

WARP2 SERIES IGBT WITH ULTRAFAST SOFT RECOVERY DIODE
Applications

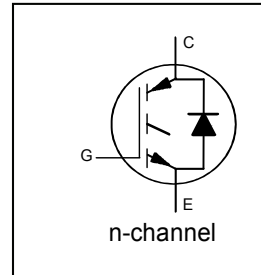
- Automotive HEV and EV
- PFC and ZVS SMPS Circuits

Features

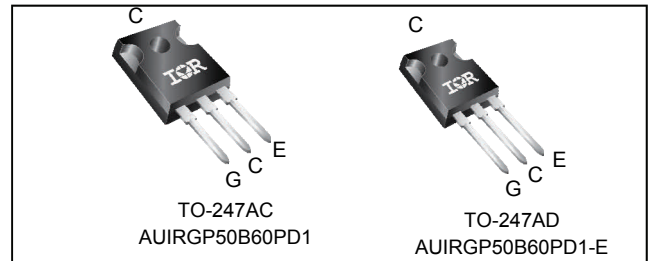
- Low $V_{CE(ON)}$ NPT Technology, Positive Temperature Coefficient
- Lower Parasitic Capacitances
- Minimal Tail Current
- HEXFRED Ultra Fast Soft-Recovery Co-Pack Diode
- Tighter Distribution of Parameters
- Lead-Free, RoHS Compliant
- Automotive Qualified *

Benefits

- Parallel Operation for Higher Current Applications
- Lower Conduction Losses and Switching Losses
- Higher Switching Frequency up to 150kHz



$V_{CES} = 600V$
 $V_{CE(on)} \text{ typ.} = 2.00V$
 @ $V_{GE} = 15V$ $I_C = 33A$
Equivalent MOSFET
Parameters①
 $R_{CE(on)} \text{ typ.} = 61m\Omega$
 I_D (FET equivalent) = 50A



G	C	E
Gate	Collector	Emitter

Base Part Number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
AUIRGP50B60PD1	TO-247AC	Tube	25	AUIRGP50B60PD1
AUIRGP50B60PD1-E	TO-247AD	Tube	25	AUIRGP50B60PD1-E

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	75⑥	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	45	
I_{CM}	Pulse Collector Current (Ref. Fig. C.T.4)	150	
I_{LM}	Clamped Inductive Load Current ②	150	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	40	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	15	V
I_{FSM}	Maximum Repetitive Forward Current ③	60	
V_{GE}	Gate-to-Emitter Voltage	±20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	390	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	156	
T_J	Operating Junction and	-55 to +150	°C
T_{STG}	Storage Temperature Range		
	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)	Thermal Resistance Junction-to-Case (each IGBT) ④	—	—	0.32	°C/W
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case (each Diode) ④	—	—	1.7	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.24	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	40	—	
	Weight	—	6.0 (0.21)	—	g(oz)

* Qualification standards can be found at www.infineon.com

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	—	0.31	—	V/ $^\circ\text{C}$	$V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-125^\circ\text{C})$	
R_G	Internal Gate Resistance	—	1.7	—	Ω	1MHz, Open Collector	4,5,6,8,9
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.00	2.35	V	$I_C = 33A, V_{GE} = 15V$	
		—	2.45	2.85		$I_C = 50A, V_{GE} = 15V$	
		—	2.60	2.95		$I_C = 33A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
		—	3.20	3.60		$I_C = 50A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	4.0	5.0	V	$I_C = 250\mu A$	7,8,9
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-10	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA$	
g_{fe}	Forward Transconductance	—	41	—	S	$V_{CE} = 50V, I_C = 33A, PW = 80\mu s$	
I_{CES}	Collector-to-Emitter Leakage Current	—	5.0	500	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	1.0	—	mA	$V_{GE} = 0V, V_{CE} = 600V, T_J = 125^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.30	1.70	V	$I_F = 15A$	10
		—	1.20	1.60		$I_F = 15A, T_J = 125^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V, V_{CE} = 0V$	

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)	—	205	308	nC	$I_C = 33A$	17
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	70	105		$V_{GE} = 15V$	CT1
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	30	45		$V_{CC} = 400V$	
E_{on}	Turn-On Switching Loss	—	255	305	μJ	$I_C = 33A, V_{CC} = 390V,$ $V_{GE} = +15V,$ $R_G = 3.3\Omega, L = 200\mu H,$ $T_J = 25^\circ\text{C} \text{ ④}$	CT3
E_{off}	Turn-Off Switching Loss	—	375	445			
E_{total}	Total Switching Loss	—	630	750			
$t_{d(on)}$	Turn-On delay time	—	30	40	ns	$I_C = 33A, V_{CC} = 390V,$ $V_{GE} = +15V,$ $R_G = 3.3\Omega, L = 200\mu H,$ $T_J = 125^\circ\text{C} \text{ ④}$	CT3 12,14 WF1,WF2
t_r	Rise time	—	10	15			
$t_{d(off)}$	Turn-Off delay time	—	130	150			
t_f	Fall time	—	11	15	μJ	$I_C = 33A, V_{CC} = 390V,$ $V_{GE} = +15V,$ $R_G = 3.3\Omega, L = 200\mu H,$ $T_J = 125^\circ\text{C} \text{ ④}$	CT3 11,13 WF1,WF2
E_{on}	Turn-On Switching Loss	—	580	700			
E_{off}	Turn-Off Switching Loss	—	480	550			
E_{total}	Total Switching Loss	—	1060	1250	ns	$I_C = 33A, V_{CC} = 390V,$ $V_{GE} = +15V,$ $R_G = 3.3\Omega, L = 200\mu H,$ $T_J = 125^\circ\text{C} \text{ ④}$	CT3 12,14 WF1,WF2
$t_{d(on)}$	Turn-On delay time	—	26	35			
t_r	Rise time	—	13	20			
$t_{d(off)}$	Turn-Off delay time	—	146	165	pF	$V_{GE} = 0V$ $V_{CC} = 30V$ $f = 1.0MHz$	16
t_f	Fall time	—	15	20			
C_{ies}	Input Capacitance	—	3648	—			
C_{oes}	Output Capacitance	—	322	—	pF	$V_{GE} = 0V, V_{CE} = 0V \text{ to } 480V$	15
C_{res}	Reverse Transfer Capacitance	—	56	—			
$C_{oes \text{ eff.}}$	Effective Output Capacitance (Time Related) ⑤	—	215	—			
$C_{oes \text{ eff. (ER)}}$	Effective Output Capacitance (Energy Related) ⑥	—	163	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 150A$ $V_{CC} = 480V, V_p = 600V$ $R_g = 22\Omega, V_{GE} = +15V \text{ to } 0V$	3 CT2
t_{rr}	Diode Reverse Recovery Time	—	42	60	ns	$T_J = 25^\circ\text{C}$	19
		—	74	120		$T_J = 125^\circ\text{C}$	
Q_{rr}	Diode Reverse Recovery Charge	—	80	180	nC	$T_J = 25^\circ\text{C}$	21
		—	220	600		$T_J = 125^\circ\text{C}$	
I_{rr}	Peak Reverse Recovery Current	—	4.0	6.0	A	$T_J = 25^\circ\text{C}$	19,20,21,22 CT5
		—	6.5	10		$T_J = 125^\circ\text{C}$	

Notes:

- $R_{CE(on)}$ typ. = equivalent on-resistance = $V_{CE(on)}$ typ. / I_C , where $V_{CE(on)}$ typ. = 2.00V and $I_C = 33A$. I_D (FET Equivalent) is the equivalent MOSFET I_D rating @ 25°C for applications up to 150kHz. These are provided for comparison purposes (only) with equivalent MOSFET solutions.
- $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 28\mu H, R_G = 22\Omega$
- Pulse width limited by max. junction temperature.
- Energy losses include "tail" and diode reverse recovery. Data generated with use of Diode 30ETH06.
- $C_{oes \text{ eff.}}$ is a fixed capacitance that gives the same charging time as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES} . $C_{oes \text{ eff. (ER)}}$ is a fixed capacitance that stores the same energy as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES} .
- Calculated continuous current based on maximum allowable junction temperature. Package current limit is 60A. Note that current limitations arising from heating of the device leads may occur with some lead mounting arrangements.

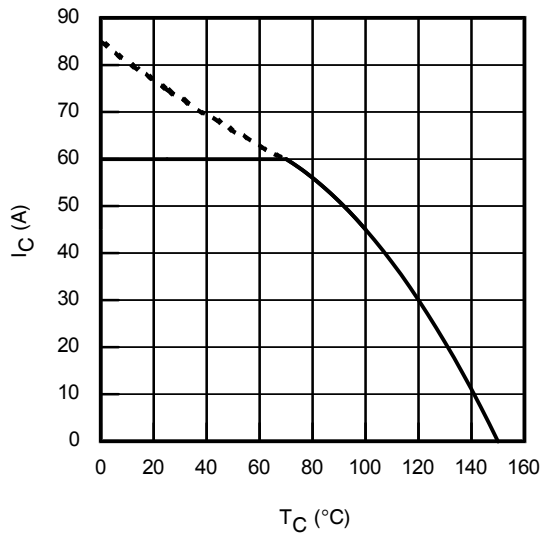


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

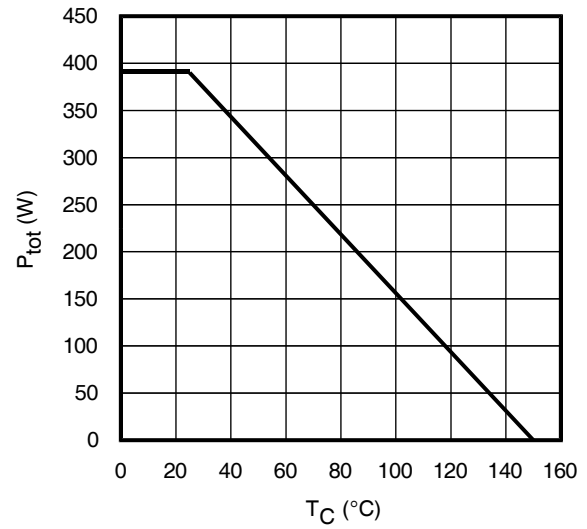


Fig. 2 - Power Dissipation vs. Case Temperature

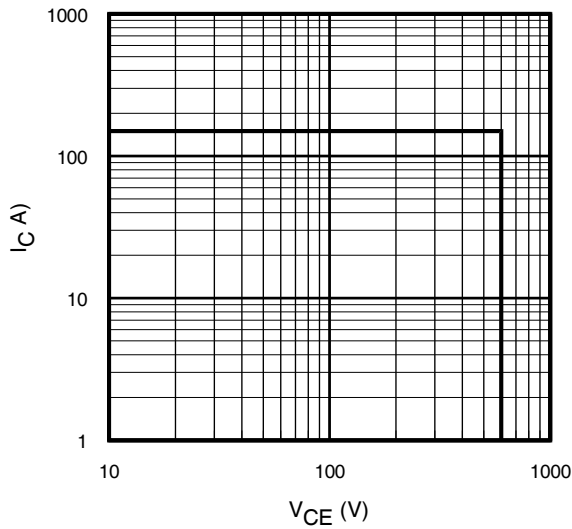


Fig. 3 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

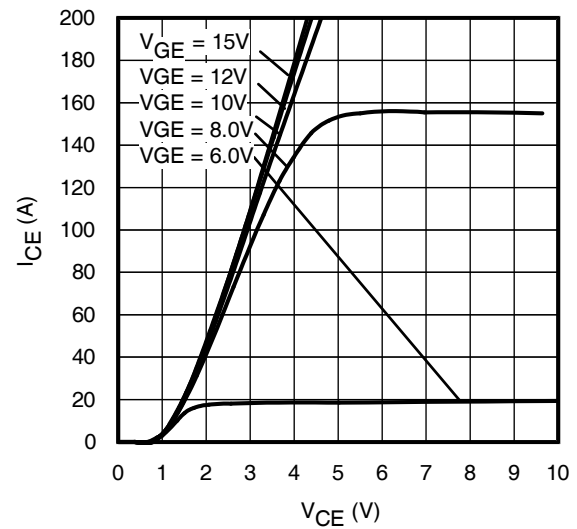


Fig. 4 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

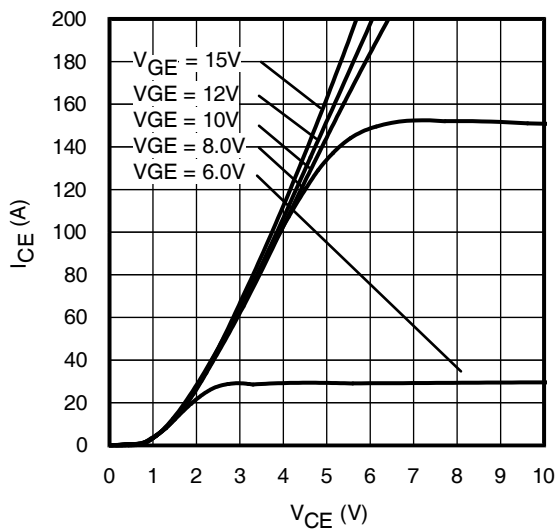


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

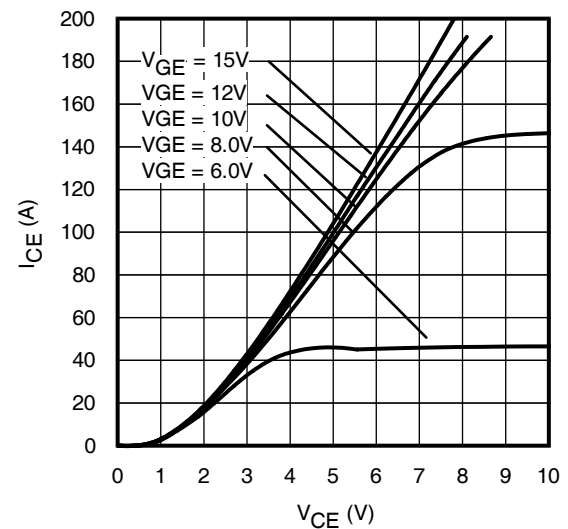


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 125^\circ\text{C}$; $t_p = 80\mu\text{s}$

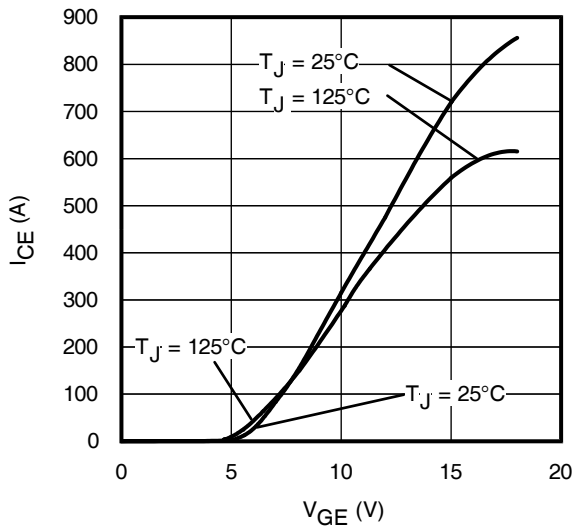


Fig. 7 - Typ. Transfer Characteristics
 $V_{CE} = 50V$; $t_p = 10\mu s$

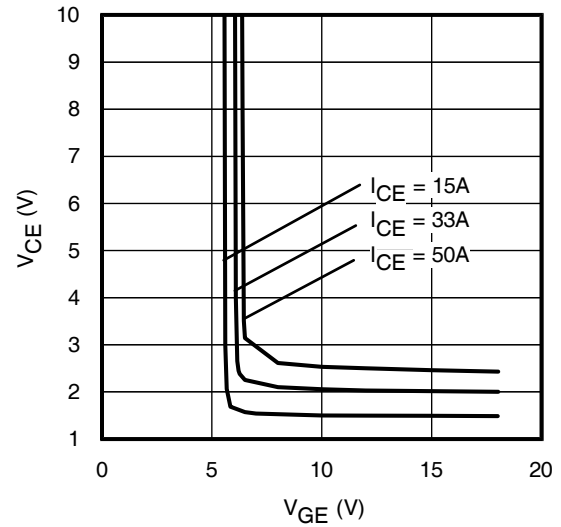


Fig. 8 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ C$

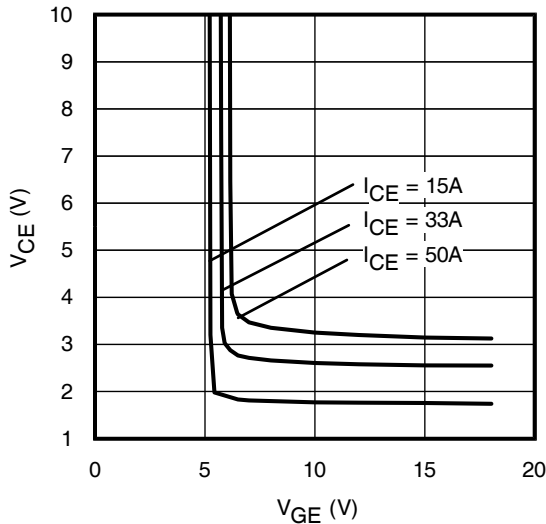


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = 125^\circ C$

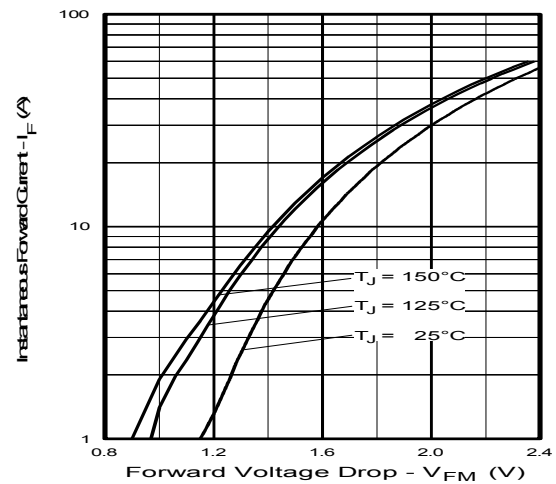


Fig. 10 - Typ. Diode Forward Characteristics
 $t_p = 80\mu s$

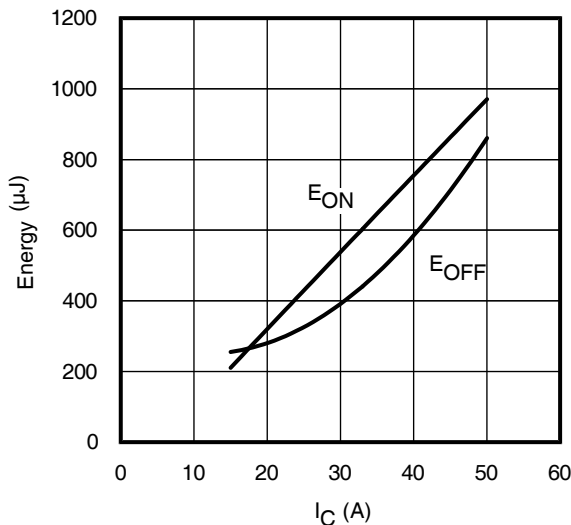


Fig. 11 - Typ. Energy Loss vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 3.3\Omega$; $V_{GE} = 15V$.
 Diode clamp used: 30ETH06 (See C.T.3)

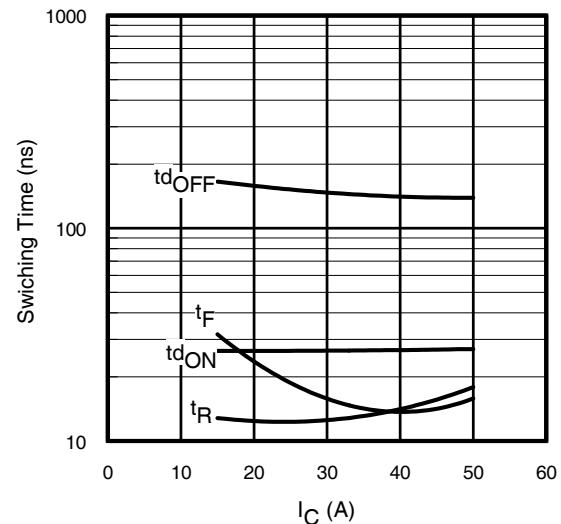


Fig. 12 - Typ. Switching Time vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 3.3\Omega$; $V_{GE} = 15V$.
 Diode clamp used: 30ETH06 (See C.T.3)

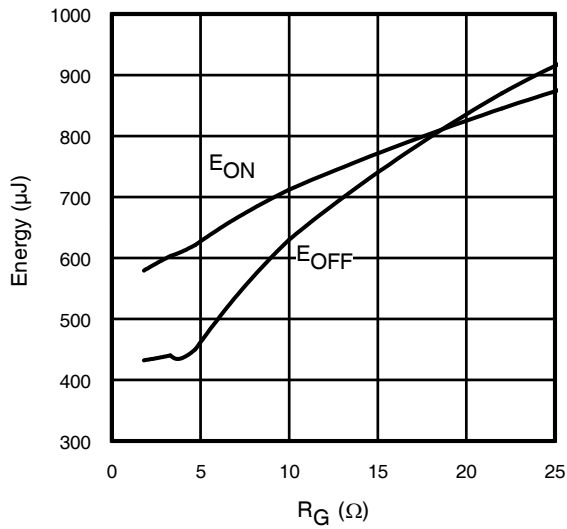


Fig. 13 - Typ. Energy Loss vs. R_G

$T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 33\text{A}$; $V_{GE} = 15\text{V}$.
Diode clamp used: 30ETH06 (See C.T.3)

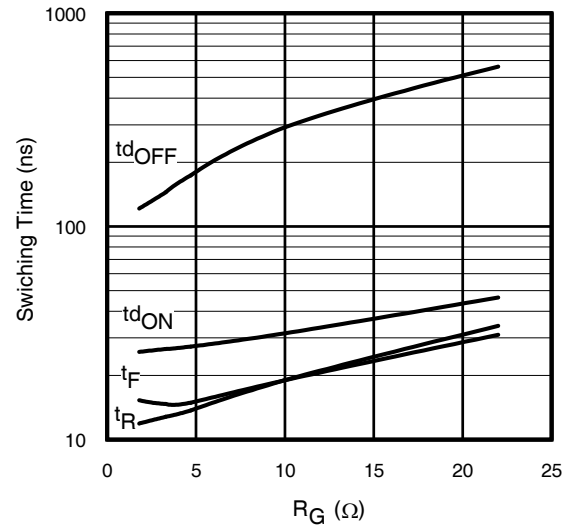


Fig. 14 - Typ. Switching Time vs. R_G

$T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 33\text{A}$; $V_{GE} = 15\text{V}$.
Diode clamp used: 30ETH06 (See C.T.3)

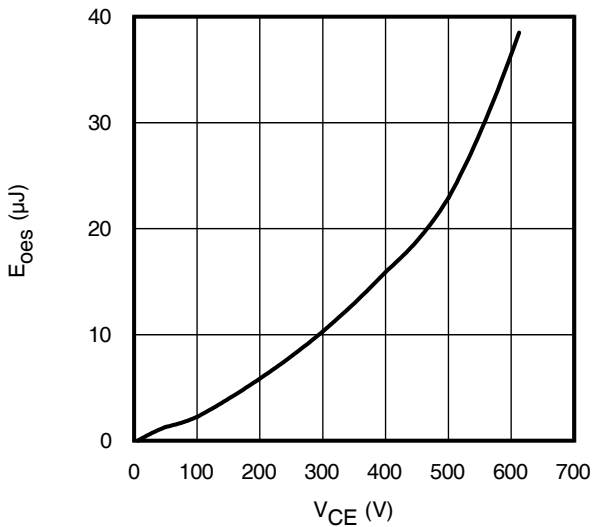


Fig. 15 - Typ. Output Capacitance
Stored Energy vs. V_{CE}

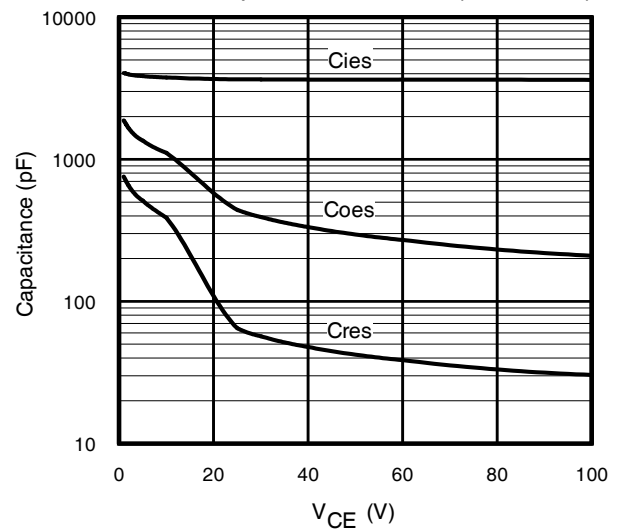


Fig. 16 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

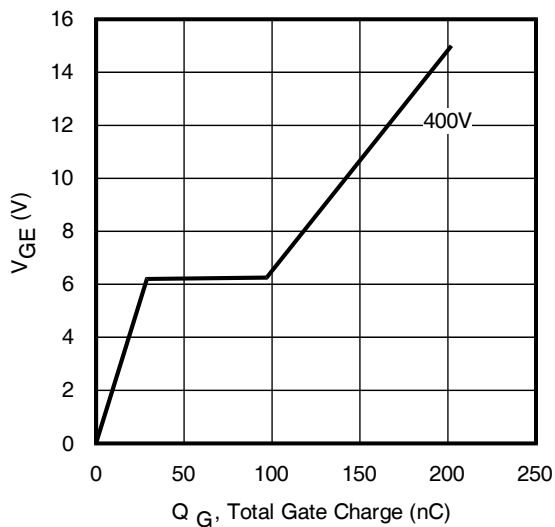


Fig. 17 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 33\text{A}$

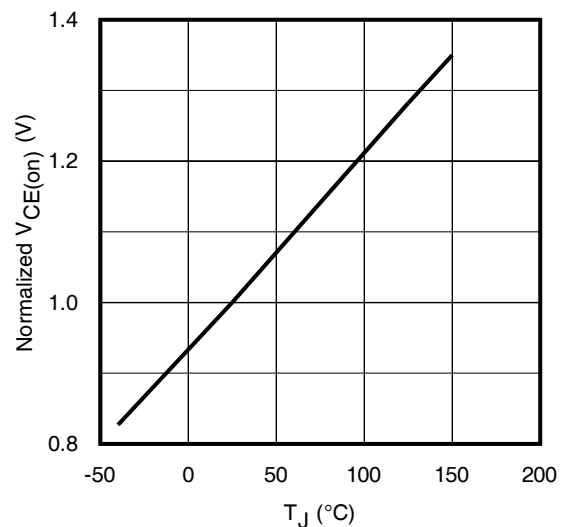


Fig. 18 Normalized Typ. $V_{CE(on)}$
vs. Junction Temperature
 $I_C = 33\text{A}$, $V_{GE} = 15\text{V}$

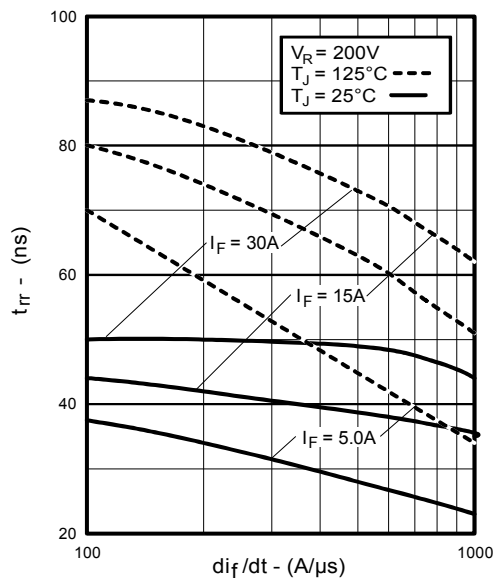


Fig. 19 - Typical Reverse Recovery vs. di_f/dt

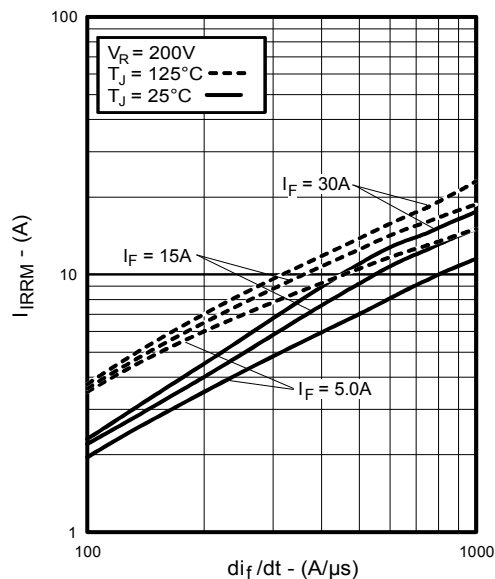


Fig. 20 - Typical Recovery Current vs. di_f/dt

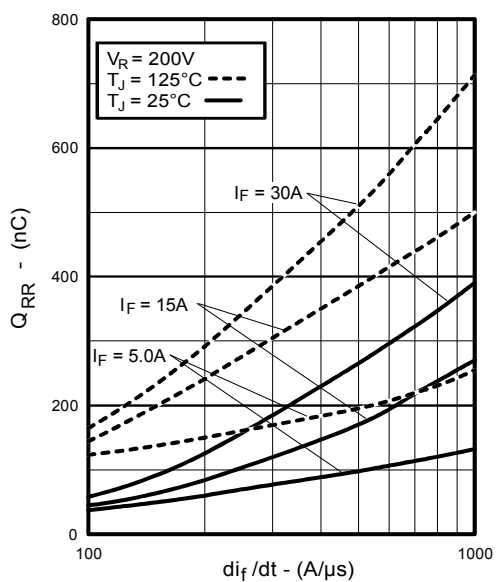


Fig. 21 - Typical Stored Charge vs. di_f/dt

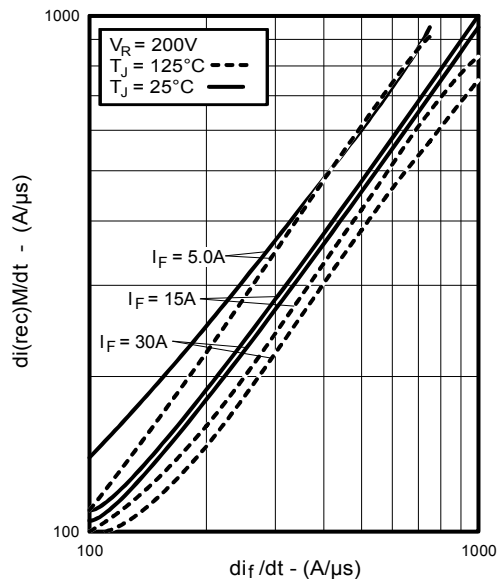


Fig. 22 - Typical $di_{(rec)}M/dt$ vs. di_f/dt

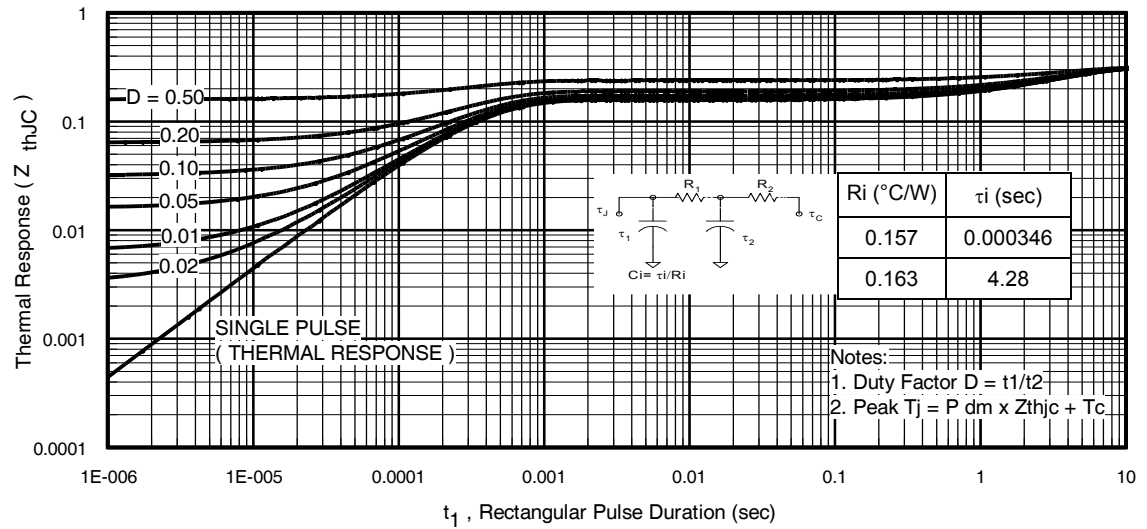


Fig 23. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

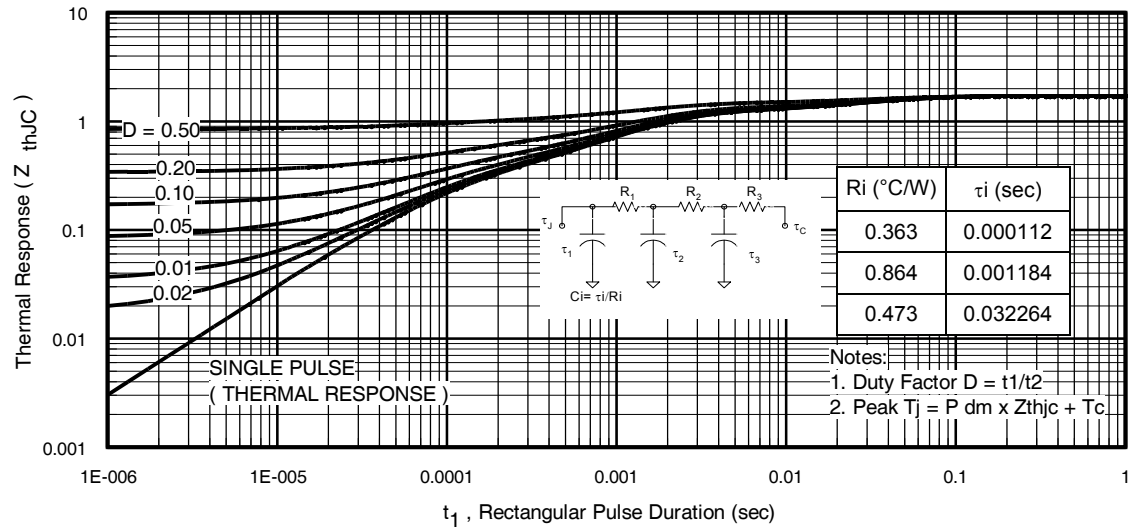
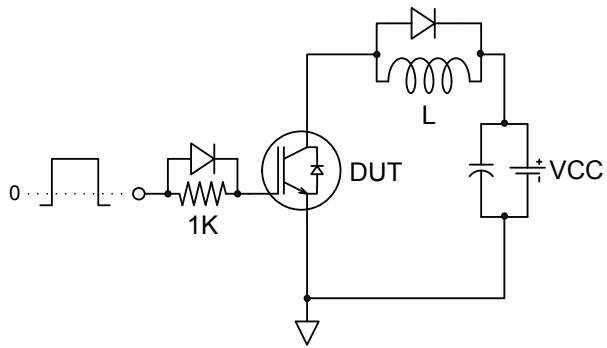
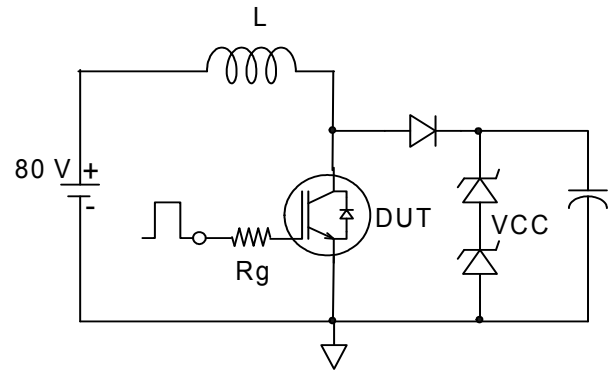
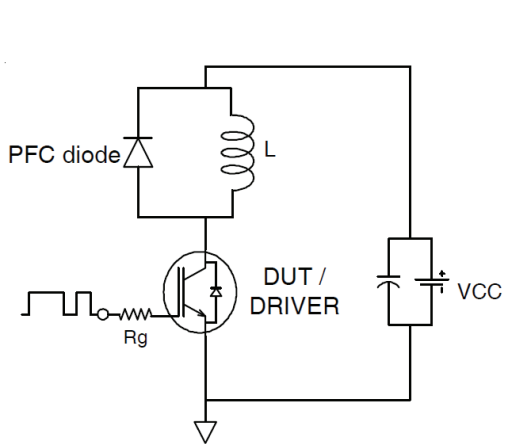
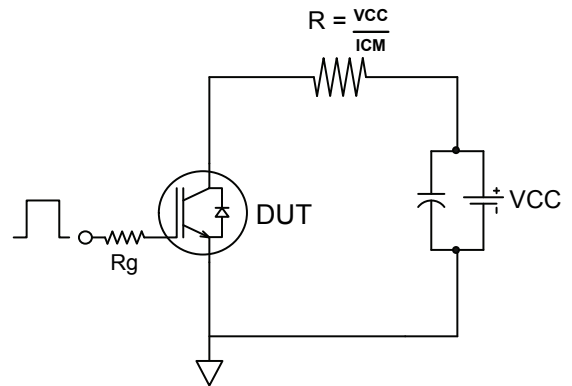
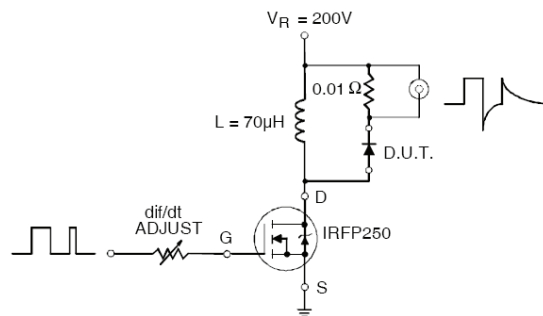


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)


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 - Resistive Load Circuit

REVERSE RECOVERY CIRCUIT


Fig.C.T.5 - Reverse Recovery Parameter Test Circuit

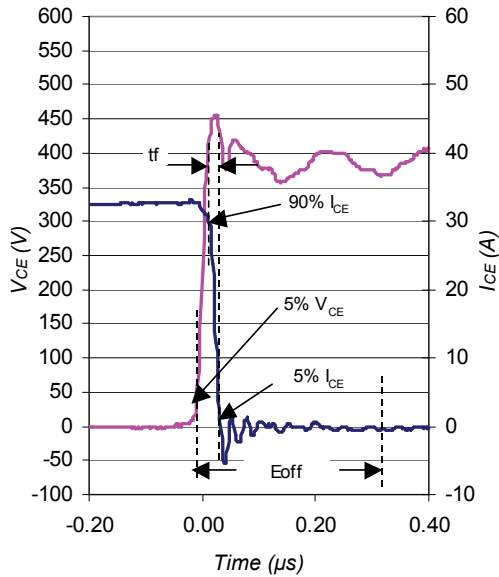


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.4

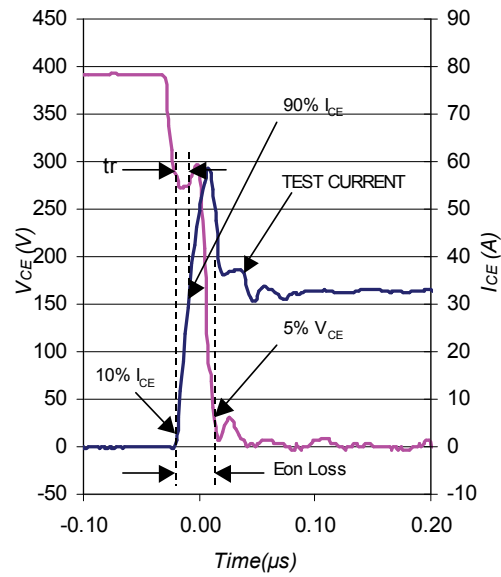


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.4

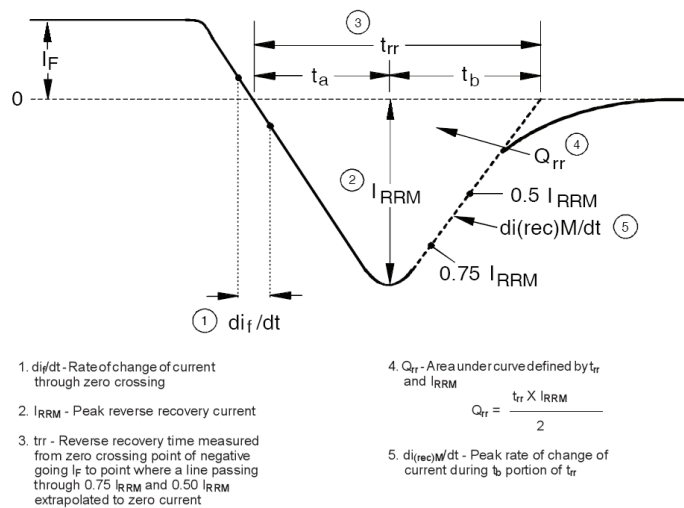
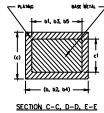
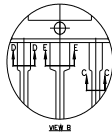
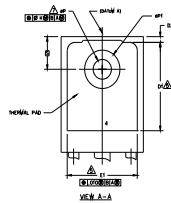
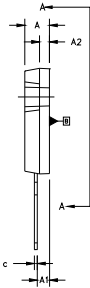
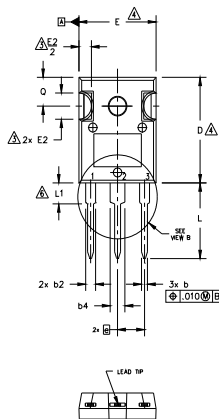


Fig. WF3 - Reverse Recovery Waveform and Definitions

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	
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		

LEAD ASSIGNMENTS

HEXFET

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

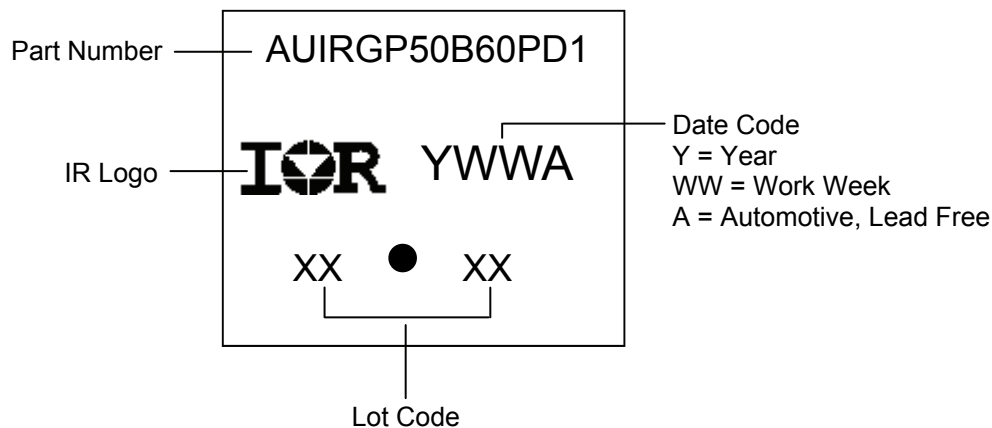
IGBTs, CoPACK

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

DIODES

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

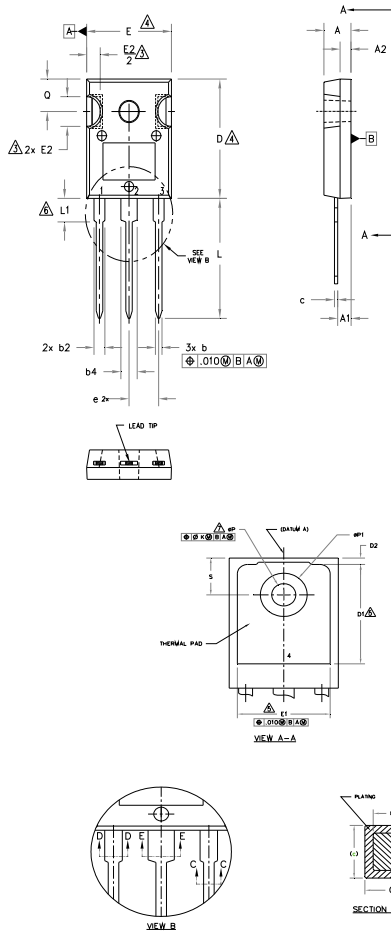
TO-247AC Part Marking Information



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

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	.190	.203	4.83	5.13		
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	4	
D	.776	.815	19.71	20.70		
D1	.515	—	13.08	—		5
D2	.020	.053	0.51	1.35		4
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	.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

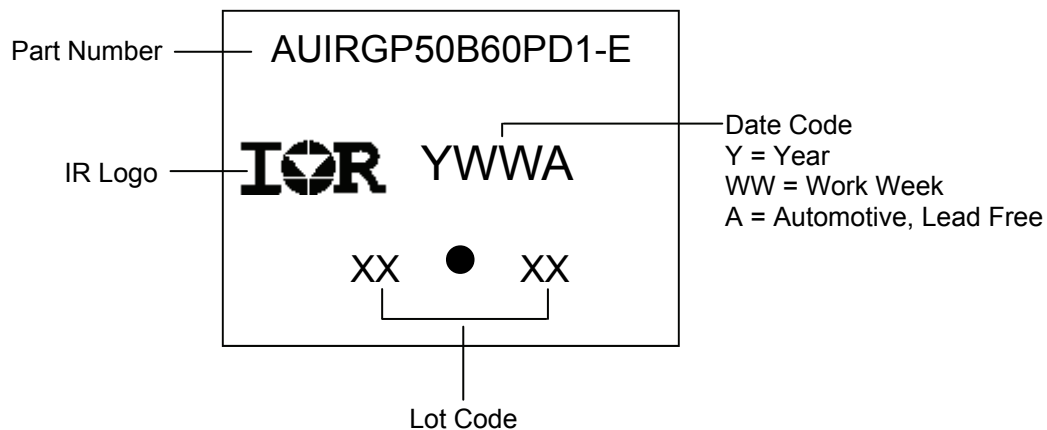
IGBTs, CoPACK

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

DIODES

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

TO-247AD Part Marking Information



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

Revision History

Date	Comments
8/29/2017	• Updated datasheet with corporate template • Corrected part marking on pages 10,11

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