



# THE DATASHEET OF AO6401

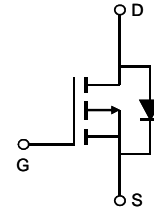
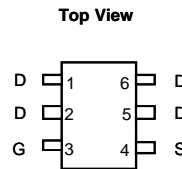
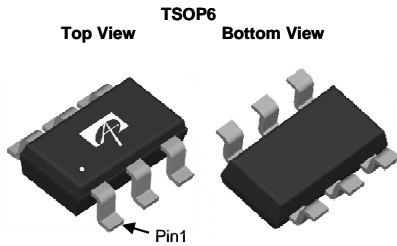


### General Description

The AO6401 uses advanced trench technology to provide excellent  $R_{DS(ON)}$ , low gate charge and operation with gate voltages as low as 2.5V. This device is suitable for use as a load switch or in PWM applications.

### Product Summary

$V_{DS}$	-30V
$I_D$ (at $V_{GS}=-10V$ )	-5A
$R_{DS(ON)}$ (at $V_{GS}=-10V$ )	< 47m $\Omega$
$R_{DS(ON)}$ (at $V_{GS}=-4.5V$ )	< 64m $\Omega$
$R_{DS(ON)}$ (at $V_{GS}=-2.5V$ )	< 85m $\Omega$



### Absolute Maximum Ratings $T_A=25^\circ\text{C}$ unless otherwise noted

Parameter	Symbol	Maximum	Units
Drain-Source Voltage	$V_{DS}$	-30	V
Gate-Source Voltage	$V_{GS}$	$\pm 12$	V
Continuous Drain Current	$I_D$	$T_A=25^\circ\text{C}$	-5
		$T_A=70^\circ\text{C}$	-4
Pulsed Drain Current <sup>C</sup>	$I_{DM}$	-28	A
Power Dissipation <sup>B</sup>	$P_D$	$T_A=25^\circ\text{C}$	2
		$T_A=70^\circ\text{C}$	1.3
Junction and Storage Temperature Range	$T_J, T_{STG}$	-55 to 150	$^\circ\text{C}$

### Thermal Characteristics

Parameter	Symbol	Typ	Max	Units
Maximum Junction-to-Ambient <sup>A</sup> $t \leq 10\text{s}$	$R_{\theta JA}$	47.5	62.5	$^\circ\text{C/W}$
Maximum Junction-to-Ambient <sup>A,D</sup> Steady-State		74	110	$^\circ\text{C/W}$
Maximum Junction-to-Lead Steady-State	$R_{\theta JL}$	37	50	$^\circ\text{C/W}$

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>STATIC PARAMETERS</b>						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	I <sub>D</sub> =-250μA, V <sub>GS</sub> =0V	-30			V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> =-30V, V <sub>GS</sub> =0V T <sub>J</sub> =55°C			-1 -5	μA
I <sub>GSS</sub>	Gate-Body leakage current	V <sub>DS</sub> =0V, V <sub>GS</sub> =±12V			±100	nA
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> =V <sub>GS</sub> , I <sub>D</sub> =-250μA	-0.5	-0.9	-1.3	V
I <sub>D(ON)</sub>	On state drain current	V <sub>GS</sub> =-10V, V <sub>DS</sub> =-5V	-28			A
R <sub>DS(ON)</sub>	Static Drain-Source On-Resistance	V <sub>GS</sub> =-10V, I <sub>D</sub> =-5A T <sub>J</sub> =125°C		39 60	47 74	mΩ
		V <sub>GS</sub> =-4.5V, I <sub>D</sub> =-4A		45	64	mΩ
		V <sub>GS</sub> =-2.5V, I <sub>D</sub> =-1A		59	85	mΩ
g <sub>FS</sub>	Forward Transconductance	V <sub>DS</sub> =-5V, I <sub>D</sub> =-5A		18		S
V <sub>SD</sub>	Diode Forward Voltage	I <sub>S</sub> =-1A, V <sub>GS</sub> =0V		-0.7	-1	V
I <sub>S</sub>	Maximum Body-Diode Continuous Current				-2.5	A
<b>DYNAMIC PARAMETERS</b>						
C <sub>iss</sub>	Input Capacitance	V <sub>GS</sub> =0V, V <sub>DS</sub> =-15V, f=1MHz		645	780	pF
C <sub>oss</sub>	Output Capacitance			80		pF
C <sub>rss</sub>	Reverse Transfer Capacitance			55	80	pF
R <sub>g</sub>	Gate resistance	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, f=1MHz	4	7.8	12	Ω
<b>SWITCHING PARAMETERS</b>						
Q <sub>g(10V)</sub>	Total Gate Charge	V <sub>GS</sub> =-10V, V <sub>DS</sub> =-15V, I <sub>D</sub> =-5A		14	17	nC
Q <sub>g(4.5V)</sub>	Total Gate Charge			7	8.5	nC
Q <sub>gs</sub>	Gate Source Charge			1.5		nC
Q <sub>gd</sub>	Gate Drain Charge			2.5		nC
t <sub>D(on)</sub>	Turn-On DelayTime	V <sub>GS</sub> =-10V, V <sub>DS</sub> =-15V, R <sub>L</sub> =3Ω, R <sub>GEN</sub> =3Ω		6.5		ns
t <sub>r</sub>	Turn-On Rise Time			3.5		ns
t <sub>D(off)</sub>	Turn-Off DelayTime			41		ns
t <sub>f</sub>	Turn-Off Fall Time			9		ns
t <sub>rr</sub>	Body Diode Reverse Recovery Time	I <sub>F</sub> =-5A, di/dt=100A/μs		11	13.5	ns
Q <sub>rr</sub>	Body Diode Reverse Recovery Charge	I <sub>F</sub> =-5A, di/dt=100A/μs		3.5		nC

A. The value of R<sub>θJA</sub> is measured with the device mounted on 1in<sup>2</sup> FR-4 board with 2oz. Copper, in a still air environment with T<sub>A</sub>=25° C. The value in any given application depends on the user's specific board design.

B. The power dissipation P<sub>D</sub> is based on T<sub>J(MAX)</sub>=150° C, using ≤ 10s junction-to-ambient thermal resistance.

C. Repetitive rating, pulse width limited by junction temperature T<sub>J(MAX)</sub>=150° C. Ratings are based on low frequency and duty cycles to keep initial T<sub>J</sub>=25° C.

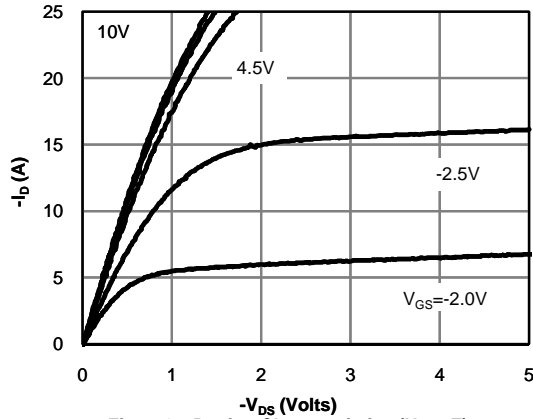
D. The R<sub>θJA</sub> is the sum of the thermal impedance from junction to lead R<sub>θJL</sub> and lead to ambient.

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

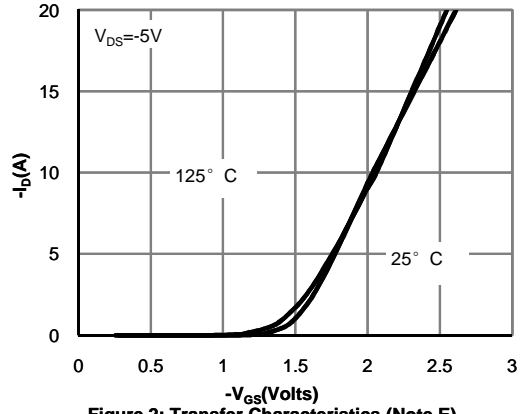
F. These curves are based on the junction-to-ambient thermal impedance which is measured with the device mounted on 1in<sup>2</sup> FR-4 board with 2oz. Copper, assuming a maximum junction temperature of T<sub>J(MAX)</sub>=150° C. The SOA curve provides a single pulse rating.

THIS PRODUCT HAS BEEN DESIGNED AND QUALIFIED FOR THE CONSUMER MARKET. APPLICATIONS OR USES AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS ARE NOT AUTHORIZED. AOS DOES NOT ASSUME ANY LIABILITY ARISING OUT OF SUCH APPLICATIONS OR USES OF ITS PRODUCTS. AOS RESERVES THE RIGHT TO IMPROVE PRODUCT DESIGN, FUNCTIONS AND RELIABILITY WITHOUT NOTICE.

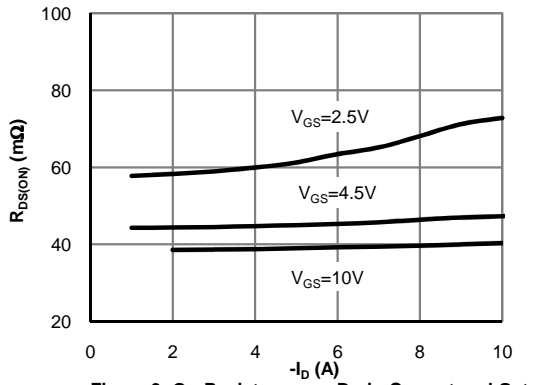
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



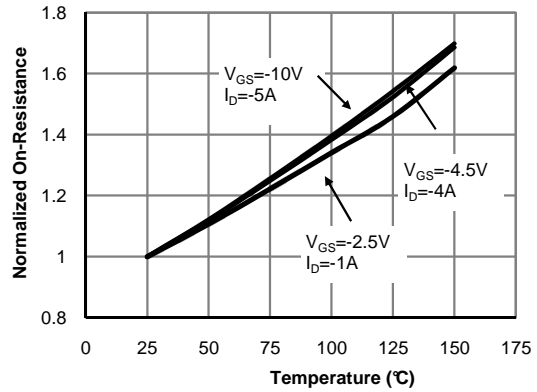
**Figure 1: On-Region Characteristics (Note E)**



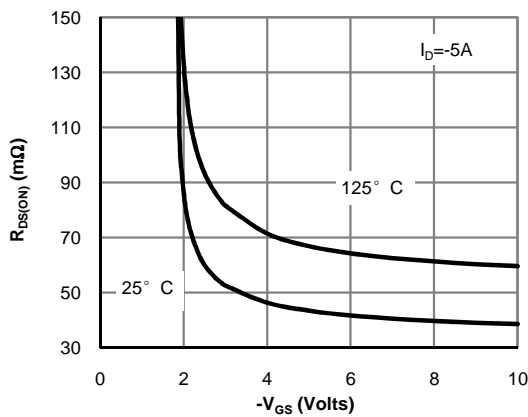
**Figure 2: Transfer Characteristics (Note E)**



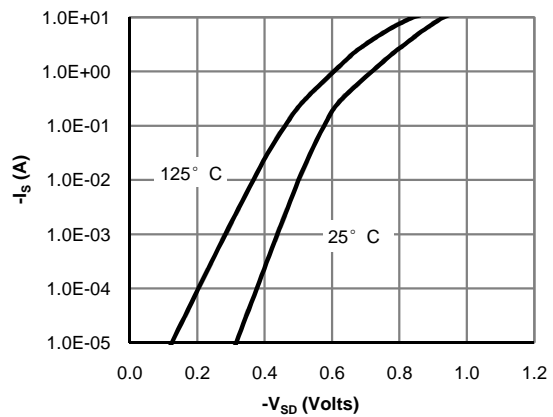
**Figure 3: On-Resistance vs. Drain Current and Gate Voltage (Note E)**



**Figure 4: On-Resistance vs. Junction Temperature (Note E)**

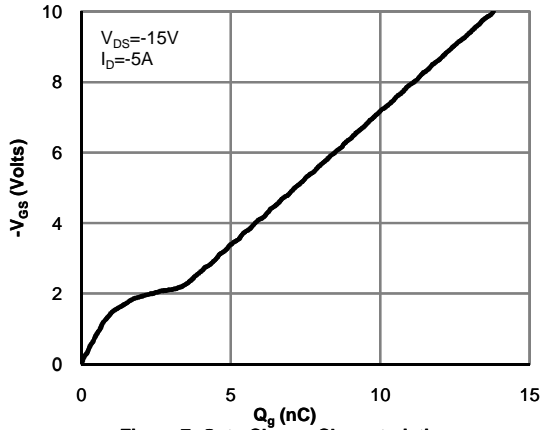


**Figure 5: On-Resistance vs. Gate-Source Voltage (Note E)**

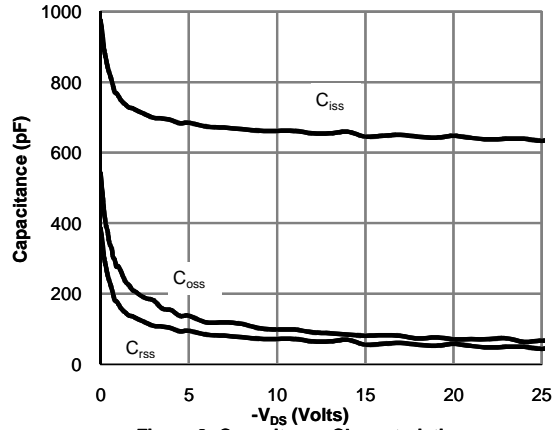


**Figure 6: Body-Diode Characteristics (Note E)**

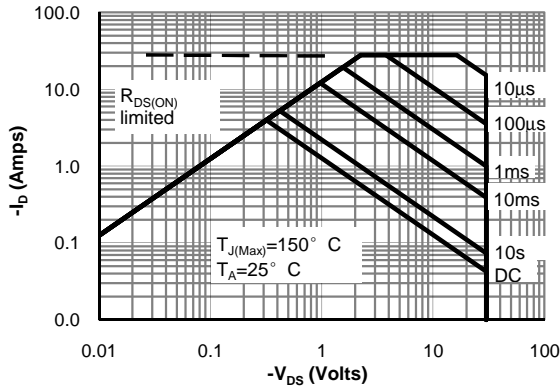
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



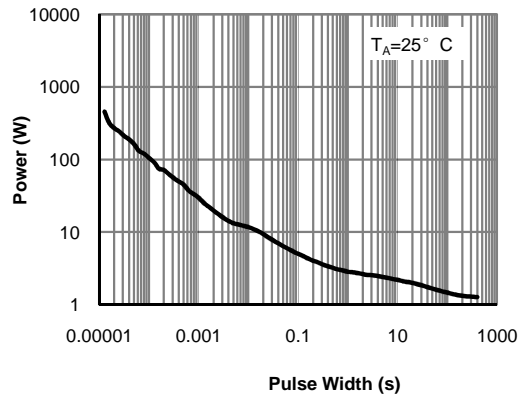
**Figure 7: Gate-Charge Characteristics**



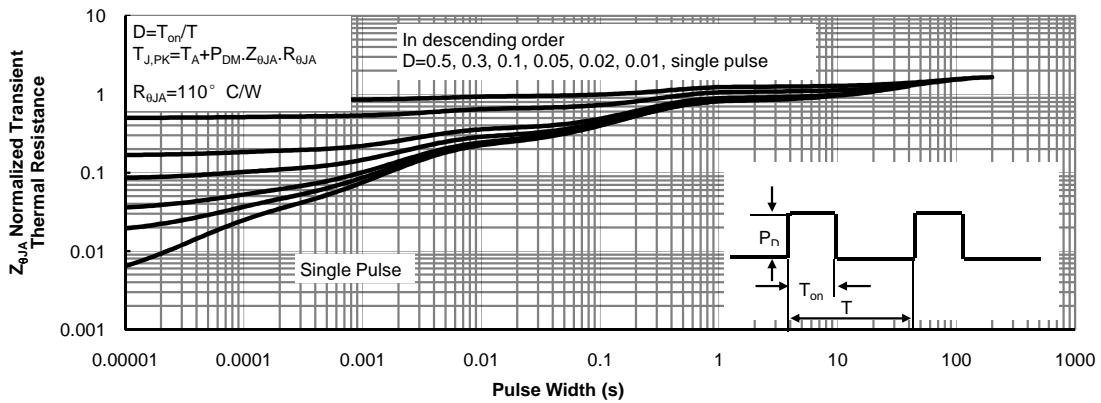
**Figure 8: Capacitance Characteristics**



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

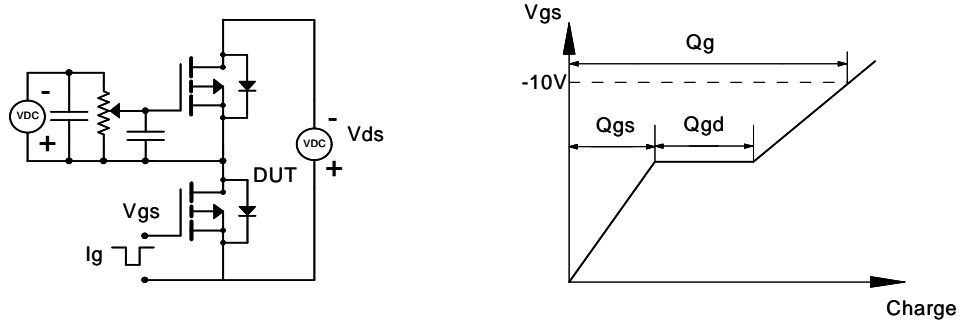


**Figure 10: Single Pulse Power Rating Junction-to-Ambient (Note F)**

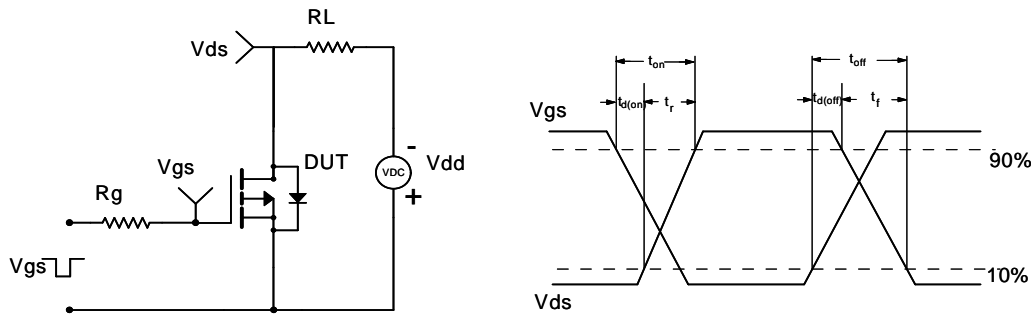


**Figure 11: Normalized Maximum Transient Thermal Impedance (Note F)**

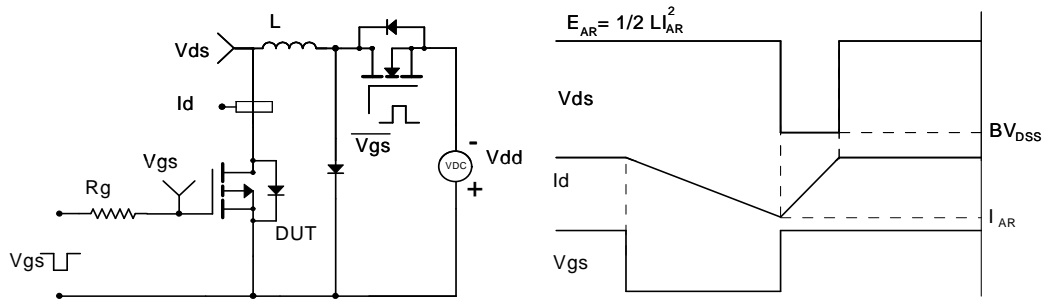
**Gate Charge Test Circuit & Waveform**



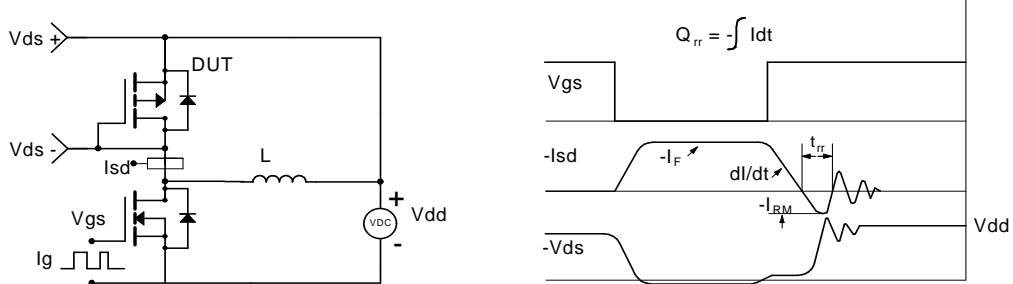
**Resistive Switching Test Circuit & Waveforms**



**Unclamped Inductive Switching (UIS) Test Circuit & Waveforms**



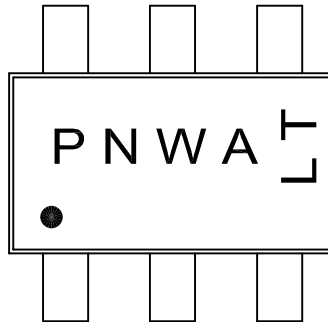
**Diode Recovery Test Circuit & Waveforms**





Document No.	PD-00119
Version	E
Title	AO6401 Marking Description

TSOP-6 PACKAGE MARKING DESCRIPTION



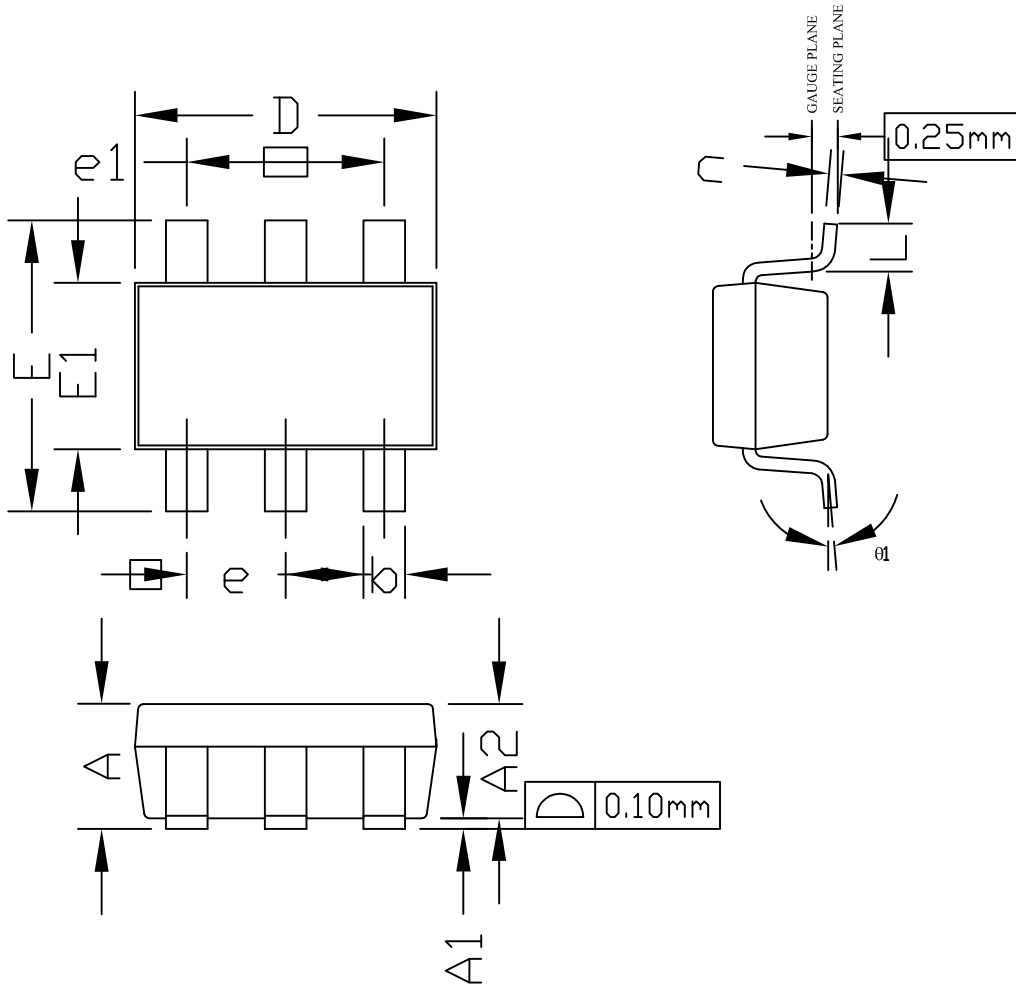
Green product

NOTE:

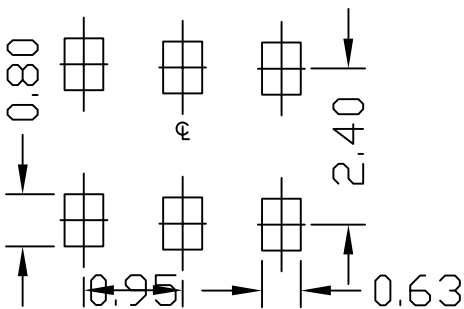
- P - Package and product type
- N - Last digital of product number
- W - Year and week code
- A - Assembly location code
- L&T - Assembly lot code

PART NO.	DESCRIPTION	CODE (PN)
AO6401	Green product	D1
AO6401L	Green product	D1

### TSOP6 PACKAGE OUTLINE



#### RECOMMENDED LAND PATTERN



UNIT: mm

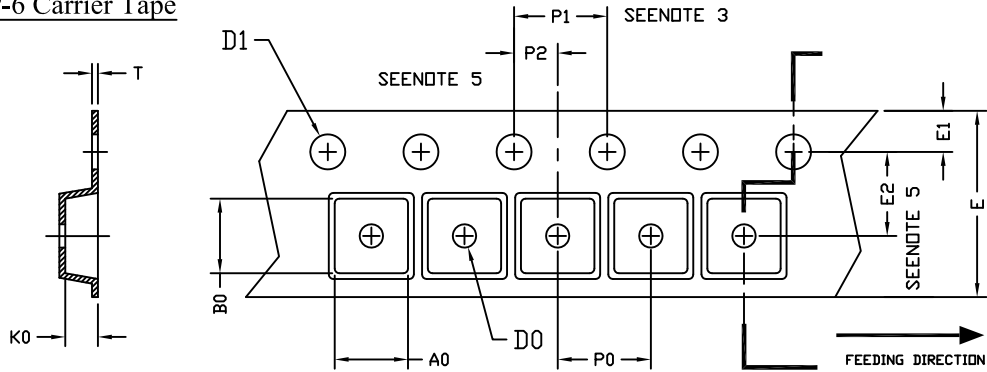
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	—	1.25	0.031	—	0.049
A1	0.00	—	0.15	0.000	—	0.006
A2	0.70	1.10	1.20	0.028	0.043	0.047
b	0.30	0.40	0.50	0.012	0.016	0.020
c	0.08	0.13	0.20	0.003	0.005	0.008
D	2.70	2.90	3.10	0.106	0.114	0.122
E	2.50	2.80	3.10	0.098	0.110	0.122
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95 BSC.			0.037BSC.		
e1	1.90 BSC.			0.075 BSC.		
L	0.30	—	0.60	0.012	—	0.024
θ1	0°	—	8°	0°	—	8°

#### NOTE

- PACKAGE BODY SIZES EXCLUDE MOLD FLASH AND GATE BURRS.  
MOLD FLASH AT THE NON-LEAD SIDES SHOULD BE LESS THAN 5 MILS EACH.
- DIMENSION "L" IS MEASURED IN GAUGE PLANE.
- TOLERANCE ±0.100 mm(4 mil) UNLESS OTHERWISE SPECIFIED.
- FOLLOWED FROM JEDEC MO-178C & MO-193C.
- CONTROLLING DIMENSIONS IS MILLIMETER.  
CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.



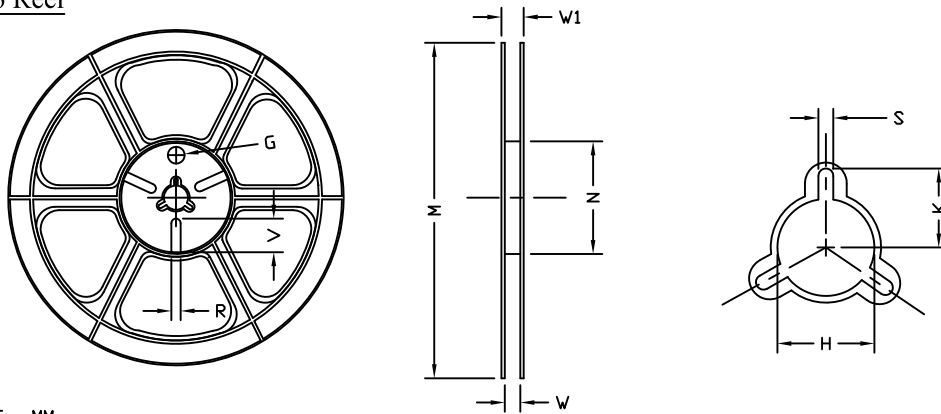
TSOP-6 Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
SDT-23 (8 mm)	3.15 ±0.10	3.27 ±0.10	1.34 ±0.10	1.10 ±0.01	1.50 +0.10	8.00 ±0.20	1.75 ±0.10	3.50 ±0.05	4.00 ±0.10	4.00 ±0.10	2.00 ±0.10	0.25 ±0.05

TSOP-6 Reel



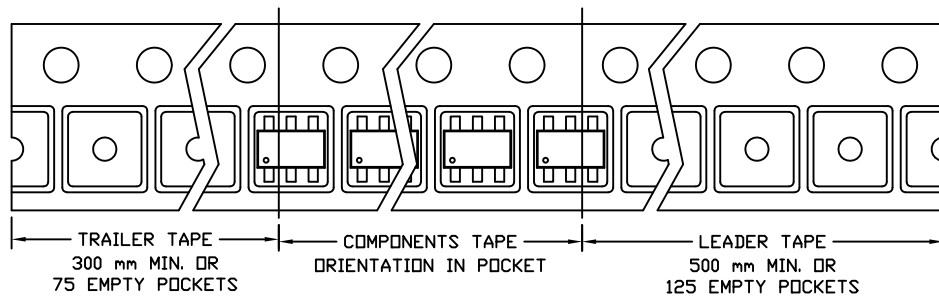
UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W	W1	H	K	S	G	R	V
8 mm	Ø180	Ø180.00 ±0.50	Ø60.50	9.00 ±0.30	11.40 ±1.00	Ø13.00 +0.50 -0.20	10.60	2.00 ±0.50	Ø9.00	5.00	18.00

TSOP-6 Tape

Leader / Trailer  
& Orientation

Unit Per Reel:  
3000pcs





# **AOS Semiconductor Product Reliability Report**

**AO6401/AO6401L, rev B**

**Plastic Encapsulated Device**

**ALPHA & OMEGA Semiconductor, Inc**

**495 Mercury Drive  
Sunnyvale, CA 94085  
U.S.**

**Tel: (408) 830-9742**

**[www.aosmd.com](http://www.aosmd.com)**

**Aug 4, 2006**

This AOS product reliability report summarizes the qualification result for AO6401. 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 AO6401 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
- V. Quality Assurance Information

### I. Product Description:

The AO6401 uses advanced trench technology to provide excellent  $R_{DS(ON)}$ , low gate charge and operation with gate voltages as low as 2.5V. This device is suitable for use as a load switch or in PWM applications. Standard Product AO6401 is Pb-free (meets ROHS & Sony 259 specifications). AO6401L is a Green Product ordering option. AO6401 and AO6401L are electrically identical.

Absolute Maximum Ratings $T_A=25^\circ\text{C}$ unless otherwise noted				
Parameter		Symbol	Maximum	Units
Drain-Source Voltage		$V_{DS}$	-30	V
Gate-Source Voltage		$V_{GS}$	$\pm 12$	V
Continuous Drain Current	$T_A=25^\circ\text{C}$	$I_D$	-5	A
	$T_A=70^\circ\text{C}$		-4.2	
Pulsed Drain Current		$I_{DM}$	-30	
Power Dissipation	$T_A=25^\circ\text{C}$	$P_D$	2	W
	$T_A=70^\circ\text{C}$		1.44	
Junction and Storage Temperature Range		$T_J, T_{STG}$	-55 to 150	$^\circ\text{C}$

Thermal Characteristics					
Parameter		Symbol	Typ	Max	Units
Maximum Junction-to-Ambient	$T \leq 10\text{s}$	$R_{\theta JA}$	47.5	62.5	$^\circ\text{C/W}$
	Steady-State		74	110	$^\circ\text{C/W}$
Maximum Junction-to-Lead	Steady-State	$R_{\theta JL}$	37	50	$^\circ\text{C/W}$

## II. Die / Package Information:

	<b>AO6401</b>	<b>AO6401L (Green Compound)</b>
<b>Process</b>	Standard sub-micron low voltage P channel process	Standard sub-micron low voltage P channel process
<b>Package Type</b>	6 leads TSOP	6 leads TSOP
<b>Lead Frame</b>	Copper with Ag spot	Copper with Ag spot
<b>Die Attach</b>	Ag epoxy	Ag epoxy
<b>Bond wire</b>	Au 2mils	Au 2mils
<b>Mold Material</b>	Epoxy resin with silica filler	Epoxy resin with silica filler
<b>Filler % (Spherical/Flake)</b>	90/10	100/0
<b>Flammability Rating</b>	UL-94 V-0	UL-94 V-0
<b>Backside Metallization</b>	Ti / Ni / Ag	Ti / Ni / Ag
<b>Moisture Level</b>	Up to Level 1 *	Up to Level 1 *

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

## III. Result of Reliability Stress for AO6401 (Standard) & AO6401L (Green)

Test Item	Test Condition	Time Point	Lot Attribution	Total Sample size	Number of Failures
Solder Reflow Precondition	Standard: 1hr PCT+3 cycle reflow @260°C Green: 168hr 85°C /85%RH +3 cycle reflow @260°C	0hr	Standard: 16 lots Green: 7 lots	3575pcs	0
HTGB	Temp = 150°C , Vgs=100% of Vgsmax	168 / 500 hrs  1000 hrs	5 lots  (Note A*)	410pcs  77+5 pcs / lot	0
HTRB	Temp = 150°C , Vds=80% of Vdsmax	168 / 500 hrs  1000 hrs	5 lots  (Note A*)	410pcs  77+5 pcs / lot	0
HAST	130 +/- 2°C , 85%RH, 33.3 psi, Vgs = 80% of Vgs max	100 hrs	Standard: 16 lots Green: 6 lots  (Note B**)	1210pcs  50+5 pcs / lot	0
Pressure Pot	121°C , 29.7 psi, 100%RH	96 hrs	Standard: 14 lots Green: 7 lots  (Note B**)	1155pcs  50+5 pcs / lot	0
Temperature Cycle	-65 to 150°C , air to air	250 / 500 cycles	Standard: 15 lots Green: 7 lots  (Note B**)	1210pcs  50+5 pcs / lot	0

### III. Result of Reliability Stress for AO6401 (Standard) & AO6401L (Green)

Continues

<b>DPA</b>	<b>Internal Vision Cross-section X-ray</b>	<b>NA</b>	<b>5 5 5</b>	<b>5 5 5</b>	<b>0</b>
<b>CSAM</b>		<b>NA</b>	<b>5</b>	<b>5</b>	<b>0</b>
<b>Bond Integrity</b>	<b>Room Temp 150°C bake 150°C bake</b>	<b>0hr 250hr 500hr</b>	<b>40 40 40</b>	<b>40 wires 40 wires 40 wires</b>	<b>0</b>
<b>Solderability</b>	<b>230°C</b>	<b>5 sec</b>	<b>15</b>	<b>15 leads</b>	<b>0</b>
<b>Die shear</b>	<b>150°C</b>	<b>0hr</b>	<b>10</b>	<b>10</b>	<b>0</b>

**Note A:** The HTGB and HTRB reliability data presents total of available AO6401 and AO6401L burn-in data up to the published date.

**Note B:** The pressure pot, temperature cycle and HAST reliability data for AO6401 and AO6401L comes from the AOS generic package qualification data.

### IV. Reliability Evaluation

**FIT rate (per billion): 9.3**

**MTTF = 12274 years**

In general, 500 hrs of HTGB, 150 deg C accelerated stress testing is equivalent to 15 years of lifetime at 55 deg C operating conditions (by applying the Arrhenius equation with an activation energy of 0.7eV and 60% of upper confidence level on the failure rate calculation). AOS reliability group also routinely monitors the product reliability up to 1000 hr at and performs the necessary failure analysis on the units failed for reliability test(s).

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size of the selected product (AO6401). Failure Rate Determination is based on JEDEC Standard JESD 85. FIT means one failure per billion hours.

$$\begin{aligned} \text{Failure Rate} &= \text{Chi}^2 \times 10^9 / 2[(N) (H) (Af)] \\ &= 1.83 \times 10^9 / 2 [(2 \times 164) (168) (258) + (2 \times 164) (500) (258) + (164) (1000) (258)] \\ &= 9.3 \end{aligned}$$

$$\text{MTTF} = 10^9 / \text{FIT} = 1.07 \times 10^8 \text{hrs} = 12274 \text{ years}$$

**Chi<sup>2</sup>** = 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**] =  $\text{Exp} [E_a / k (1/T_j u - 1/T_j s)]$

**Acceleration Factor ratio list:**

	<b>55 deg C</b>	<b>70 deg C</b>	<b>85 deg C</b>	<b>100 deg C</b>	<b>115 deg C</b>	<b>130 deg C</b>	<b>150 deg C</b>
<b>Af</b>	<b>258</b>	<b>87</b>	<b>32</b>	<b>13</b>	<b>5.64</b>	<b>2.59</b>	<b>1</b>

**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<sup>-5</sup>eV / K



## V. Quality Assurance Information

Acceptable Quality Level for outgoing inspection: **0.1%** for electrical and visual.

Guaranteed Outgoing Defect Rate: **< 25 ppm**

Quality Sample Plan: conform to **Mil-Std-105D**

## Looking for pricing, stock, or lifecycle information?

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- [Alpha & Omega Semiconductor Inc. Information](#)

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- ✓ Shortage Management
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