

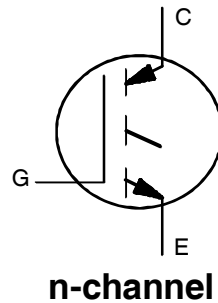
## INSULATED GATE BIPOLAR TRANSISTOR

### Features

- Standard: Optimized for minimum saturation voltage and low operating frequencies (< 1kHz)
- Generation 4 IGBT design provides tighter parameter distribution and higher efficiency
- Industry standard TO-247AC package
- Lead-Free
- Automotive Qualified \*

### Benefits

- Generation 4 IGBT's offer highest efficiency available
- IGBT's optimized for specified application conditions



$$V_{CES} = 1200V$$

$$I_C = 81A @ T_C = 100^{\circ}C$$

$$V_{CE(on)} \text{ typ.} = 1.47V @ 33A$$



TO-247AC

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

| Base part number | Package Type | Standard Pack |          | Complete Part Number |
|------------------|--------------|---------------|----------|----------------------|
|                  |              | Form          | Quantity |                      |
| AUIRG4PH50S      | TO-247AC     | Tube          | 25       | AUIRG4PH50S          |

### Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; and functional operation of the device at these or any other condition beyond those indicated in the specifications is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Ambient temperature ( $T_A$ ) is  $25^{\circ}C$ , unless otherwise specified.

|                            | Parameter  | Max.               | Units       |
|----------------------------|--|--------------------|-------------|
| $V_{CES}$                  | Collector-to-Emitter Voltage                         | 1200               | V           |
| $I_C @ T_C = 25^{\circ}C$  | Continuous Collector Current                         | 141 <sup>⑤</sup>   | A           |
| $I_C @ T_C = 100^{\circ}C$ | Continuous Collector Current                         | 81                 |             |
| $I_{CM}$                   | Pulse Collector Current, $V_{GE} = 15V$ ②            | 99                 |             |
| $I_{LM}$                   | Clamped Inductive Load Current, $V_{GE} = 20V$ ①     | 99                 |             |
| $V_{GE}$                   | Continuous Gate-to-Emitter Voltage                   | $\pm 20$           | V           |
|                            | Transient Gate-to-Emitter Voltage                    | $\pm 30$           |             |
| $P_D @ T_C = 25^{\circ}C$  | Maximum Power Dissipation                            | 543                | W           |
| $P_D @ T_C = 100^{\circ}C$ | Maximum Power Dissipation                            | 217                |             |
| $T_J$                      | Operating Junction and                               | -55 to +150        | $^{\circ}C$ |
| $T_{STG}$                  | Storage Temperature Range                            |                    |             |
|                            | Soldering Temperature, for 10 sec. (1.6mm from case) | 300                |             |
|                            | Mounting Torque, 6-32 or M3 Screw                    | 10 lbf-in (1.1N-m) |             |

### Thermal Resistance

|                        | Parameter  | Min. | Typ. | Max. | Units         |
|------------------------|--|------|------|------|---------------|
| $R_{\theta JC}$ (IGBT) | Thermal Resistance Junction-to-Case (IGBT) ④             | —    | —    | 0.23 | $^{\circ}C/W$ |
| $R_{\theta CS}$        | Thermal Resistance, Case-to-Sink (flat, greased surface) | —    | 0.24 | —    |               |
| $R_{\theta JA}$        | Thermal Resistance, Junction-to-Ambient                  | —    | 40   | —    |               |

\*Qualification standards can be found at <http://www.irf.com/>

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

|                                 | Parameter                               | Min. | Typ. | Max.      | Units                | Conditions  |
|---------------------------------|---|------|------|-----------|----------------------|---|
| $V_{(BR)CES}$                   | Collector-to-Emitter Breakdown Voltage  | 1200 | —    | —         | V                    | $V_{GE} = 0V$ , $I_C = 250\mu A$ ③  |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | —    | 1.2  | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V$ , $I_C = 1mA$ ( $25^\circ\text{C}$ - $150^\circ\text{C}$ ) ③        |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage | —    | 1.47 | 1.7       | V                    | $I_C = 33A$ , $V_{GE} = 15V$ , $T_J = 25^\circ\text{C}$                           |
|                                 |   | —    | 1.55 | —         |                      | $I_C = 33A$ , $V_{GE} = 15V$ , $T_J = 150^\circ\text{C}$                          |
| $V_{GE(th)}$                    | Gate Threshold Voltage                  | 3.0  | —    | 6.0       | V                    | $V_{CE} = V_{GE}$ , $I_C = 250\mu A$  |
| $\Delta V_{GE(th)}/\Delta T_J$  | Threshold Voltage temp. coefficient     | —    | -11  | —         | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}$ , $I_C = 250\mu A$ ( $25^\circ\text{C}$ - $150^\circ\text{C}$ ) |
| $g_{fe}$                        | Forward Transconductance                | —    | 30   | —         | S                    | $V_{CE} = 50V$ , $I_C = 33A$ , $PW = 20\mu s$                                     |
| $I_{CES}$                       | Collector-to-Emitter Leakage Current    | —    | —    | 250       | $\mu A$              | $V_{GE} = 0V$ , $V_{CE} = 1200V$ , $T_J = 25^\circ\text{C}$                       |
|                                 |   | —    | —    | 1000      |                      | $V_{GE} = 0V$ , $V_{CE} = 1200V$ , $T_J = 150^\circ\text{C}$                      |
| $I_{GES}$                       | 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   |
|--------------|------------------------------------|-------------|------|------|-------|--|
| $Q_g$        | Total Gate Charge (turn-on)        | —           | 151  | 227  | nC    | $I_C = 33A$<br>$V_{GE} = 15V$<br>$V_{CC} = 600V$   |
| $Q_{ge}$     | Gate-to-Emitter Charge (turn-on)   | —           | 26   | 39   |       |  |
| $Q_{gc}$     | Gate-to-Collector Charge (turn-on) | —           | 62   | 93   |       |  |
| $E_{off}$    | Turn-Off Switching Loss            | —           | 15   | 16   | mJ    | $I_C = 33A$ , $V_{CC} = 600V$ , $V_{GE} = 15V$<br>$R_G = 5\Omega$ , $L = 400\mu H$ , $T_J = 25^\circ\text{C}$<br>Energy losses include tail  |
| $t_{d(off)}$ | Turn-Off delay time                | —           | 485  | 616  | ns    | $I_C = 33A$ , $V_{CC} = 600V$ , $V_{GE} = 15V$<br>$R_G = 5\Omega$ , $L = 400\mu H$ , $T_J = 25^\circ\text{C}$                                |
| $t_f$        | Fall time                          | —           | 1193 | 1371 |       |  |
| $E_{off}$    | Turn-Off Switching Loss            | —           | 29   | —    | mJ    | $I_C = 33A$ , $V_{CC} = 600V$ , $V_{GE} = 15V$<br>$R_G = 5\Omega$ , $L = 400\mu H$ , $T_J = 150^\circ\text{C}$<br>Energy losses include tail |
| $t_{d(off)}$ | Turn-Off delay time                | —           | 689  | —    | ns    | $I_C = 33A$ , $V_{CC} = 600V$ , $V_{GE} = 15V$<br>$R_G = 5\Omega$ , $L = 400\mu H$ , $T_J = 150^\circ\text{C}$                               |
| $t_f$        | Fall time                          | —           | 2462 | —    |       |  |
| $C_{ies}$    | Input Capacitance                  | —           | 3804 | —    | pF    | $V_{GE} = 0V$  |
| $C_{oes}$    | Output Capacitance                 | —           | 161  | —    |       | $V_{CC} = 30V$   |
| $C_{res}$    | Reverse Transfer Capacitance       | —           | 31   | —    |       | $f = 1.0MHz$   |
| RBSOA        | Reverse Bias Safe Operating Area   | FULL SQUARE |      |      |       | $T_J = 150^\circ\text{C}$ , $I_C = 99A$<br>$V_{CC} = 960V$ , $V_p \leq 1200V$<br>$R_G = 5\Omega$ , $V_{GE} = +20V$ to $0V$                   |

**Notes:**

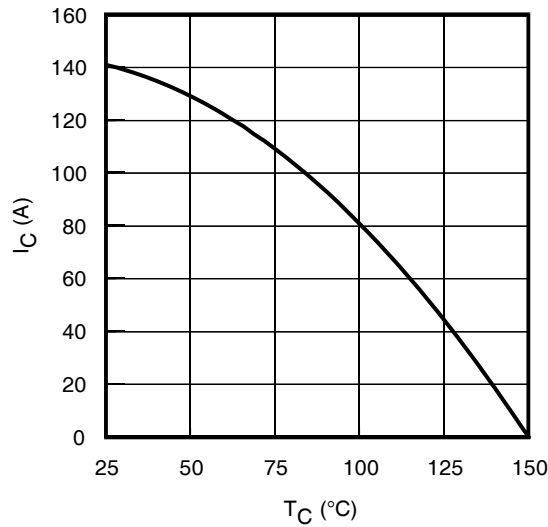
- ①  $V_{CC} = 80\%$  ( $V_{CES}$ ),  $V_{GE} = 20V$ ,  $L = 400\mu H$ ,  $R_G = 50\Omega$ .
- ② Pulse width limited by max. junction temperature.
- ③ Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely.
- ④  $R_\theta$  is measured at  $T_J$  of approximately  $90^\circ\text{C}$ .
- ⑤ Calculated continuous current based on maximum allowable junction temperature. Bond wire current limit is 78A. Note that current limitations arising from heating of the device leads may occur with some lead mounting arrangements.

**Qualification Information<sup>†</sup>**

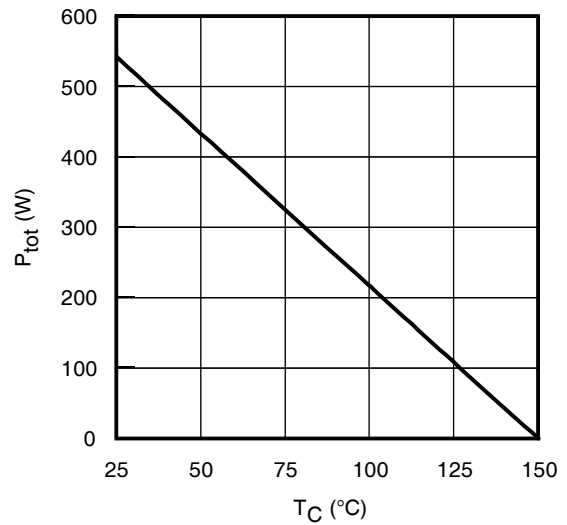
|                                   |                      |   |     |
|-----------------------------------|----------------------|---|-----|
| <b>Qualification Level</b>        |                      | Automotive<br>(per AEC-Q101) <sup>††</sup>  |     |
|                                   |                      | This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level. |     |
| <b>Moisture Sensitivity Level</b> |                      | TO-247AC  | N/A |
| <b>ESD</b>                        | Machine Model        | Class M3<br>AEC-Q101-002  |     |
|                                   | Human Body Model     | Class H2<br>AEC-Q101-001  |     |
|                                   | Charged Device Model | Class C4<br>AEC-Q101-005  |     |
| <b>RoHS Compliant</b>             |                      | Yes   |     |

<sup>†</sup> Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/>

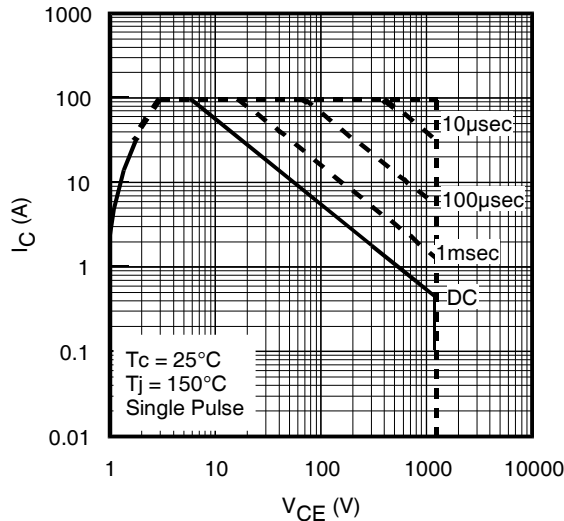
<sup>††</sup> Highest passing voltage.



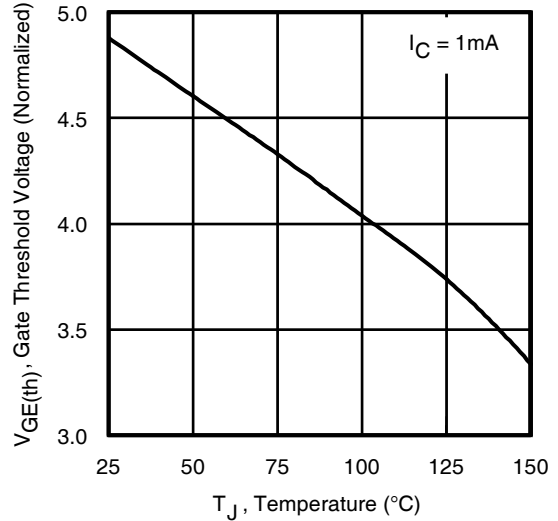
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



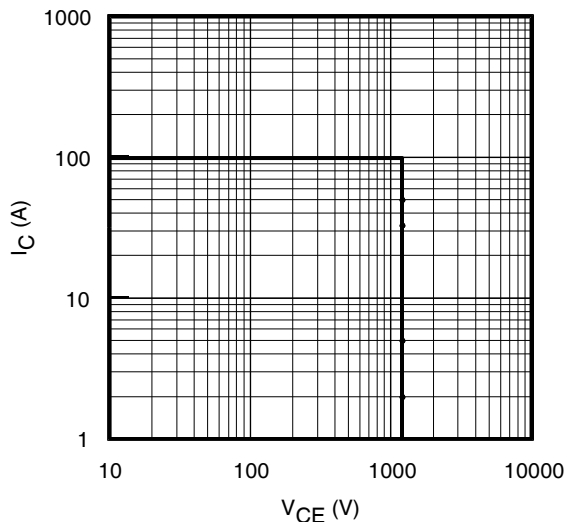
**Fig. 2** - Power Dissipation vs. Case Temperature



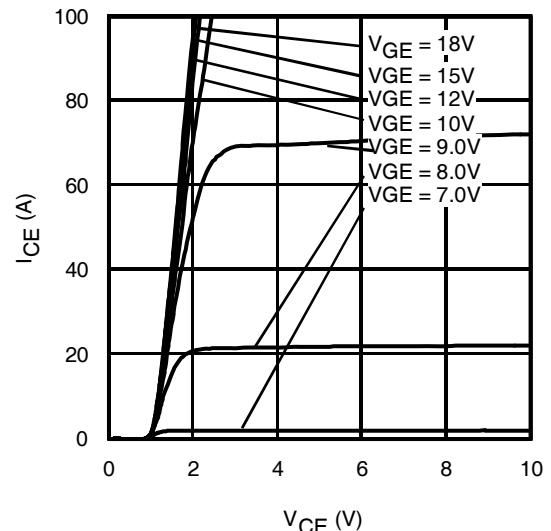
**Fig. 3** - Forward SOA  
 $T_C = 25^{\circ}\text{C}$ ,  $T_J \leq 150^{\circ}\text{C}$ ;  $V_{GE} = 15\text{V}$



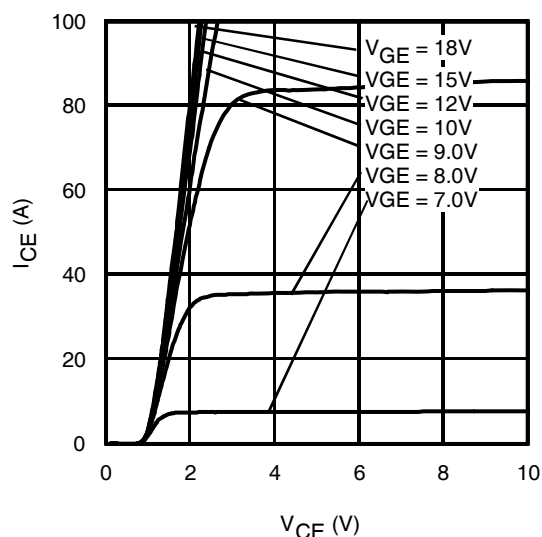
**Fig. 4** - Typical Gate Threshold Voltage (Normalized) vs. Junction Temperature



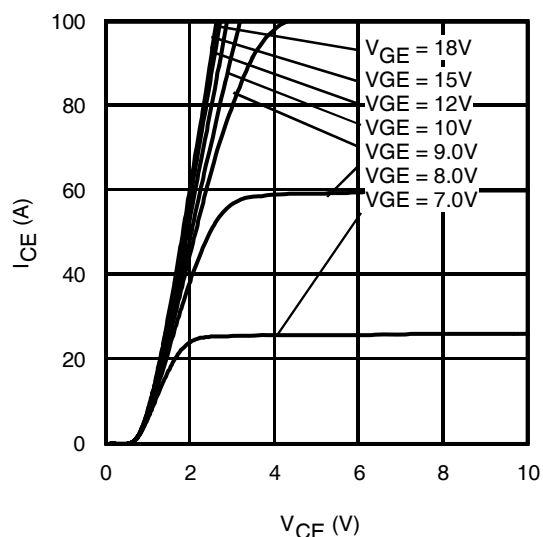
**Fig. 5**- Reverse Bias SOA  
 $T_J = 150^{\circ}\text{C}$ ;  $V_{GE} = 20\text{V}$



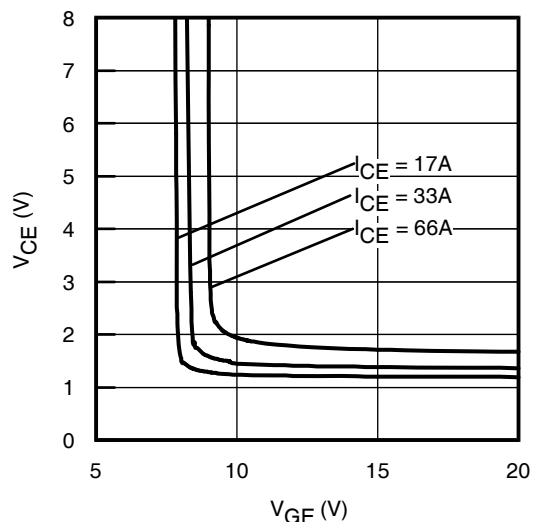
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = -40^{\circ}\text{C}$ ;  $t_p = 20\mu\text{s}$



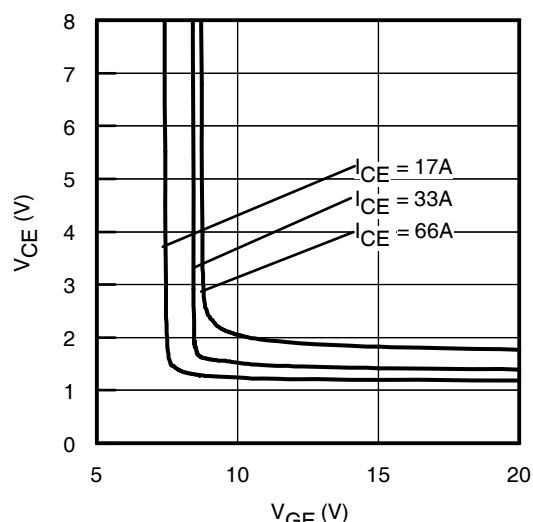
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 25^{\circ}\text{C}$ ;  $t_p = 20\mu\text{s}$



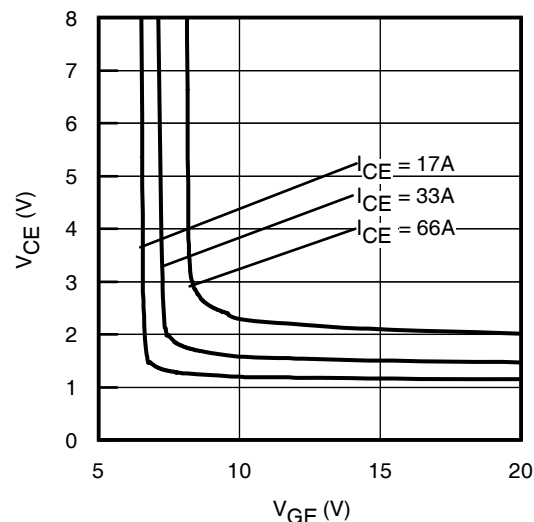
**Fig. 8 - Typ. IGBT Output Characteristics**  
 $T_J = 150^{\circ}\text{C}$ ;  $t_p = 20\mu\text{s}$



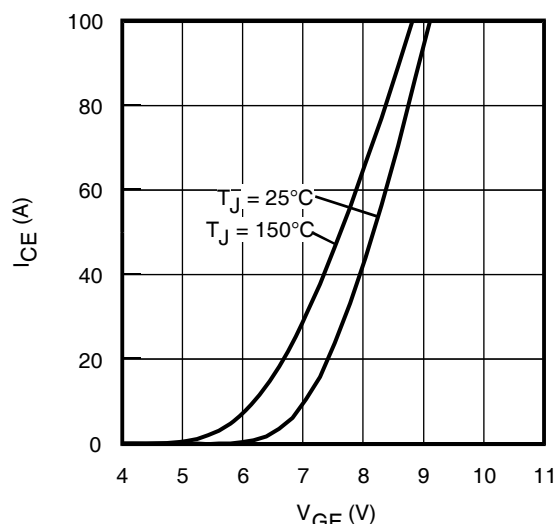
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^{\circ}\text{C}$



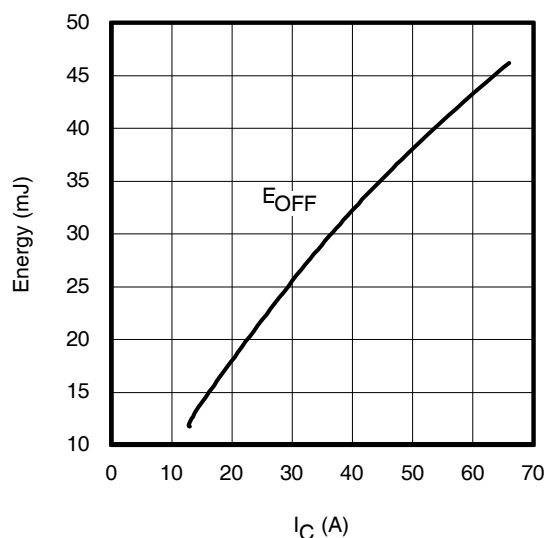
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^{\circ}\text{C}$



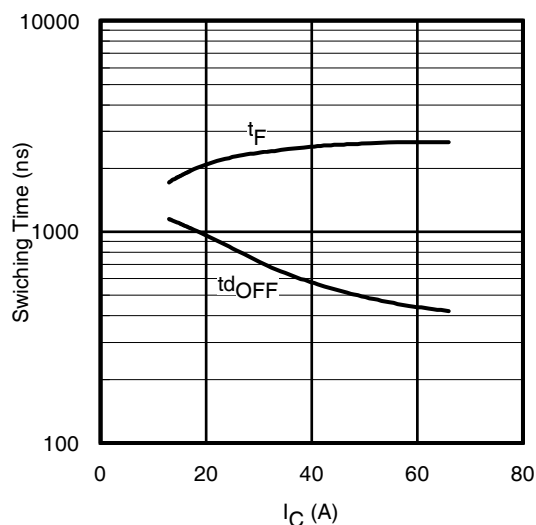
**Fig. 11 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 150^{\circ}\text{C}$



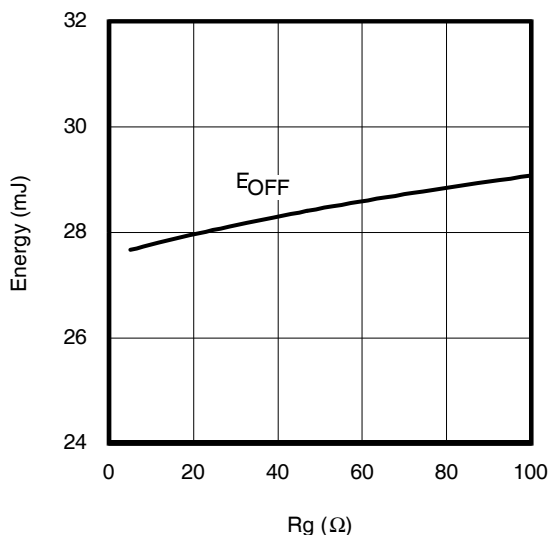
**Fig. 12- Typ. Transfer Characteristics**  
 $V_{CE} = 50\text{V}$ ;  $t_p = 20\mu\text{s}$



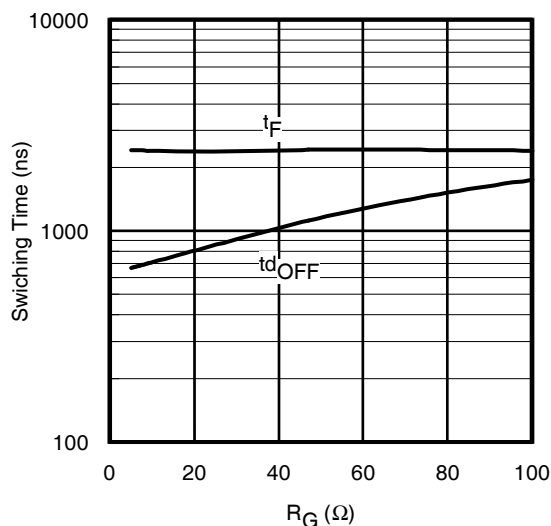
**Fig. 13 - Typ. Energy Loss vs.  $I_C$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 400\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $R_G = 5\Omega$ ;  $V_{GE} = 15\text{V}$



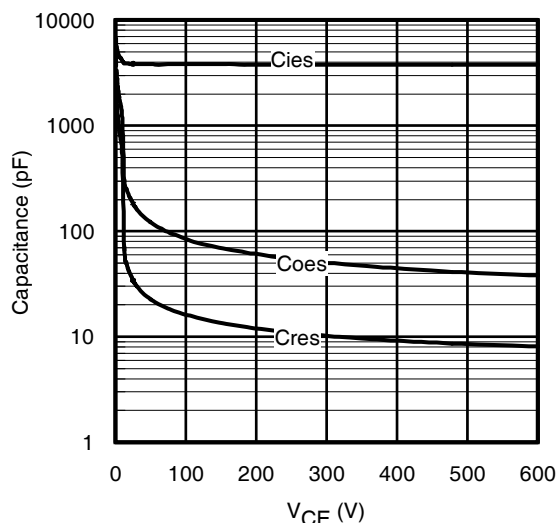
**Fig. 14 - Typ. Switching Time vs.  $I_C$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 400\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $R_G = 5\Omega$ ;  $V_{GE} = 15\text{V}$



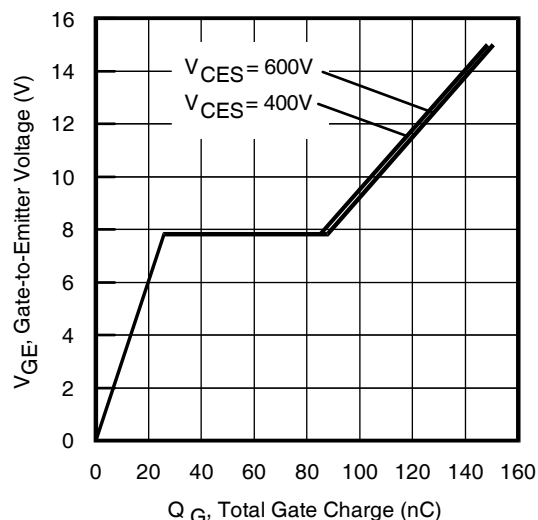
**Fig. 15 - Typ. Energy Loss vs.  $R_G$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 400\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $I_{CE} = 33\text{A}$ ;  $V_{GE} = 15\text{V}$



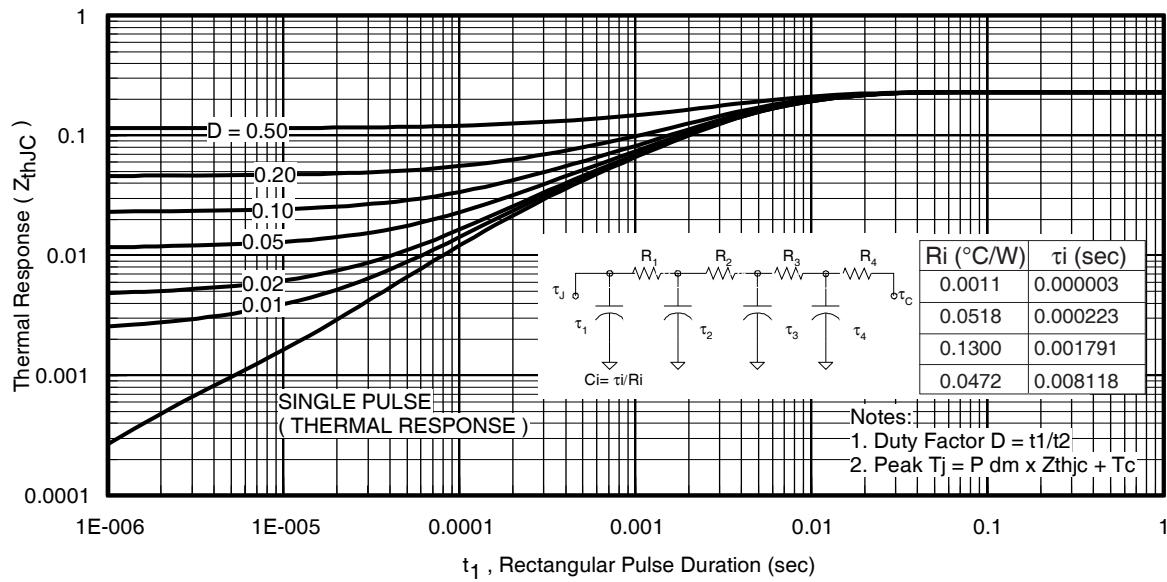
**Fig. 16 - Typ. Switching Time vs.  $R_G$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 400\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $I_{CE} = 33\text{A}$ ;  $V_{GE} = 15\text{V}$



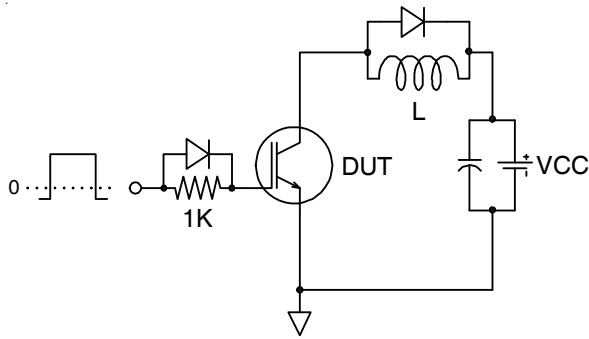
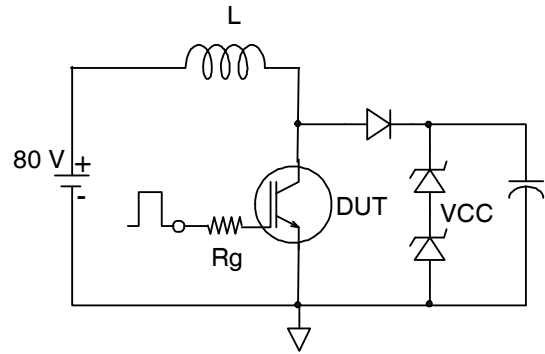
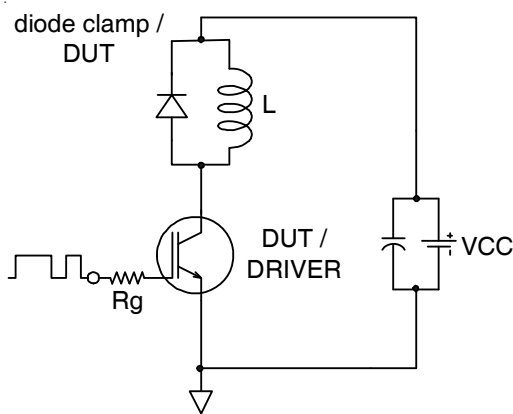
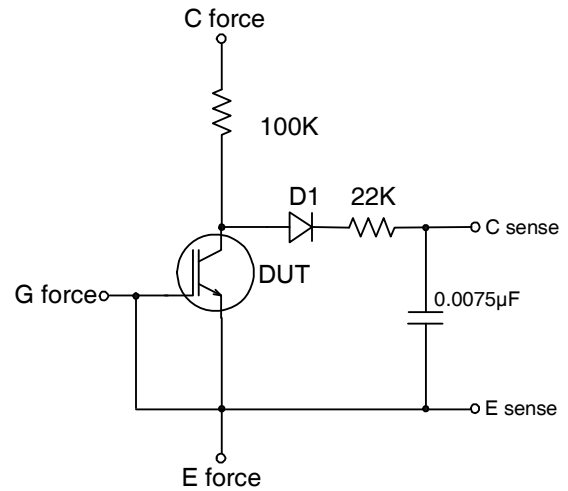
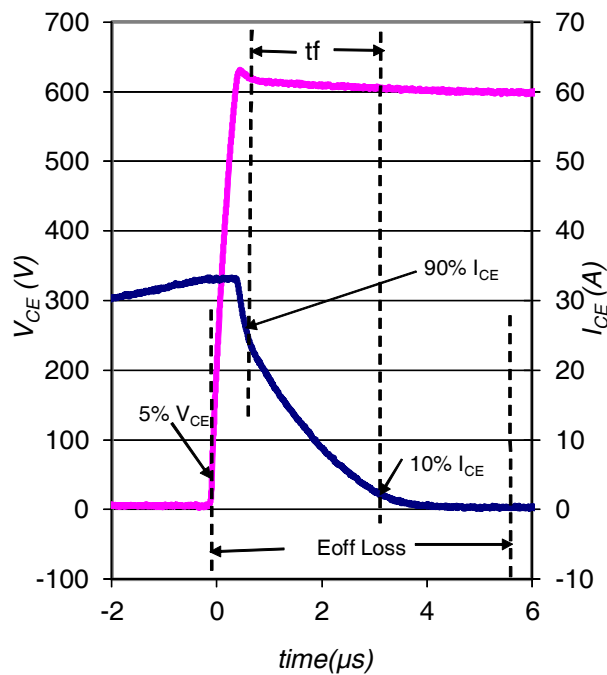
**Fig. 17 - Typ. Capacitance vs.  $V_{CE}$**   
 $V_{GE} = 0\text{V}$ ;  $f = 1\text{MHz}$



**Fig. 18 - Typical Gate Charge vs.  $V_{GE}$**   
 $I_{CE} = 33\text{A}$ ;  $L = 2.0\text{mH}$



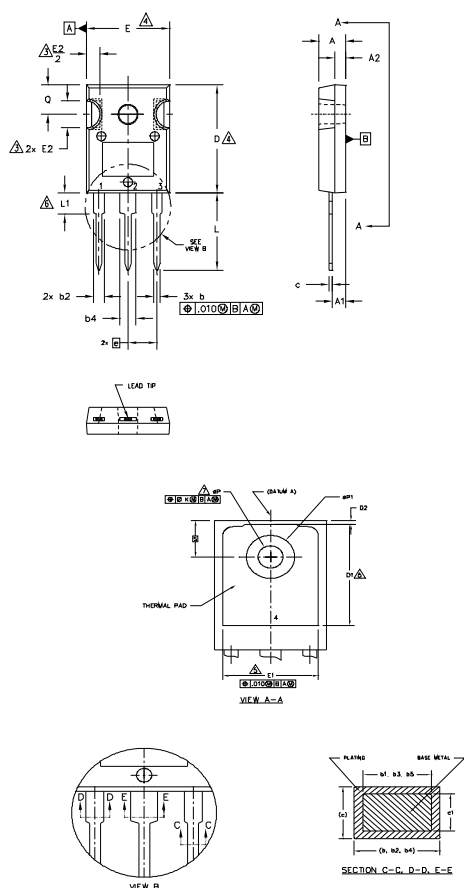
**Fig 19.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)


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

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

**Fig.C.T.3** - Switching Loss Circuit

**Fig.C.T.4** - BVCES Filter Circuit

**Fig. WF1** - Typ. Turn-off Loss Waveform  
@ T<sub>J</sub> = 150°C using Fig. CT.3



## TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
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. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. ØP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AC .

| SYMBOL | DIMENSIONS |      |             |       | NOTES   |
|--------|------------|------|-------------|-------|---|
|        | INCHES     |      | MILLIMETERS |       |   |
|        | MIN.       | MAX. | MIN.        | MAX.  |   |
| A      | .183       | .209 | 4.65        | 5.31  | 4<br>5<br><br><br><br><br><br><br><br><br><br><br><br>4 |
| A1     | .087       | .102 | 2.21        | 2.59  |   |
| A2     | .059       | .098 | 1.50        | 2.49  |   |
| b      | .039       | .055 | 0.99        | 1.40  |   |
| b1     | .039       | .053 | 0.99        | 1.35  |   |
| b2     | .065       | .094 | 1.65        | 2.39  |   |
| b3     | .065       | .092 | 1.65        | 2.34  |   |
| b4     | .102       | .135 | 2.59        | 3.43  |   |
| b5     | .102       | .133 | 2.59        | 3.38  |   |
| c      | .015       | .035 | 0.38        | 0.89  |   |
| c1     | .015       | .033 | 0.38        | 0.84  |   |
| D      | .776       | .815 | 19.71       | 20.70 |   |
| D1     | .515       | —    | 13.08       | —     |   |
| D2     | .020       | .053 | 0.51        | 1.35  |   |
| E      | .602       | .625 | 15.29       | 15.87 |   |
| E1     | .530       | —    | 13.46       | —     |   |
| E2     | .178       | .216 | 4.52        | 5.49  |   |
| e      | .215 BSC   |      | 5.46 BSC    |       |   |
| øk     | .010       |      | 0.25        |       |   |
| L      | .559       | .634 | 14.20       | 16.10 |   |
| L1     | .146       | .169 | 3.71        | 4.29  |   |
| øP     | .140       | .144 | 3.56        | 3.66  |   |
| øP1    | —          | .291 | —           | 7.39  |   |
| Q      | .209       | .224 | 5.31        | 5.69  |   |
| S      | .217 BSC   |      | 5.51 BSC    |       |   |

## LEAD ASSIGNMENTS

## HEXFET

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

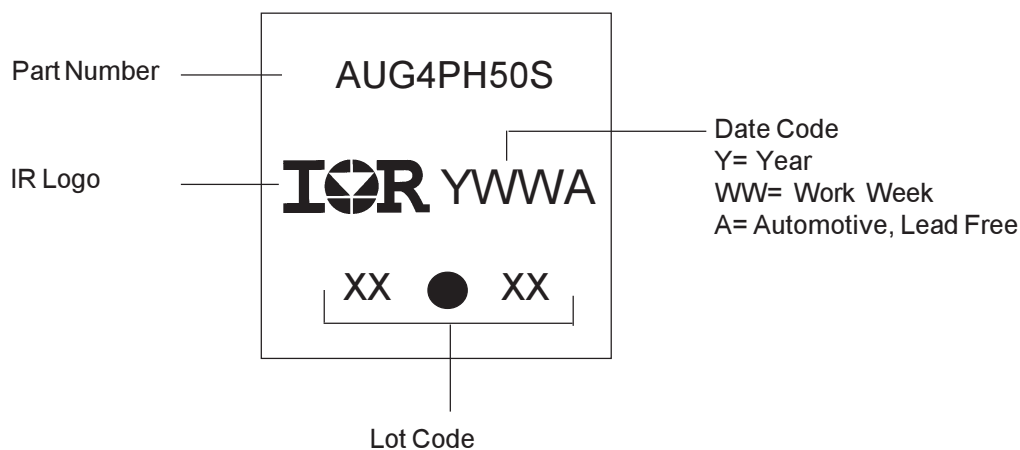
## IGBTs, CoPACK

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

## DIODES

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

## TO-247AC Part Marking Information



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

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For technical support, please contact IR’s Technical Assistance Center

<http://www.irf.com/technical-info/>

### WORLD HEADQUARTERS:

101 N. Sepulveda Blvd., El Segundo, California 90245

Tel: (310) 252-7105

**Revision History**

| Date      | Comments   |
|-----------|--|
| 7/8/2014  | <ul style="list-style-type: none"> <li>Updated datasheet based on new template and retest data.</li> </ul>   |
| 7/11/2014 | <ul style="list-style-type: none"> <li>Removed <math>I_C</math> Nominal current on page 1.</li> <li>Updated typo on switch time test condition from "25C" to "150C" on page 2.</li> </ul>  |
| 1/9/2015  | <ul style="list-style-type: none"> <li>Corrected typo on <math>V_{(BR)CES}</math> test condition from "100<math>\mu</math>A" to "250<math>\mu</math>A" on page 2.</li> <li>Corrected typo on <math>V_{GE(TH)}</math> test condition from "1mA" to "250<math>\mu</math>A" on page 2.</li> </ul> |
| 3/2/2015  | <ul style="list-style-type: none"> <li>Removed <math>I_{CES} = 2\mu A</math> @ <math>V_{CE} = 10V</math> on page 2.</li> </ul>   |