ALPHA & OMEGA SEMICONDUCTOR

AOD5B60D

600V, 5A Alpha IGBT™ with Diode

General Description

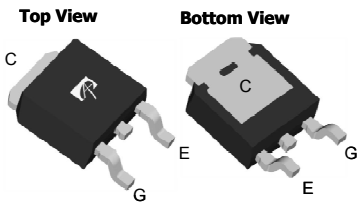
The Alpha IGBT™ line of products offers best-in-class performance in conduction and switching losses, with robust short circuit capability. They are designed for ease of paralleling, minimal gate spike under high dV/dt conditions and resistance to oscillations. The co-packaged soft diode is optimized to minimize losses in motor control applications.

Product Summary

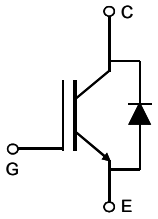
V_{CE}	600V
I_C (T_C=100°C)	5A
$V_{CE(sat)}$ (T_C=25°C)	1.55V

Green Product

TO252
DPAK



AOD5B60D



Absolute Maximum Ratings T_A=25°C unless otherwise noted

Parameter		Symbol	AOD5B60D	Units
Collector-Emitter Voltage		V_{CE}	600	V
Gate-Emitter Voltage		V_{GE}	±20	V
Continuous Collector Current[A]	T_C=25°C	I_C	23	A
	T_C=100°C		10	
Pulsed Collector Current, Limited by T_{Jmax}		I_{CM}	20	A
Turn off SOA, $V_{CE} \leqslant$ 600V, Limited by T_{Jmax}		I_{LM}	20	A
Continuous Diode Forward Current	T_C=25°C	I_F	10	A
	T_C=100°C		5	
Diode Pulsed Current, Limited by T_{Jmax}		I_{FM}	20	A
Short circuit withstanding time V_{GE} = 15V, $V_{CE} \leqslant$ 400V, delay between short circuits $\geqslant$ 1.0s, T_C=25°C		t_{SC}	10	µs
Power Dissipation	T_C=25°C	P_D	54.4	W
	T_C=100°C		21.7	
Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 150	°C
Maximum lead temperature for soldering purpose, 1/8" from case for 5 seconds		T_L	300	°C

Thermal Characteristics

Parameter	Symbol	AOD5B60D	Units
Maximum Junction-to-Ambient	$R_{\theta JA}$	55	°C/W
Maximum IGBT Junction-to-Case	$R_{\theta JC}$	2.3	°C/W
Maximum Diode Junction-to-Case	$R_{\theta JC}$	3	°C/W

Note A:I_C limited by package limitation

Electrical Characteristics (T_J=25°C unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
STATIC PARAMETERS							
BV_{CES}	Collector-Emitter Breakdown Voltage	I_C=1mA, V_{GE}=0V, T_J=25°C		600	-	-	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	V_{GE}=15V, I_C=5A	T_J=25°C	-	1.55	1.8	V
			T_J=125°C	-	1.78	-	
			T_J=150°C	-	1.85	-	
V_F	Diode Forward Voltage	V_{GE}=0V, I_C=5A	T_J=25°C	-	1.46	1.75	V
			T_J=125°C	-	1.36	-	
			T_J=150°C	-	1.3	-	
$V_{GE(th)}$	Gate-Emitter Threshold Voltage	V_{CE}=V_{GE}, I_C=1mA		-	6	-	V
I_{CES}	Zero Gate Voltage Collector Current	V_{CE}=600V, V_{GE}=0V	T_J=25°C	-	-	10	µA
			T_J=125°C	-	-	100	
			T_J=150°C	-	-	500	
I_{GES}	Gate-Emitter Leakage Current	V_{CE}=0V, V_{GE}=±20V		-	-	±100	nA
g_{FS}	Forward Transconductance	V_{CE}=20V, I_C=5A		-	2.3	-	S
DYNAMIC PARAMETERS							
C_{ies}	Input Capacitance	V_{GE}=0V, V_{CE}=25V, f=1MHz		-	367	-	pF
C_{oes}	Output Capacitance			-	34	-	pF
C_{res}	Reverse Transfer Capacitance			-	1.47	-	pF
Q_g	Total Gate Charge	V_{GE}=15V, V_{CE}=480V, I_C=5A		-	9.4	-	nC
Q_{ge}	Gate to Emitter Charge			-	3.15	-	nC
Q_{gc}	Gate to Collector Charge			-	3.6	-	nC
$I_{C(SC)}$	Short circuit collector current, Max. 1000 short circuits, Delay between short circuits ⩾ 1.0s	V_{GE}=15V, V_{CE}=400V, R_G=60Ω		-	21	-	A
R_g	Gate Resistance	V_{GE}=0V, V_{CE}=0V, f=1MHz		-	3	-	Ω
SWITCHING PARAMETERS, (Load Inductive, T_J=25°C)							
$t_{D(on)}$	Turn-On Delay Time	T_J=25°C V_{GE}=15V, V_{CE}=400V, I_C=5A, R_G=60Ω, Parasitic Inductance=75nH		-	12	-	ns
t_r	Turn-On Rise Time			-	15	-	ns
$t_{D(off)}$	Turn-Off Delay Time			-	82	-	ns
t_f	Turn-Off Fall Time			-	10	-	ns
E_{on}	Turn-On Energy			-	0.14	-	mJ
E_{off}	Turn-Off Energy			-	0.04	-	mJ
E_{total}	Total Switching Energy			-	0.18	-	mJ
t_{rr}	Diode Reverse Recovery Time	T_J=25°C I_F=5A,dI/dt=200A/µs,V_{CE}=400V		-	98	-	ns
Q_{rr}	Diode Reverse Recovery Charge			-	0.23	-	µC
I_{rm}	Diode Peak Reverse Recovery Current			-	4.4	-	A
SWITCHING PARAMETERS, (Load Inductive, T_J=150°C)							
$t_{D(on)}$	Turn-On DelayTime	T_J=150°C V_{GE}=15V, V_{CE}=400V, I_C=5A, R_G=60Ω, Parasitic Inductance=75nH		-	11	-	ns
t_r	Turn-On Rise Time			-	16	-	ns
$t_{D(off)}$	Turn-Off Delay Time			-	110	-	ns
t_f	Turn-Off Fall Time			-	14	-	ns
E_{on}	Turn-On Energy			-	0.18	-	mJ
E_{off}	Turn-Off Energy			-	0.08	-	mJ
E_{total}	Total Switching Energy			-	0.26	-	mJ
t_{rr}	Diode Reverse Recovery Time	T_J=150°C I_F=5A,dI/dt=200A/µs,V_{CE}=400V		-	166	-	ns
Q_{rr}	Diode Reverse Recovery Charge			-	0.4	-	µC
I_{rm}	Diode Peak Reverse Recovery Current			-	5.2	-	A

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

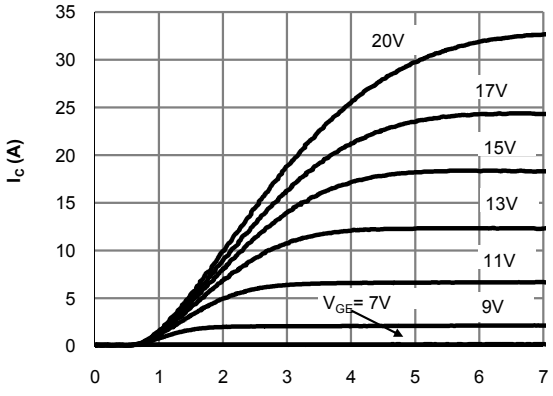


Fig 1: Output Characteristic (T_j=25°C)

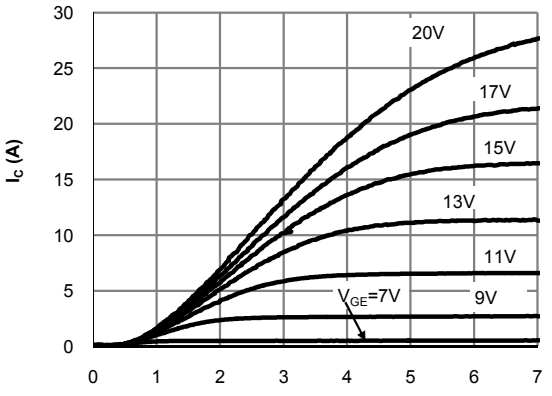


Fig 2: Output Characteristic (T_j=150°C)

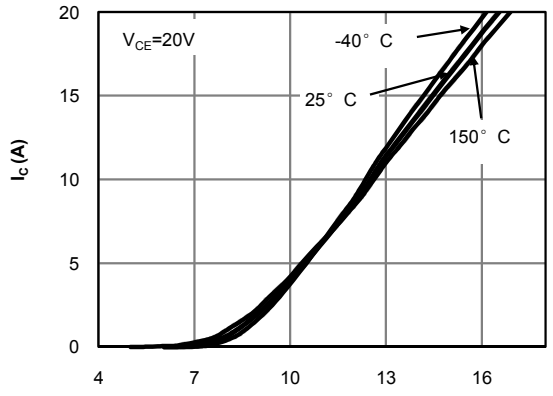


Fig 3: Transfer Characteristic

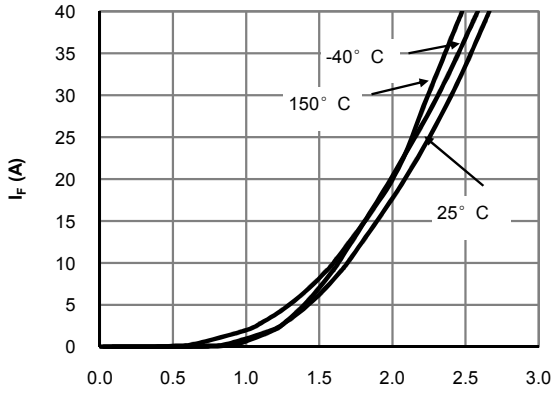


Fig 4: Diode Characteristic

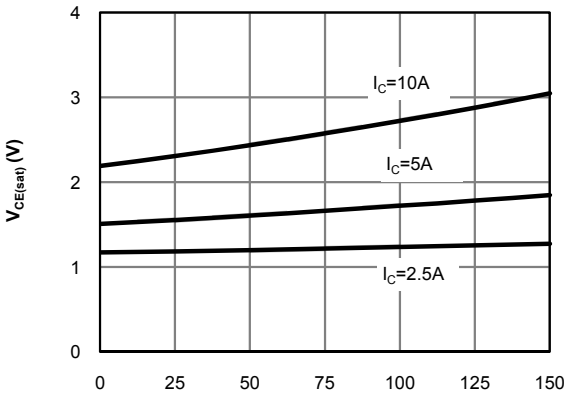


Fig 5: Collector-Emitter Saturation Voltage vs. Junction Temperature

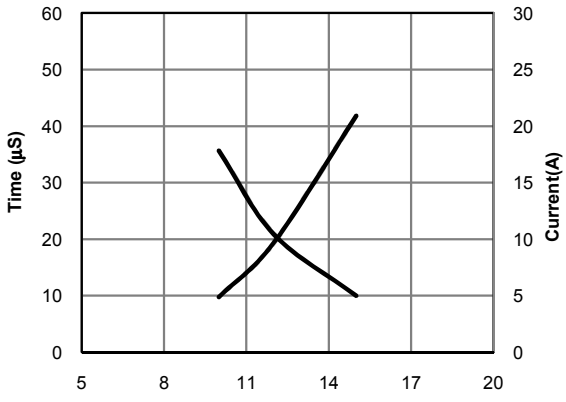


Fig 6: V_{GE} vs. Short Circuit Time (V_{CE}=400V,T_C=25°C)

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

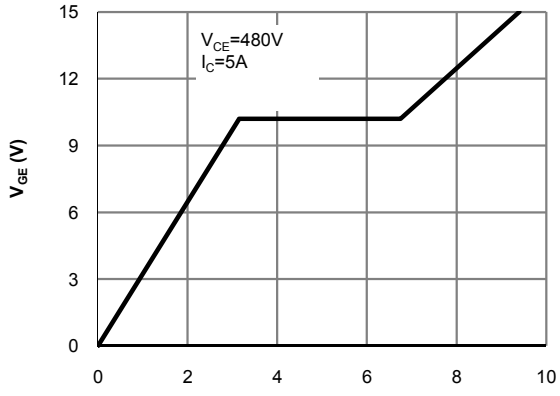


Fig 7: Gate-Charge Characteristics

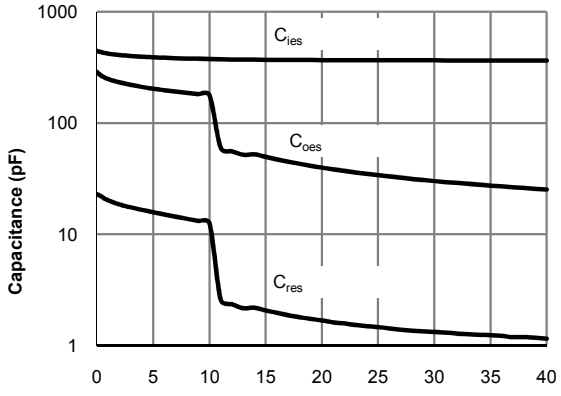


Fig 8: Capacitance Characteristic

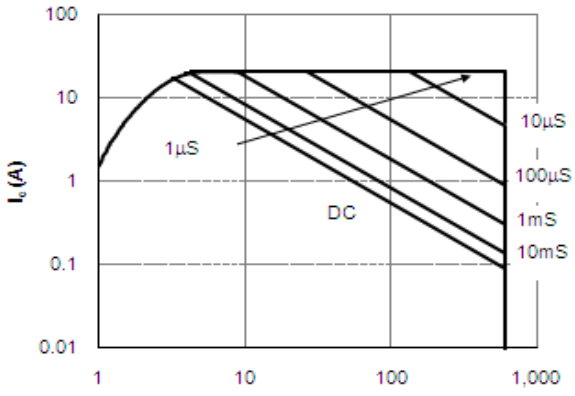


Fig 9: Forward Bias Safe Operating Area
(T_C=25°C,V_{GE}=15V)

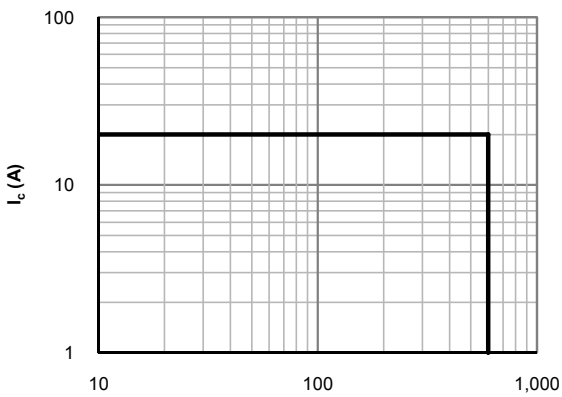


Fig 10: Reverse Bias SOA
(T_j=150°C,V_{GE}=15V)

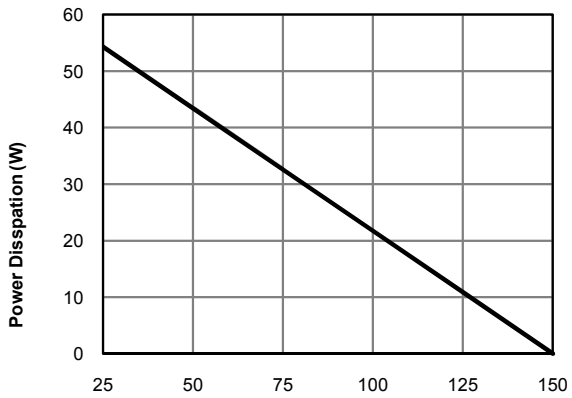


Fig 11: Power Disspation as a Function of Case

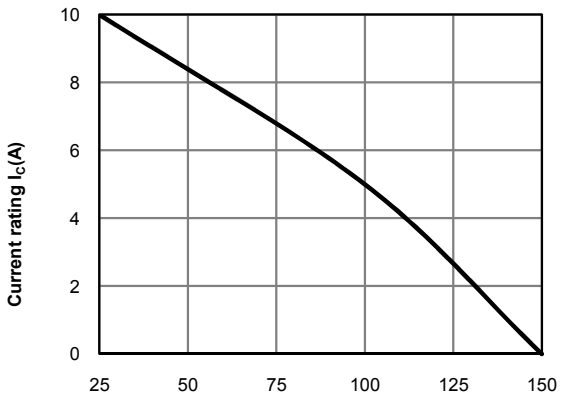


Fig 12: Current De-rating

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

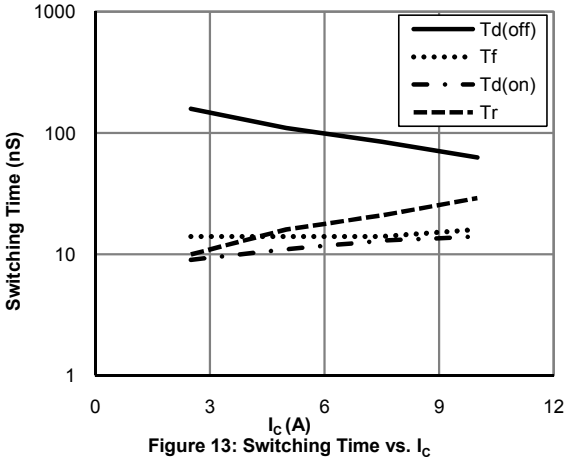


Figure 13: Switching Time vs. I_C
(T_j=150°C,V_{GE}=15V,V_{CE}=400V,R_g=60Ω)

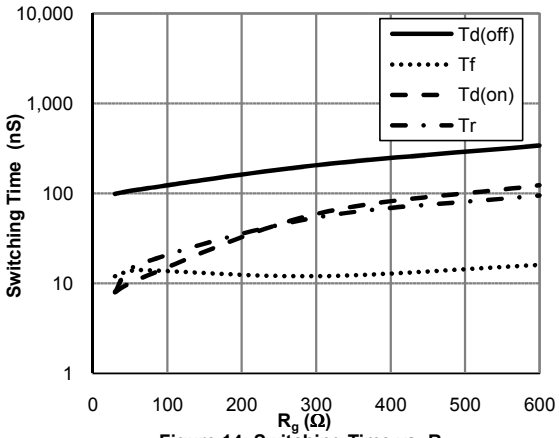


Figure 14: Switching Time vs. R_g
(T_j=150°C,V_{GE}=15V,V_{CE}=400V,I_C=5A)

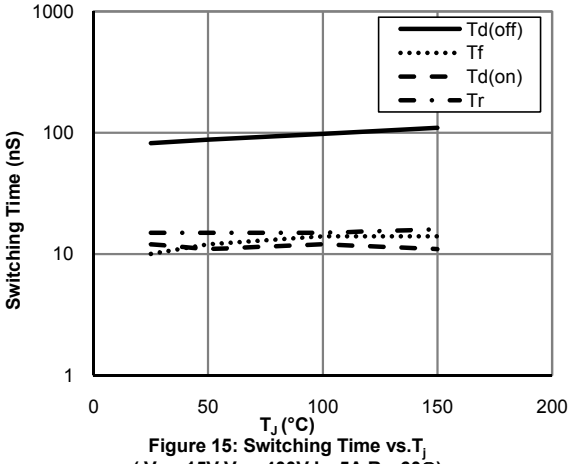


Figure 15: Switching Time vs.T_j
(V_{GE}=15V,V_{CE}=400V,I_C=5A,R_g=60Ω)

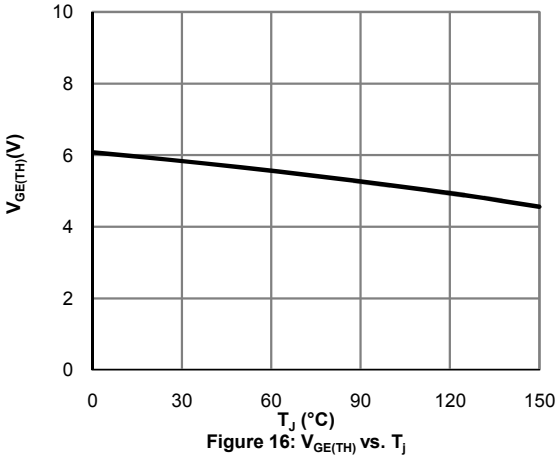


Figure 16: $V_{GE(TH)}$ vs. T_j

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

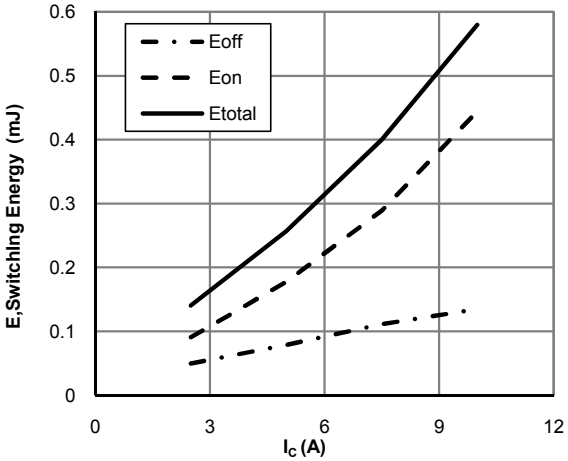


Figure 17: Switching Loss vs. I_C
(T_j=150°C,V_{GE}=15V,V_{CE}=400V,R_g=60Ω)

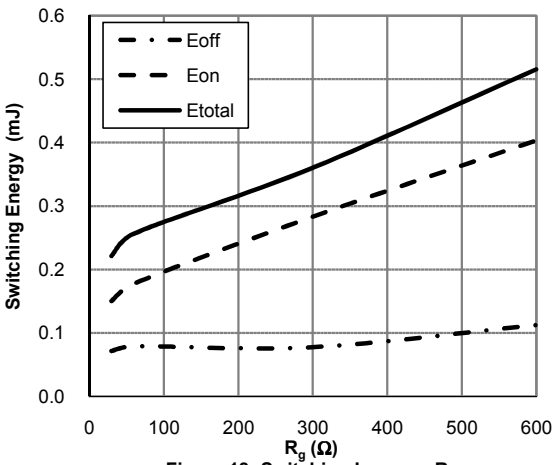


Figure 18: Switching Loss vs. R_g
(T_j=150°C,V_{GE}=15V,V_{CE}=400V,I_C=5A)

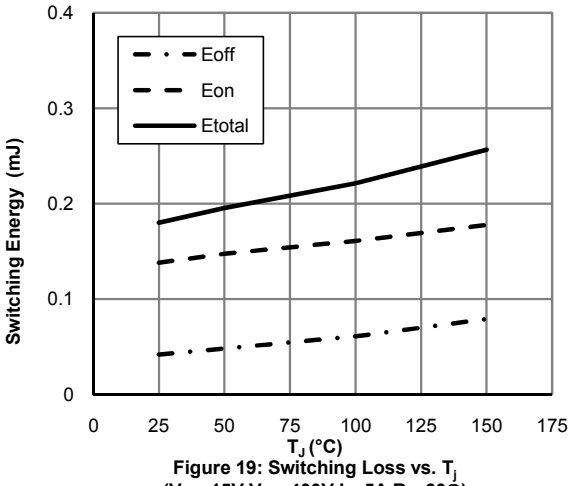


Figure 19: Switching Loss vs. T_j
(V_{GE}=15V,V_{CE}=400V,I_C=5A,R_g=60Ω)

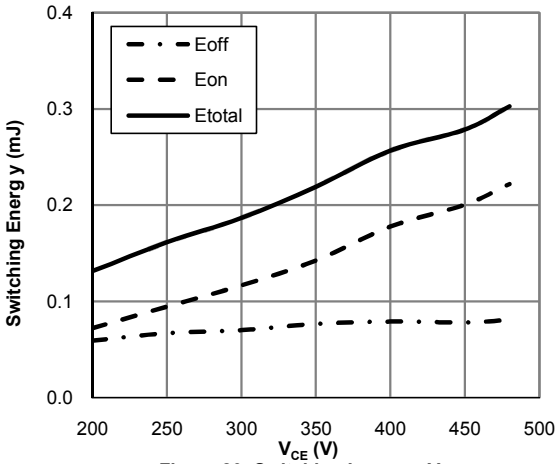


Figure 20: Switching Loss vs. V_{CE}
(T_j=150°C,V_{GE}=15V,I_C=5A,R_g=60Ω)

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

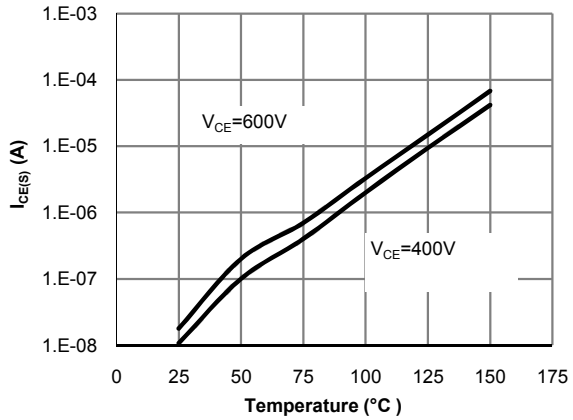


Fig 21: Reverse Leakage Current vs. Junction Temperature

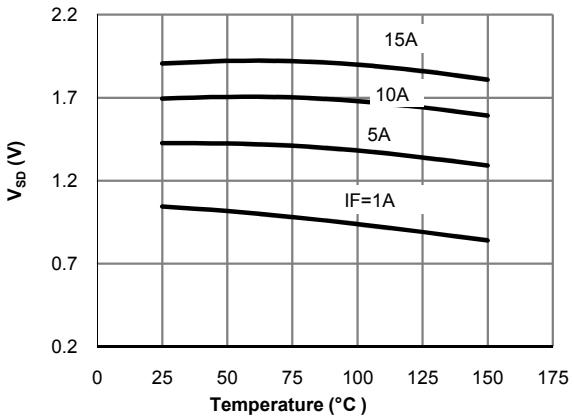


Fig 22: Diode Forward Voltage vs. Junction Temperature

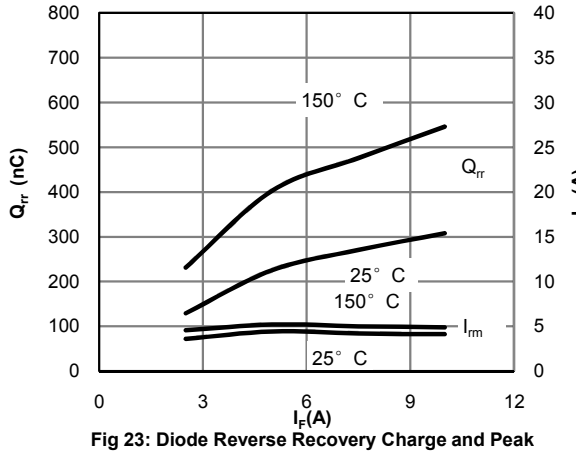


Fig 23: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current (V_{GE}=15V,V_{CE}=400V, di/dt=200A/µs)

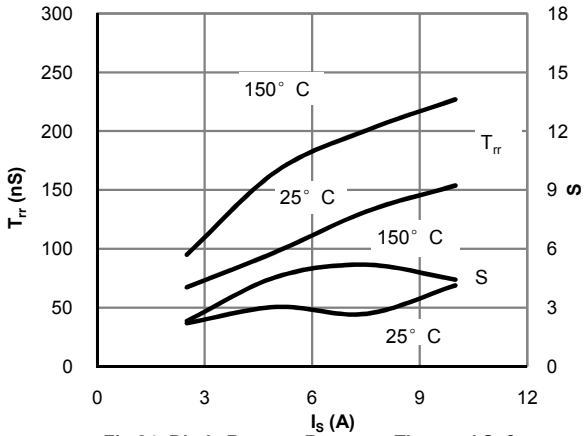


Fig 24: Diode Reverse Recovery Time and Softness Factor vs. Conduction Current (V_{GE}=15V,V_{CE}=400V, di/dt=200A/µs)

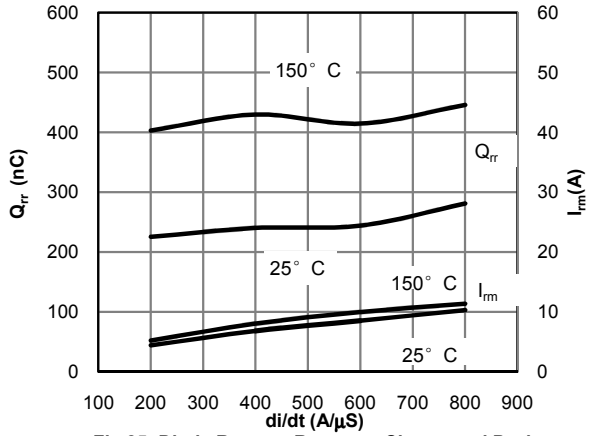


Fig 25: Diode Reverse Recovery Charge and Peak Current vs. di/dt (V_{GE}=15V,V_{CE}=400V,I_F=5A)

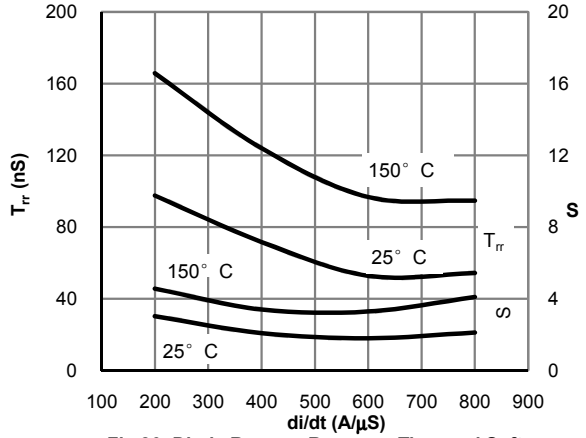


Fig 26: Diode Reverse Recovery Time and Softness Factor vs. di/dt (V_{GE}=15V,V_{CE}=400V,I_F=5A)

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

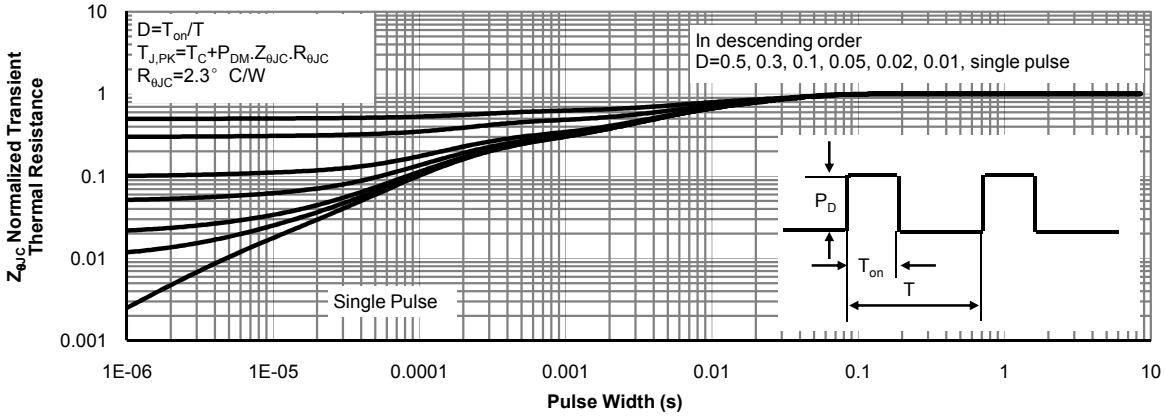


Figure 27: Normalized Maximum Transient Thermal Impedance for IGBT

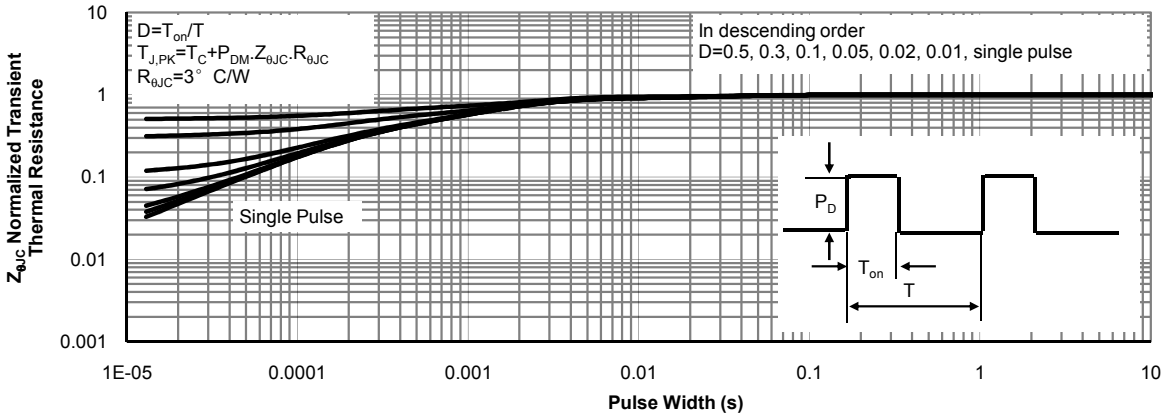
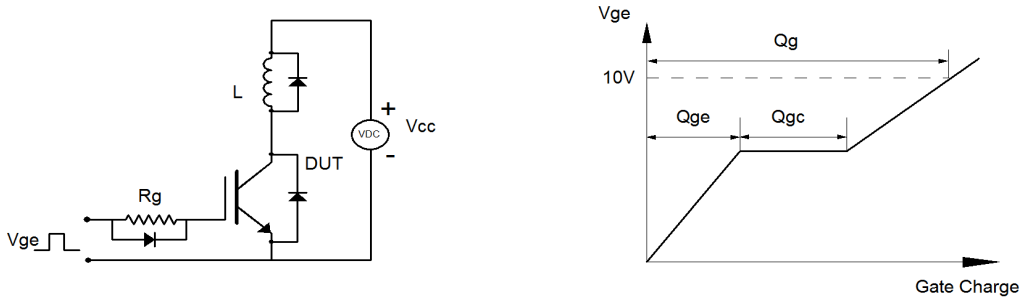
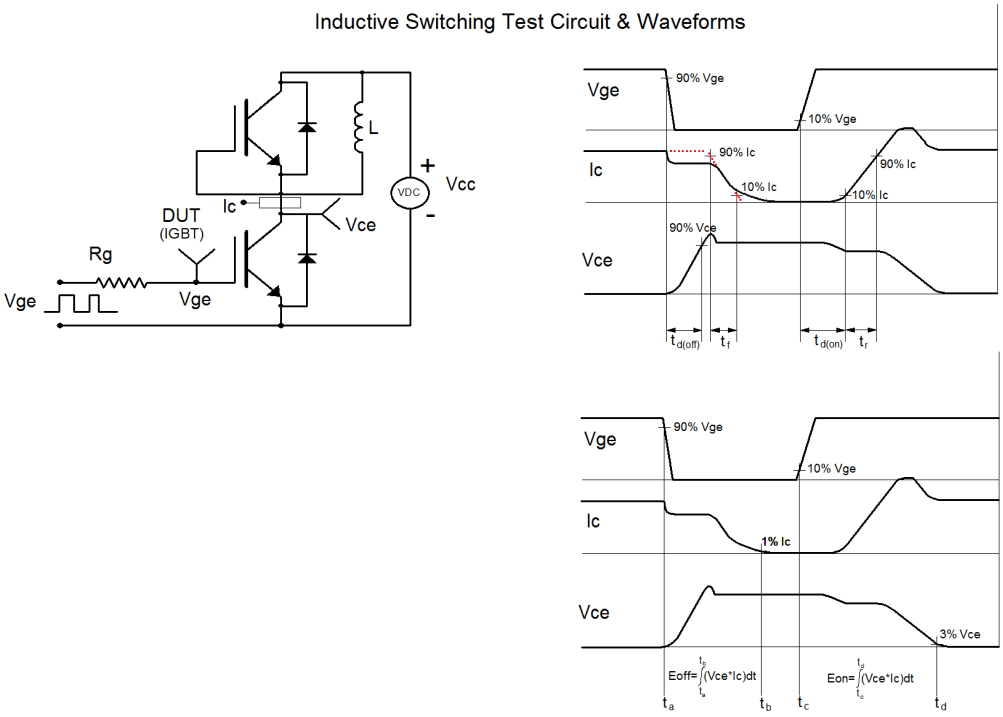


Figure 28: Normalized Maximum Transient Thermal Impedance for Diode

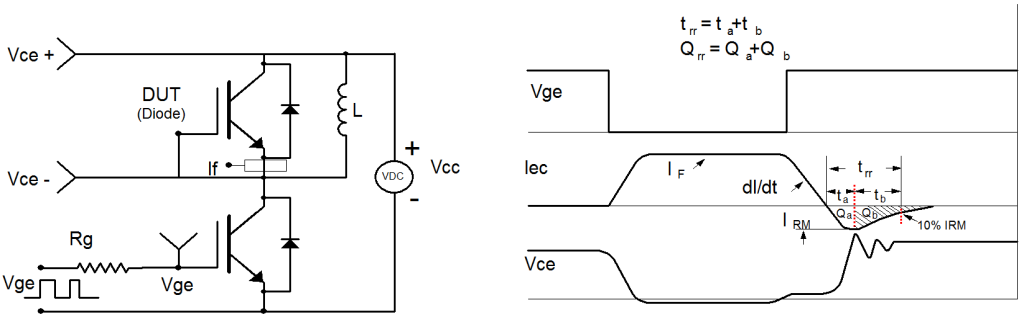
Gate Charge Test Circuit & Waveform



Inductive Switching Test Circuit & Waveforms



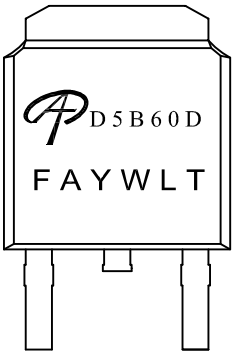
Diode Recovery Test Circuit & Waveforms



ALPHA & OMEGA SEMICONDUCTOR

Document No.	PD-01933
Version	A
Title	AOD5B60D Marking Description

DPAK (TO-252) PACKAGE MARKING DESCRIPTION



Green product

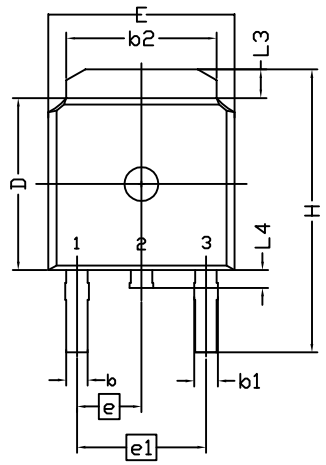
NOTE:
LOGO - AOS Logo
D5B60D - Part number code
F - Fab code
A - Assembly location code
Y - Year code
W - Week code
L&T - Assembly lot code

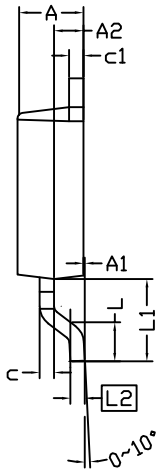
PART NO.	DESCRIPTION	CODE
AOD5B60D	Green product	D5B60D
AOD5B60DL	Green product	D5B60D

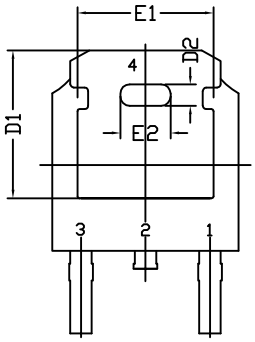
ALPHA & OMEGA
SEMICONDUCTOR, LTD.

Document No.	PO−00009
Version	S

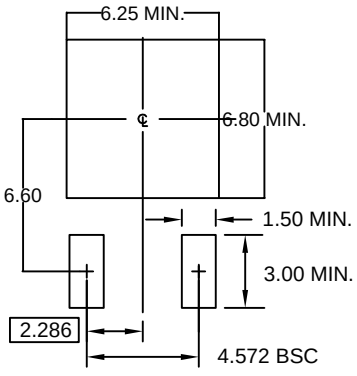
TO252(DPAK) PACKAGE OUTLINE







RECOMMENDED LAND PATTERN



UNIT: mm

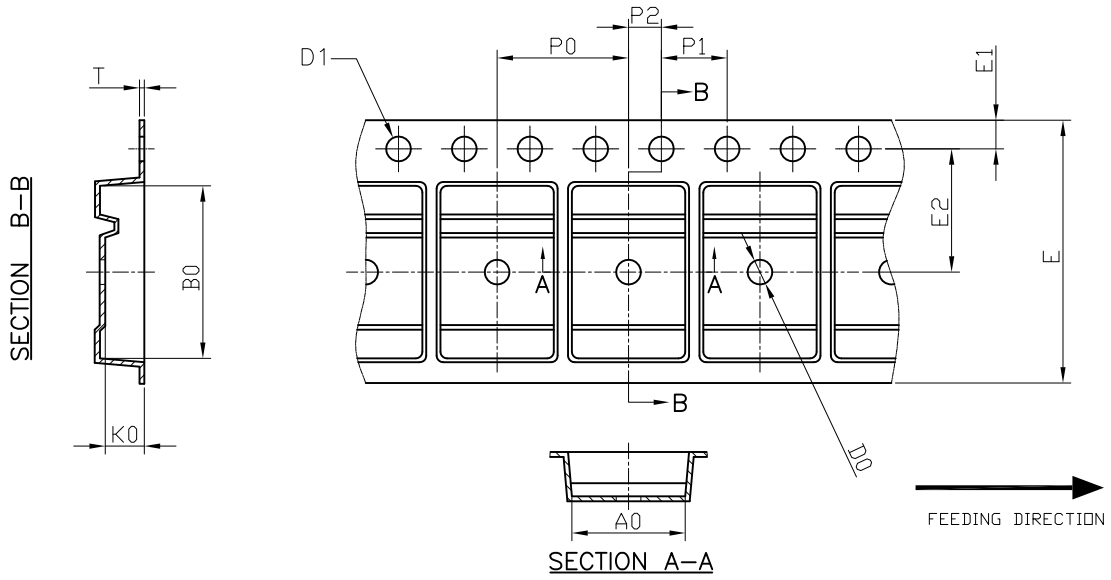
SYMBOL	DIMENSION IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	2.184	2.286	2.388	0.086	0.090	0.094
A1	0.000	-----	0.127	0.000	-----	0.005
A2	0.889	1.041	1.143	0.035	0.041	0.045
b	0.635	0.762	0.889	0.025	0.030	0.035
b1	0.762	0.840	1.143	0.030	0.033	0.045
b2	4.953	5.340	5.461	0.195	0.210	0.215
c	0.450	0.508	0.610	0.018	0.020	0.024
c1	0.450	0.508	0.610	0.018	0.020	0.024
D	5.969	6.096	6.223	0.235	0.240	0.245
D1	5.210	5.249	5.380	0.205	0.207	0.212
D2	0.662	0.762	0.862	0.026	0.030	0.034
E	6.350	6.604	6.731	0.250	0.260	0.265
E1	4.318	4.826	4.901	0.170	0.190	0.193
E2	1.678	1.778	1.878	0.066	0.070	0.074
e	2.286 BSC			0.090 BSC		
e1	4.572 BSC			0.180 BSC		
H	9.398	10.033	10.414	0.370	0.395	0.410
L	1.270	1.520	2.032	0.050	0.060	0.080
L1	2.921 REF.			0.115REF.		
L2	0.408	0.508	0.608	0.016	0.020	0.024
L3	0.889	1.016	1.270	0.035	0.040	0.050
L4	0.635	-----	1.016	0.025	-----	0.040

NOTE
1. PACKAGE BODY SIZES EXCLUDE MOLD FLASH AND GATE BURRS. MOLD FLASH SHOULD BE LESS THAN 6 MILS.
2. DIMENSION L IS MEASURED IN GAUGE PLANE
3. TOLERANCE 0.10 mm UNLESS OTHERWISE SPECIFIED
4. CONTROLLING DIMENSION IS MILLIMETER. CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.
5. REFER TO JEDEC TO-252 (AA)

ALPHA & OMEGA SEMICONDUCTOR

DPAK Tape and Reel Data

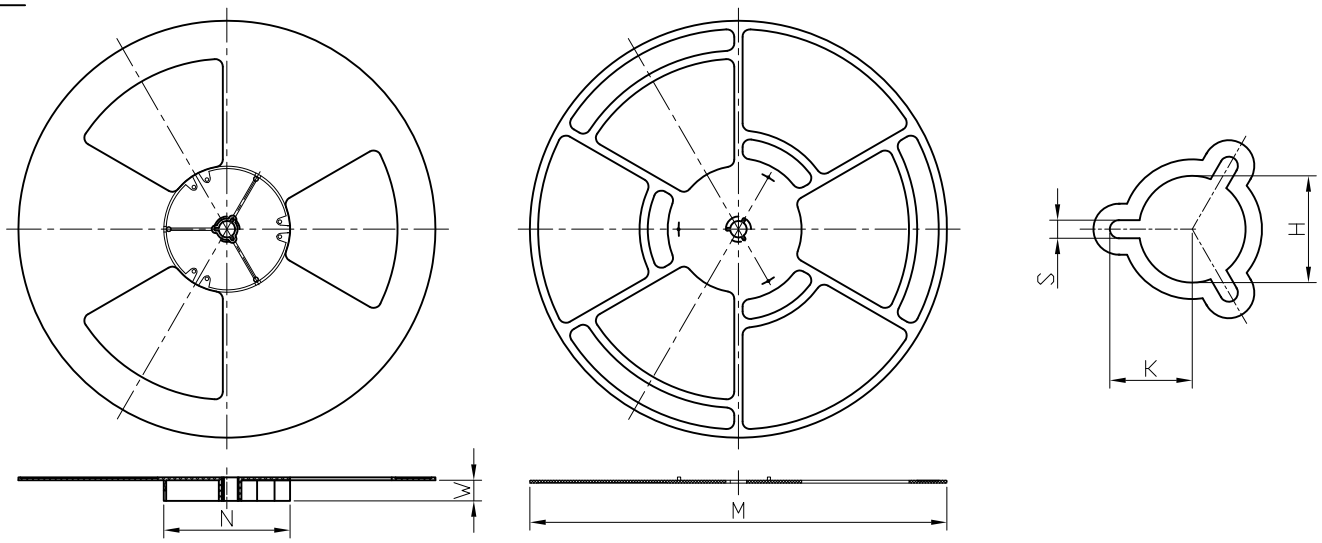
DPAK Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
DPAK (16 mm)	6.90 ±0.10	10.50 ±0.10	2.50 ±0.10	1.50 +0.1 −0	1.50 +0.1 −0	16.00 ±0.30	1.75 ±0.10	7.50 ±0.10	8.00 ±0.10	4.00 ±0.10	2.00 ±0.10	0.30 ±0.05

DPAK Reel



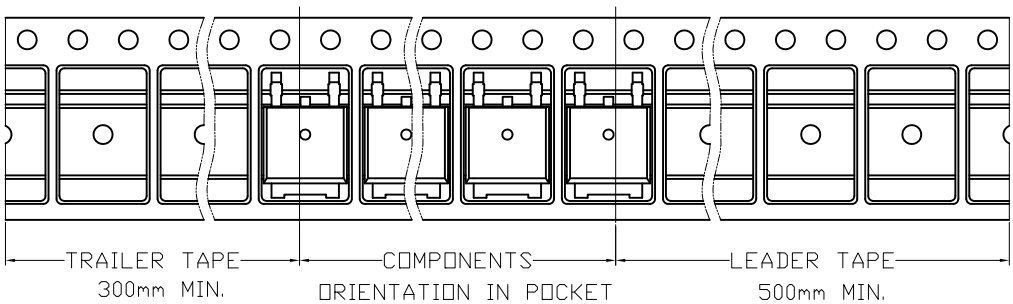
UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W	H	K	S
16 mm	ø330	ø330.00 +0.25 −4.00	ø100.00 ±0.2	16.4 +2.0 −0.0	ø13.00 +0.50 −0.20	10.5 ±0.25	2.2 ±0.25

DPAK Tape

Leader / Trailer & Orientation

Unit Per Reel: 2500pcs



AOS Semiconductor
Product Reliability Report

AOD5B60D, rev B

Plastic Encapsulated Device

ALPHA & OMEGA Semiconductor, Inc

www.aosmd.com

This AOS product reliability report summarizes the qualification result for AOD5B60D. Accelerated environmental tests are performed on a specific sample size, and then followed by electrical test at end point. Review of final electrical test result confirms that AOD5B60D passes AOS quality and reliability requirements. The released product will be categorized by the process family and be routine monitored for continuously improving the product quality.

Table of Contents:

I. Product Description:

The Alpha IGBT™ line of products offers best-in-class performance in conduction and switching losses, with robust short circuit capability. They are designed for ease of paralleling, minimal gate spike under high dV/dt conditions and resistance to oscillations. The co-packaged soft diode is optimized to minimize losses in motor control applications.

Details refer to the datasheet.

II. Die / Package Information:

	AOD5B60D
Process	Standard sub-micron 600V Alpha IGBT™ with Diode
Package Type	TO252
Lead Frame	Bare Cu
Die Attach	Soft solder
Bond	Al wire
Mold Material	Epoxy resin with silica filler
Moisture Level	Up to Level 1

III. Reliability Stress Test Summary and Results

Test Item*	Test Condition	Time Point	Total Sample Size	Number of Failures	Reference Standard
MSL Precondition	168hr 85°C / 85%RH + 3 cycle reflow@260°C (MSL 1)	-	3465 pcs	0	JESD22-A113
HTGB	Temp = 150°C , Vgs=100% of Vgsmax	168 / 500 / 1000 hours	924 pcs	0	JESD22-A108
HTRB	Temp = 150°C , Vds=80% of Vdsmax	168 / 500 / 1000 hours	924 pcs	0	JESD22-A108
HAST	130°C , 85%RH, 33.3 psi, Vds = 80% of Vdsmax up to 42V	96 hours	924 pcs	0	JESD22-A110
H3TRB	85°C , 85%RH, Vds = 80% of Vdsmax up to 100V	1000 hours	693 pcs	0	JESD22-A101
Autoclave	121°C , 29.7psi, RH=100%	96 hours	924 pcs	0	JESD22-A102
Temperature Cycle	-65°C to 150°C , air to air,	250 / 500 cycles	924 pcs	0	JESD22-A104

Note: The reliability data presents total of available generic data up to the published date.

IV. Reliability Evaluation

FIT rate (per billion): 3.16
MTTF = 36173 years

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size. Failure Rate Determination is based on JEDEC Standard JESD 85. FIT means one failure per billion hours.

Failure Rate = $Chi^2 \times 10^9$ **/ [**2 (N) (H) (Af)**] =** 3.16
MTTF = 10^9 / FIT = 36173 years

Chi² = Chi Squared Distribution, determined by the number of failures and confidence interval
N = Total Number of units from burn-in tests
H = Duration of burn-in testing
Af = Acceleration Factor from Test to Use Conditions (Ea = 0.7eV and Tuse = 55°C)
Acceleration Factor [**Af**] = **Exp** [Ea / **k** (1/Tj u – 1/Tj s)]
Acceleration Factor ratio list:

	55 deg C	70 deg C	85 deg C	100 deg C	115 deg C	130 deg C	150 deg C
Af	259	87	32	13	5.64	2.59	1

Tj s = Stressed junction temperature in degree (Kelvin), K = C+273.16
Tj u =The use junction temperature in degree (Kelvin), K = C+273.16
k = Boltzmann's constant, 8.617164 X 10^{-5}eV / K