

WARP2 SERIES IGBT WITH ULTRAFAST SOFT RECOVERY DIODE
Features

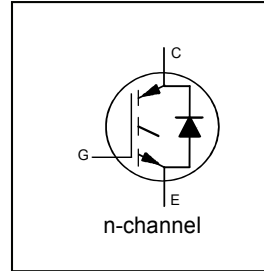
- NPT Technology, Positive Temperature Coefficient
- Lower $V_{CE(SAT)}$
- Lower Parasitic Capacitances
- Minimal Tail Current
- HEXFRED Ultra Fast Soft-Recovery Co-Pack Diode
- Tighter Distribution of Parameters
- Higher Reliability
- Lead-Free, RoHS Compliant
- Automotive Qualified *

Applications

- PFC and ZVS SMPS Circuits
- DC/DC Converter Charger

Benefits

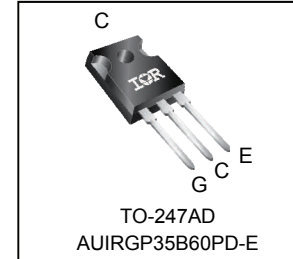
- Parallel Operation for Higher Current Applications
- Lower Conduction Losses and Switching Losses
- Higher Switching Frequency up to 150kHz



$V_{CES} = 600V$
 $V_{CE(on)} \text{ typ.} = 1.85V$
 @ $V_{GE} = 15V$ $I_C = 22A$

Equivalent MOSFET Parameters^①

$R_{CE(on)} \text{ typ.} = 84m\Omega$
 I_D (FET equivalent) = 35A



G	C	E
Gate	Collector	Emitter

Base Part Number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
AUIRGP35B60PD-E	TO-247AD	Tube	25	AUIRGP35B60PD-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	60	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	34	
I_{CM}	Pulse Collector Current (Ref. Fig. C. T.4)	120	
I_{LM}	Clamped Inductive Load Current ^②	120	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	40	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	15	
I_{FSM}	Maximum Repetitive Forward Current	60	
V_{GE}	Gate-to-Emitter Voltage	±20	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	308	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	123	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°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)	Thermal Resistance Junction-to-Case (each IGBT)	—	—	0.41	°C/W
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case (each Diode)	—	—	1.7	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.50	—	
$R_{\theta JA}$	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°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 = 500μA	
ΔV _{(BR)CES} /ΔT _J	Temperature Coeff. of Breakdown Voltage	—	0.78	—	V/°C	V _{GE} = 0V, I _C = 1mA (25°C-125°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	—	1.85	2.15	V	I _C = 22A, V _{GE} = 15V	
		—	2.25	2.55		I _C = 35A, V _{GE} = 15V	
		—	2.37	2.80		I _C = 22A, V _{GE} = 15V, T _J = 125°C	
		—	3.00	3.45		I _C = 35A, V _{GE} = 15V, T _J = 125°C	
V _{GE(th)}	Gate Threshold Voltage	3.0	4.0	5.0	V	I _C = 250μA	7,8,9
ΔV _{GE(th)} /ΔT _J	Threshold Voltage temp. coefficient	—	-10	—	mV/°C	V _{CE} = V _{GE} , I _C = 1.0mA	
g _{fe}	Forward Transconductance	—	36	—	S	V _{CE} = 50V, I _C = 22A, PW = 80μs	
I _{CES}	Collector-to-Emitter Leakage Current	—	3.0	375	μA	V _{GE} = 0V, V _{CE} = 600V	
		—	0.35	—	mA	V _{GE} = 0V, V _{CE} = 600V, T _J = 125°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°C	
I _{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V _{GE} = ±20V, V _{CE} = 0V	

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref. Fig.
Q _g	Total Gate Charge (turn-on)	—	160	240	nC	I _C = 22A	17
Q _{ge}	Gate-to-Emitter Charge (turn-on)	—	55	83		V _{GE} = 15V	CT1
Q _{gc}	Gate-to-Collector Charge (turn-on)	—	21	32		V _{CC} = 400V	
E _{on}	Turn-On Switching Loss	—	220	270	μJ	I _C = 22A, V _{CC} = 390V, V _{GE} = +15V, R _G = 3.3Ω, L = 200μH, T _J = 25°C ④	CT3
E _{off}	Turn-Off Switching Loss	—	215	265			
E _{total}	Total Switching Loss	—	435	535	μJ	I _C = 22A, V _{CC} = 390V, V _{GE} = +15V, R _G = 3.3Ω, L = 200μH, T _J = 125°C ④	CT3 11,13 WF1,WF2
t _{d(on)}	Turn-On delay time	—	26	34			
t _r	Rise time	—	6.0	8.0	ns	I _C = 22A, V _{CC} = 390V, V _{GE} = +15V, R _G = 3.3Ω, L = 200μH, T _J = 125°C ④	CT3 12,14 WF1,WF2
t _{d(off)}	Turn-Off delay time	—	110	122			
t _f	Fall time	—	8.0	10	μJ	I _C = 22A, V _{CC} = 390V, V _{GE} = +15V, R _G = 3.3Ω, L = 200μH, T _J = 125°C ④	CT3 11,13 WF1,WF2
E _{on}	Turn-On Switching Loss	—	410	465			
E _{off}	Turn-Off Switching Loss	—	330	405	ns	I _C = 22A, V _{CC} = 390V, V _{GE} = +15V, R _G = 3.3Ω, L = 200μH, T _J = 125°C ④	CT3 12,14 WF1,WF2
E _{total}	Total Switching Loss	—	740	870			
t _{d(on)}	Turn-On delay time	—	26	34	pF	V _{GE} = 0V V _{CC} = 30V f = 1.0Mhz	16
t _r	Rise time	—	8.0	11			
t _{d(off)}	Turn-Off delay time	—	130	150	pF	V _{GE} = 0V, V _{CE} = 0V to 480V	15
t _f	Fall time	—	12	16			
C _{ies}	Input Capacitance	—	3715	—	A	T _J = 150°C, I _C = 120A V _{CC} = 480V, V _p ≤ 600V R _g = 22Ω, V _{GE} = +15V to 0V	3 CT2
C _{oes}	Output Capacitance	—	265	—			
C _{res}	Reverse Transfer Capacitance	—	47	—			
C _{oes eff.}	Effective Output Capacitance (Time Related)	—	135	—			
C _{oes eff. (ER)}	Effective Output Capacitance (Energy Related)	—	179	—	ns	T _J = 25°C T _J = 125°C	19
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE					
t _{rr}	Diode Reverse Recovery Time	—	42	60	nA	I _F = 15A, V _R = 200V, di/dt = 200A/μs	21
Q _{rr}	Diode Reverse Recovery Charge	—	80	180			
I _{rr}	Peak Reverse Recovery Current	—	4.0	6.0	A	T _J = 25°C T _J = 125°C	19,20,21,22 CT5
		—	6.5	10			

Notes:

- R_{CE(on)} typ. = equivalent on-resistance = V_{CE(on)} typ. / I_C, where V_{CE(on)} typ. = 1.85V and I_C = 22A. 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 μH, R_G = 22 Ω
- Pulse width limited by max. junction temperature.
- Energy losses include "tail" and diode reverse recovery, Data generated with use of Diode 30ETH06.
- 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}.

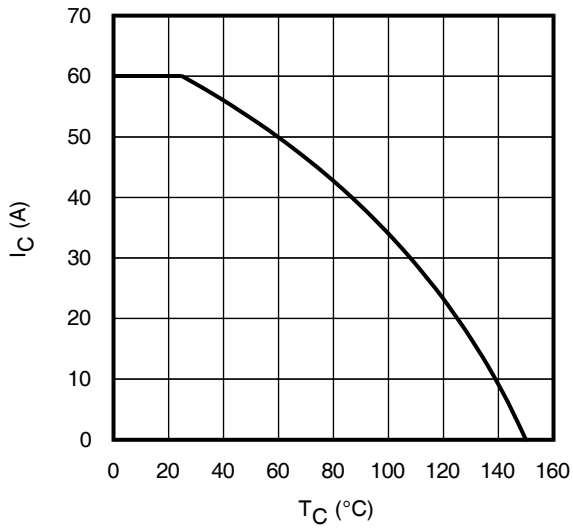


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

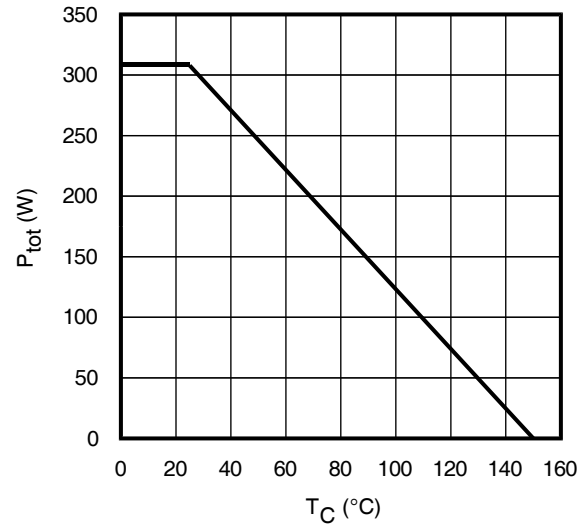


Fig. 2 - Power Dissipation vs. Case Temperature

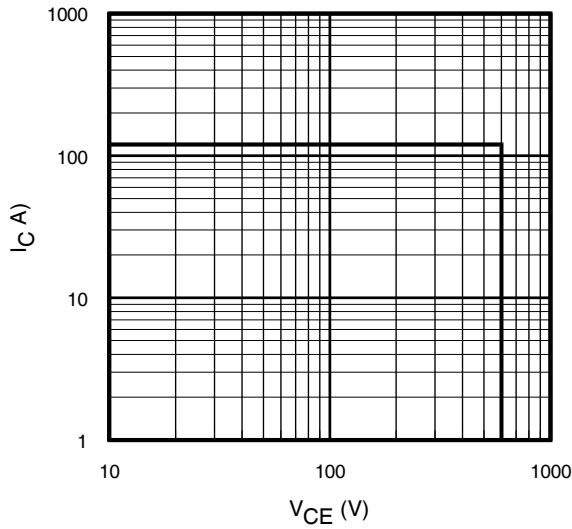


Fig. 3 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

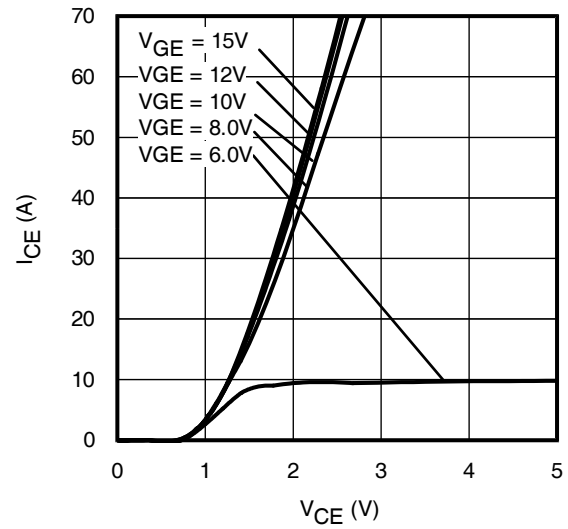


Fig. 4 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

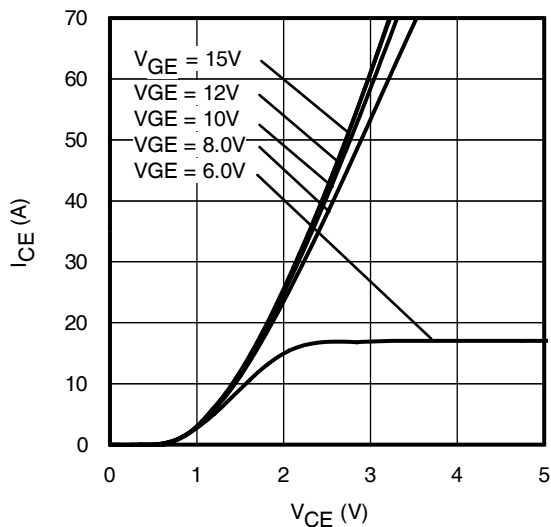


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

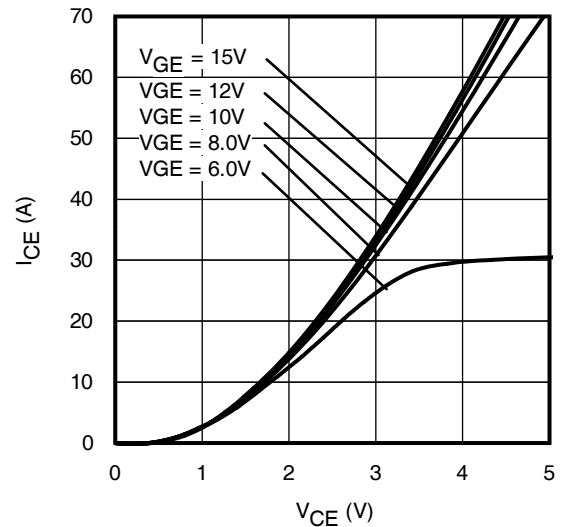


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 125^\circ\text{C}$; $t_p = 80\mu\text{s}$

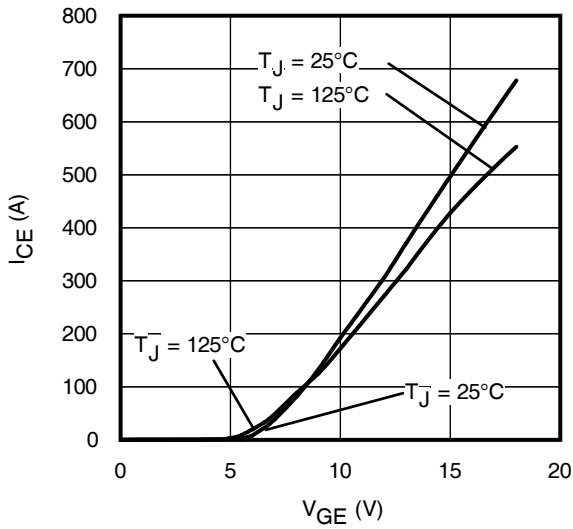


Fig. 7 - Typ. Transfer Characteristics
 $V_{CE} = 50V$; $t_p = 10\mu s$

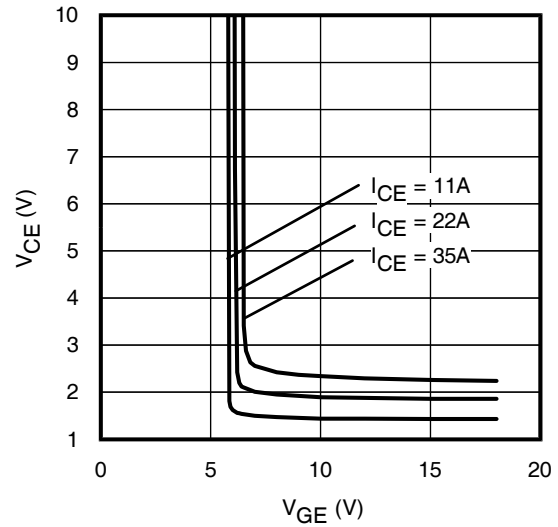


Fig. 8 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ C$

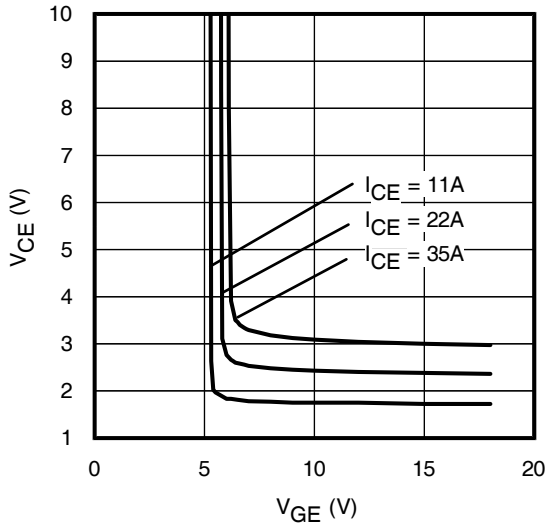


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = 125^\circ C$

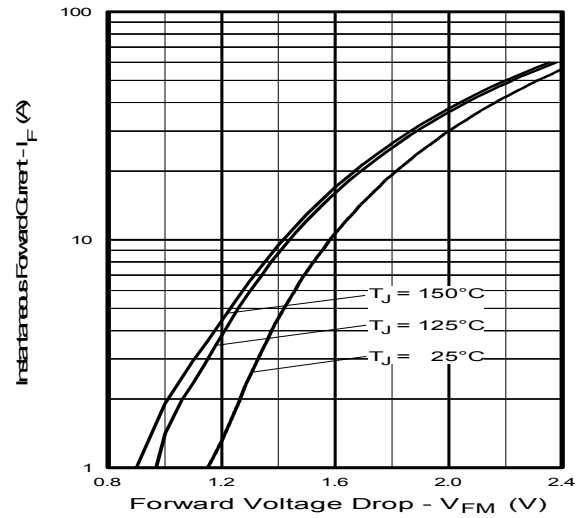


Fig. 10 - Typ. Diode Forward Characteristics
 $t_p = 80\mu s$

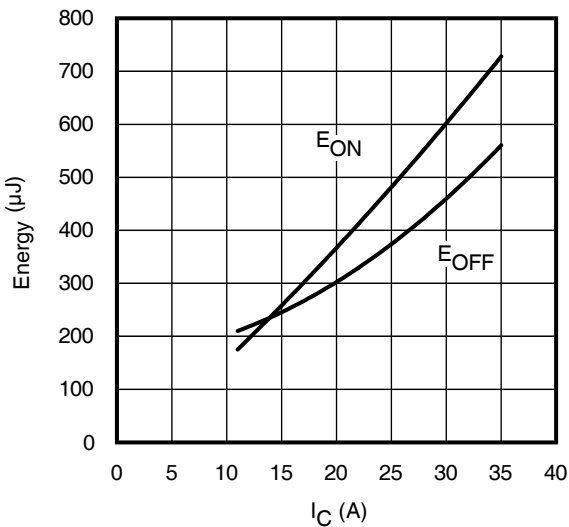


Fig. 11 - Typ. Energy Loss vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$, $R_G = 3.3\Omega$; $V_{GE} = 15V$.
 Diode clamp used: 30ETH06 (See C.T.3)

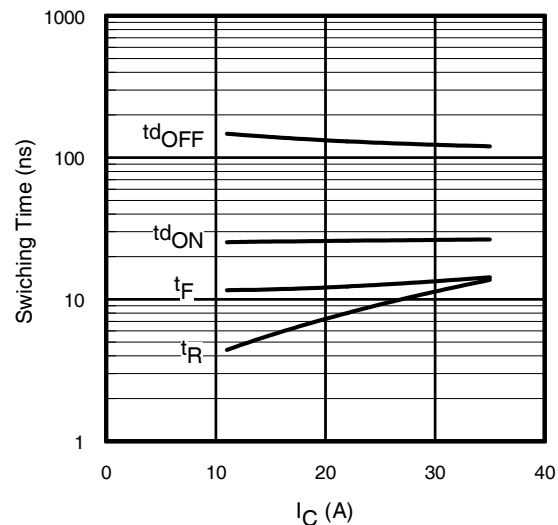
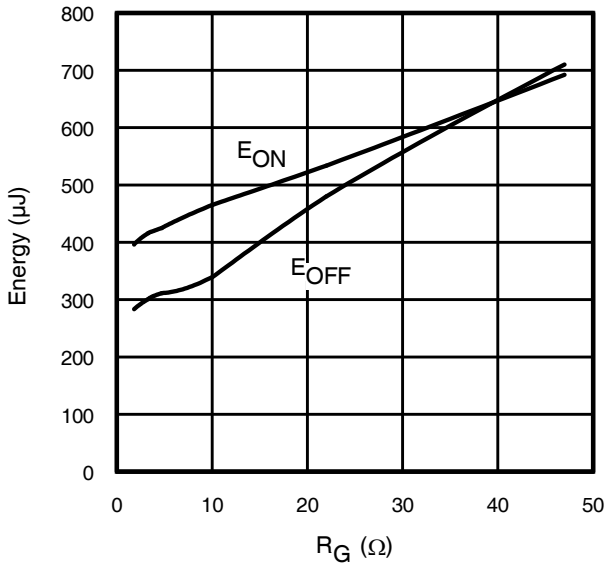
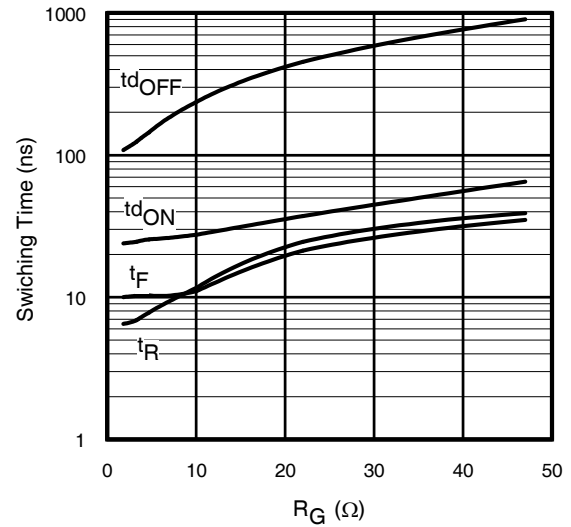


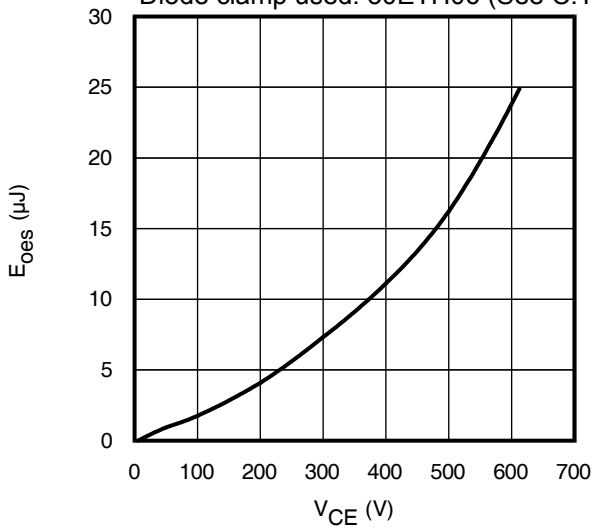
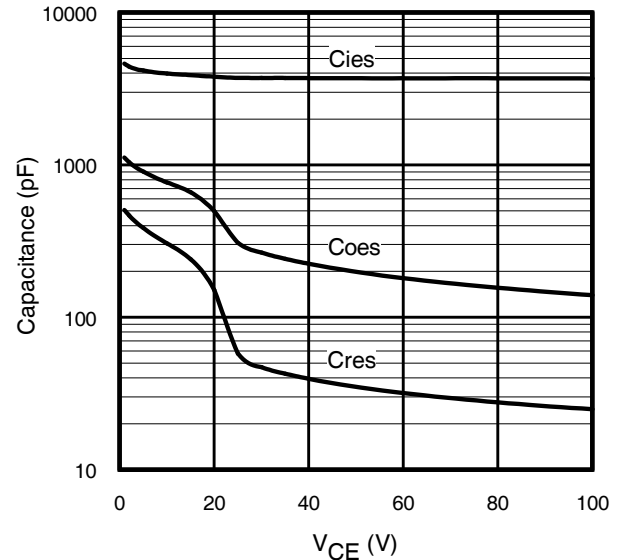
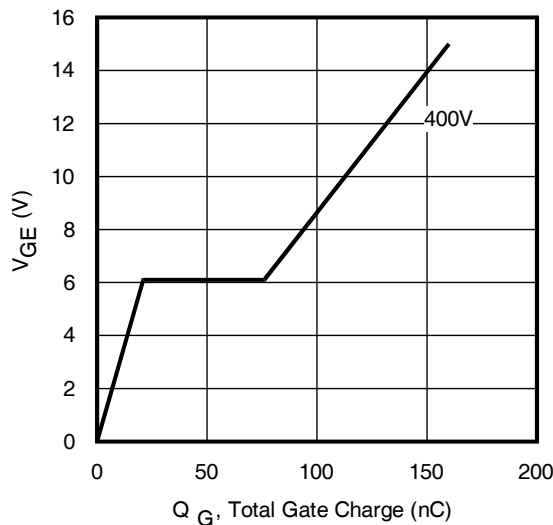
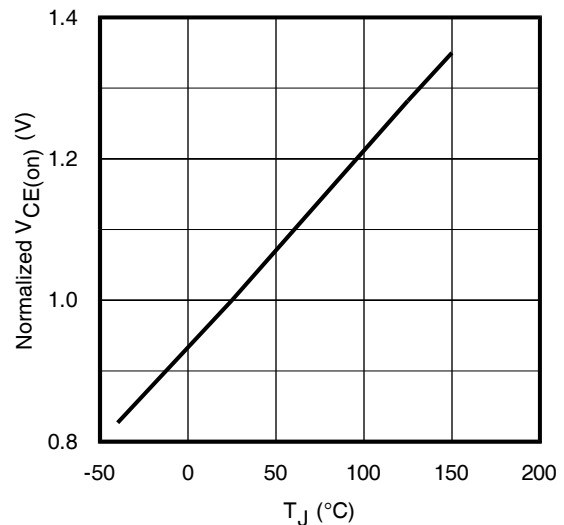
Fig. 12 - Typ. Switching Time vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$, $R_G = 3.3\Omega$; $V_{GE} = 15V$.
 Diode clamp used: 30ETH06 (See C.T.3)

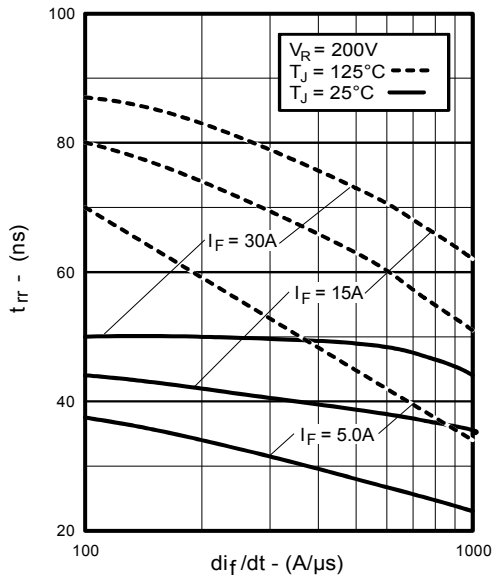
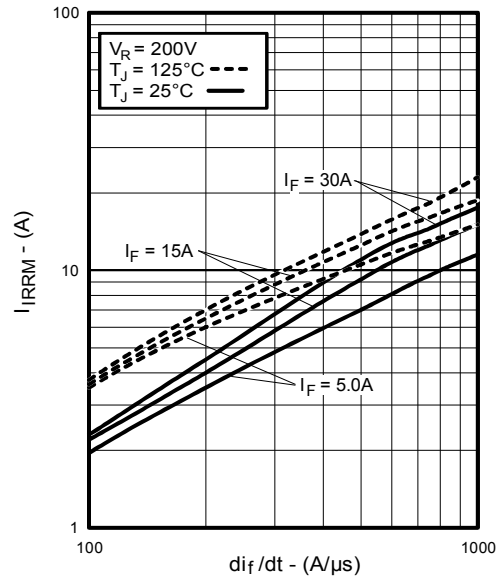
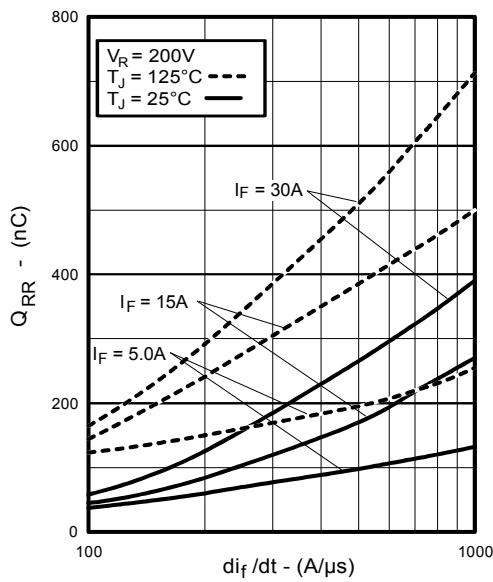
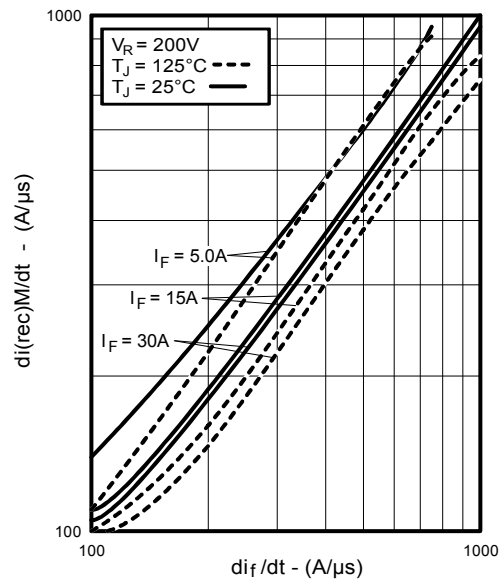

Fig. 13 - Typ. Energy Loss vs. R_G

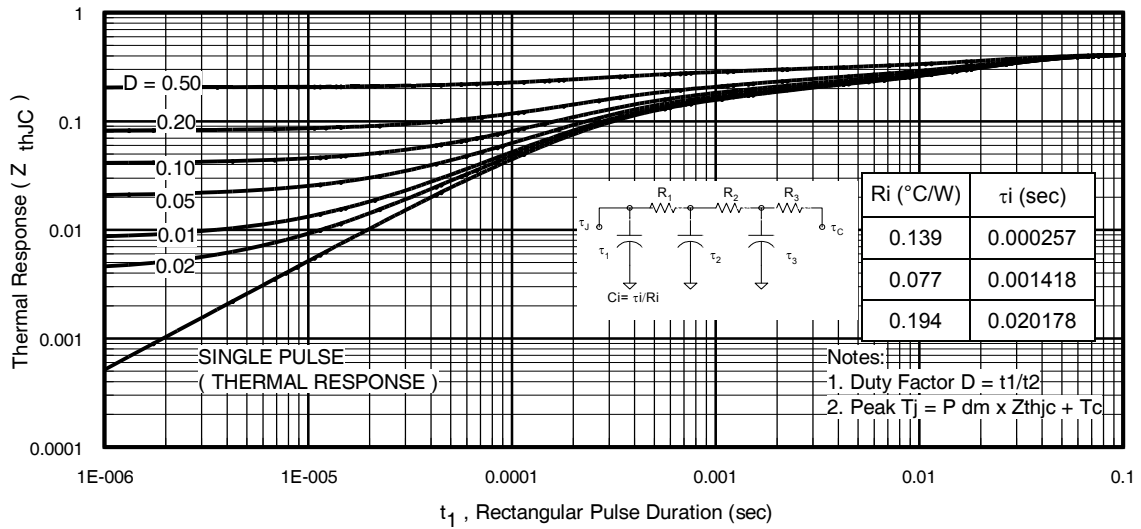
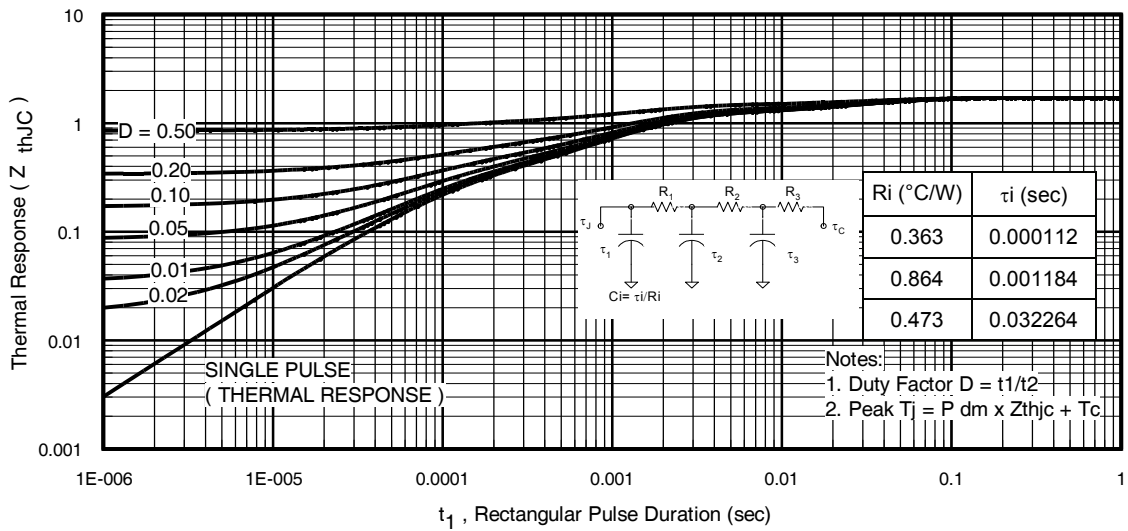
$T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 22\text{A}$; $V_{GE} = 15\text{V}$
Diode clamp used: 30ETH06 (See C.T.3)

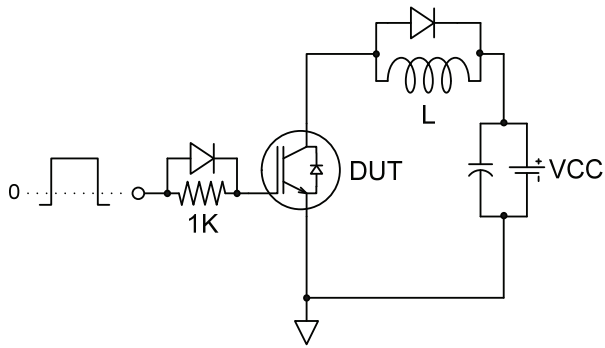
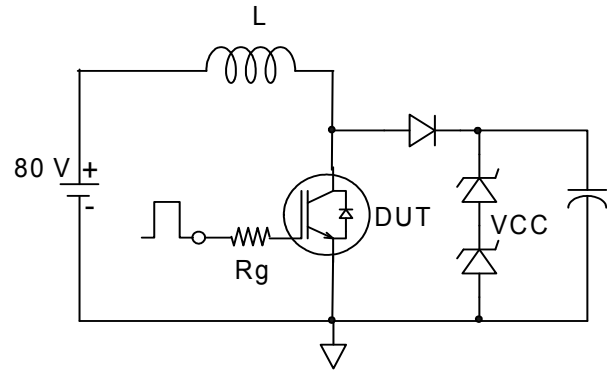
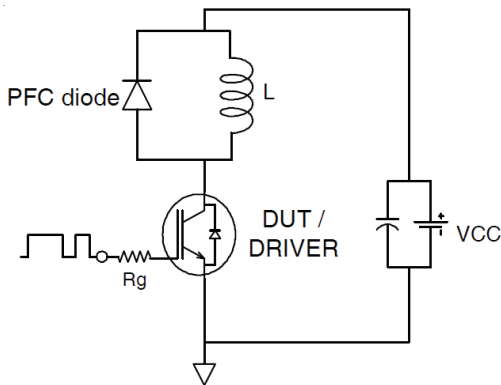
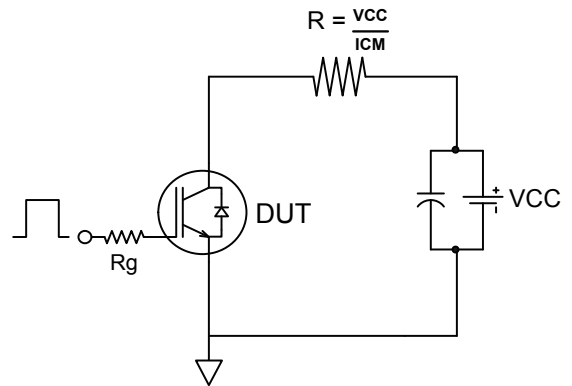
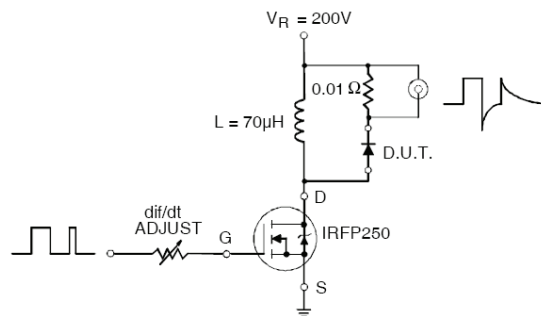

Fig. 14 - Typ. Switching Time vs. R_G

$T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 22\text{A}$; $V_{GE} = 15\text{V}$
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}
 $I_{CE} = 22\text{A}$

Fig. 18 Normalized Typ. $V_{CE(on)}$ vs. Junction Temperature
 $I_C = 22\text{A}$, $V_{GE} = 15\text{V}$


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

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

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

Fig. 22 - Typical $di(\text{rec})M/dt$ vs. di/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 - Switching Loss Circuit

Fig.C.T.4 - Resistive Load Circuit
REVERSE RECOVERY CIRCUIT

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

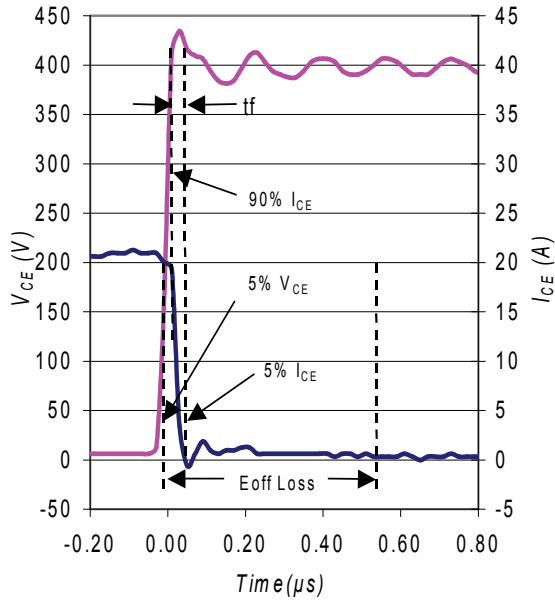


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

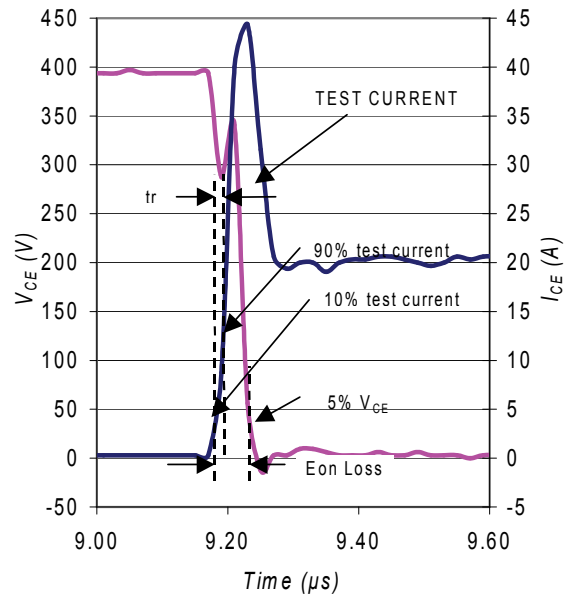


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

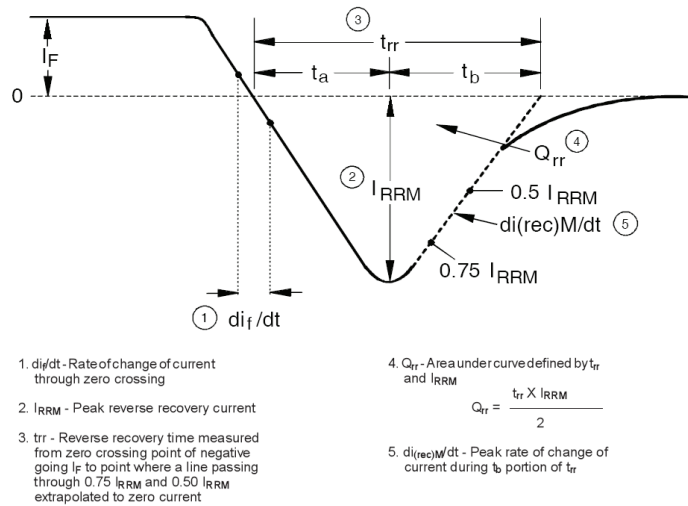
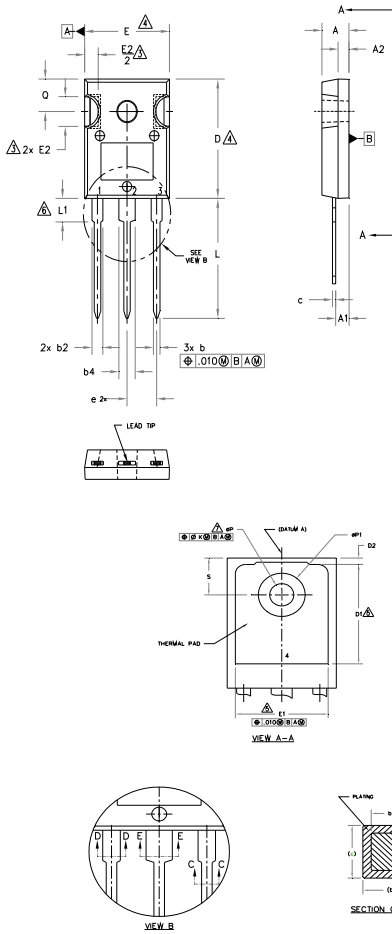


Fig. WF3 - Reverse Recovery Waveform and Definitions

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. ϕP 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	
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		
ϕk	.010		0.25		
L	.780	.827	19.57	21.00	
L1	.146	.169	3.71	4.29	
ϕP	.140	.144	3.56	3.66	
$\phi P1$	-	.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

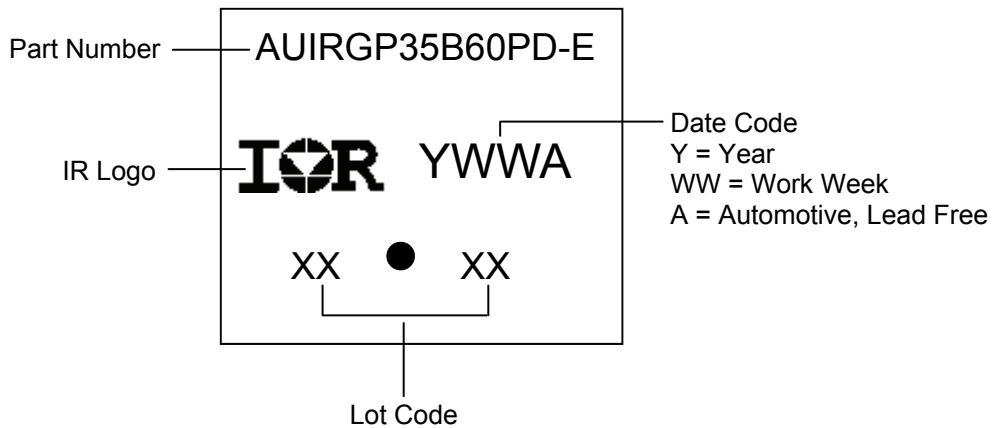
IGBTs, CoPACK

- 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.

Qualification Information

Qualification Level	Automotive (per AEC-Q101)	
	This part number(s) passed Automotive qualification. Infineon's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
Moisture Sensitivity Level	TO-247AD	N/A
ESD	Machine Model	Class M4(+/- 425V) [†] AEC-Q101-002
	Human Body Model	Class H2(+/- 4000V) [†] AEC-Q101-001
	Charged Device Model	Class C5 (+/- 1125V) [†] AEC-Q101-005
RoHS Compliant	Yes	

† Highest passing voltage.

Revision History

Date	Comments
8/24/2017	<ul style="list-style-type: none"> Updated datasheet with corporate template Corrected typo Qual table -Moisture Sensitivity Level-from "MSL1" to N/A-page 11 Corrected part marking on pages 10

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