ALPHA & OMEGA SEMICONDUCTOR, LTD

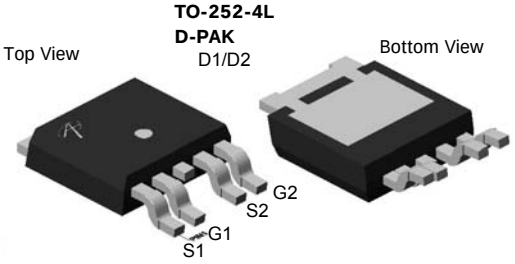
AOD609
Complementary Enhancement Mode Field Effect Transistor

General Description
The AOD609 uses advanced trench technology MOSFETs to provide excellent $R_{DS(ON)}$ and low gate charge. The complementary MOSFETs may be used in H-bridge, Inverters and other applications.

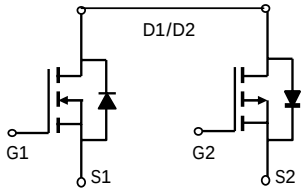
-RoHS Compliant
-Halogen Free*

Features
n-channel
V_{DS} (V) = 40V, I_D = 12A (V_{GS}=10V)
$R_{DS(ON)}$< 30mΩ (V_{GS}=10V)
$R_{DS(ON)}$< 40mΩ (V_{GS}=4.5V)
p-channel
V_{DS} (V) = -40V, I_D = -12A (V_{GS}=-10V)
$R_{DS(ON)}$< 45mΩ (VGS= -10V)
$R_{DS(ON)}$< 66mΩ (VGS= -4.5V)
100% UIS Tested!
100% Rg Tested!

TO-252-4L
D-PAK



Top View
Drain Connected to Tab



n-channel **p-channel**

Absolute Maximum Ratings T_A=25°C unless otherwise noted

Parameter		Symbol	Max n-channel	Max p-channel	Units
Drain-Source Voltage		V_{DS}	40	-40	V
Gate-Source Voltage		V_{GS}	±20	±20	V
Continuous Drain Current [B,H]	T_C=25°C	I_D	12	-12	A
	T_C=100°C		12	-12	
Pulsed Drain Current [B]		I_{DM}	30	-30	
Avalanche Current [C]		I_{AR}	14	-20	
Repetitive avalanche energy L=0.1mH [C]		E_{AR}	9.8	20	mJ
Power Dissipation	T_C=25°C	P_D	27	30	W
	T_C=100°C		14	15	
Power Dissipation	T_A=25°C	P_{DSM}	2	2	W
	T_A=70°C		1.3	1.3	
Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 175	-55 to 175	°C

Thermal Characteristics: n-channel and p-channel

Parameter		Symbol	Device	Typ	Max	Units
Maximum Junction-to-Ambient [A,D]	t ≤ 10s	$R_{\theta JA}$	n-ch	17.4	25	°C/W
Maximum Junction-to-Ambient [A,D]	Steady-State		n-ch	50	60	°C/W
Maximum Junction-to-Lead [C]	Steady-State	$R_{\theta JC}$	n-ch	4	5.5	°C/W
Maximum Junction-to-Ambient [A,D]	t ≤ 10s	$R_{\theta JA}$	p-ch	16.7	25	°C/W
Maximum Junction-to-Ambient [A,D]	Steady-State		p-ch	50	60	°C/W
Maximum Junction-to-Lead [C]	Steady-State	$R_{\theta JC}$	p-ch	3.5	5	°C/W

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
STATIC PARAMETERS						
BV_{DSS}	Drain-Source Breakdown Voltage	I_D=250µA, V_{GS}=0V	40			V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS}=40V, V_{GS}=0V			1	µA
		T_J=55°C			5	
I_{GSS}	Gate-Body leakage current	V_{DS}=0V, V_{GS}= ±20V			±100	nA
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS}=V_{GS} I_D=250µA	1.7	2.5	3	V
$I_{D(ON)}$	On state drain current	V_{GS}=10V, V_{DS}=5V	30			A
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS}=10V, I_D=12A		24	30	mΩ
		T_J=125°C		37	46	
		V_{GS}=4.5V, I_D=8A		31	40	
g_{FS}	Forward Transconductance	V_{DS}=5V, I_D=12A		25		S
V_{SD}	Diode Forward Voltage	I_S=1A,V_{GS}=0V		0.76	1	V
I_S	Maximum Body-Diode Continuous Current				2	A
DYNAMIC PARAMETERS						
C_{iss}	Input Capacitance	V_{GS}=0V, V_{DS}=20V, f=1MHz		516	650	pF
C_{oss}	Output Capacitance			82		pF
C_{rss}	Reverse Transfer Capacitance			43		pF
R_g	Gate resistance	V_{GS}=0V, V_{DS}=0V, f=1MHz		4.6	6.9	Ω
SWITCHING PARAMETERS						
Q_g (10V)	Total Gate Charge	V_{GS}=10V, V_{DS}=20V, I_D=12A		8.3	10.8	nC
Q_{gs}	Gate Source Charge			2.3		nC
Q_{gd}	Gate Drain Charge			1.6		nC
$t_{D(on)}$	Turn-On DelayTime	V_{GS}=10V, V_{DS}=20V, R_L=1.4Ω, R_{GEN}=3Ω		6.4		ns
t_r	Turn-On Rise Time			3.6		ns
$t_{D(off)}$	Turn-Off DelayTime			16.2		ns
t_f	Turn-Off Fall Time			6.6		ns
t_{rr}	Body Diode Reverse Recovery Time	I_F=12A, dI/dt=100A/µs		18	24	ns
Q_{rr}	Body Diode Reverse Recovery Charge	I_F=12A, dI/dt=100A/µs		10		nC

A: The value of $R_{\theta JA}$ is measured with the device in a still air environment with T_A =25°C. The power dissipation P_{DSM} and current rating I_{DSM} are based on $T_{J(MAX)}$=150°C, using the steady state junction-to-ambient thermal resistance.

B. The power dissipation P_D is based on $T_{J(MAX)}$=175°C, using junction-to-case thermal resistance, and is more useful in setting the upper dissipation lim for cases where additional heatsinking is used.

C: Repetitive rating, pulse width limited by junction temperature $T_{J(MAX)}$=175°C.

D. The $R_{\theta JA}$ is the sum of the thermal impedence from junction to case $R_{\theta JC}$ and case to ambient.

E. The static characteristics in Figures 1 to 6 are obtained using <300µs pulses, duty cycle 0.5% max.

F. These curves are based on the junction-to-case thermal impedence which is measured with the device mounted to a large heatsink, assuming a maximum junction temperature of $T_{J(MAX)}$=175°C. The SOA curve provides a single pulse rating.

G. These tests are performed with the device mounted on 1 in^2 FR-4 board with 2oz. Copper, in a still air environment with T_A=25°C.

H. The maximum current rating is limited by bond-wires.

*This device is guaranteed green after data code 8X11 (Sep 9^{T} 2008).

Rev4: Aug 2009

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS: N-CHANNEL

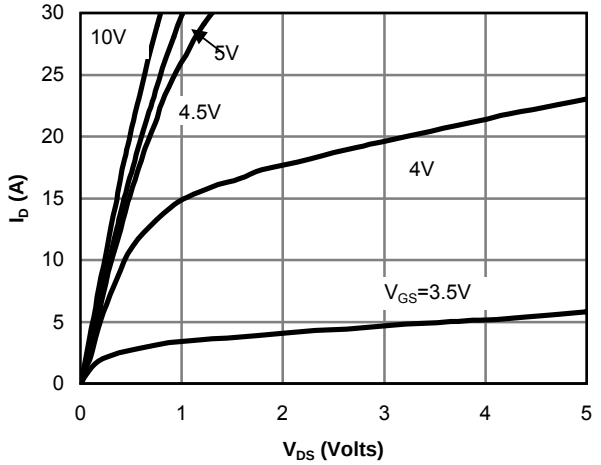


Fig 1: On-Region Characteristics

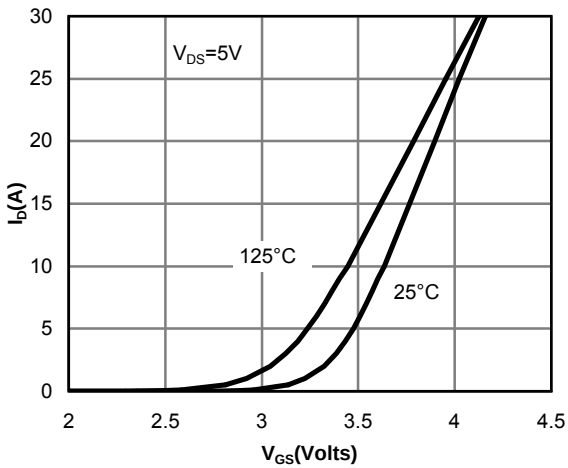


Figure 2: Transfer Characteristics

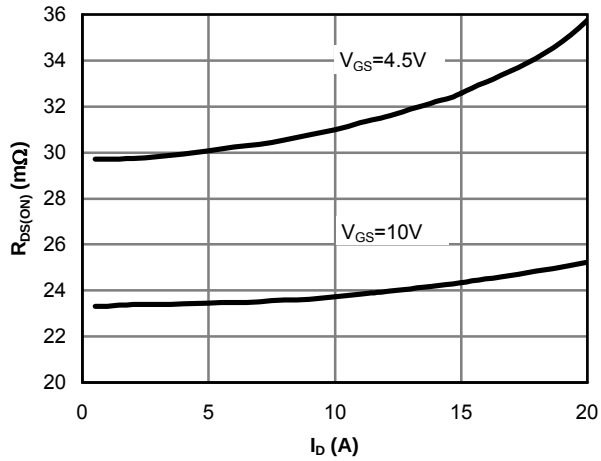


Figure 3: On-Resistance vs. Drain Current and Gate Voltage

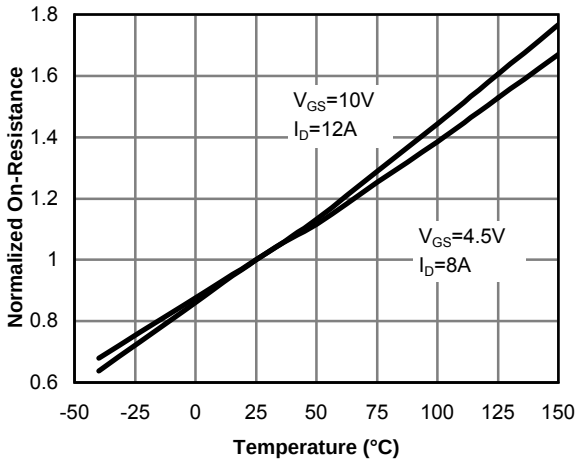


Figure 4: On-Resistance vs. Junction Temperature

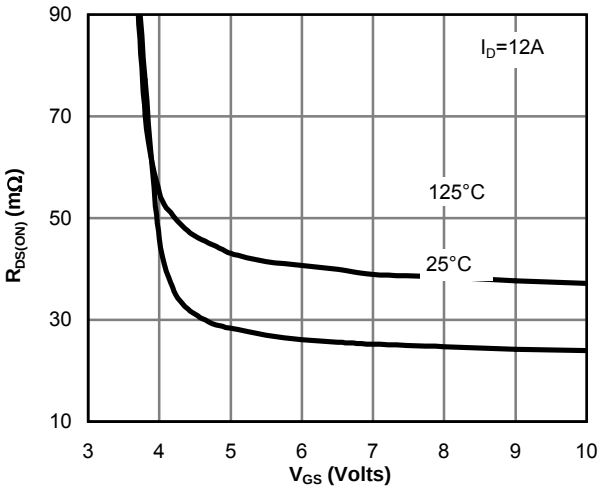


Figure 5: On-Resistance vs. Gate-Source Voltage

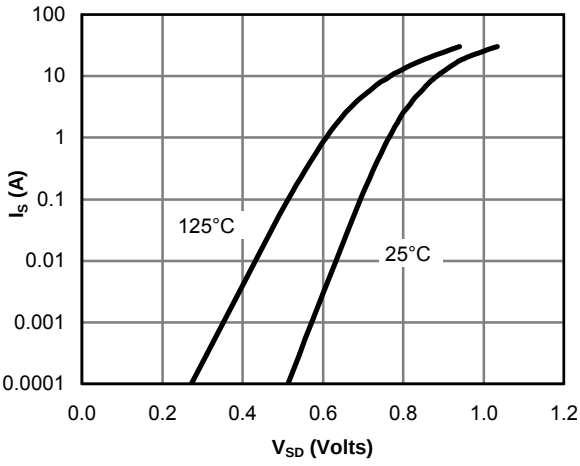


Figure 6: Body-Diode Characteristics

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS: N-CHANNEL

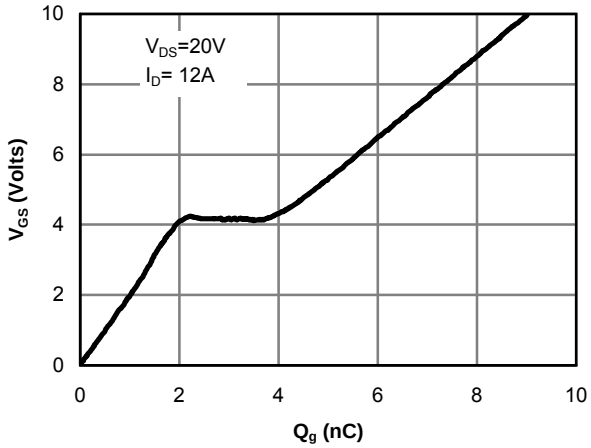


Figure 7: Gate-Charge Characteristics

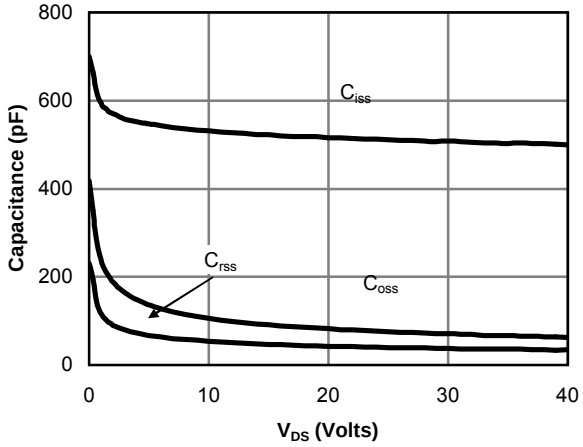


Figure 8: Capacitance Characteristics

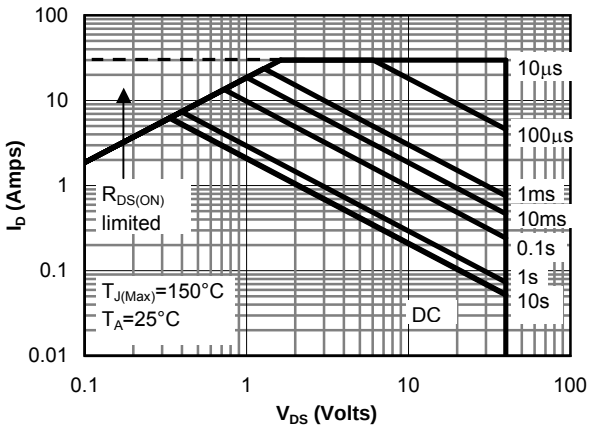


Figure 9: Maximum Forward Biased Safe Operating Area (Note E)

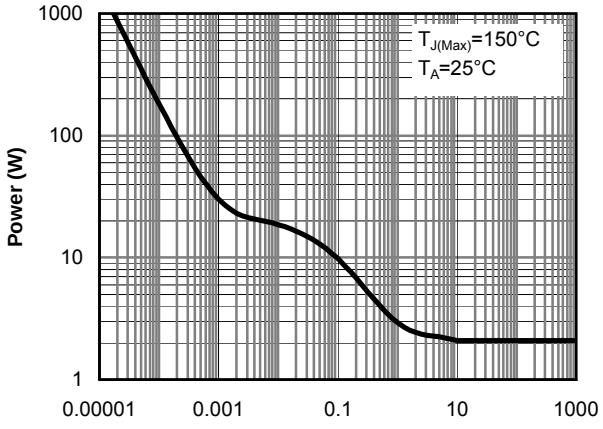


Figure 10: Single Pulse Power Rating Junction-to-Ambient (Note E)

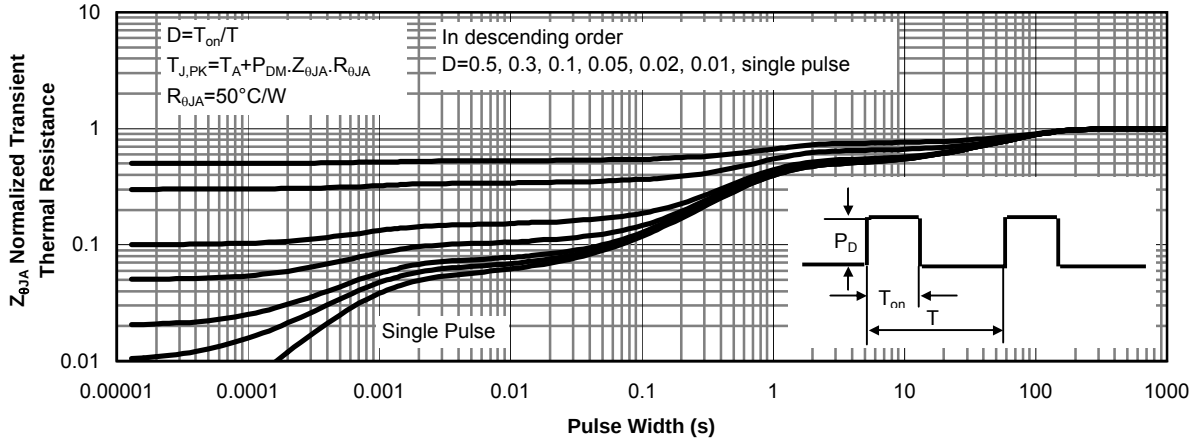
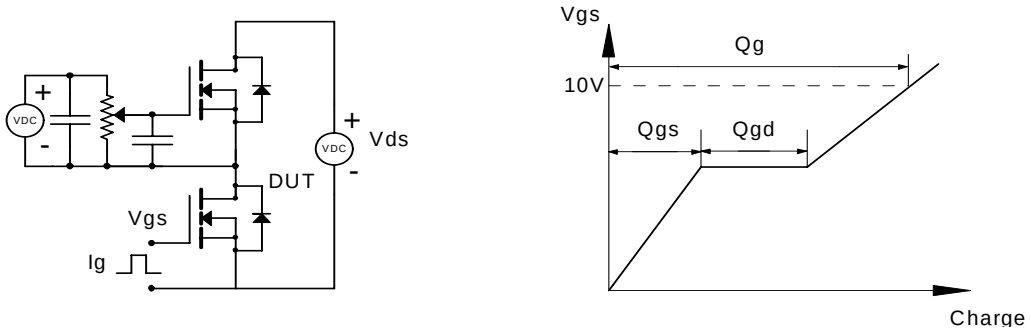
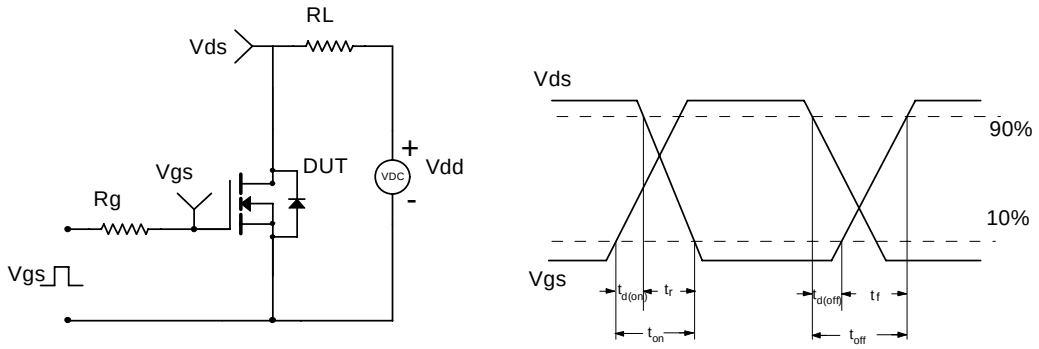


Figure 11: Normalized Maximum Transient Thermal Impedance

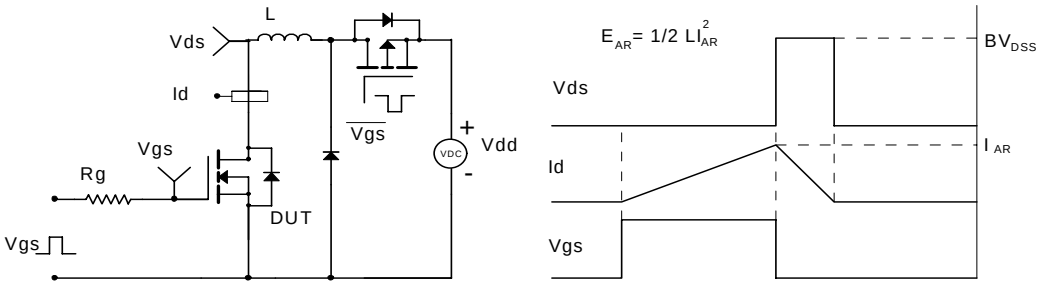
Gate Charge Test Circuit & Waveform



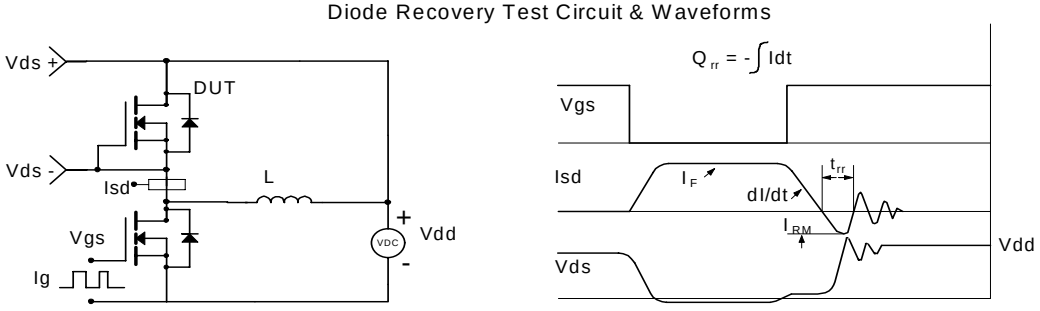
Resistive Switching Test Circuit & Waveforms



Unclamped Inductive Switching (UIS) Test Circuit & Waveforms



Diode Recovery Test Circuit & Waveforms



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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
STATIC PARAMETERS						
BV_{DSS}	Drain-Source Breakdown Voltage	I_D= -250µA, V_{GS}=0V	-40			V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS}= -40V, V_{GS}=0V			-1	µA
		T_J=55°C			-5	
I_{GSS}	Gate-Body leakage current	V_{DS}=0V, V_{GS}= ±20V			±100	nA
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS}=V_{GS} I_D= -250µA	-1.7	-2	-3	V
$I_{D(ON)}$	On state drain current	V_{GS}= -10V, V_{DS}= -5V	-30			A
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS}= -10V, I_D= -12A		36	45	mΩ
		T_J=125°C		52	65	
		V_{GS}= -4.5V, I_D= -8A		51	66	
g_{FS}	Forward Transconductance	V_{DS}= -5V, I_D= -12A		22		S
V_{SD}	Diode Forward Voltage	I_S= -1A,V_{GS}=0V		-0.76	-1	V
I_S	Maximum Body-Diode Continuous Current				-2	A
DYNAMIC PARAMETERS						
C_{iss}	Input Capacitance	V_{GS}=0V, V_{DS}= -20V, f=1MHz		900	1125	pF
C_{oss}	Output Capacitance			97		pF
C_{rss}	Reverse Transfer Capacitance			68		pF
R_g	Gate resistance	V_{GS}=0V, V_{DS}=0V, f=1MHz		14		Ω
SWITCHING PARAMETERS						
Q_g (-10V)	Total Gate Charge	V_{GS}= -10V, V_{DS}= -20V, I_D= -12A		16.2	21	nC
Q_g (-4.5V)	Total Gate Charge			7.2	9.4	nC
Q_{gs}	Gate Source Charge			3.8		nC
Q_{gd}	Gate Drain Charge			3.5		nC
$t_{D(on)}$	Turn-On DelayTime	V_{GS}= -10V, V_{DS}= -20V, R_L=1.4Ω, R_{GEN}=3Ω		6.2		ns
t_r	Turn-On Rise Time			8.4		ns
$t_{D(off)}$	Turn-Off DelayTime			44.8		ns
t_f	Turn-Off Fall Time			41.2		ns
t_{rr}	Body Diode Reverse Recovery Time	I_F= -12A, dI/dt=100A/µs		21	27	ns
Q_{rr}	Body Diode Reverse Recovery Charge	I_F= -12A, dI/dt=100A/µs		14		nC

A: The value of $R_{\theta JA}$ is measured with the device in a still air environment with T_A =25°C. The power dissipation P_{DSM} and current rating I_{DSM} are based on $T_{J(MAX)}$=150°C, using t ≤ 10s junction-to-ambient thermal resistance.

B. The power dissipation P_D is based on $T_{J(MAX)}$=175°C, using junction-to-case thermal resistance, and is more useful in setting the upper dissipation limit for cases where additional heatsinking is used.

C: Repetitive rating, pulse width limited by junction temperature $T_{J(MAX)}$=175°C.

D. The $R_{\theta JA}$ is the sum of the thermal impedence from junction to case $R_{\theta JC}$ and case to ambient.

E. The static characteristics in Figures 1 to 6 are obtained using <300µs pulses, duty cycle 0.5% max.

F. These curves are based on the junction-to-case thermal impedence which is measured with the device mounted to a large heatsink, assuming a maximum junction temperature of $T_{J(MAX)}$=175°C. The SOA curve provides a single pulse rating.

G. These tests are performed with the device mounted on 1 in^2 FR-4 board with 2oz. Copper, in a still air environment with T_A=25°C.

H. The maximum current rating is limited by bond-wires.

*This device is guaranteed green after data code 8X11 (Sep 1st 2008).

Rev4: Aug 2009

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS: P-CHANNEL

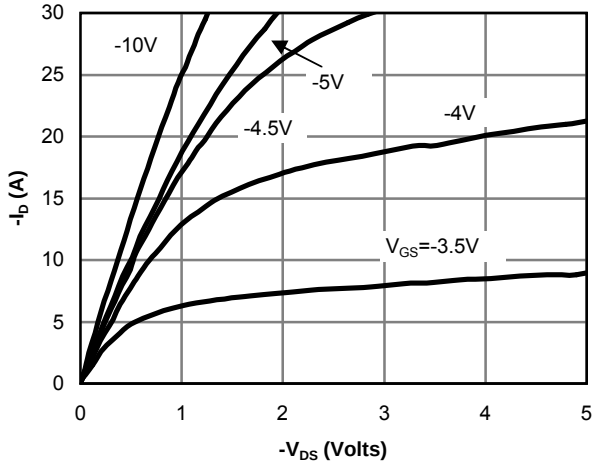


Fig 12: On-Region Characteristics

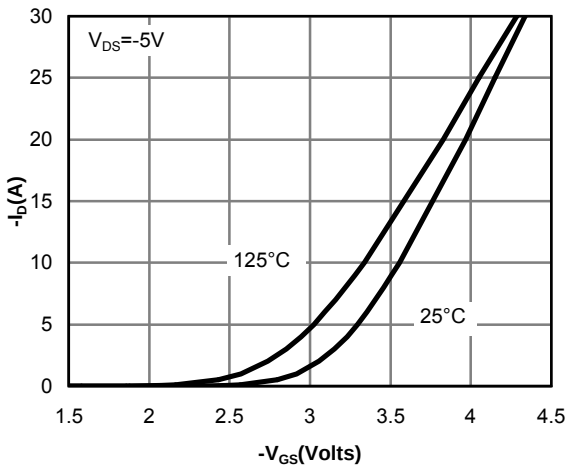


Figure 13: Transfer Characteristics

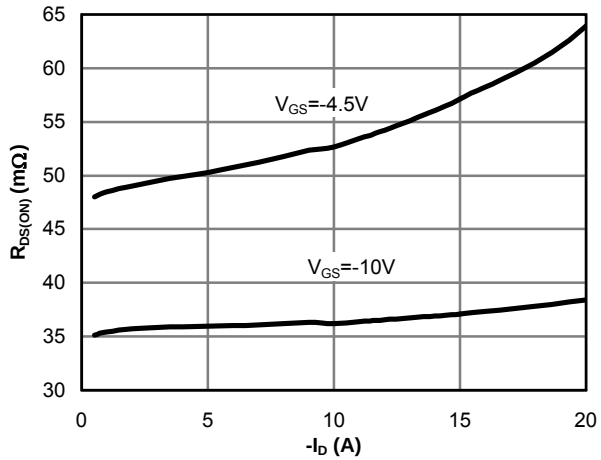


Figure 14: On-Resistance vs. Drain Current and Gate Voltage

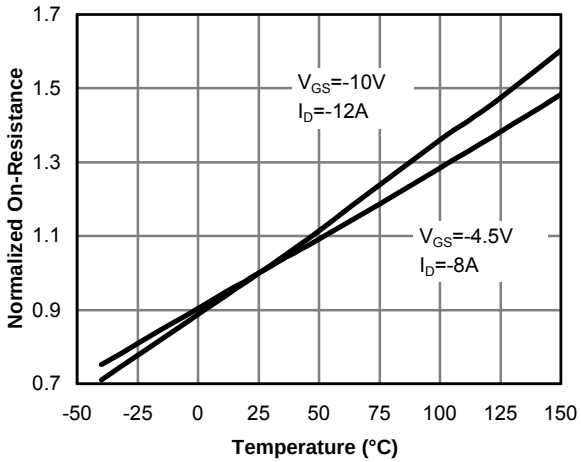


Figure 15: On-Resistance vs. Junction Temperature

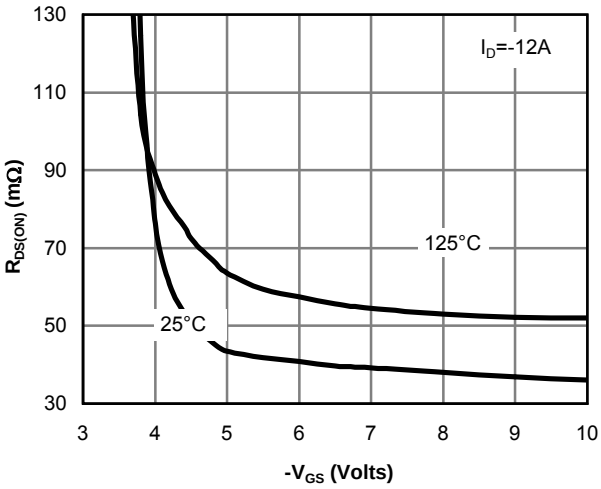


Figure 16: On-Resistance vs. Gate-Source Voltage

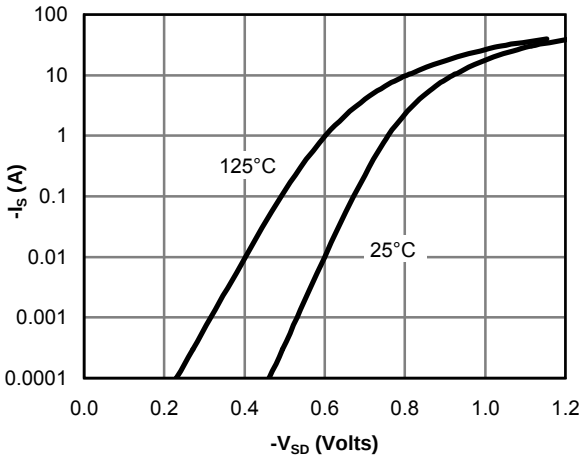


Figure 17: Body-Diode Characteristics

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS: P-CHANNEL

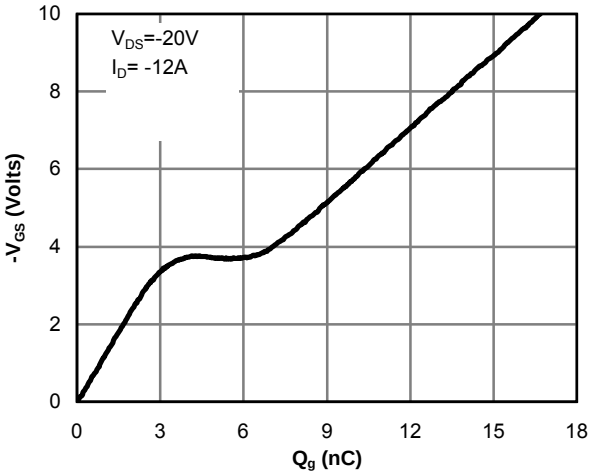


Figure 18: Gate-Charge Characteristics

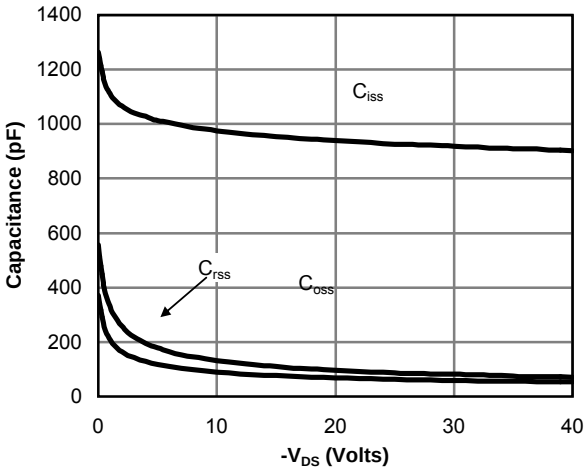


Figure 19: Capacitance Characteristics

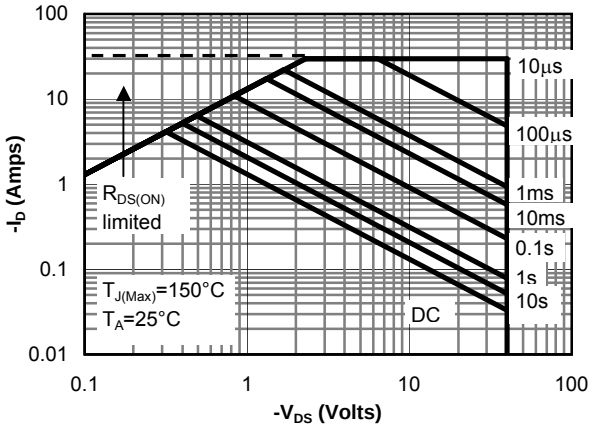


Figure 20: Maximum Forward Biased Safe Operating Area (Note E)

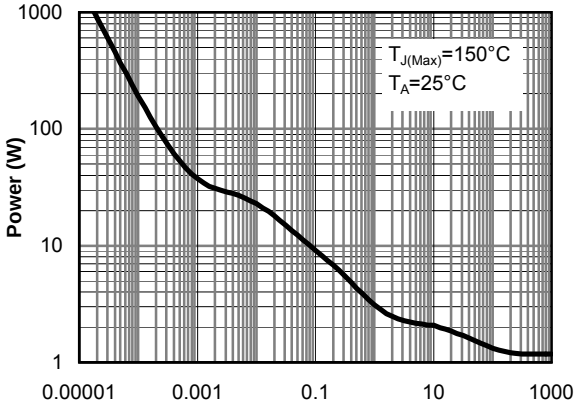


Figure 21: Single Pulse Power Rating Junction-to-Ambient (Note E)

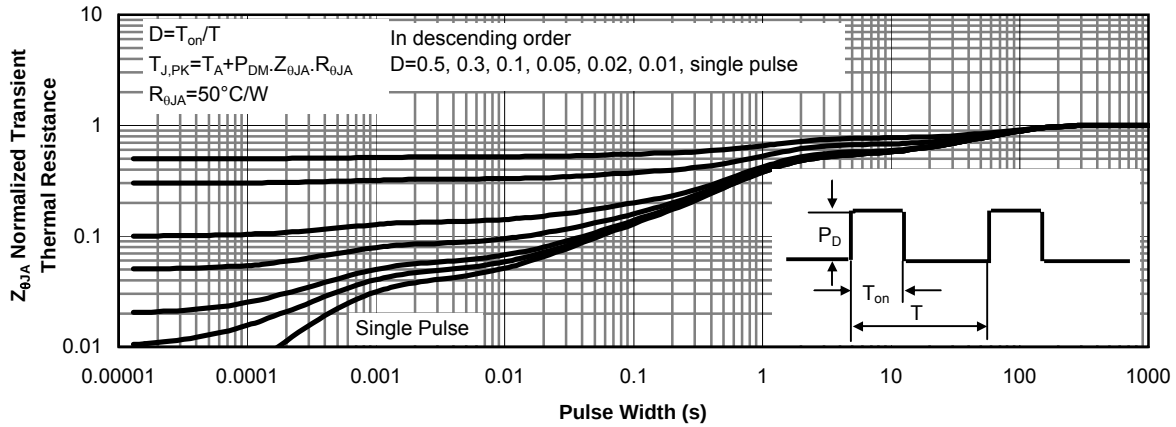
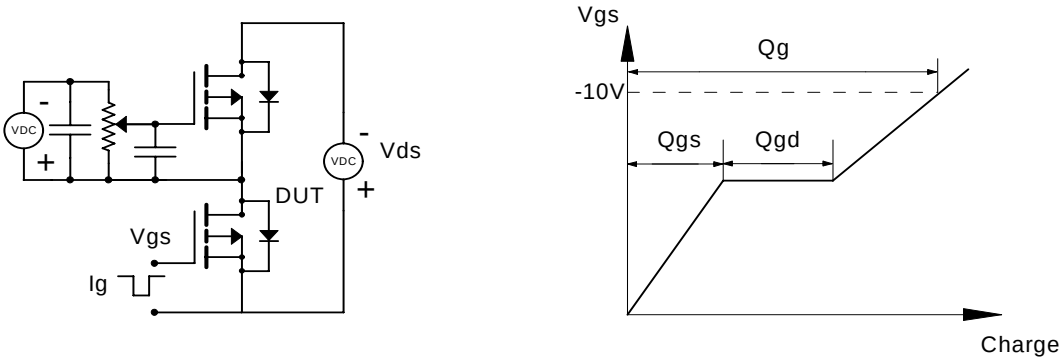
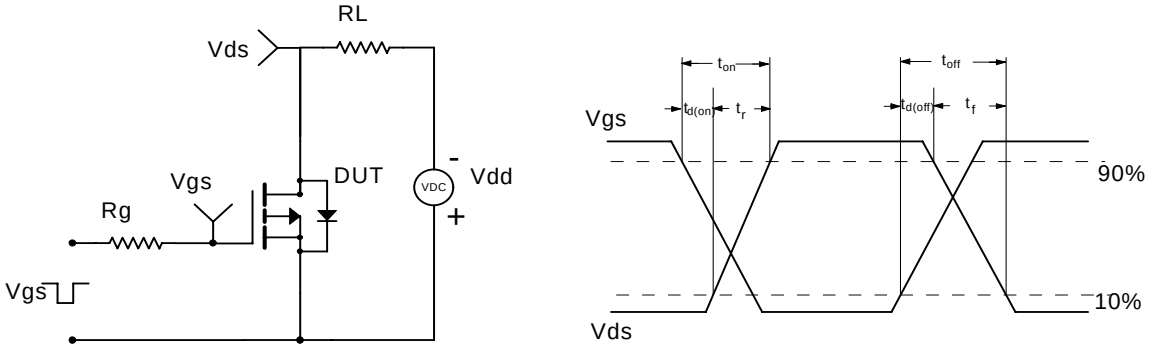


Figure 22: Normalized Maximum Transient Thermal Impedance

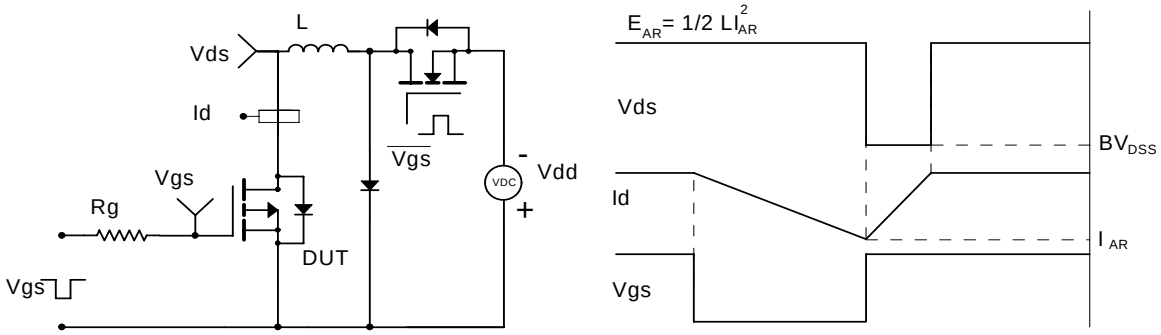
Gate Charge Test Circuit & Waveform



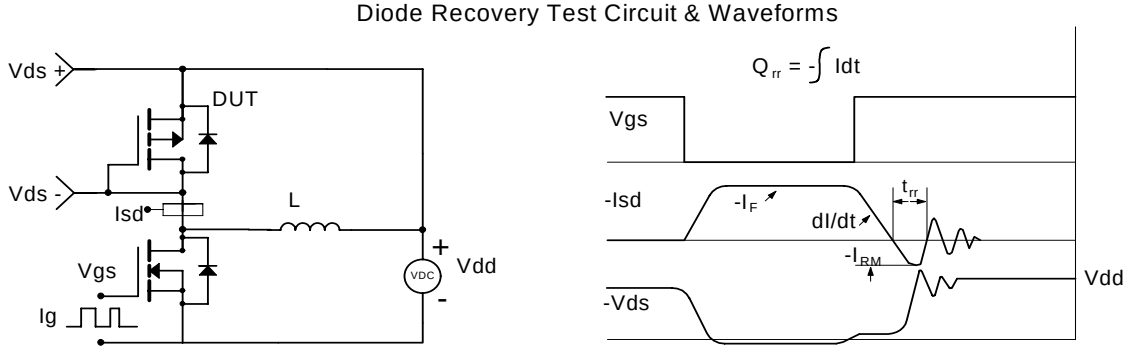
Resistive Switching Test Circuit & Waveforms



Unclamped Inductive Switching (UIS) Test Circuit & Waveforms



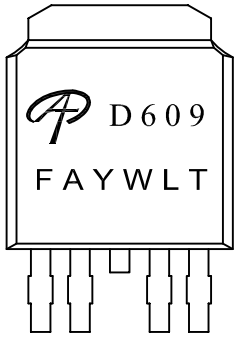
Diode Recovery Test Circuit & Waveforms



ALPHA & OMEGA SEMICONDUCTOR

Document No.	PD-00796
Version	C
Title	AOD609 Marking Description

DPAK PACKAGE MARKING DESCRIPTION



Green product

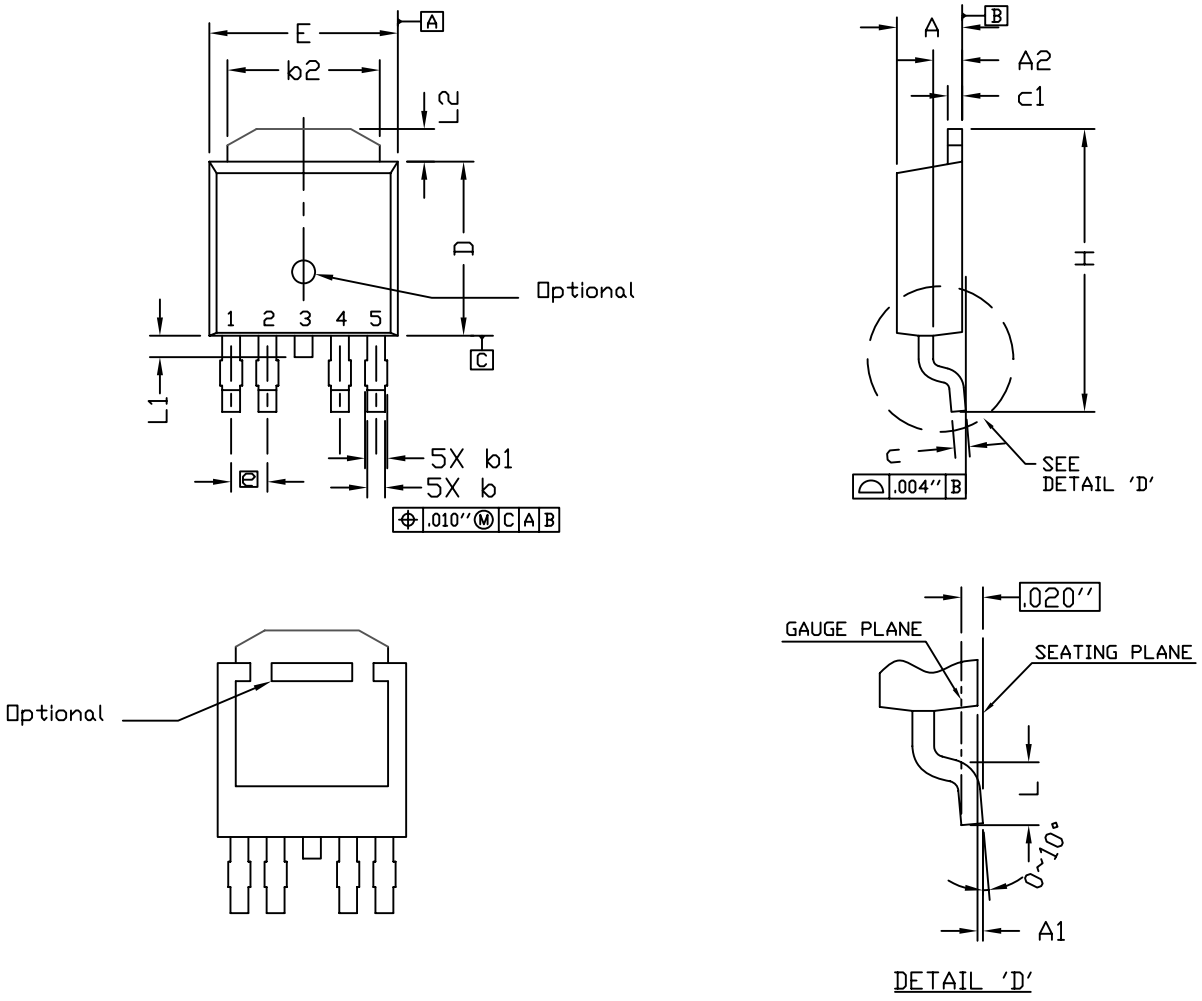
NOTE:
LOGO - AOS Logo
D609 - Part number code
F - Fab code
A - Assembly location code
Y - Year code
W - Week code
L&T - Assembly lot code

PART NO.	DESCRIPTION	CODE
AOD609	Green product	D609
AOD609L	Green product	D609

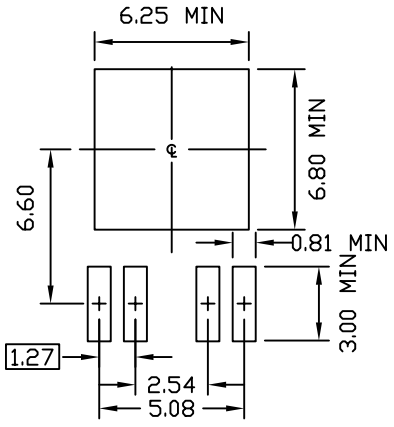
ALPHA & OMEGA
SEMICONDUCTOR, LTD.

Document No.	PO-00033
Version	rev E

TO252_4L 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	-----	1.143	0.035	-----	0.045
b	0.508	-----	0.711	0.020	-----	0.028
b1	0.584	-----	0.787	0.023	-----	0.031
b2	4.953	-----	5.461	0.195	-----	0.215
c	0.457	0.508	0.610	0.018	0.020	0.024
c1	0.457	-----	0.610	0.018	-----	0.024
D	5.969	6.096	6.223	0.235	0.240	0.245
E	6.350	6.604	6.731	0.250	0.260	0.265
e	1.270 BSC.			0.050 BSC.		
H	9.398	-----	10.414	0.370	-----	0.410
L	1.270	-----	2.032	0.050	-----	0.080
L1	-----	-----	1.016	-----	-----	0.040
L2	0.889	-----	1.270	0.035	-----	0.050

NOTE
1. PACKAGE BODY SIZES EXCLUDE MOLD FLASH AND GATE BURRS. MOLD FLASH SHOULD BE LESS THAN 6 MIL.
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 (AD).

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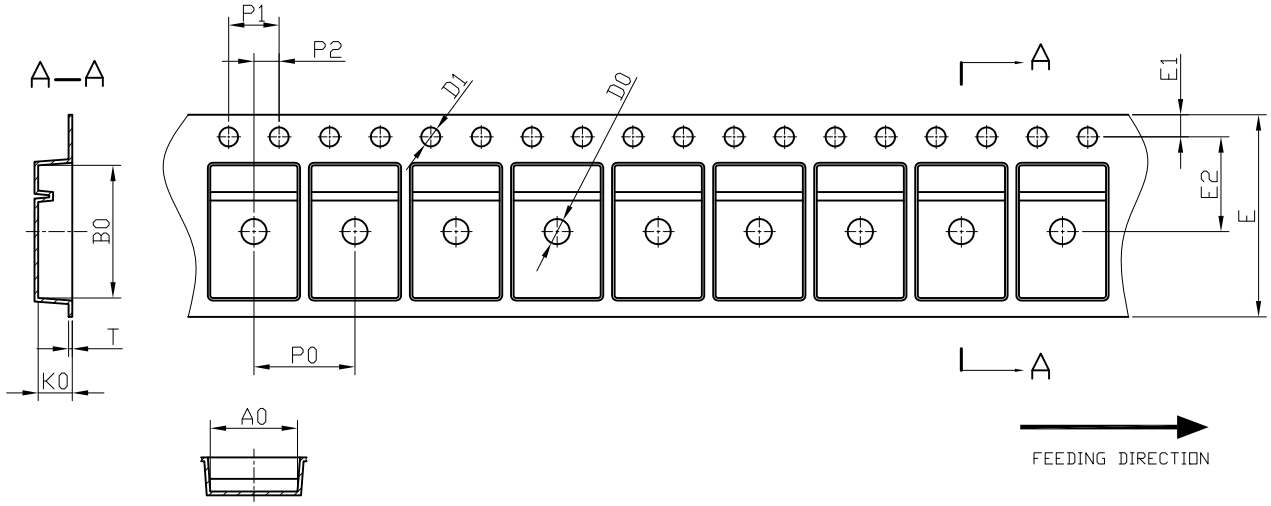
TO-252-4L Tape and Reel Data

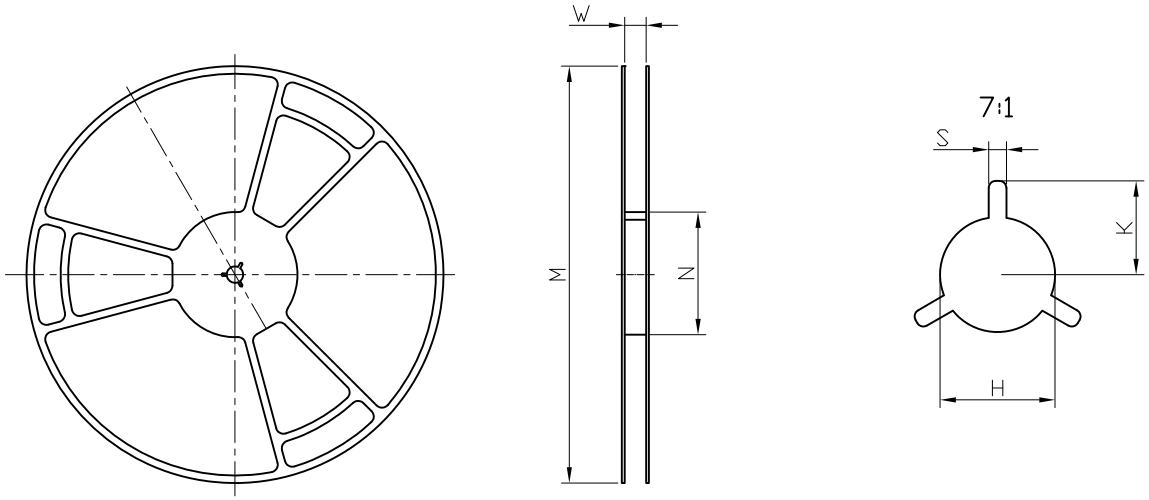
TO-252-4L Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
TO-252-4L (16 mm)	6.90 ±0.10	10.50 ±0.10	2.70 ±0.10	2.00 ±0.25	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

TO-252-4L Reel



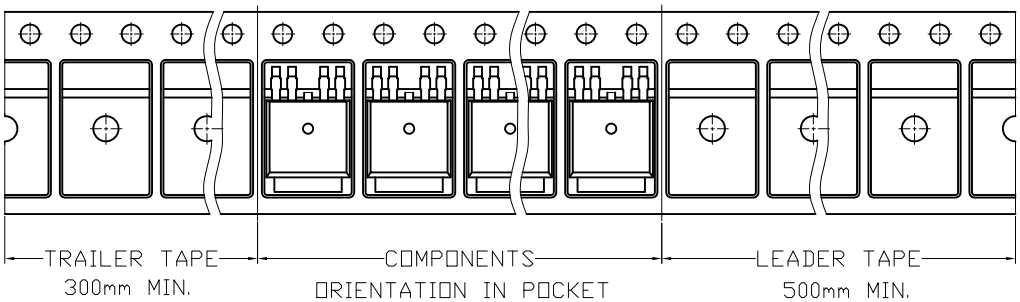
UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W	H	K	S
16 mm	ø330	ø330.00 ±0.5	ø97.00 ±1.0	17.0 +1.5 −0	ø13.00 +0.50 −0.20	10.6 ±0.25	2.0 ±0.5

TO-252-4L Tape

Leader / Trailer & Orientation

Unit Per Reel: 2500pcs



AOS Semiconductor
Product Reliability Report

AOD609, rev B

Plastic Encapsulated Device

ALPHA & OMEGA Semiconductor, Inc

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ALPHA & OMEGA SEMICONDUCTOR

This AOS product reliability report summarizes the qualification result for AOD609. 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 AOD609 passes AOS quality and reliability requirements. The released product will be categorized by the process family and be monitored on a quarterly basis for continuously improving the product quality.

Table of Contents:

I. Product Description
II. Package and Die information
III. Environmental Stress Test Summary and Result
IV. Reliability Evaluation

I. Product Description:

The AOD609 uses advanced trench technology MOSFETs to provide excellent $R_{DS(ON)}$ and low gate charge. The complementary MOSFETs may be used in H-bridge, Inverters and other applications.

-RoHS Compliant
-Halogen Free*

Absolute Maximum Ratings T_A=25°C unless otherwise noted					
Parameter		Symbol	Max n-channel	Max p-channel	Units
Drain-Source Voltage		V_{DS}	40	-40	V
Gate-Source Voltage		V_{GS}	±20	±20	V
Continuous Drain Current [B,H]	T_C=25°C	I_D	23	-20	A
	T_C=100°C		17	-14	
Pulsed Drain Current [B]		I_{DM}	30	-30	
Avalanche Current [C]		I_{AR}	14	-20	
Repetitive avalanche energy L=0.1mH [C]		E_{AR}	9.8	20	mJ
Power Dissipation	T_C=25°C	P_D	27	30	W
	T_C=100°C		14	15	
Power Dissipation	T_A=25°C	P_{DSM}	2	2	W
	T_A=70°C		1.3	1.3	
Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 175	-55 to 175	°C

Thermal Characteristics: n-channel and p-channel						
Parameter		Symbol	Device	Typ	Max	Units
Maximum Junction-to-Ambient [A,D]	t ≤ 10s	$R_{\theta JA}$	n-ch	17.4	25	°C/W
Maximum Junction-to-Ambient [A,D]	Steady-State		n-ch	50	60	°C/W
Maximum Junction-to-Lead [C]	Steady-State	$R_{\theta JC}$	n-ch	4	5.5	°C/W
Maximum Junction-to-Ambient [A,D]	t ≤ 10s	$R_{\theta JA}$	p-ch	16.7	25	°C/W
Maximum Junction-to-Ambient [A,D]	Steady-State		p-ch	50	60	°C/W
Maximum Junction-to-Lead [C]	Steady-State	$R_{\theta JC}$	p-ch	3.5	5	°C/W

ALPHA & OMEGA SEMICONDUCTOR

II. Die / Package Information:

	AOD609
Process	Standard sub-micron Low voltage N+P channel process
Package Type	3 leads TO252
Lead Frame	Cu, S/pad, Ag spot
Die Attach	Ag epoxy
Bond wire	G:1.3 mils Au; S: 2mils Cu
Mold Material	Epoxy resin with silica filler
Flammability Rating	UL-94 V-0
Backside Metallization	Ti / Ni / Ag
Moisture Level	Up to Level 1 *

Note * based on info provided by assembler and mold compound supplier

III. Result of Reliability Stress for AOD609

Test Item	Test Condition	Time Point	Lot Attribution	Total Sample size	Number of Failures
Solder Reflow Precondition	**168hr 85°c /85%RH +3 cycle reflow@260°c**	**-**	**9 lots**	**1210pcs**	**0**
HTGB	**Temp = 150°c , Vgs=100% of Vgsmax**	**168 / 500 hrs** **1000 hrs**	**1 lot** **(Note A*)**	**82pcs** **77+5 pcs / lot**	**0**
HTRB	**Temp = 150°c , Vds=80% of Vdsmax**	**168 / 500 hrs** **1000 hrs**	**1 lot** **(Note A*)**	**82pcs** **77+5 pcs / lot**	**0**
HAST	**130 +/- 2°c , 85%RH, 33.3 psi, Vgs = 80% of Vgs max**	**100 hrs**	**9 lots** **(Note B**)**	**495pcs** **50+5 pcs / lot**	**0**
Pressure Pot	**121°c , 29.7psi, RH=100%**	**96 hrs**	**5 lots** **(Note B**)**	**275pcs** **50+5 pcs / lot**	**0**
Temperature Cycle	**-65°c to 150°c , air to air,**	**250 / 500 cycles**	**8 lots** **(Note B**)**	**440pcs** **50+5 pcs / lot**	**0**

ALPHA & OMEGA SEMICONDUCTOR

III. Result of Reliability Stress for AOD609

Continues

DPA	**Internal Vision** **Cross-section** **X-ray**	**NA**	**5** **5** **5**	**5** **5** **5**	**0**
CSAM		**NA**	**5**	**5**	**0**
Bond Integrity	**Room Temp** **150°c bake** **150°c bake**	**0hr** **250hr** **500hr**	**40** **40** **40**	**40 wires** **40 wires** **40 wires**	**0**
Solderability	**245°c**	**5 sec**	**15**	**15 leads**	**0**
Solder dunk	**260°c**	**10secs** **3 cycles**	**1**	**30 units**	**0**

Note A: The HTGB and HTRB reliability data presents total of available AOD609 burn-in data up to the published date.
Note B: The pressure pot, temperature cycle and HAST reliability data for AOD609 comes from the AOS generic package qualification data.

IV. Reliability Evaluation

FIT rate (per billion): 64
MTTF = 1780 years

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size of the selected product (AOD609). 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)**]** = 1.83×10^9 / **[**2 (164) (500) (258)**]** = 64
MTTF = 10^9 / FIT = 1.56×10^7hrs = 1780 years

Chi² = Chi Squared Distribution, determined by the number of failures and confidence interval
N = Total Number of units from HTRB and HTGB tests
H = Duration of HTRB/HTGB 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	258	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, 8.617164×10^{-5}eV / K