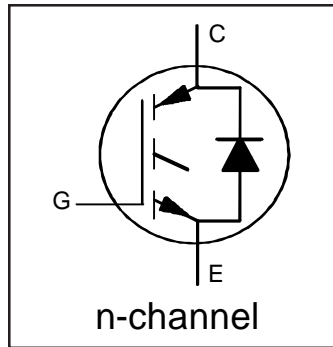


### INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRA-LOW V<sub>F</sub> DIODE FOR INDUCTION HEATING AND SOFT SWITCHING APPLICATIONS

#### Features

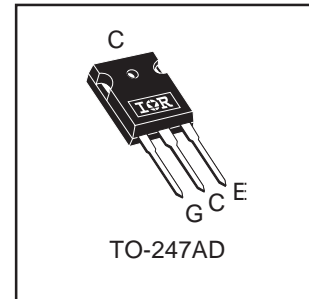
- Low V<sub>CE(ON)</sub> trench IGBT Technology
- Low Switching Losses
- Square RBSOA
- Ultra-Low V<sub>F</sub> Diode
- 1300Vpk Repetitive Transient Capacity
- 100% of the Parts Tested for I<sub>LM</sub>①
- Positive V<sub>CE(ON)</sub> Temperature Co-Efficient
- Tight Parameter Distribution
- Lead Free Package



V<sub>CES</sub> = 1200V  
 I<sub>C</sub> = 25A, T<sub>C</sub> = 100°C  
 T<sub>J(max)</sub> = 150°C  
 V<sub>CE(on)</sub> typ. = 1.9V @ I<sub>C</sub> = 20A

#### Benefits

- Device optimized for induction heating and soft switching applications
- High Efficiency due to Low V<sub>CE(on)</sub>, low switching losses and Ultra-low V<sub>F</sub>
- Rugged transient performance for increased reliability
- Excellent current sharing in parallel operation
- Low EMI



<b>G</b>	<b>C</b>	<b>E</b>
Gate	Collector	Emitter

Base part number	Package Type	Standard Pack		Orderable part number
		Form	Quantity	
IRG7PH35UD1MPbF	TO-247AD	Tube	25	IRG7PH35UD1MPbF

#### Absolute Maximum Ratings

Parameter	Parameter	Max.	Units
V <sub>CES</sub>	Collector-to-Emitter Voltage	1200	V
V <sub>(BR)Transient</sub>	Repetitive Transient Collector-to-Emitter Voltage ⑥	1300	
I <sub>C</sub> @ T <sub>C</sub> = 25°C	Continuous Collector Current	50	A
I <sub>C</sub> @ T <sub>C</sub> = 100°C	Continuous Collector Current	25	
I <sub>CM</sub>	Pulse Collector Current, V <sub>GE</sub> =15V ② ③	150	
I <sub>LM</sub>	Clamped Inductive Load Current, V <sub>GE</sub> =20V ①	80	
I <sub>F</sub> @ T <sub>C</sub> = 25°C	Diode Continuous Forward Current	50	
I <sub>F</sub> @ T <sub>C</sub> = 100°C	Diode Continuous Forward Current	25	
I <sub>FM</sub>	Diode Maximum Forward Current ②	80	
V <sub>GE</sub>	Continuous Gate-to-Emitter Voltage	±30	V
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Maximum Power Dissipation	179	W
P <sub>D</sub> @ T <sub>C</sub> = 100°C	Maximum Power Dissipation	71	
T <sub>J</sub>	Operating Junction and	-55 to +150	°C
T <sub>STG</sub>	Storage Temperature Range		
	Soldering Temperature, for 10 sec.		
	Mounting Torque, 6-32 or M3 Screw	10 lbf-in (1.1 N-m)	

#### Thermal Resistance

Parameter	Parameter	Min.	Typ.	Max.	Units
R <sub>θJC</sub> (IGBT)	Thermal Resistance Junction-to-Case-(each IGBT)④	—	—	0.70	°C/W
R <sub>θJC</sub> (Diode)	Thermal Resistance Junction-to-Case-(each Diode) ④	—	—	1.35	
R <sub>θCS</sub>	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.24	—	
R <sub>θJA</sub>	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	40	—	

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

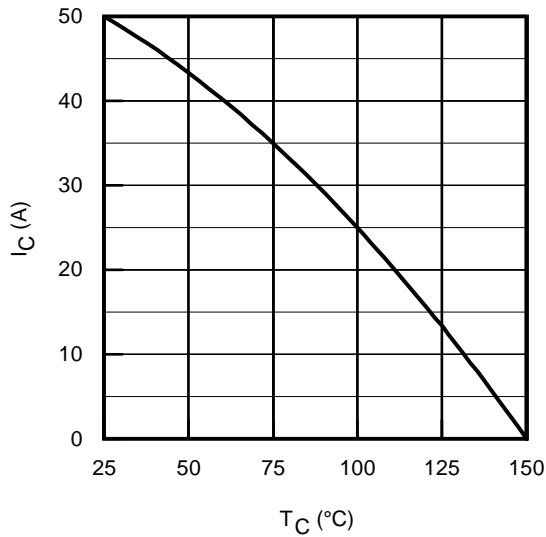
	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	1200	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 100μA ③
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	1.2	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1mA (25°C-150°C)
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.9	2.2	V	I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C
		—	2.3	—		I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.0	—	6.0	V	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 600μA
g <sub>fe</sub>	Forward Transconductance	—	22	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 20A, PW = 30μs
I <sub>CES</sub>	Collector-to-Emitter Leakage Current	—	1.0	100	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V
		—	120	—		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> = 150°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.15	1.26	V	I <sub>F</sub> = 20A
		—	1.08	—		I <sub>F</sub> = 20A, T <sub>J</sub> = 150°C
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ±30V

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

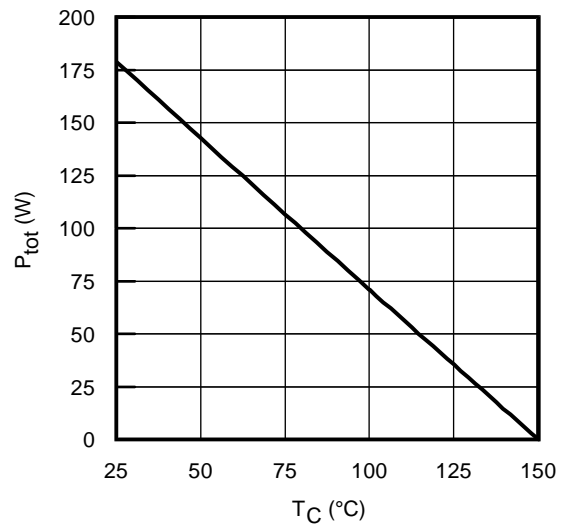
	Parameter	Min.	Typ.	Max.	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	85	130	nC	I <sub>C</sub> = 20A V <sub>GE</sub> = 15V V <sub>CC</sub> = 600V
Q <sub>ge</sub>	Gate-to-Emitter Charge (turn-on)	—	15	20		
Q <sub>gc</sub>	Gate-to-Collector Charge (turn-on)	—	35	50		
E <sub>off</sub>	Turn-Off Switching Loss	—	620	850	μJ	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V, V <sub>GE</sub> = 15V R <sub>G</sub> = 10Ω, L = 200μH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 25°C Energy losses include tail
t <sub>d(off)</sub>	Turn-Off delay time	—	160	180	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V, V <sub>GE</sub> = 15V R <sub>G</sub> = 10Ω, L = 200μH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 25°C
t <sub>f</sub>	Fall time	—	80	105		
E <sub>off</sub>	Turn-Off Switching Loss	—	1120	—	μJ	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V, V <sub>GE</sub> = 15V R <sub>G</sub> = 10Ω, L = 200μH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 150°C Energy losses include tail
t <sub>d(off)</sub>	Turn-Off delay time	—	190	—	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V, V <sub>GE</sub> = 15V R <sub>G</sub> = 10Ω, L = 200μH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 150°C
t <sub>f</sub>	Fall time	—	210	—		
C <sub>ies</sub>	Input Capacitance	—	1940	—	pF	V <sub>GE</sub> = 0V V <sub>CC</sub> = 30V f = 1.0Mhz
C <sub>oes</sub>	Output Capacitance	—	120	—		
C <sub>res</sub>	Reverse Transfer Capacitance	—	40	—		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 150°C, I <sub>C</sub> = 80A V <sub>CC</sub> = 960V, V <sub>p</sub> = 1200V R <sub>G</sub> = 10Ω, V <sub>GE</sub> = +20V to 0V

**Notes:**

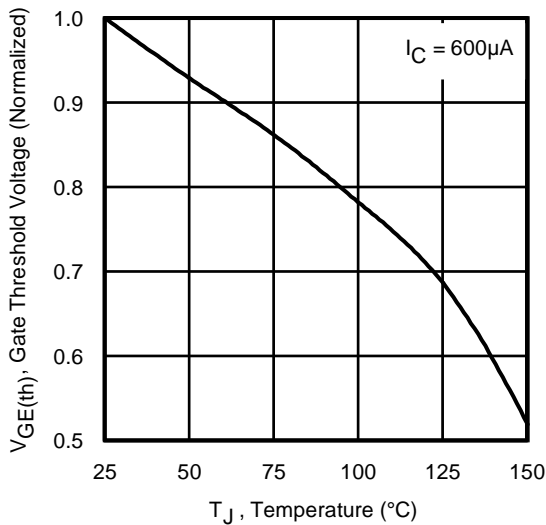
- ① V<sub>CC</sub> = 80% (V<sub>CES</sub>), V<sub>GE</sub> = 20V, R<sub>G</sub> = 10Ω.
- ② Pulse width limited by max. junction temperature.
- ③ Refer to AN-1086 for guidelines for measuring V<sub>(BR)CES</sub> safely.
- ④ R<sub>θ</sub> is measured at T<sub>J</sub> approximately 90°C.
- ⑤ FBSOA operating conditions only.
- ⑥ V<sub>GE</sub> = 0V, T<sub>J</sub> = 75°C, PW ≤ 10μs.



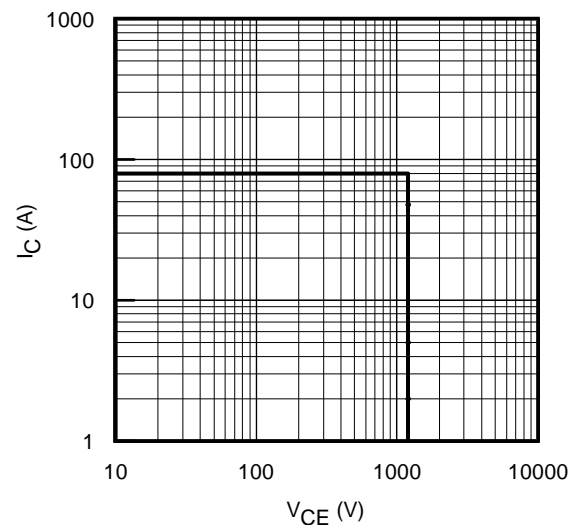
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



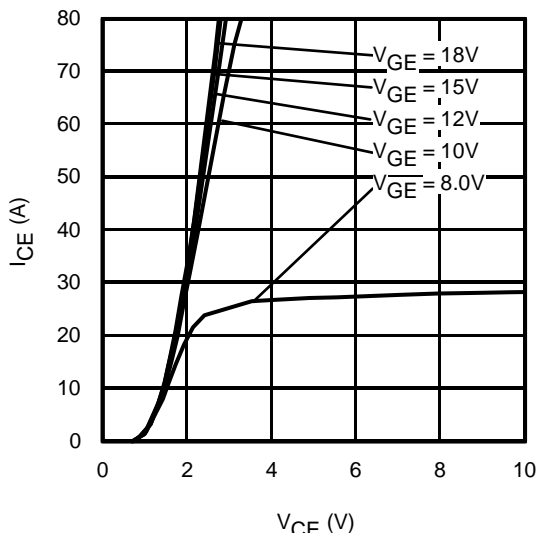
**Fig. 2** - Power Dissipation vs. Case Temperature



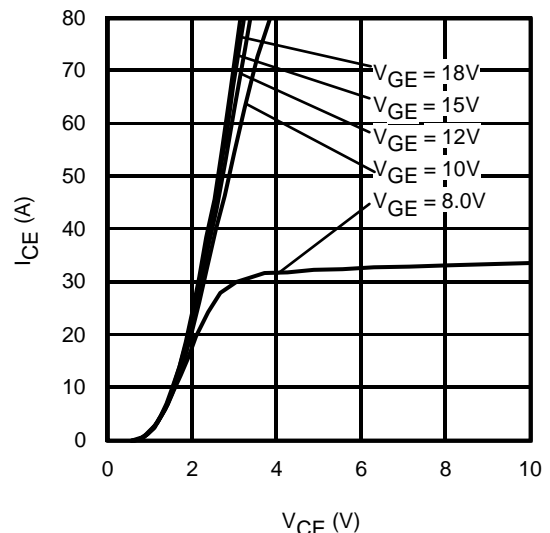
**Fig. 3** - Typical Gate Threshold Voltage (Normalized) vs. Junction Temperature



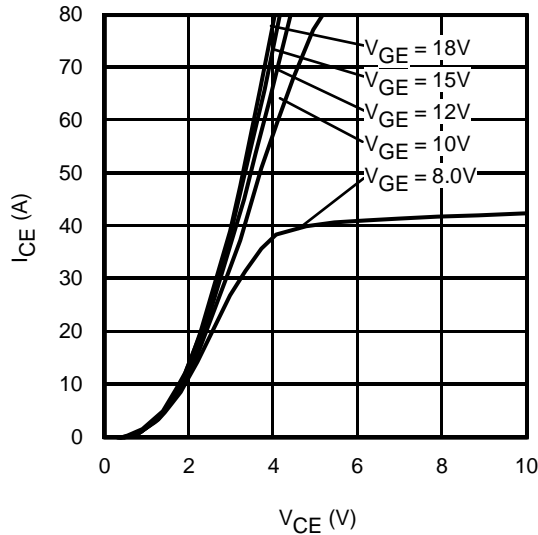
**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{GE} = 20\text{V}$



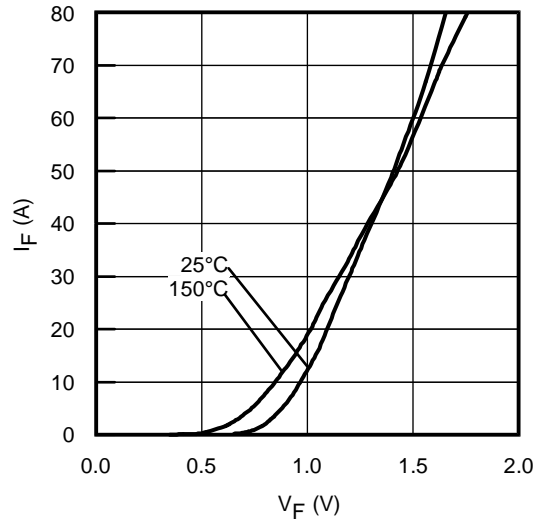
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



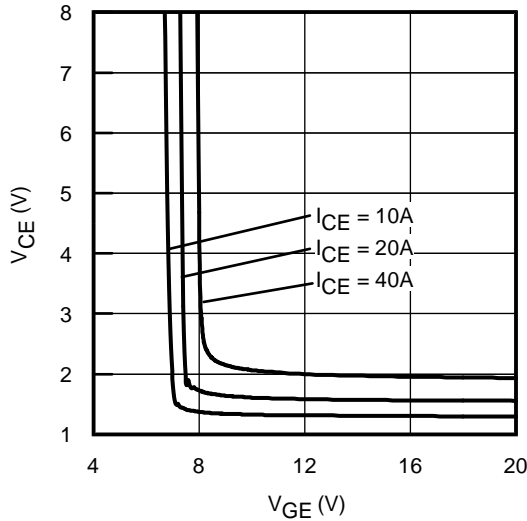
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



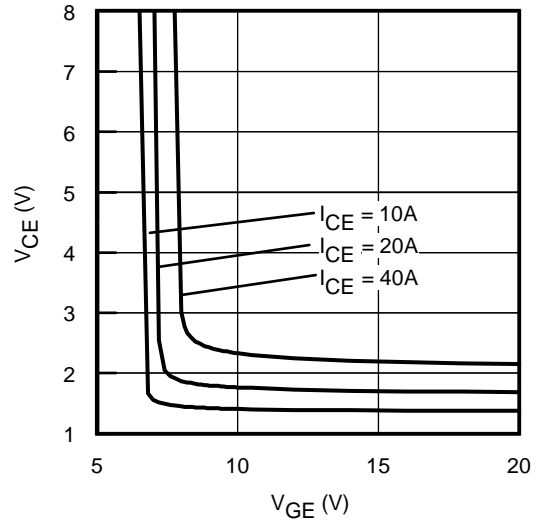
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 150^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



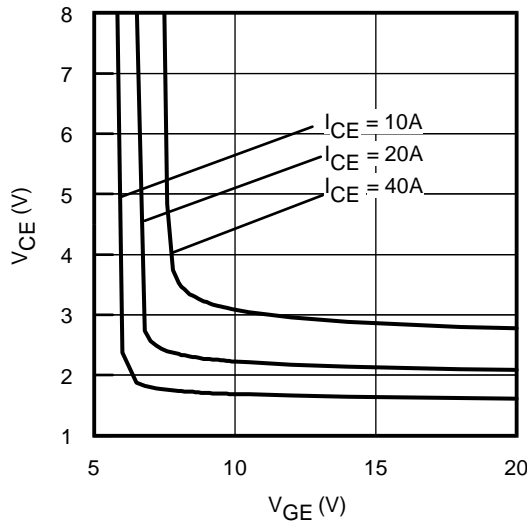
**Fig. 8 - Typ. Diode Forward Voltage Drop Characteristics**



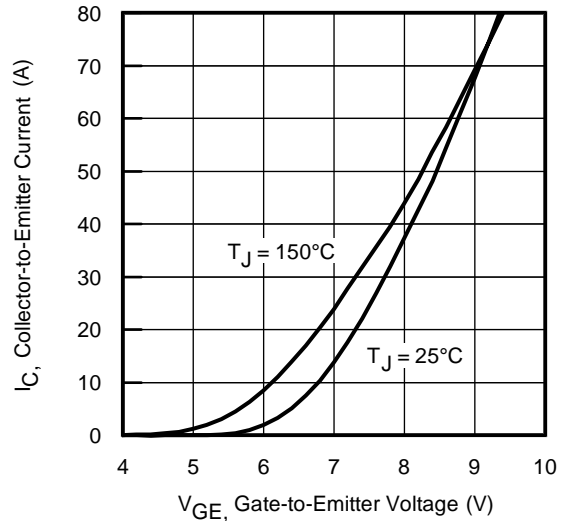
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^\circ\text{C}$



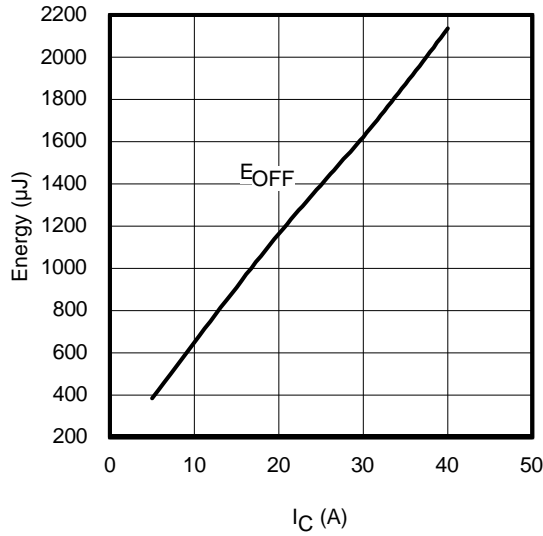
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^\circ\text{C}$



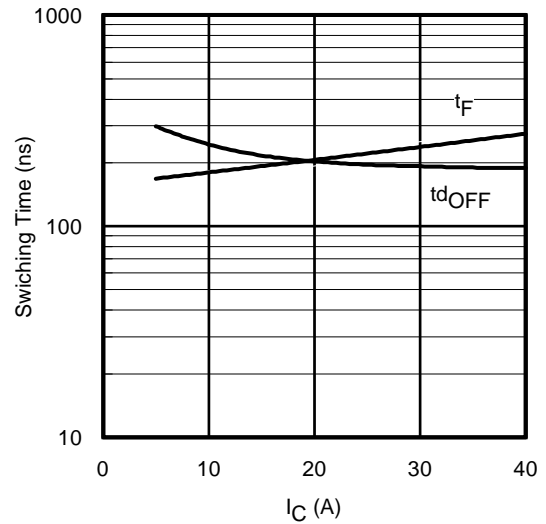
**Fig. 11 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 150^\circ\text{C}$



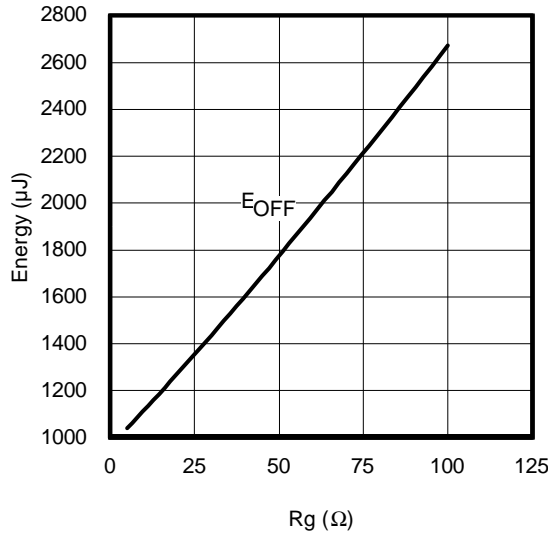
**Fig. 12 - Typ. Transfer Characteristics**  
 $V_{CE} = 50\text{V}$ ;  $t_p = 30\mu\text{s}$



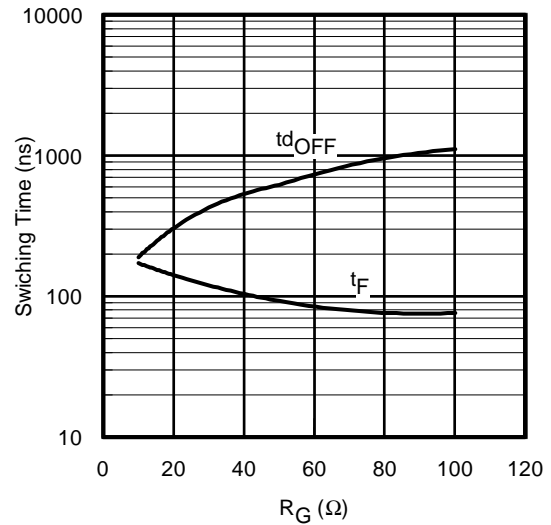
**Fig. 13 - Typ. Energy Loss vs.  $I_C$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 680\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



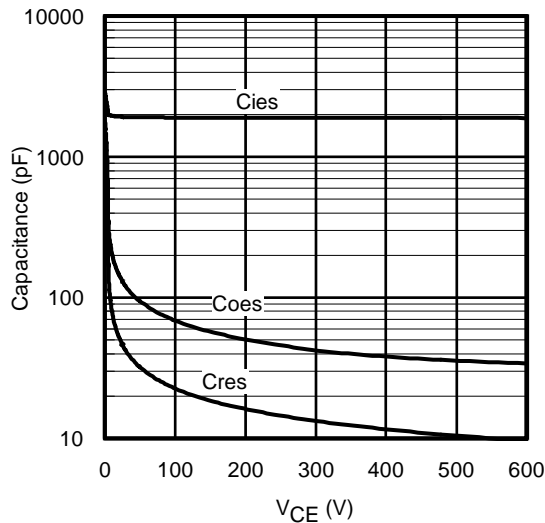
**Fig. 14 - Typ. Switching Time vs.  $I_C$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 680\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



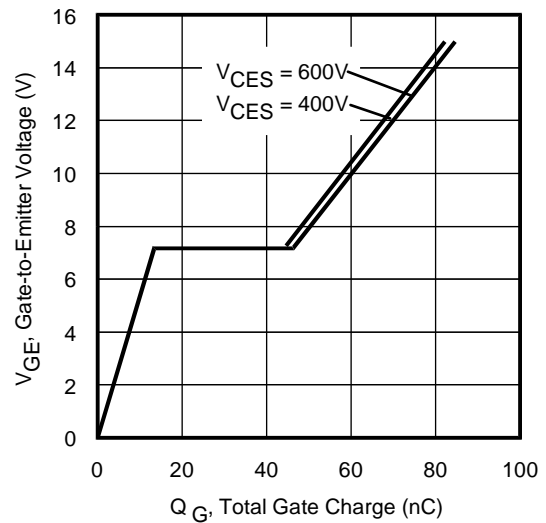
**Fig. 15 - Typ. Energy Loss vs.  $R_G$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 680\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $I_{CE} = 20\text{A}$ ;  $V_{GE} = 15\text{V}$



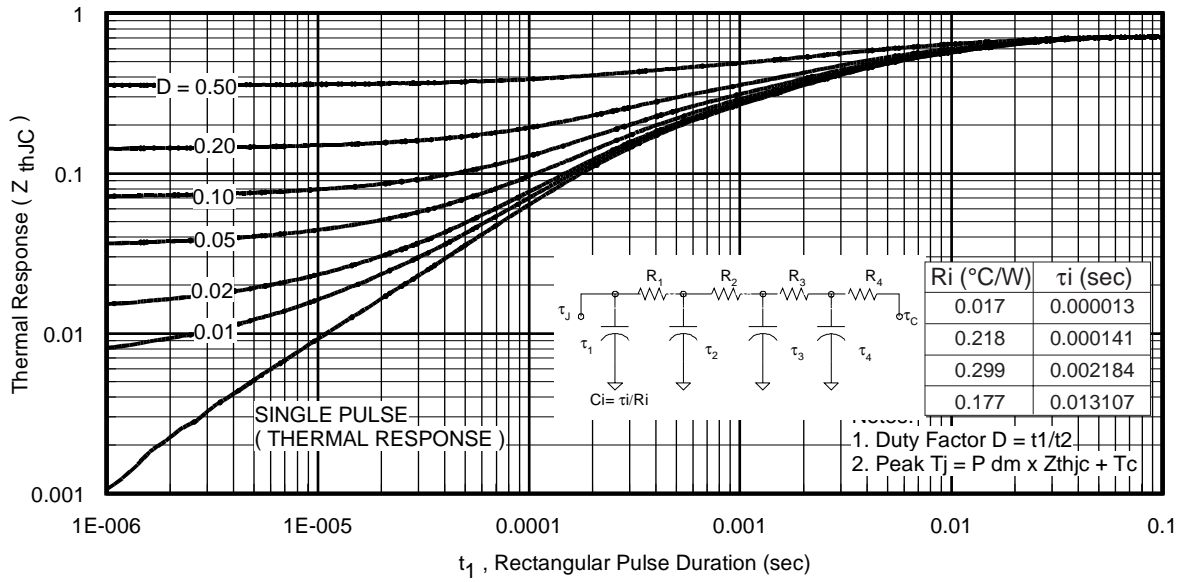
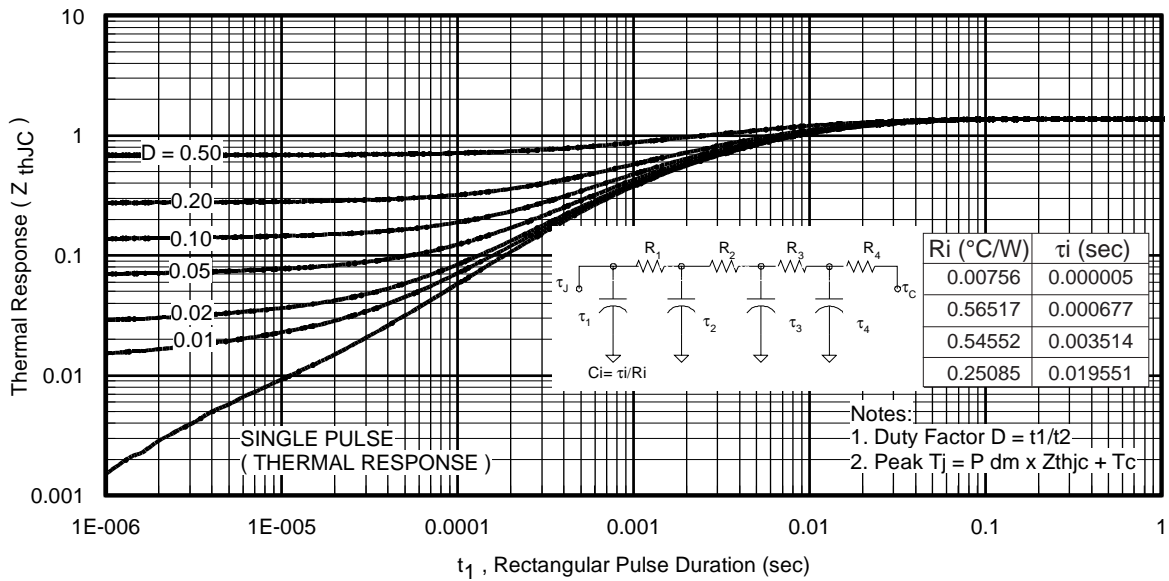
**Fig. 16 - Typ. Switching Time vs.  $R_G$**   
 $T_J = 150^\circ\text{C}$ ;  $L = 680\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ,  $I_{CE} = 20\text{A}$ ;  $V_{GE} = 15\text{V}$



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



**Fig. 18 - Typical Gate Charge vs.  $V_{GE}$**   
 $I_{CE} = 20\text{A}$ ;  $L = 2.4\text{mH}$


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

**Fig. 20.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

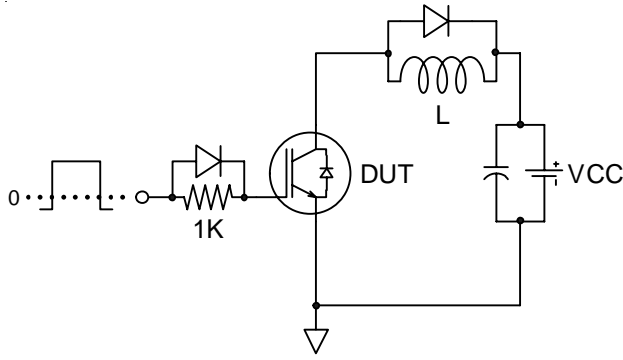


Fig.C.T.1 - Gate Charge Circuit (turn-off)

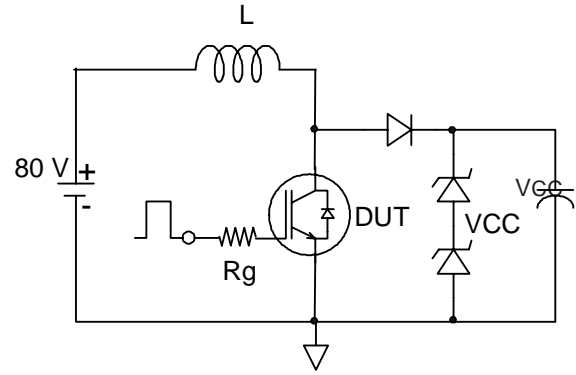


Fig.C.T.2 - RBSOA Circuit

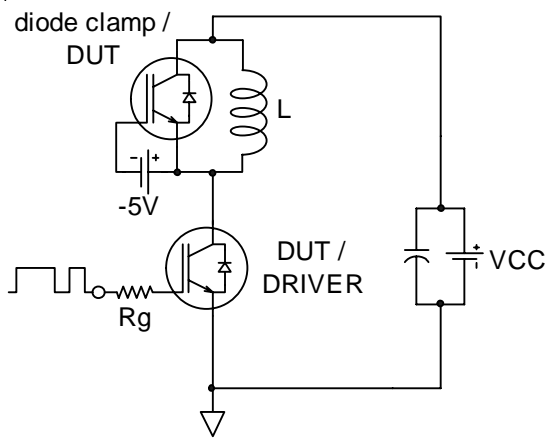


Fig.C.T.3 - Switching Loss Circuit

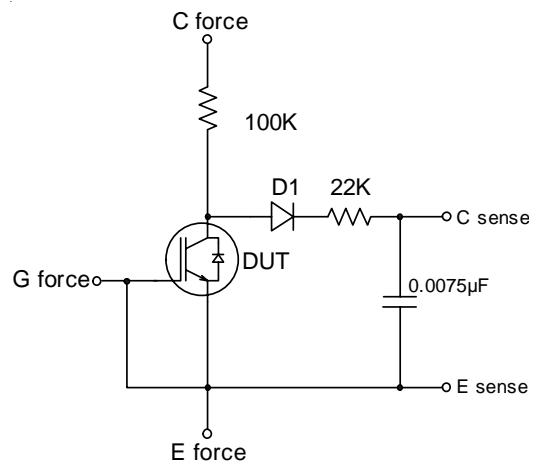


Fig.C.T.4 - BVCES Filter Circuit

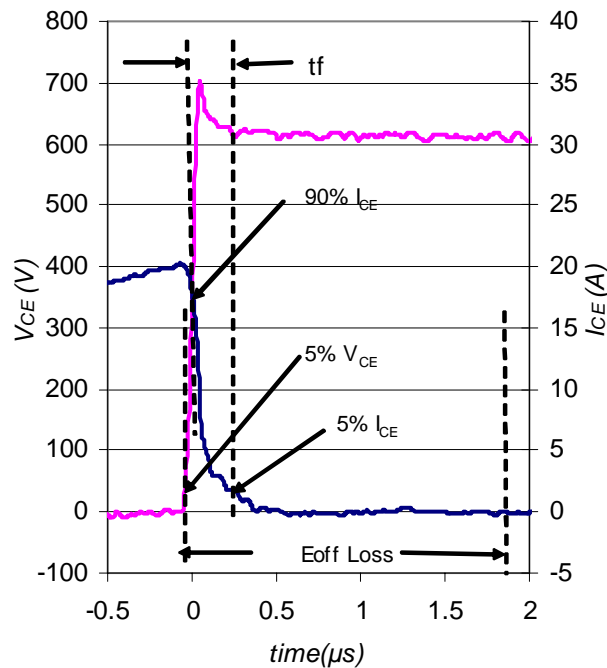
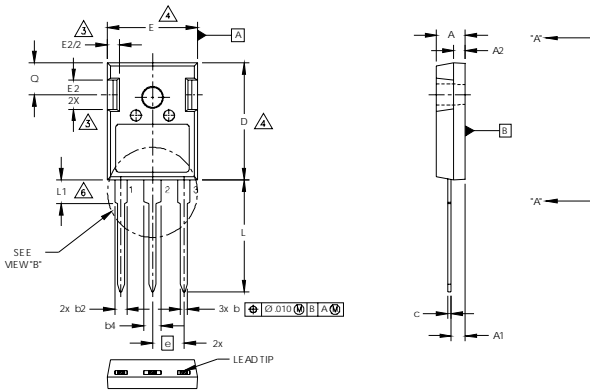


Fig. WF1 - Typ. Turn-off Loss Waveform  
@  $T_J = 150^{\circ}\text{C}$  using Fig. CT.3

# TO-247AD Package Outline

(Dimensions are shown in millimeters (inches))



SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.190	.204	4.83	5.20	4 5 4
A1	.090	.100	2.29	2.54	
A2	.075	.085	1.91	2.16	
b	.042	.052	1.07	1.33	
b2	.075	.094	1.91	2.41	
b4	.113	.133	2.87	3.38	
c	.022	.026	0.55	0.68	
D	.819	.830	20.80	21.10	
D1	.640	.694	16.25	17.65	
E	.620	.635	15.75	16.13	
E1	.512	.570	13.00	14.50	
E2	.145	.196	3.68	5.00	
e	.215 Typical		5.45 Typical		
L	.780	.800	19.80	20.32	
L1	.161	.173	4.10	4.40	
φ P	.138	.143	3.51	3.65	
Q	.216	.236	5.49	6.00	
S	.238	.248	6.04	6.30	

### LEAD ASSIGNMENTS

#### HEXFET

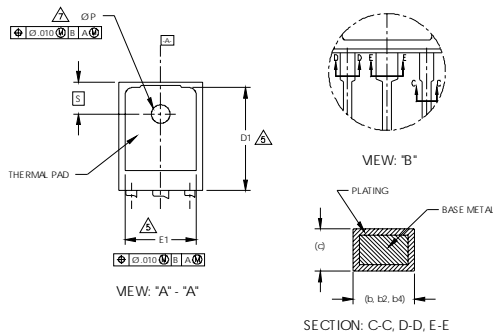
- 1.- GATE
- 2.- DRAIN
- 3.- SOURCE
- 4.- DRAIN

#### IGBTs, CoPACK

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

#### DIODES

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



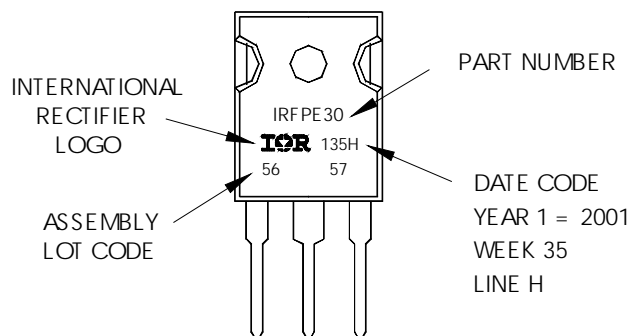
### NOTES:

- 1 DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
- 2 DIMENSIONS ARE SHOWN IN INCHES AND MILLIMETERS.
- 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 φ P TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.

## TO-247AD Part Marking Information

EXAMPLE: THIS IS AN IRFPE30  
WITH ASSEMBLY  
LOT CODE 5657  
ASSEMBLED ON WW 35, 2001  
IN THE ASSEMBLY LINE "H"

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



TO-247AD package is not recommended for Surface Mount Application.

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



**Qualification information<sup>†</sup>**

Qualification level	Industrial <sup>††</sup> (per JEDEC JE S D47F <sup>†††</sup> guidelines )	
Moisture Sensitivity Level	TO-247AD	N/A (per JEDEC J-STD-020D <sup>†††</sup> )
RoHS compliant	Yes	

† Qualification standards can be found at International Rectifier's web site

<http://www.irf.com/product-info/reliability>

†† Higher qualification ratings may be available should the user have such requirements.  
Please contact your International Rectifier sales representative for further information:

<http://www.irf.com/whoto-call/salesrep/>

††† Applicable version of JEDEC standard at the time of product release.