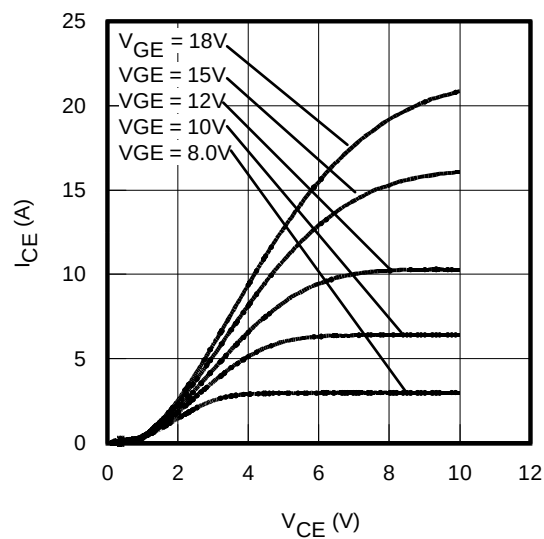
# IRGB/S/SL4B60KPbF



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

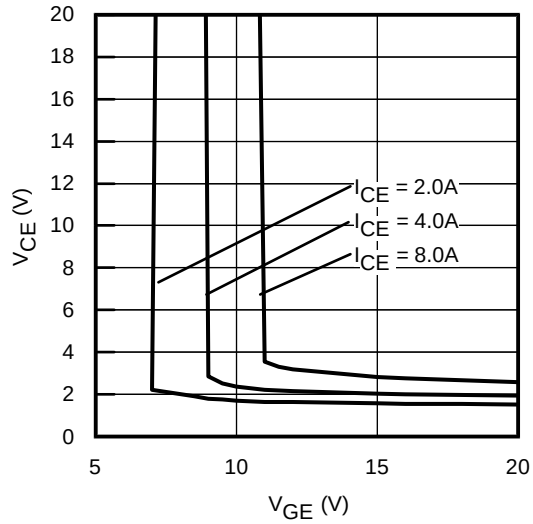


**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_j = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$

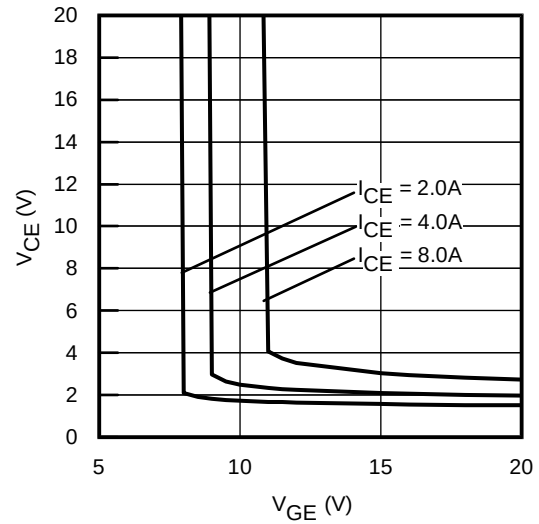


**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_j = 150^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$

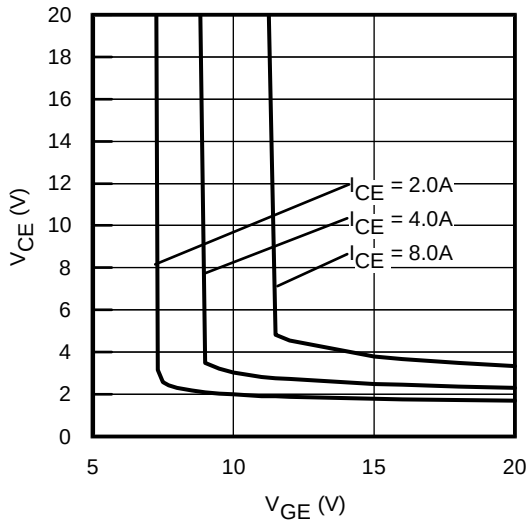
## IRGB/S/SL4B60KPbF



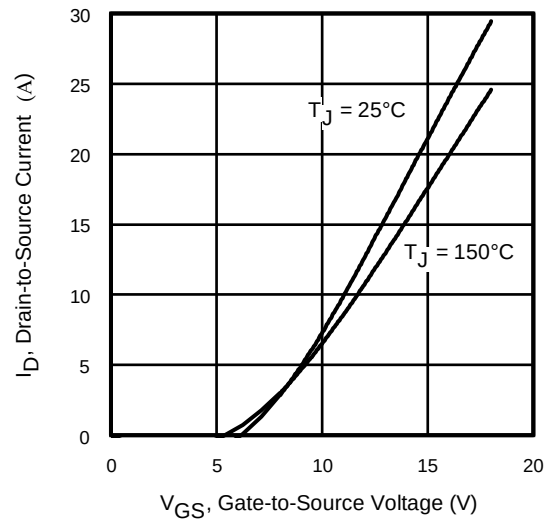
**Fig. 8** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



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

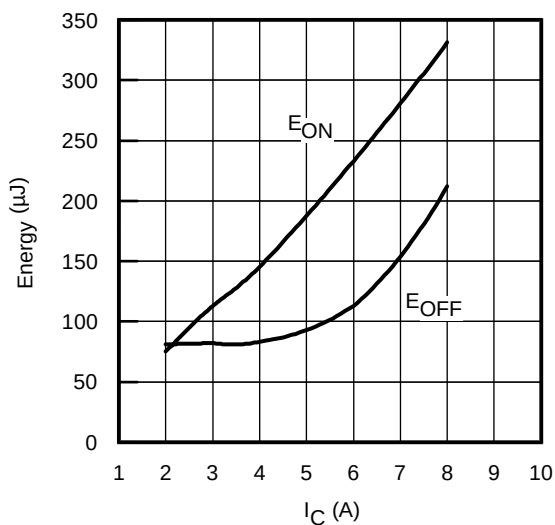


**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 150^\circ\text{C}$

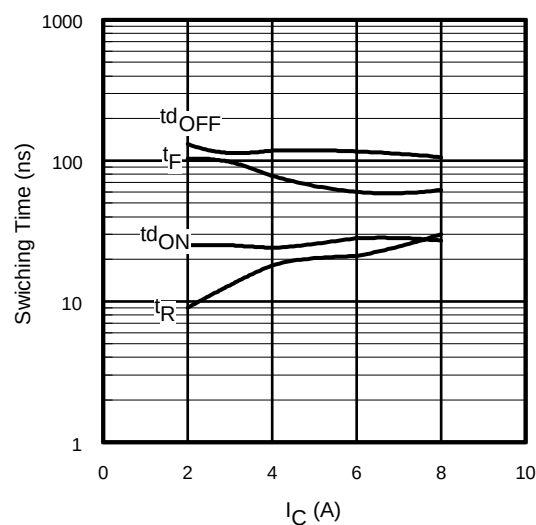


**Fig. 11** - Typ. Transfer Characteristics  
 $V_{CE} = 360\text{V}$ ;  $t_p = 10\mu\text{s}$

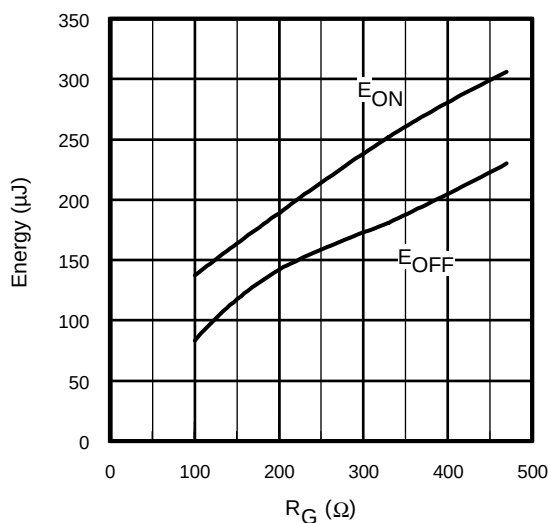
# IRGB/S/SL4B60KPbF



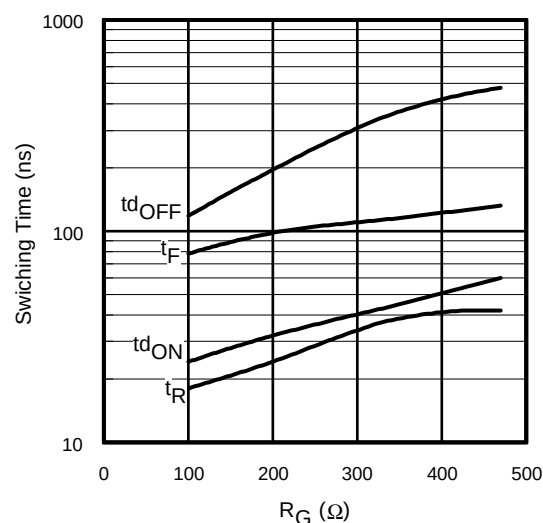
**Fig. 12** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L=2.5\text{mH}$ ;  $V_{CE}=400\text{V}$ ,  
 $R_G=100\Omega$ ;  $V_{GE}=15\text{V}$



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

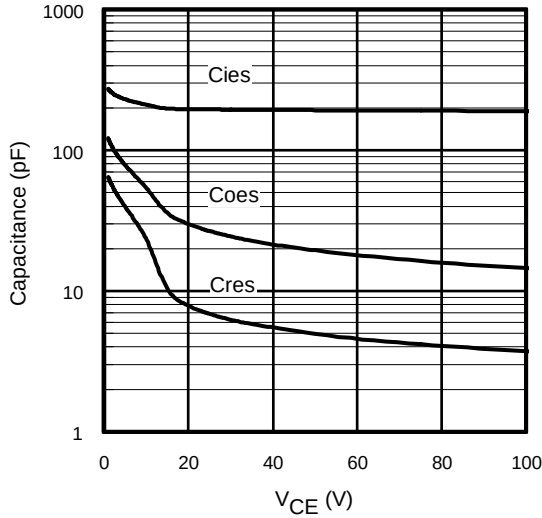


**Fig. 14** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L=2.5\text{mH}$ ;  $V_{CE}=400\text{V}$   
 $I_{CE}=4.0\text{A}$ ;  $V_{GE}=15\text{V}$

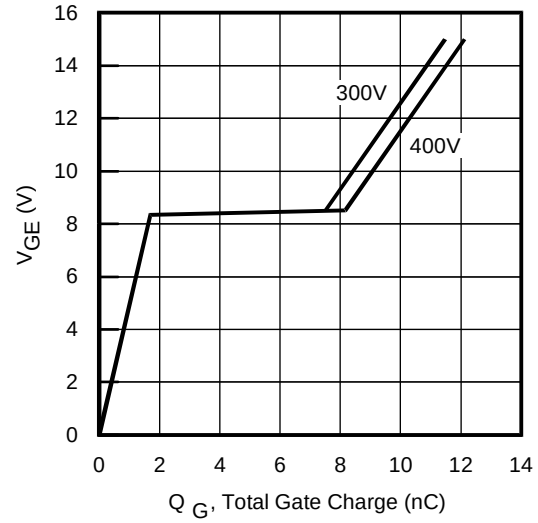


**Fig. 15** - Typ. Switching Time vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L=2.5\text{mH}$ ;  $V_{CE}=400\text{V}$   
 $I_{CE}=4.0\text{A}$ ;  $V_{GE}=15\text{V}$

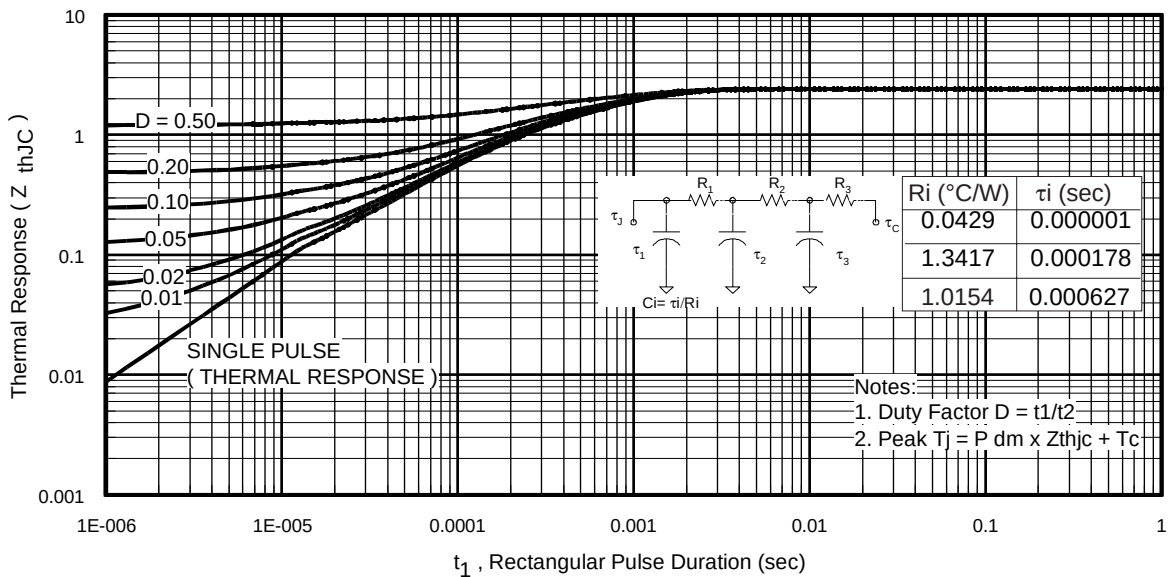
## IRGB/S/SL4B60KPbF



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

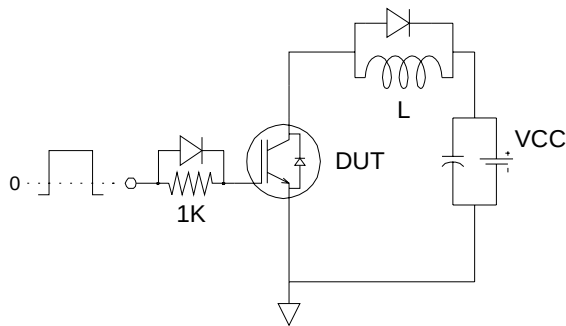


**Fig. 17 -** Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 4.0A$ ;  $L = 3150\mu H$

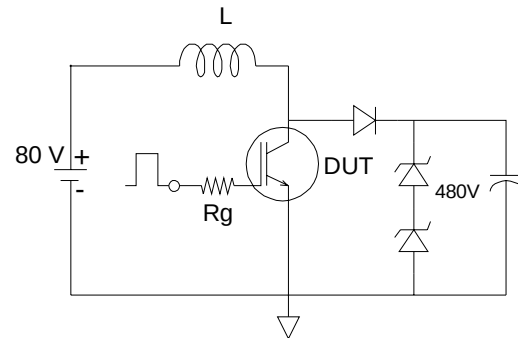


**Fig 18.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

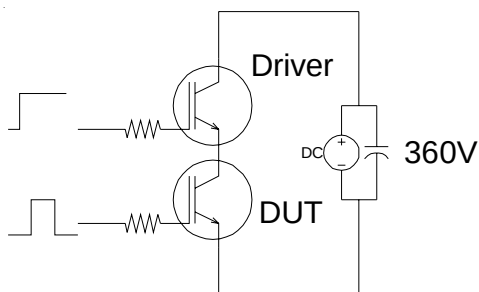
# IRGB/S/SL4B60KPbF



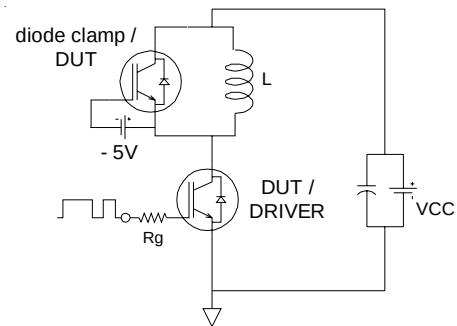
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



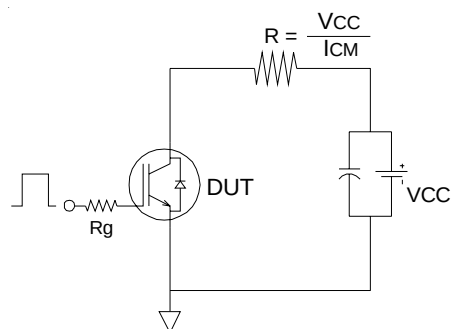
**Fig.C.T.2** - RBSOA Circuit



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



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



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



## IRGB/S/SL4B60KPbF

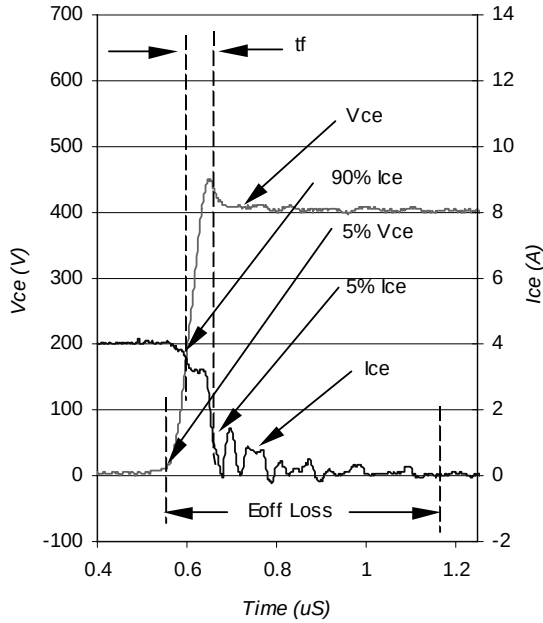


Fig. WF1- Typ. Turn-off Loss Waveform  
@  $T_J = 150^{\circ}\text{C}$  using Fig. CT.4

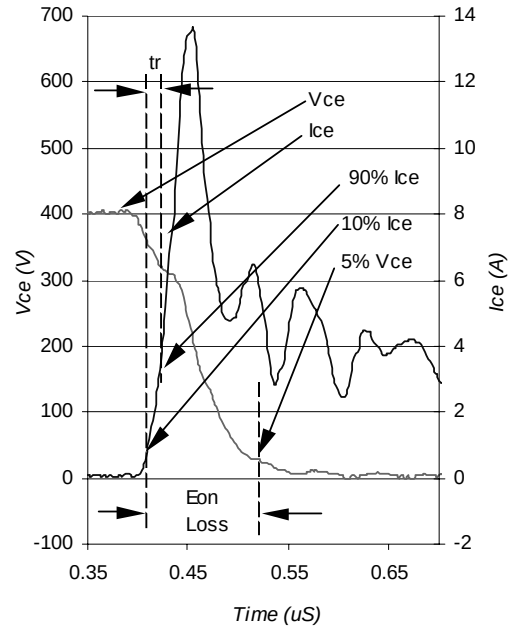


Fig. WF2- Typ. Turn-on Loss Waveform  
@  $T_J = 150^{\circ}\text{C}$  using Fig. CT.4

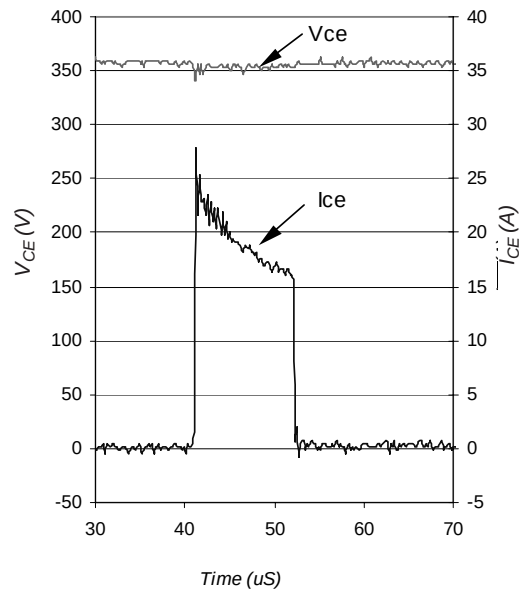


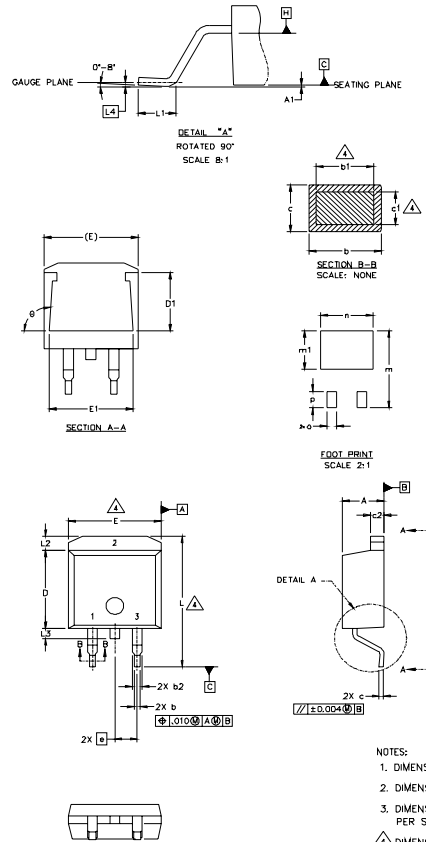
Fig. WF3- Typ. S.C Waveform  
@  $T_C = 150^{\circ}\text{C}$  using Fig. CT.3



## IRGB/S/SL4B60KPbF

## D<sup>2</sup>Pak Package Outline

Dimensions are shown in millimeters (inches)



| SYMBOL | DIMENSIONS  |       |        |      | NOTES |
|--------|-------------|-------|--------|------|-------|
|        | MILLIMETERS |       | INCHES |      |       |
|        | MIN.        | MAX.  | MIN.   | MAX. |       |
| A      | 4.06        | 4.83  | .160   | .190 |       |
| A1     |             | 0.127 |        | .005 |       |
| b      | 0.51        | 0.99  | .020   | .039 |       |
| b1     | 0.51        | 0.89  | .020   | .035 | 4     |
| b2     | 1.14        | 1.40  | .045   | .055 |       |
| c      | 0.43        | 0.63  | .017   | .025 |       |
| c1     | 0.38        | 0.74  | .015   | .029 | 4     |
| c2     | 1.14        | 1.40  | .045   | .055 |       |
| 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      | 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   |      |       |
| ø      | 90°         | 93°   | 90°    | 93°  |       |

### LEAD ASSIGNMENTS

| <u>HEFET</u> | <u>IGBTs, CoPACK</u> | <u>DIODES</u> |
|--------------|----------------------|---------------|
| 1.- GATE     | 1.- GATE             | 1.- ANODE *   |
| 2.- DRAIN    | 2.- COLLECTOR        | 2.- CATHODE   |
| 3.- SOURCE   | 3.- EMITTER          | 3.- ANODE     |

\* PART DEPENDENT.

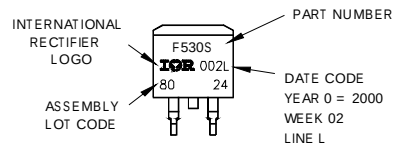
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE GIVEN 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.

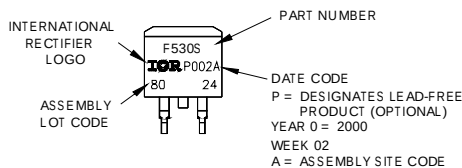
## D<sup>2</sup>Pak Part Marking Information

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"



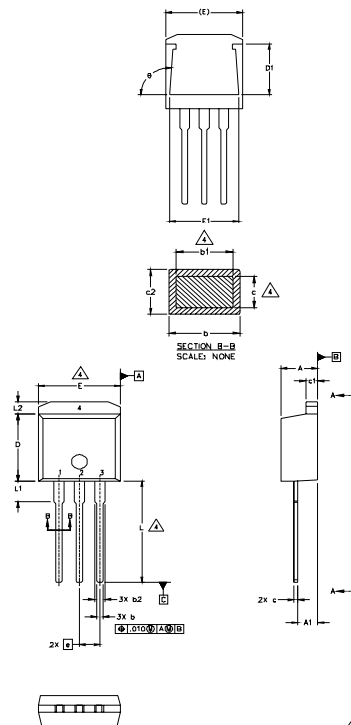
OR



# IRGB/S/SL4B60KPbF

## 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 |      | 3     |
| 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

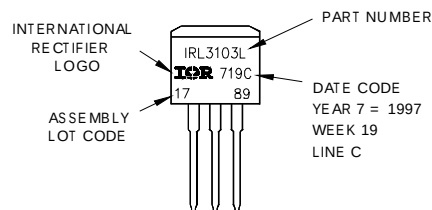
#### NOTES:

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.

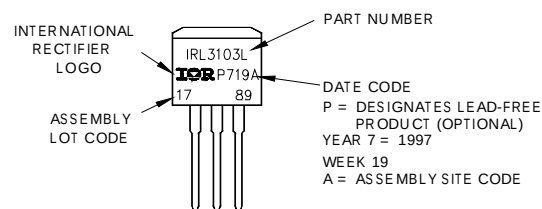
## TO-262 Part Marking Information

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"



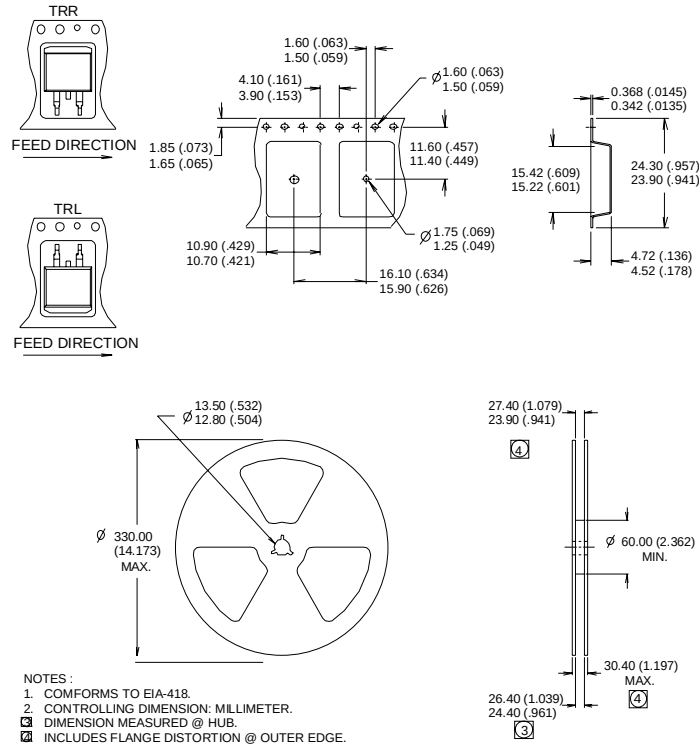
OR



# IRGB/S/SL4B60KPbF

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

Dimensions are shown in millimeters (inches)



### Notes:

- ①  $V_{CC} = 80\% (V_{CES})$ ,  $V_{GE} = 20V$ ,  $L = 100\mu H$ ,  $R_G = 50\Omega$ .
- 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

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