

### CooliRIGBT™

#### Features

- Designed And Qualified for Automotive Applications
- Ultra Fast Switching IGBT:70-200kHz
- Extremely Low Switching Losses
- Maximum Junction Temperature 175 °C
- Square RBSOA
- Positive  $V_{CE(on)}$  Temperature Coefficient

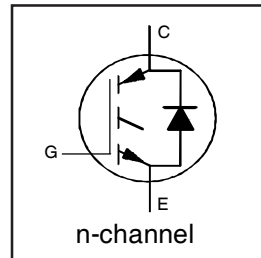
#### Benefits

- Optimized High Frequency Switching Applications
- Rugged Transient Performance for Increased Reliability
- Excellent Current Sharing in Parallel Operation

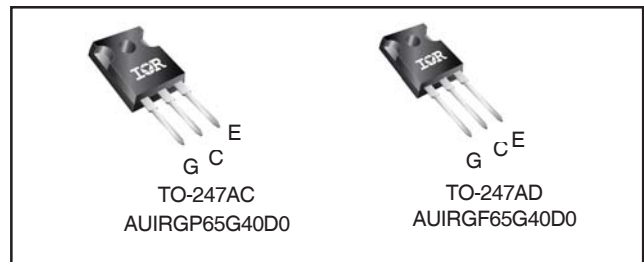
#### Applications

- DC-DC Converter
- PFC

### ULTRAFAST IGBT WITH ULTRAFAST SOFT RECOVERY DIODE



$V_{CES} = 600V$
$V_{CE(on)} \text{ typ.} = 1.8V$
$I_C @ T_C = 100^\circ C = 41A$
$T_J \text{ max} = 175^\circ C$



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

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
AUIRGP65G40D0	TO-247AC	Tube	25	AUIRGP65G40D0
AUIRGF65G40D0	TO-247AD	Tube	25	AUIRGF65G40D0

### 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°C, unless otherwise specified.

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current ⑥	62	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current ⑥	41	
$I_{NOMINAL}$	Nominal Current @ 200kHz ⑦	20	
$I_{CM}$	Pulse Collector Current	84	
$I_{LM}$	Clamped Inductive Load Current ①	112	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	46.1	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	30	
$I_{FRM}$	Maximum Repetitive Forward Current ②	112	V
$V_{GE}$	Gate-to-Emitter Voltage	±20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	625	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	313	
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	°C
	Soldering Temperature for 10 sec.	300 (0.063 in. (1.6mm) from case)	
	Mounting Torque, 6-32 or M3 Screw	10 lbf·in (1.1 N·m)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$ (IGBT)	Junction-to-Case-(each IGBT) ④	—	—	0.24	°C/W
$R_{\theta JC}$ (Diode)	Junction-to-Case-(each Diode) ④	—	—	1.78	
$R_{\theta CS}$	Case-to-Sink (flat, greased surface)	—	0.24	—	
$R_{\theta JA}$	Junction-to-Ambient (typical socket mount)	—	—	40	
		—	6.0 (0.21)	—	g (oz)

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

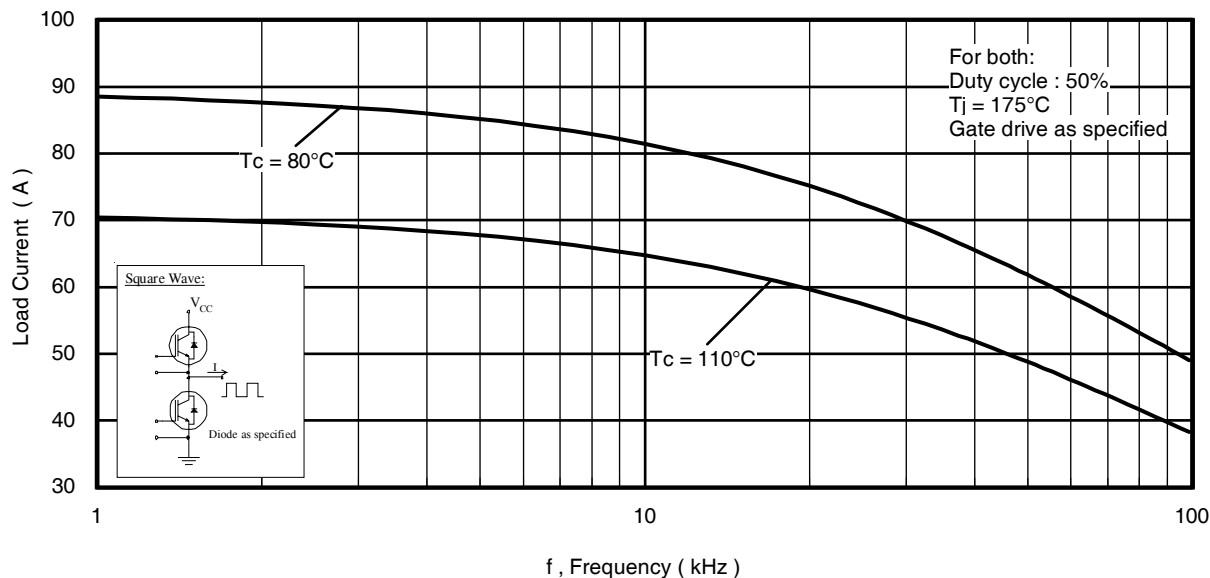
**Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 500μA ③
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.18	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1.0mA (25°C-175°C)
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.4	—	V	I <sub>C</sub> = 12A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C
		—	1.8	2.2		I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C
		—	1.9	—		I <sub>C</sub> = 12A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C
		—	2.6	—		I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C
		—	2.2	—		I <sub>C</sub> = 12A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 175°C
		—	3.0	—		I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 175°C
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.0	—	5.5	V	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA
ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>	Threshold Voltage temp. coefficient	—	-12	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1.0mA (25°C - 175°C)
g <sub>fe</sub>	Forward Transconductance	—	36	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 20A
I <sub>CES</sub>	Collector-to-Emitter Leakage Current	—	3.2	25	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V
		—	0.81	—	mA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 175°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.7	2.45	V	I <sub>F</sub> = 20A
		—	1.4	—		I <sub>F</sub> = 20A, T <sub>J</sub> = 175°C
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ±20V

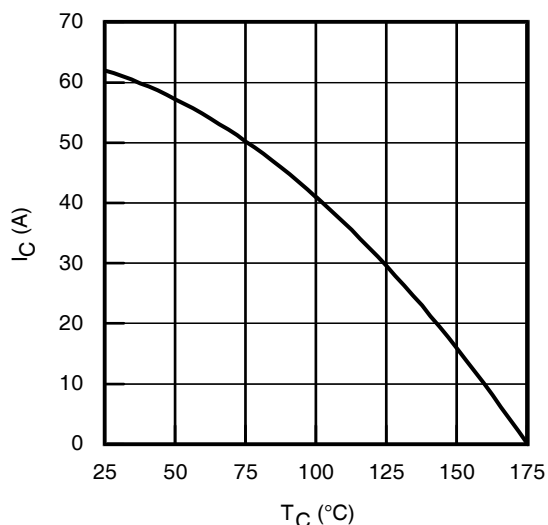
**Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	180	270	nC	I <sub>C</sub> = 20A
Q <sub>ge</sub>	Gate-to-Emitter Charge (turn-on)	—	28	42		V <sub>GE</sub> = 15V
Q <sub>gc</sub>	Gate-to-Collector Charge (turn-on)	—	64	96		V <sub>CC</sub> = 400V
E <sub>on</sub>	Turn-On Switching Loss	—	298	389	μJ	I <sub>C</sub> = 20A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
E <sub>off</sub>	Turn-Off Switching Loss	—	147	234		R <sub>G</sub> = 4.7Ω, L = 485μH, T <sub>J</sub> = 25°C
E <sub>total</sub>	Total Switching Loss	—	445	623		Energy losses include tail & diode reverse recovery
t <sub>d(on)</sub>	Turn-On delay time	—	35	53	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
t <sub>r</sub>	Rise time	—	12	29		R <sub>G</sub> = 4.7Ω, L = 485μH, T <sub>J</sub> = 25°C
t <sub>d(off)</sub>	Turn-Off delay time	—	142	163		
t <sub>f</sub>	Fall time	—	15	32		
E <sub>on</sub>	Turn-On Switching Loss	—	630	—		μJ
E <sub>off</sub>	Turn-Off Switching Loss	—	137	—	R <sub>G</sub> = 4.7Ω, L = 485μH, T <sub>J</sub> = 175°C	
E <sub>total</sub>	Total Switching Loss	—	767	—	Energy losses include tail & diode reverse recovery	
t <sub>d(on)</sub>	Turn-On delay time	—	33	—	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
t <sub>r</sub>	Rise time	—	12	—		R <sub>G</sub> = 4.7Ω, L = 485μH
t <sub>d(off)</sub>	Turn-Off delay time	—	165	—		T <sub>J</sub> = 175°C
t <sub>f</sub>	Fall time	—	16	—		
C <sub>ies</sub>	Input Capacitance	—	4673	—	pF	V <sub>GE</sub> = 0V
C <sub>oes</sub>	Output Capacitance	—	337	—		V <sub>CC</sub> = 30V
C <sub>res</sub>	Reverse Transfer Capacitance	—	58	—		f = 1.0Mhz
C <sub>oes eff.</sub>	Effective Output Capacitance (Time Related) ⑤	—	406	—		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 0V to 480V
C <sub>oes eff. (ER)</sub>	Effective Output Capacitance (Energy Related) ⑥	—	162	—		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				
t <sub>rr</sub>	Diode Reverse Recovery Time	—	41	—	ns	T <sub>J</sub> = 25°C I <sub>F</sub> = 20A, V <sub>R</sub> = 200V,
		—	70	—		T <sub>J</sub> = 125°C di/dt = 200A/μs
Q <sub>rr</sub>	Diode Reverse Recovery Charge	—	116	—	nC	T <sub>J</sub> = 25°C I <sub>F</sub> = 20A, V <sub>R</sub> = 200V,
		—	580	—		T <sub>J</sub> = 125°C di/dt = 200A/μs
I <sub>rr</sub>	Peak Reverse Recovery Current	—	4.8	—	A	T <sub>J</sub> = 25°C I <sub>F</sub> = 20A, V <sub>R</sub> = 200V,
		—	7.2	—		T <sub>J</sub> = 125°C di/dt = 200A/μs

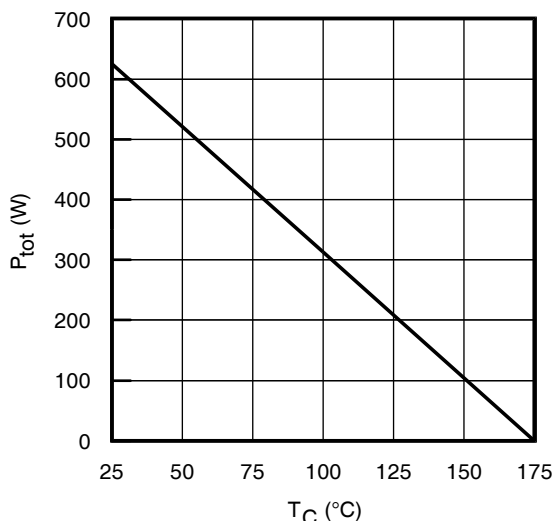
Notes ① through ⑦ are on page 13



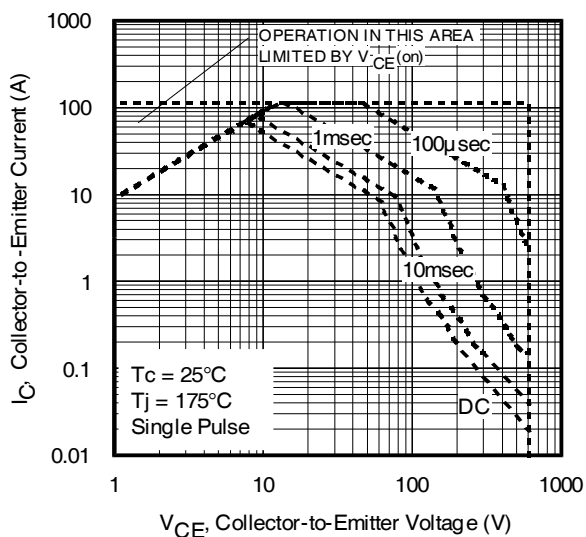
**Fig. 1 - Typical Load Current vs. Frequency**  
(Load Current = IRMS of fundamental)



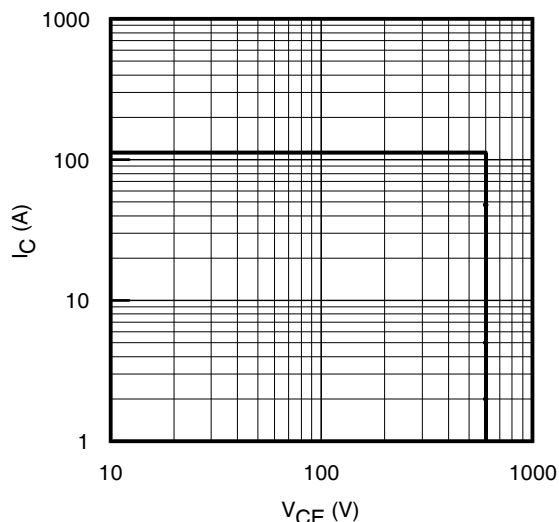
**Fig. 2 - Maximum DC Collector Current vs. Case Temperature**



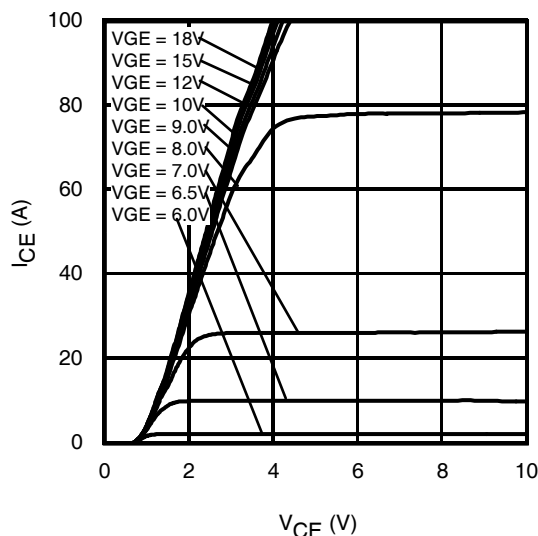
**Fig. 3 - Power Dissipation vs. Case Temperature**



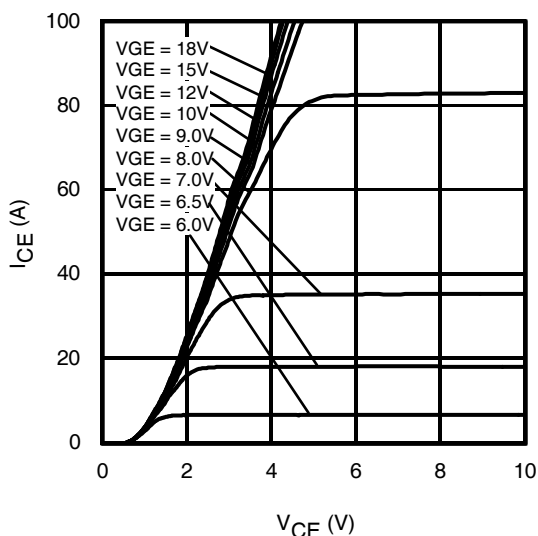
**Fig. 4 - Forward SOA**  
 $T_C = 25^\circ\text{C}; T_J \leq 175^\circ\text{C}; V_{GE} = 15\text{V}$



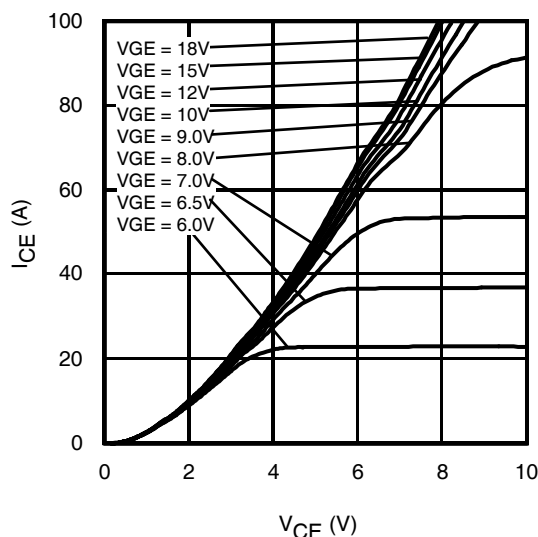
**Fig. 5 - Reverse Bias SOA**  
 $T_J = 175^\circ\text{C}; V_{GE} = 20\text{V}$



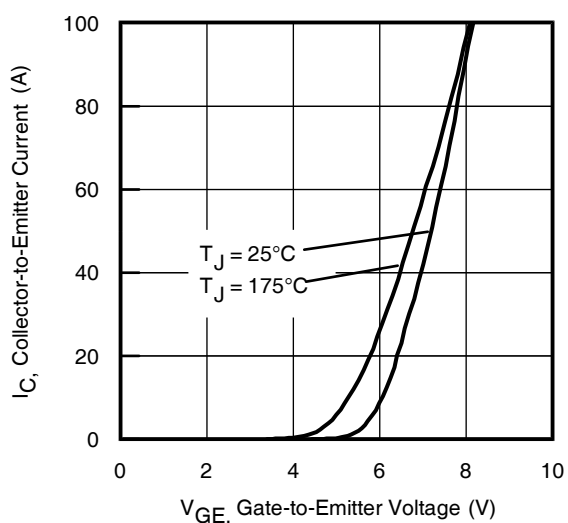
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



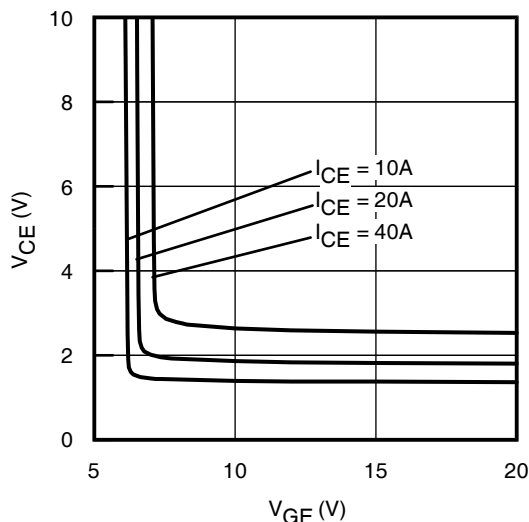
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



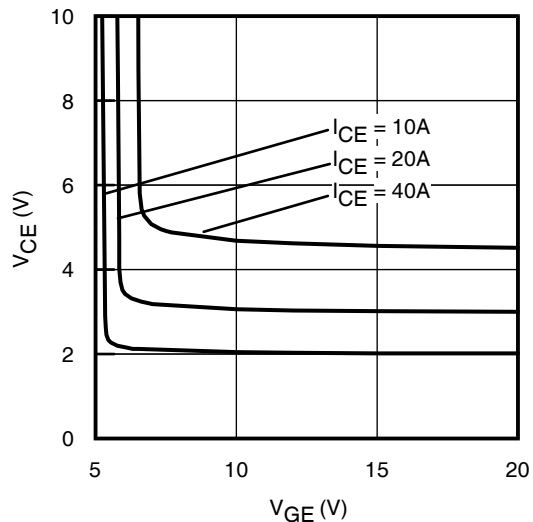
**Fig. 8** - Typ. IGBT Output Characteristics  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 30\mu\text{s}$



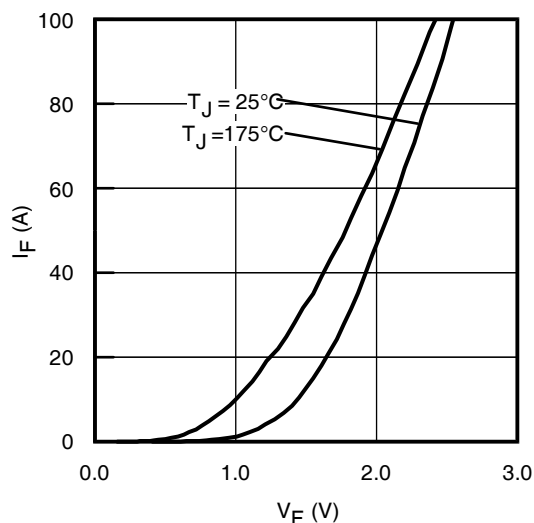
**Fig. 9** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 30\mu\text{s}$



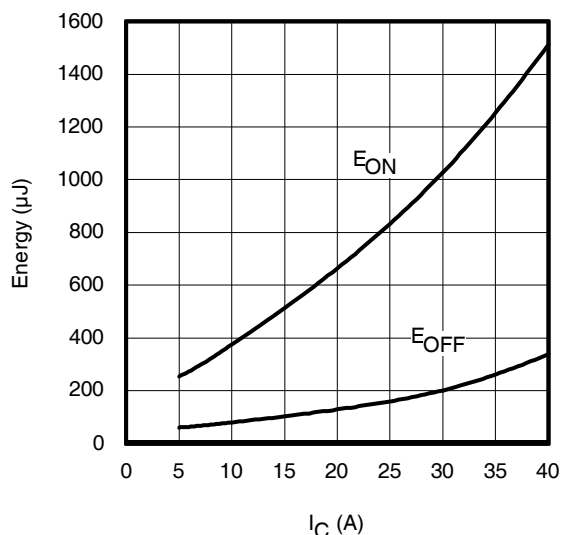
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



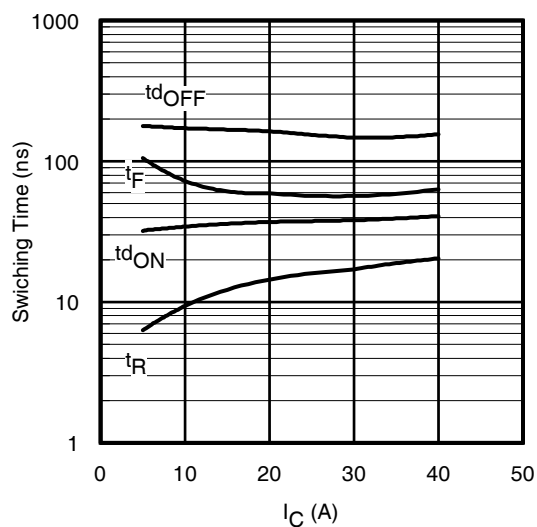
**Fig. 11** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 175^\circ\text{C}$



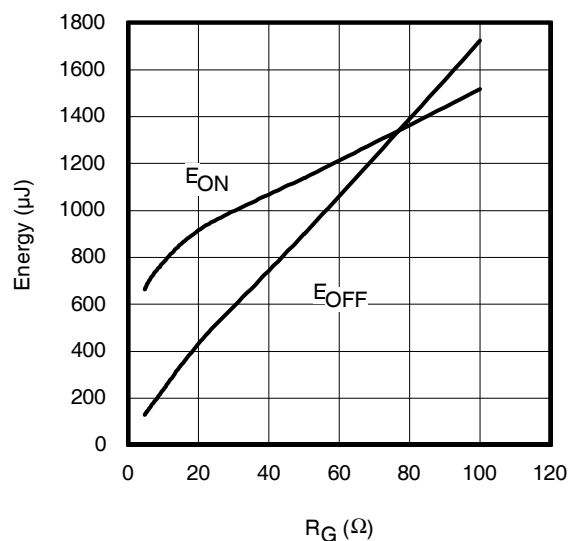
**Fig. 12** - Typ. Diode Forward Characteristics  
 $t_p = 30\mu s$



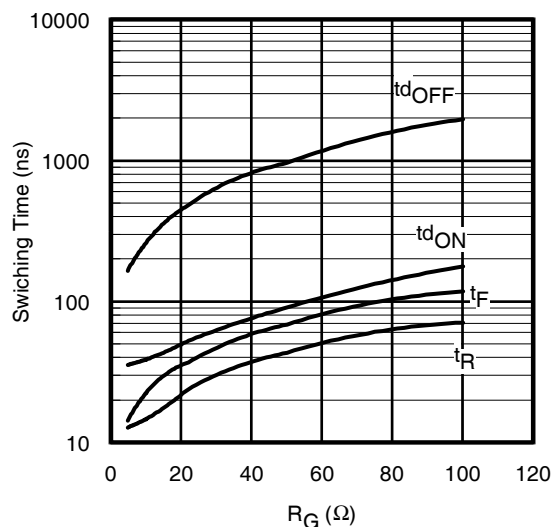
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 175^\circ C$ ;  $L = 0.49mH$ ;  $V_{CE} = 400V$ ;  $R_G = 4.7\Omega$ ;  $V_{GE} = 15V$



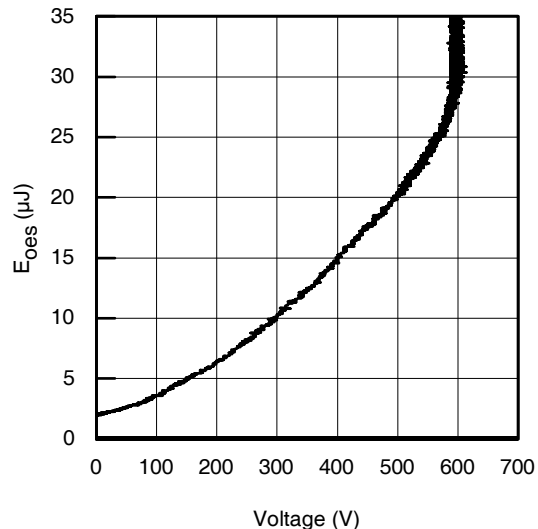
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 175^\circ C$ ;  $L = 0.49mH$ ;  $V_{CE} = 400V$ ;  $R_G = 4.7\Omega$ ;  $V_{GE} = 15V$



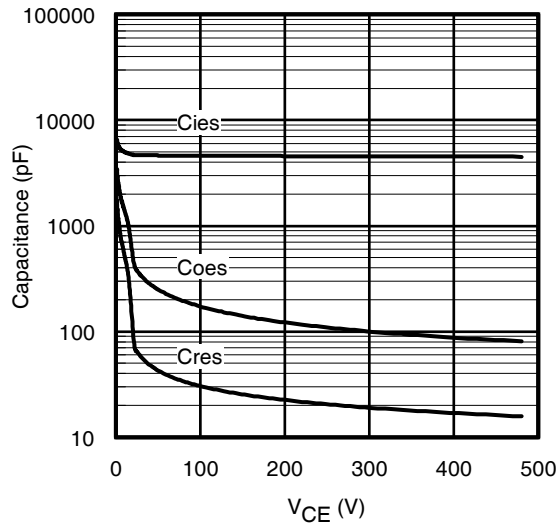
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 175^\circ C$ ;  $L = 0.49mH$ ;  $V_{CE} = 400V$ ;  $I_{CE} = 20A$ ;  $V_{GE} = 15V$



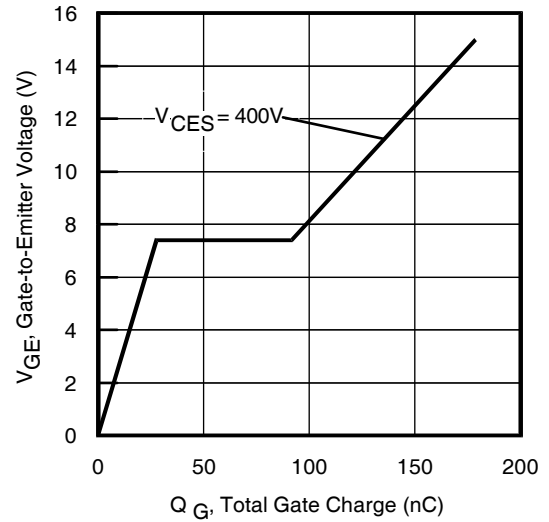
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 175^\circ C$ ;  $L = 0.49mH$ ;  $V_{CE} = 400V$ ;  $I_{CE} = 20A$ ;  $V_{GE} = 15V$



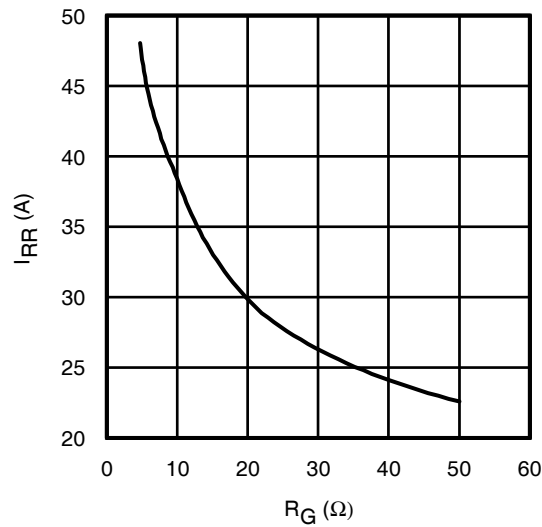
**Fig. 17** - Typ. Output Capacitance  
 Stored Energy vs.  $V_{CE}$



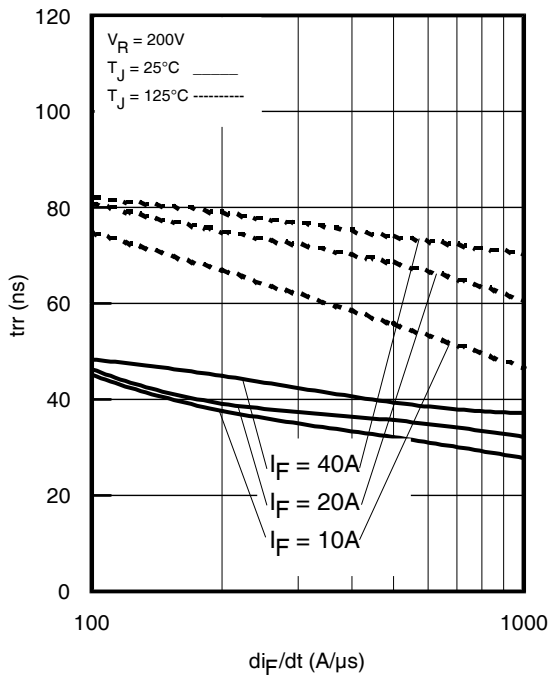
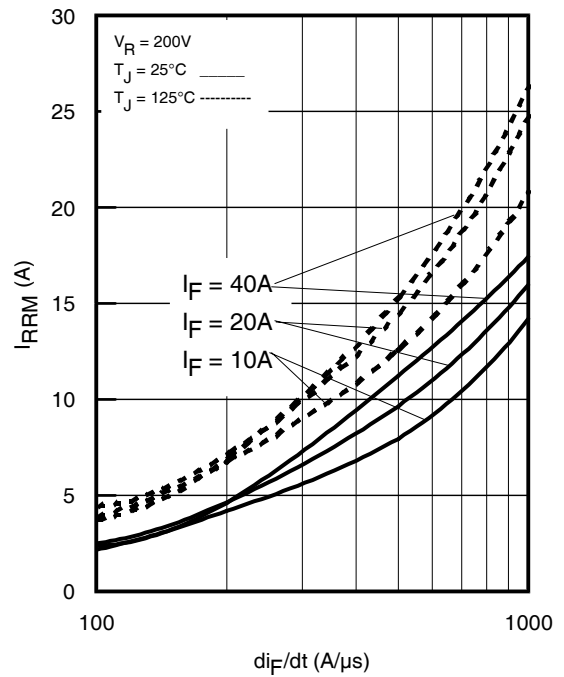
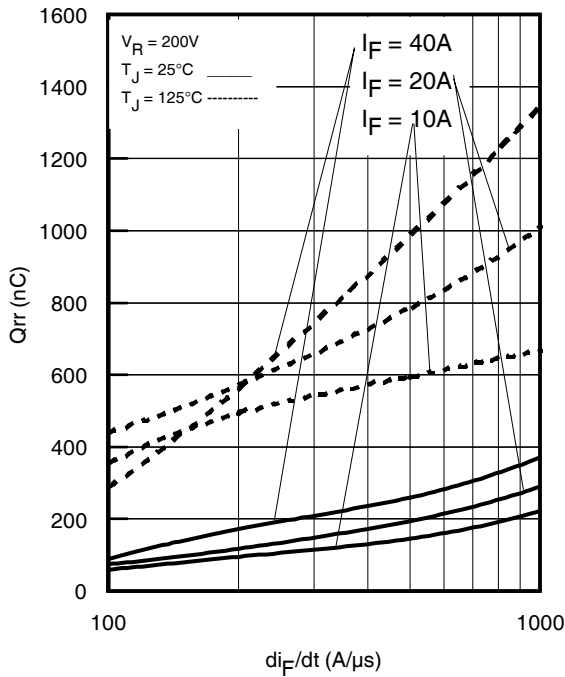
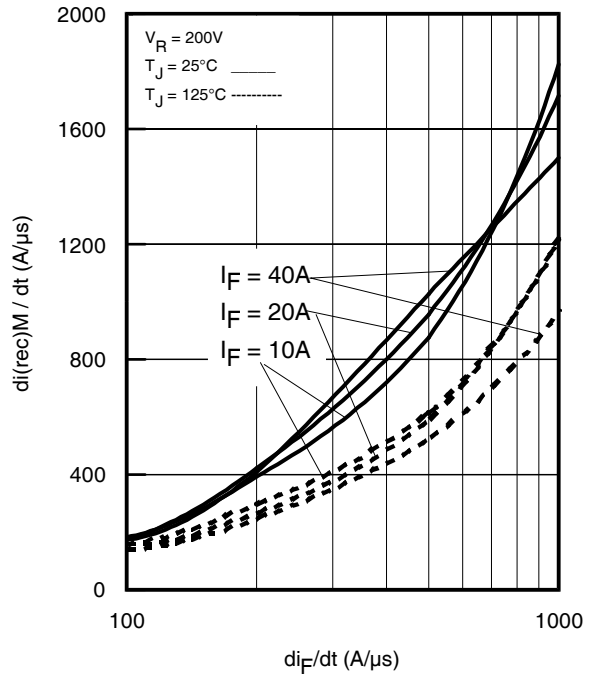
**Fig. 18** - Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0V$ ;  $f = 1MHz$

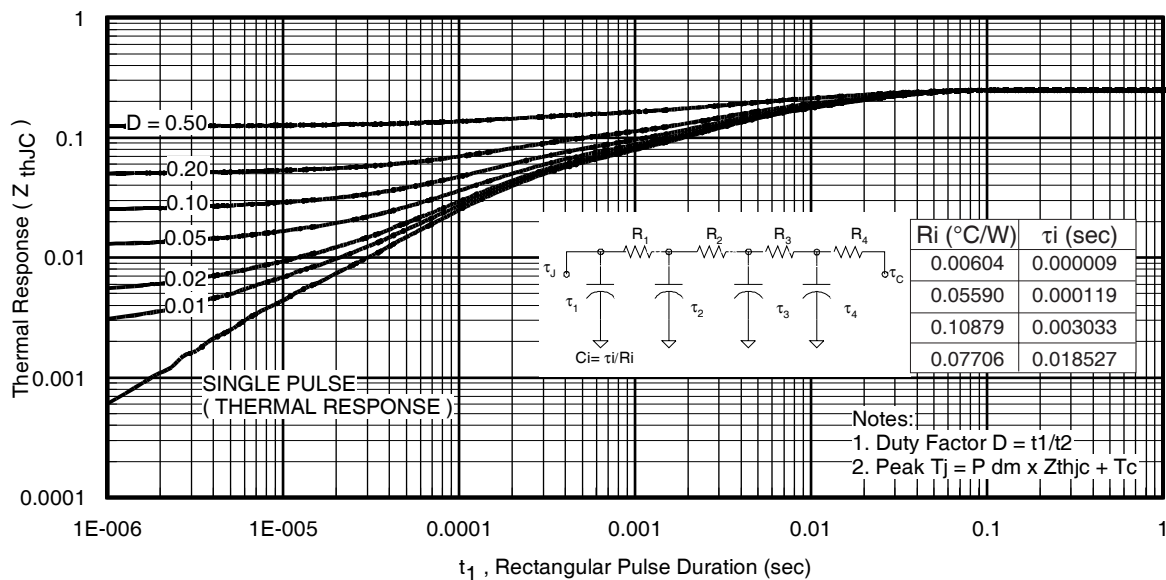
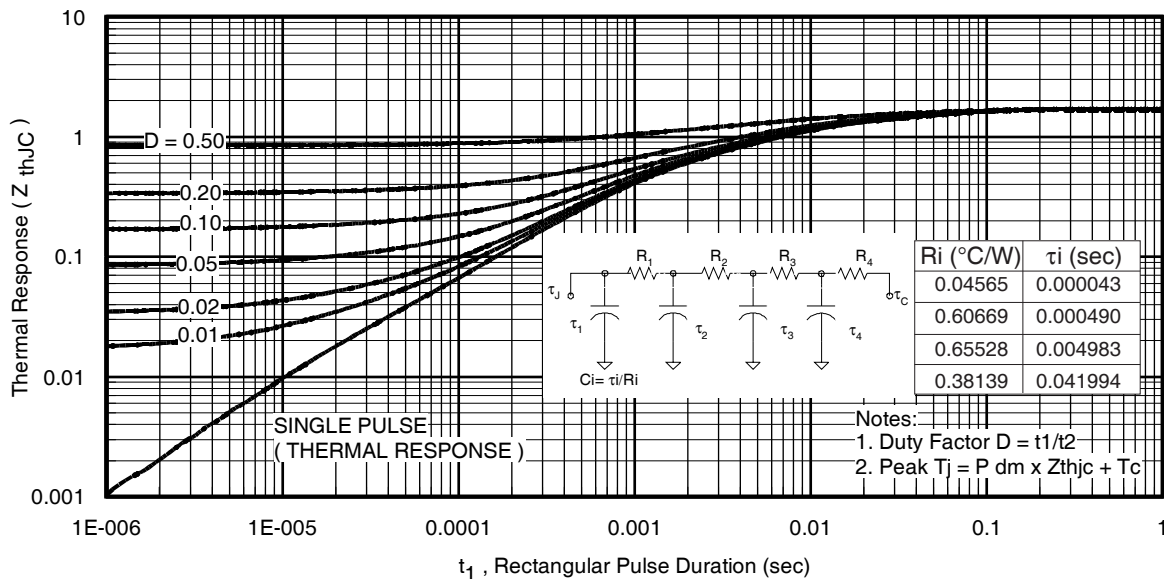


**Fig. 19** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 20A$ ;  $L = 200\mu H$

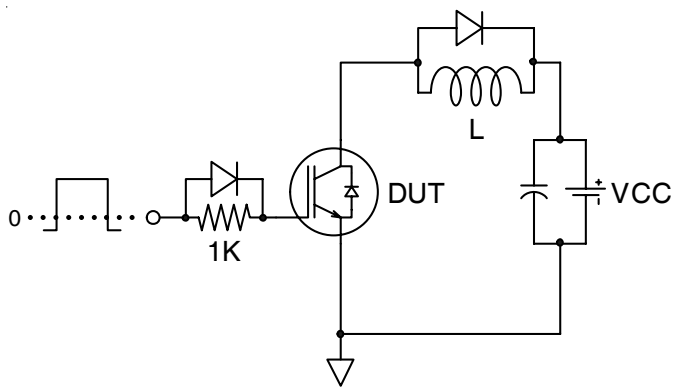
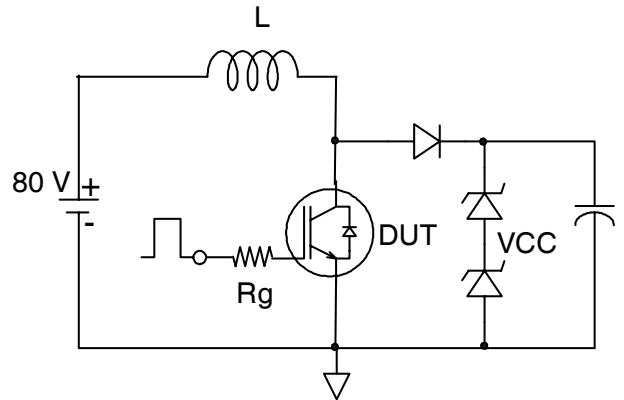
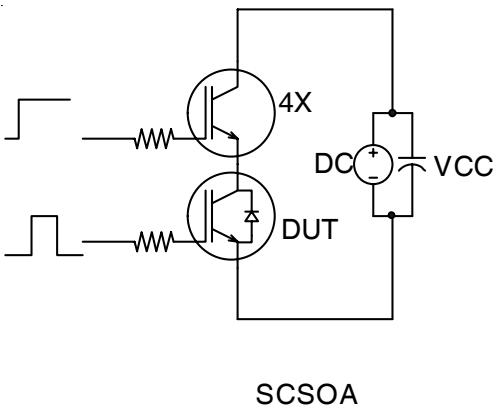
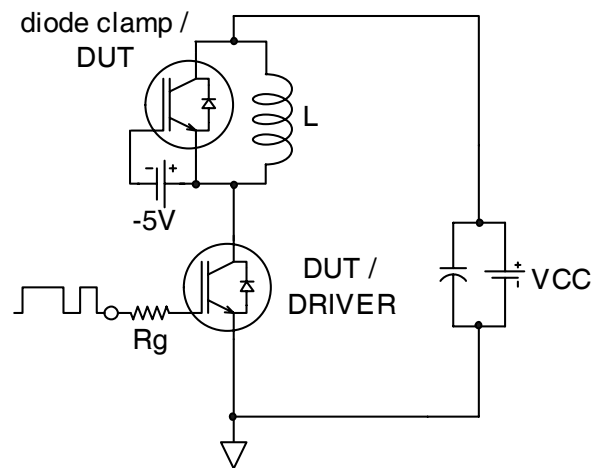
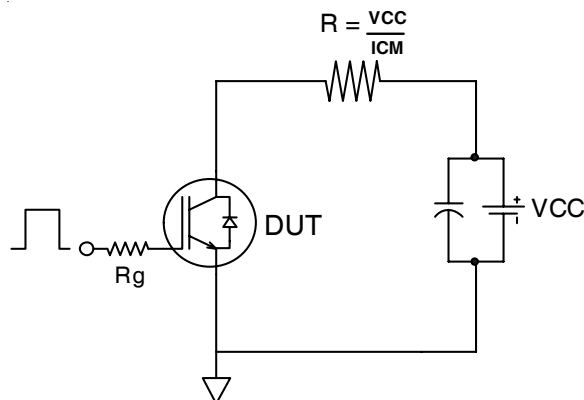


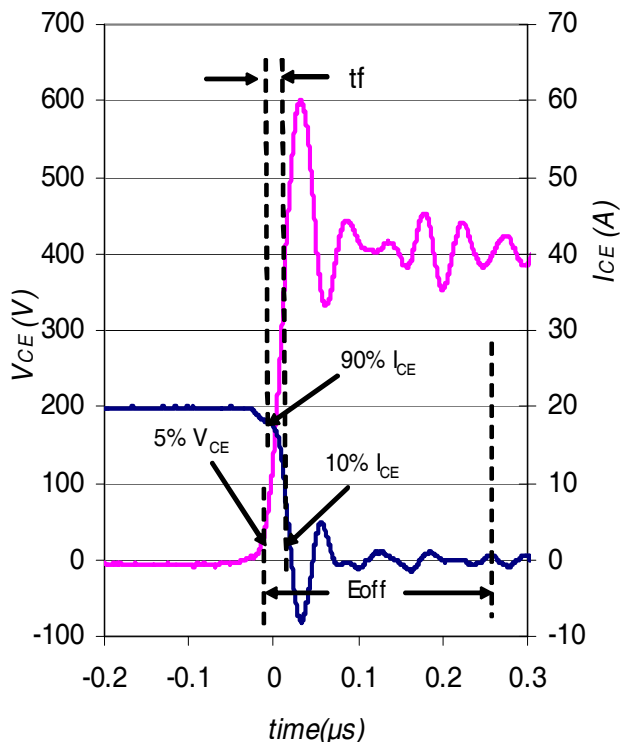
**Fig. 20** - Typ. Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 175^\circ C$


**Fig. 21 - Typical Reverse Recovery vs.  $di_F/dt$** 

**Fig. 22 - Typical Recovery Current vs.  $di_F/dt$** 

**Fig. 23 - Typical Stored Charge vs.  $di_F/dt$** 

**Fig. 24 - Typical  $di_{(rec)M}/dt$  vs.  $di_F/dt$ ,**

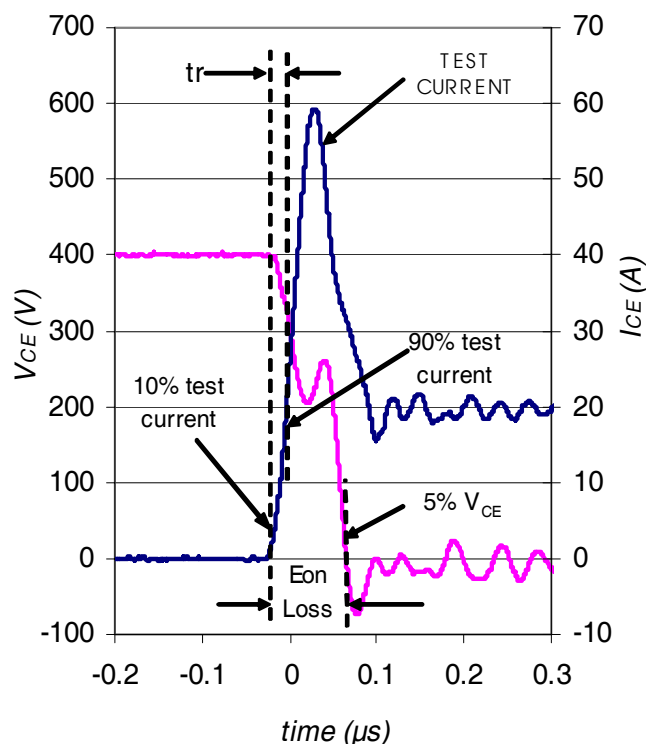

**Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)**

**Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)**



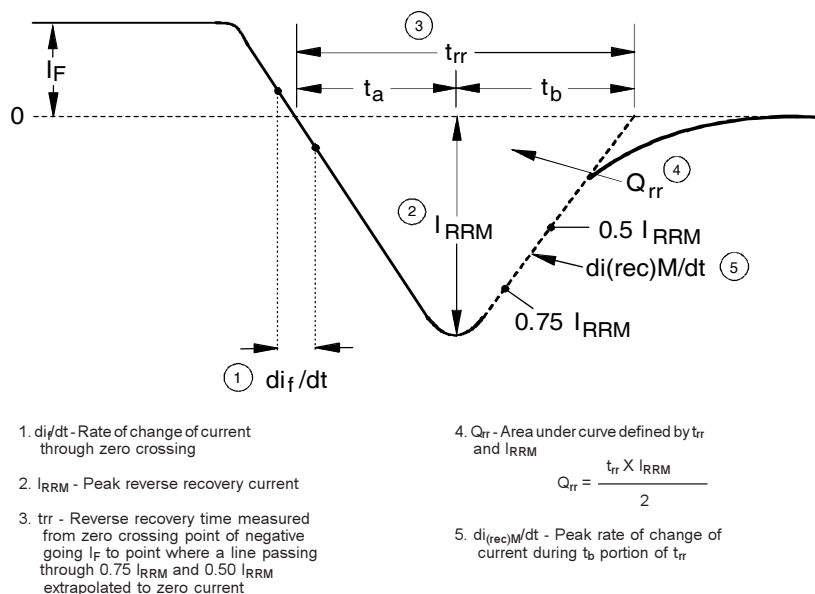

**Fig.C.T.1 - Gate Charge Circuit (turn-off)**

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

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

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

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



**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



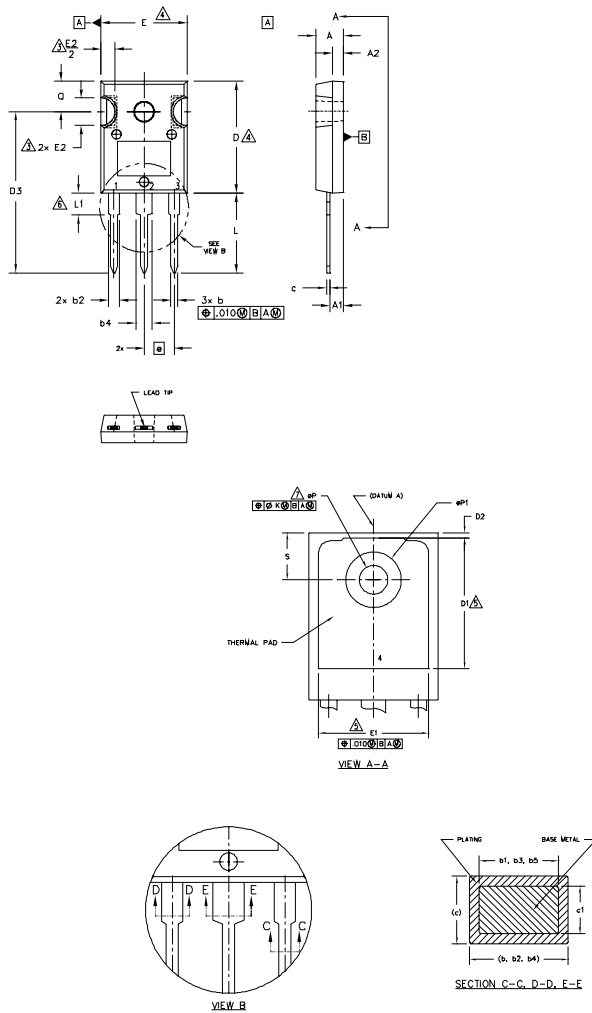
**Fig. WF2** - Typ. Turn-on Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



**Fig. WF3** - Reverse Recovery Waveform and Definitions

# 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	
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	4
D1	.515	-	13.08	-	5
D2	.020	.053	0.51	1.35	
D3	1.122	1.161	28.50	29.50	
E	.602	.625	15.29	15.87	4
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		

**PART NUMBERS AFFECTED:**

- AUIRGP4PH50S
- AUIRGP4066D1/E
- AUIRGP4063D/E
- AUIRGP50860PD1/E
- AUIRGP35860PD/E
- AUIRGP4062D1/E
- AUIRGP65A20D0
- AUIRGP65G20D0
- AUIRGP/F66524D0
- AUIRGP/F76524D0
- AUIRGP/F66548D0
- AUIRGP/F76548D0

**LEAD ASSIGNMENTS**

**HEXFET**

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

**IGBTs, CoPACK**

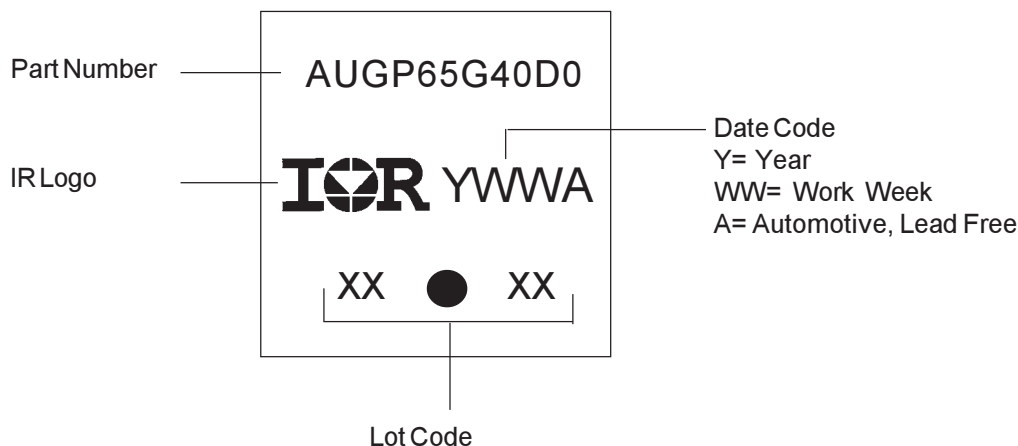
**DIODES**

- 1.- GATE
- 2.- ANODE/OPEN
- 2.- COLLECTOR
- 2.- CATHODE
- 3.- EMITTER
- 3.- ANODE
- 4.- COLLECTOR

**SPECIAL NOTE:**

- a) ADDED D3 FOR SPECIAL REQUIREMENT

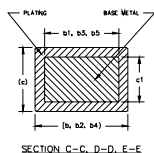
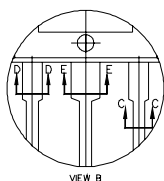
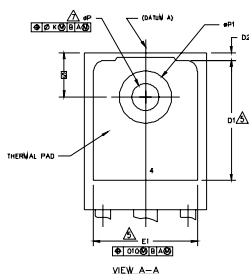
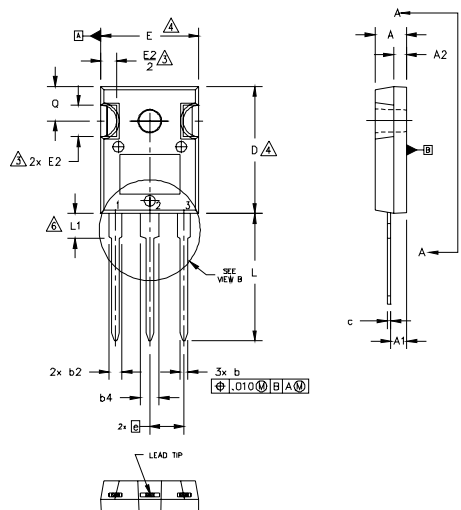
## TO-247AC Part Marking Information



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

# TO-247AD 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-247AD.

SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.183	.209	4.65	5.31	
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	4
D1	.515	-	13.08	-	5
D2	.020	.053	0.51	1.35	
E	.602	.625	15.29	15.87	4
E1	.530	-	13.46	-	
E2	.178	.216	4.52	5.49	
e	.215 BSC		5.46 BSC		
Øk	.010		0.25		
L	.780	.827	19.57	21.00	
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

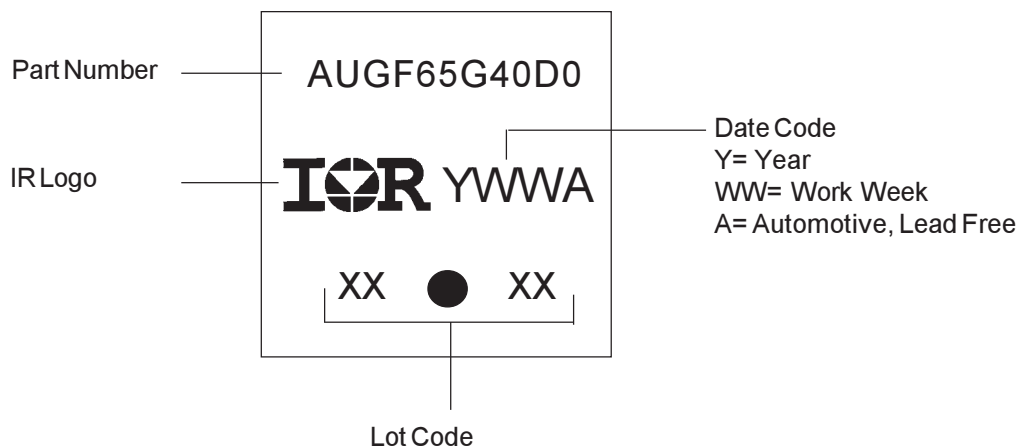
**IGBTs, CoPACK**

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

**DIODES**

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

## TO-247AD Part Marking Information



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

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

<b>Qualification Level</b>		Automotive (per AEC-Q101)	
		Comments: 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
		TO-247AD	N/A
<b>ESD</b>	Machine Model	Class M4 (+/- 400V) <sup>††</sup> AEC-Q101-002	
	Human Body Model	Class H3B (+/- 8000V) <sup>††</sup> AEC-Q101-001	
	Charged Device Model	Class C5 (+/- 1000V) <sup>††</sup> AEC-Q101-005	
<b>RoHS Compliant</b>		Yes	

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

†† Highest passing voltage.

**Notes:**

- ①  $V_{CC} = 80\% (V_{CES})$ ,  $V_{GE} = 20V$ ,  $L = 485\mu H$ ,  $R_G = 4.7\Omega$ , tested in production  $I_{LM} \leq 400A$ .
- 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  $90^{\circ}C$ .
- ⑤  $C_{oes}$  eff. is a fixed capacitance that gives the same charging time as  $C_{oes}$  while  $V_{CE}$  is rising from 0 to  $80\% V_{CES}$ .  $C_{oes}$  eff.(ER) is a fixed capacitance that stores the same energy as  $C_{oes}$  while  $V_{CE}$  is rising from 0 to  $80\% V_{CES}$ .
- ⑥ Calculated continuous current based on maximum allowable junction temperature.
- ⑦ Nominal current limit is suggested for 400V, 200kHz operation. Actual current rating varies with application and is subjected to  $T_J$  and SOA limits.

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**Revision History**

<b>Date</b>	<b>Comments</b>
9/8/2015	• Removed "short circuit rating on page 1 & 2.

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