ALPHA & OMEGA SEMICONDUCTOR

# AO6405
30V P-Channel MOSFET

General Description

The AO6405 uses advanced trench technology to provide excellent $R_{DS(ON)}$ with low gate charge. 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)	< 52mΩ
$R_{DS(ON)}$ (at V_{GS} = 4.5V)	< 87mΩ

Green Product

TSOP6
Top View   Bottom View

Top View

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D ⊏ 1      6 ⊐ D
D ⊏ 2      5 ⊐ D
G ⊏ 3      4 ⊐ S
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Pin1
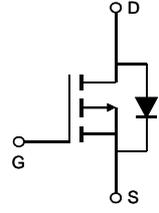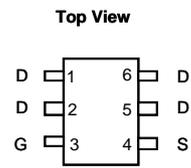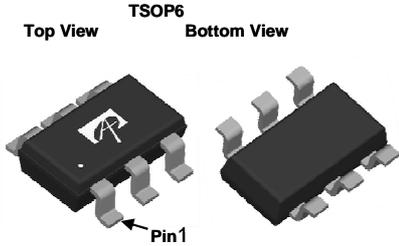
Absolute Maximum Ratings T_A=25℃ unless otherwise noted

Parameter		Symbol	Maximum	Units
Drain-Source Voltage		V_{DS}	-30	V
Gate-Source Voltage		V_{GS}	±20	V
Continuous Drain Current	T_A=25℃	I_D	-5	A
	T_A=70℃		-4.2	
Pulsed Drain Current ^{C}		I_{DM}	-20	
Power Dissipation ^{B}	T_A=25℃	P_D	2	W
	T_A=70℃		1.3	
Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 150	℃

Thermal Characteristics

Parameter		Symbol	Typ	Max	Units
Maximum Junction-to-Ambient ^{A}	t ≤ 10s	$R_{θJA}$	47.5	62.5	℃/W
Maximum Junction-to-Ambient $^{A\,D}$	Steady-State		74	110	℃/W
Maximum Junction-to-Lead	Steady-State	$R_{θJL}$	37	50	℃/W

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Electrical Characteristics (T$_J$=25℃ unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
STATIC PARAMETERS							
BV$_{DSS}$	Drain-Source Breakdown Voltage	I$_D$=-250µA, V$_{GS}$=0V		-30			V
I$_{DSS}$	Zero Gate Voltage Drain Current	V$_{DS}$=-30V, V$_{GS}$=0V				-1	µA
			T$_J$=55℃			-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		-1.4	-1.9	-2.4	V
I$_{D(ON)}$	On state drain current	V$_{GS}$=-10V, V$_{DS}$=-5V		-20			A
R$_{DS(ON)}$	Static Drain-Source On-Resistance	V$_{GS}$=-10V, I$_D$=-5A			34	52	mΩ
			T$_J$=125℃		52	70	
		V$_{GS}$=-4.5V, I$_D$=-4A			54	87	mΩ
g$_{FS}$	Forward Transconductance	V$_{DS}$=-5V, I$_D$=-5A			10		S
V$_{SD}$	Diode Forward Voltage	I$_S$=-1A,V$_{GS}$=0V			-0.7	-1	V
I$_S$	Maximum Body-Diode Continuous Current					-2.5	A
DYNAMIC PARAMETERS							
C$_{iss}$	Input Capacitance	V$_{GS}$=0V, V$_{DS}$=-15V, f=1MHz			520		pF
C$_{oss}$	Output Capacitance				100		pF
C$_{rss}$	Reverse Transfer Capacitance				65		pF
R$_g$	Gate resistance	V$_{GS}$=0V, V$_{DS}$=0V, f=1MHz		3.5	7.5	11.5	Ω
SWITCHING PARAMETERS							
Q$_g$(10V)	Total Gate Charge	V$_{GS}$=-10V, V$_{DS}$=-15V, I$_D$=-5A			9.2	11	nC
Q$_g$(4.5V)	Total Gate Charge				4.6	6	nC
Q$_{gs}$	Gate Source Charge				1.6		nC
Q$_{gd}$	Gate Drain Charge				2.2		nC
t$_{D(on)}$	Turn-On DelayTime	V$_{GS}$=-10V, V$_{DS}$=-15V, R$_L$=3Ω, R$_{GEN}$=3Ω			7.5		ns
t$_r$	Turn-On Rise Time				5.5		ns
t$_{D(off)}$	Turn-Off DelayTime				19		ns
t$_f$	Turn-Off Fall Time				7		ns
t$_{rr}$	Body Diode Reverse Recovery Time	I$_F$=-5A, dI/dt=100A/µs			11		ns
Q$_{rr}$	Body Diode Reverse Recovery Charge	I$_F$=-5A, dI/dt=100A/µs			5.3		nC

A. The value of R$_{θJA}$ is measured with the device mounted on 1in^2 FR-4 board with 2oz. Copper, in a still air environment with T$_A$ =25° C. The value in any given application depends on the user's specific board design.
B. The power dissipation P$_D$ is based on T$_{J(MAX)}$=150° C, using ≤ 10s junction-to-ambient thermal resistance.
C. Repetitive rating, pulse width limited by junction temperature T$_{J(MAX)}$=150° C. Ratings are based on low frequency and duty cycles to keep initialT$_J$=25° C.
D. The R$_{θJA}$ is the sum of the thermal impedance from junction to lead R$_{θJL}$ 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^2 FR-4 board with 2oz. Copper, assuming a maximum junction temperature of T$_{J(MAX)}$=150° C. The SOA curve provides a single pulse rating.

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TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS


Fig 1: On-Region Characteristics (Note E)
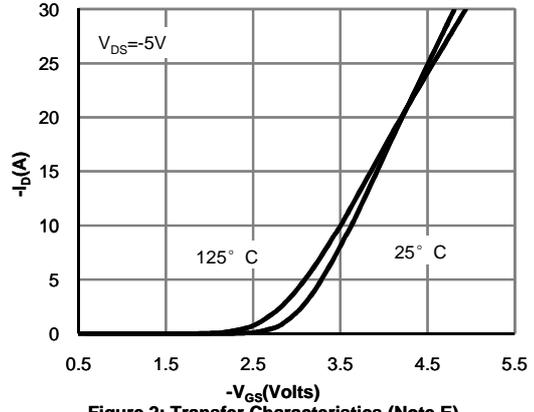
Figure 2: Transfer Characteristics (Note E)
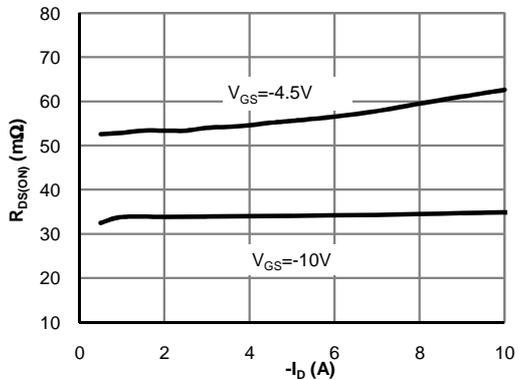
Figure 3: On-Resistance vs. Drain Current and Gate Voltage (Note E)
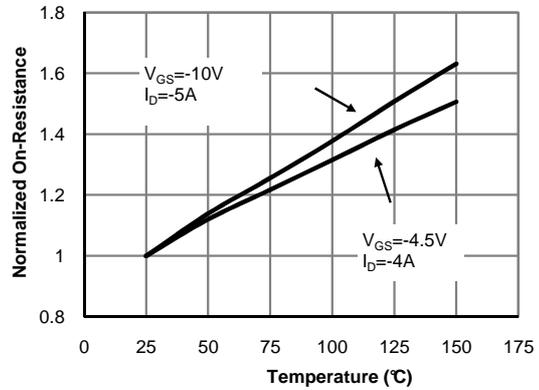
Figure 4: On-Resistance vs. Junction Temperature (Note E)
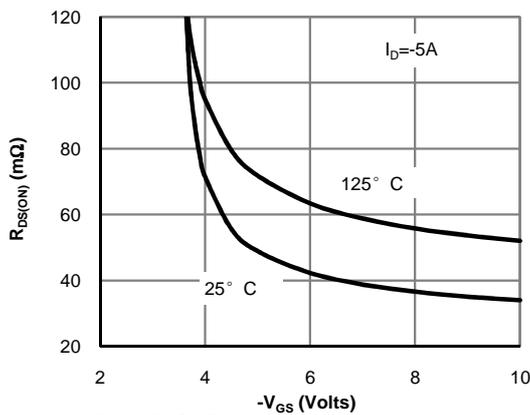
Figure 5: On-Resistance vs. Gate-Source Voltage (Note E)
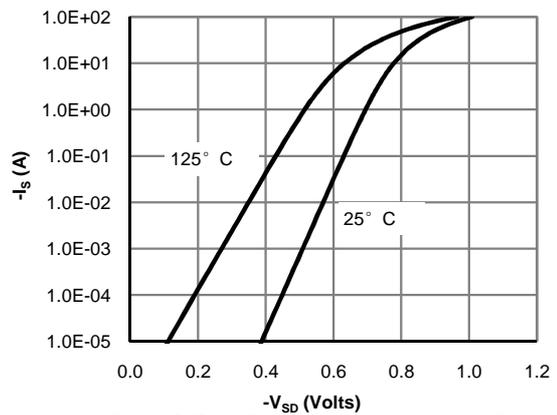
Figure 6: Body-Diode Characteristics (Note E)

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

V_{DS}=-15V
I_D=-5A
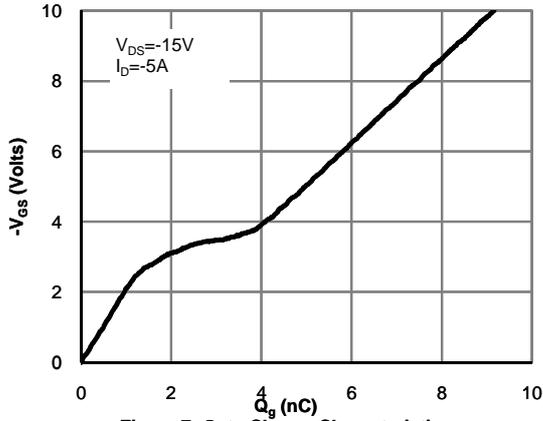
Figure 7: Gate-Charge Characteristics

C_{iss}
C_{oss}
C_{rss}
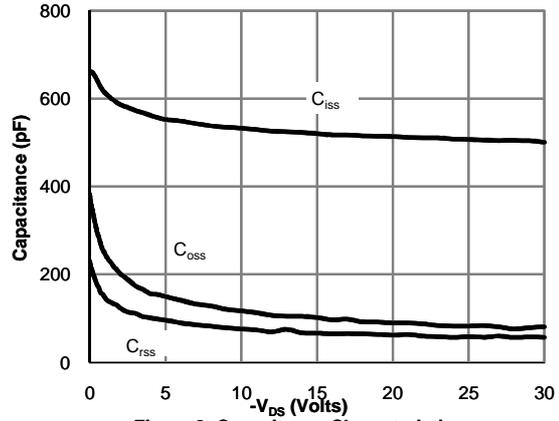
Figure 8: Capacitance Characteristics

$R_{DS(ON)}$ limited

10μs
100μs
1ms
10ms
100ms
10s
DC

$T_{J(Max)}$=150°C
T_A=25°C
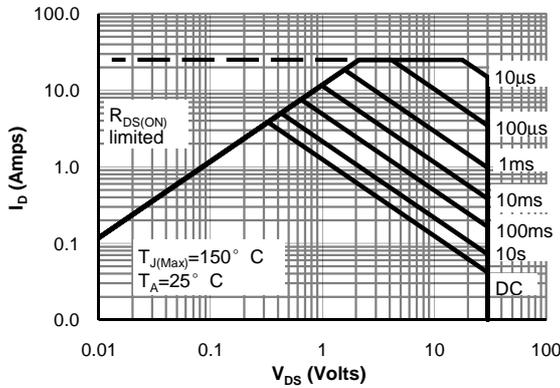
Figure 9: Maximum Forward Biased Safe
Operating Area (Note F)

T_A=25°C
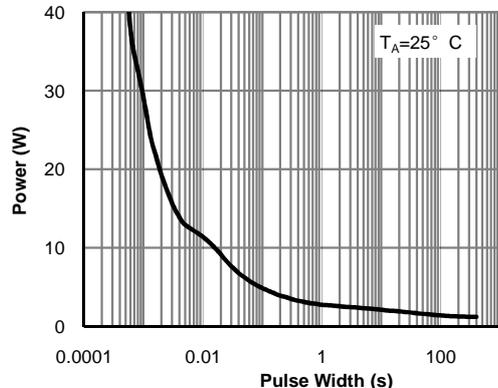
Figure 10: Single Pulse Power Rating Junction-to-
Ambient (Note F)

D=T_{on}/T
$T_{J,PK}$=T_A+P_{DM}·$Z_{\theta JA}$·$R_{\theta JA}$
$R_{\theta JA}$=110°C/W

In descending order
D=0.5, 0.3, 0.1, 0.05, 0.02, 0.01, single pulse

Single Pulse

P_D
T_{on}
T
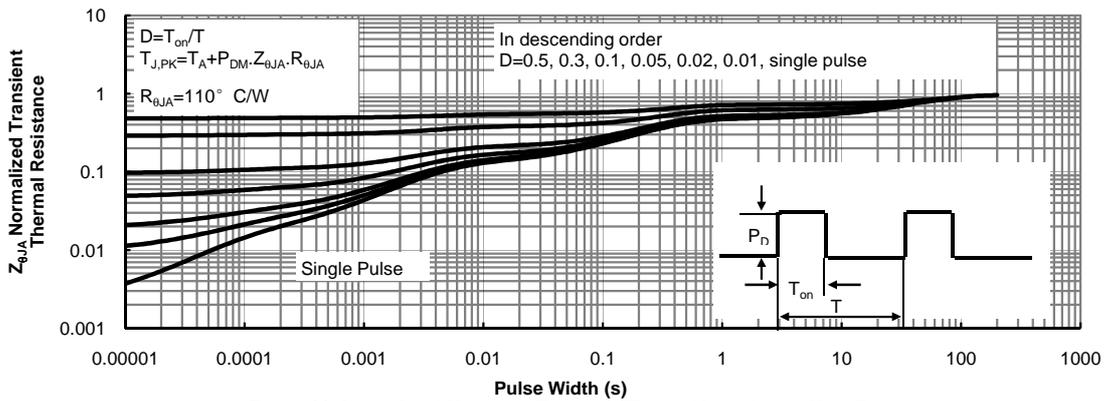
Figure 11: Normalized Maximum Transient Thermal Impedance (Note F)

Gate Charge Test Circuit & Waveform

VDC
Vds
DUT
Vgs
Ig

Vgs
Qg
-10V
Qgs
Qgd
Charge
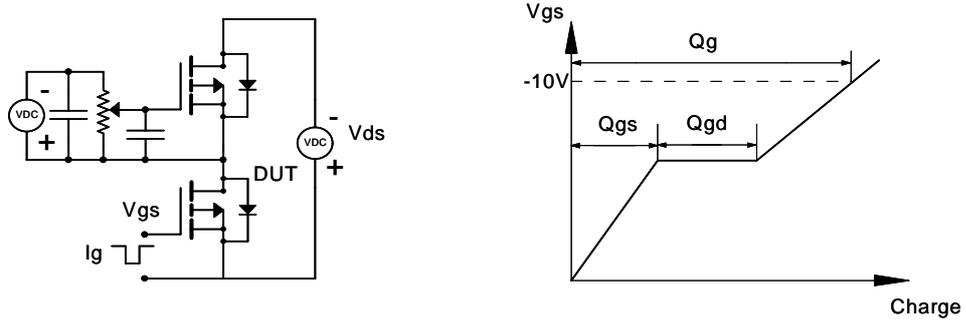
Resistive Switching Test Circuit & Waveforms

RL
Vds
DUT
Vdd
Rg
Vgs
Vgs

t_{on}
t_{off}
Vgs
$t_{d(on)}$
t_r
$t_{d(off)}$
t_f
90%
Vds
10%
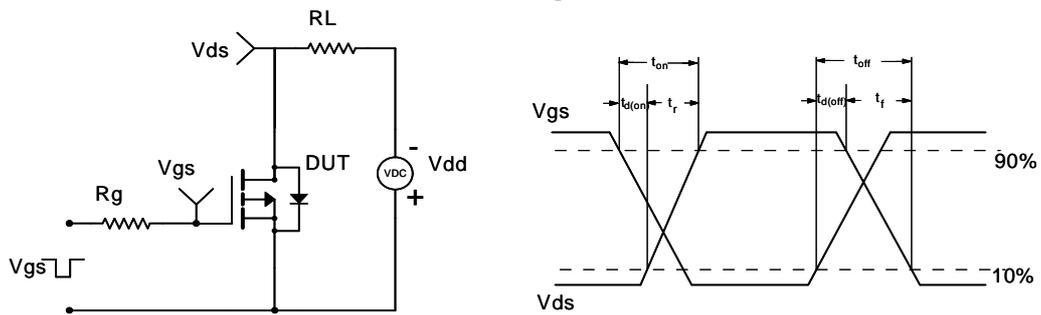
Diode Recovery Test Circuit & Waveforms

Vds +
DUT
Vds -
Isd
L
Vgs
Ig
Vdd

$Q_{rr} = -\int I dt$

Vgs
-Isd
$-I_F$
dI/dt
t_{rr}
$-I_{RM}$
Vdd
-Vds
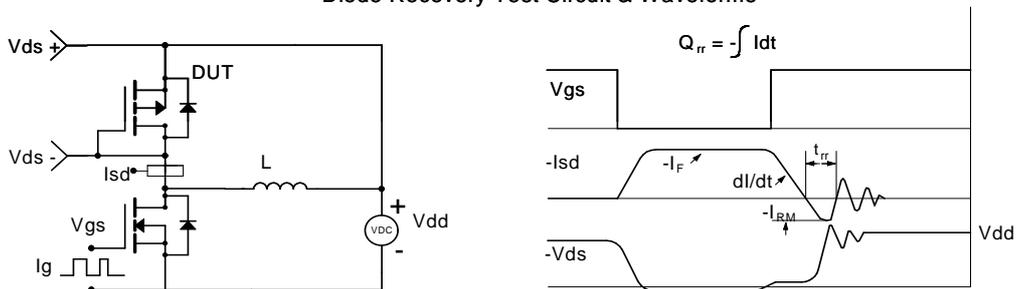
TSOP-6 PACKAGE MARKING DESCRIPTION
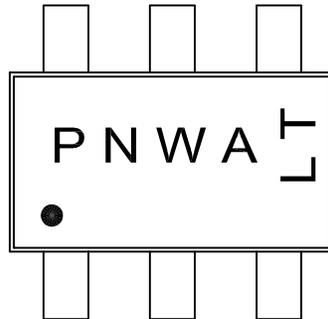
Green product

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)
AO6405	Green product	D5
AO6405L	Green product	D5

TSOP6 PACKAGE OUTLINE
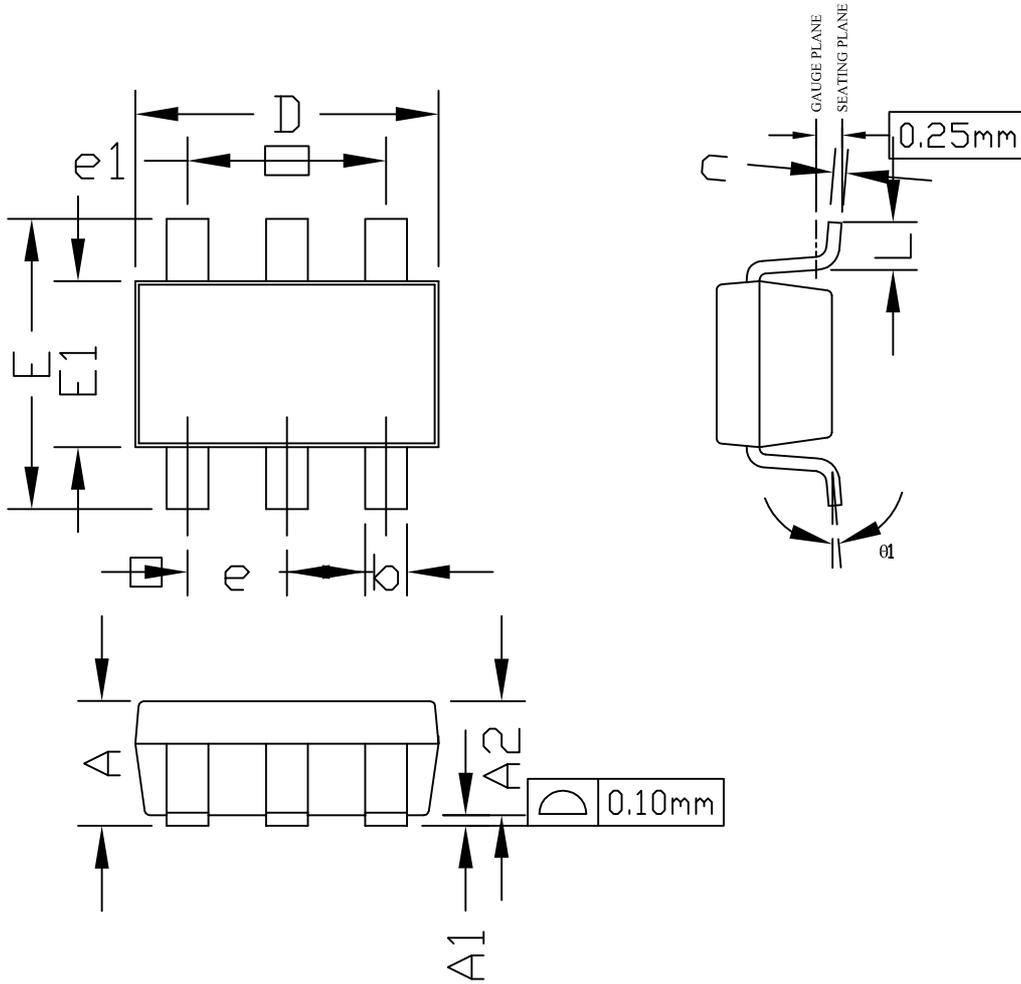
RECOMMENDED LAND PATTERN
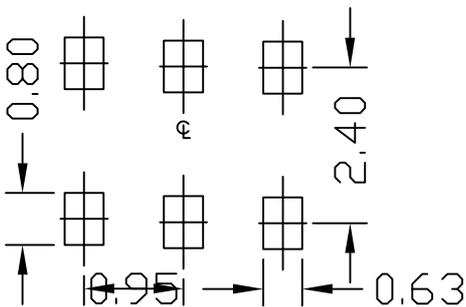
UNIT: mm

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

TSOP-6 Carrier Tape
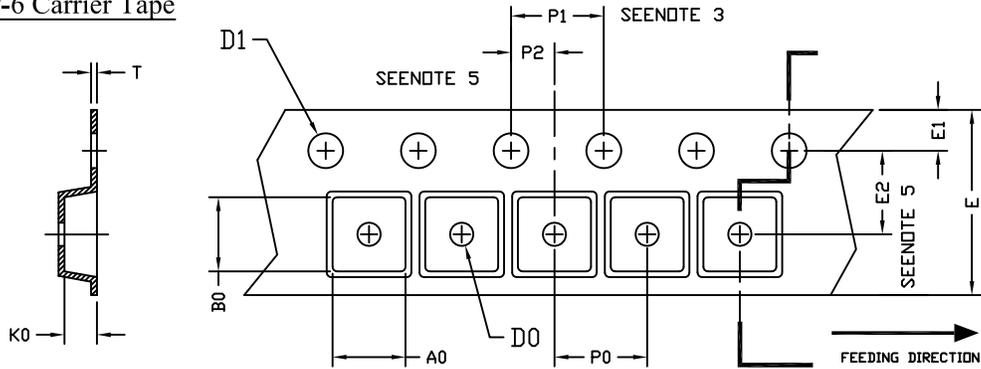
UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
SOT-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
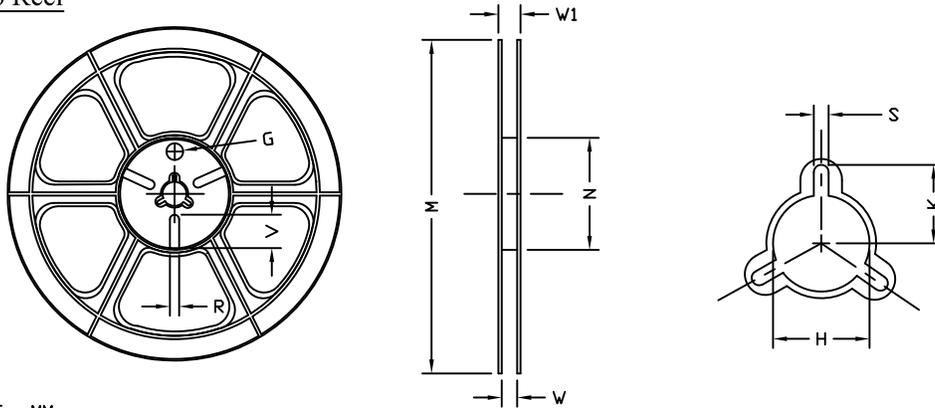
UNIT: MM

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

TRAILER TAPE
300 mm MIN. OR
75 EMPTY POCKETS

COMPONENTS TAPE
ORIENTATION IN POCKET

LEADER TAPE
500 mm MIN. OR
125 EMPTY POCKETS
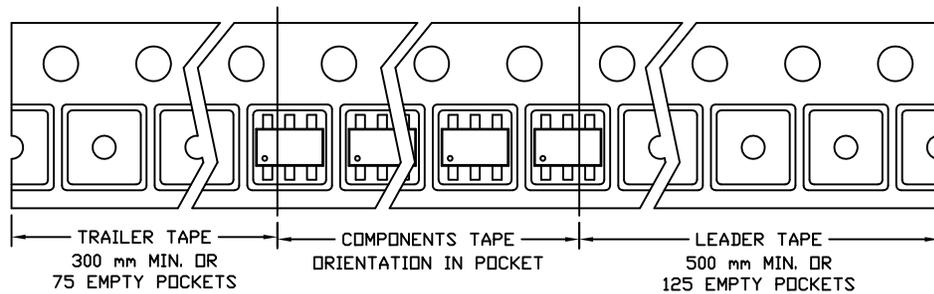
AOS Semiconductor
Product Reliability Report

AO6405, rev D

Plastic Encapsulated Device

ALPHA & OMEGA Semiconductor, Inc

www.aosmd.com

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This AOS product reliability report summarizes the qualification result for AO6405. 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 AO6405 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:

The AO6405 uses advanced trench technology to provide excellent $R_{DS(ON)}$ with low gate charge. This device is suitable for use as a load switch or in PWM applications.

-RoHS Compliant
-Halogen free

Detailed information refers to datasheet.

II. Die / Package Information:

	AO6405
Process	Standard sub-micron
	Low voltage P channel
Package Type	TSOP6
Lead Frame	Copper
Die Attach	Silver epoxy
Bonding Wire	Cu & Au wire
Mold Material	Epoxy resin with silica filler
MSL (moisture sensitive level)	Level 1 based on J-STD-020

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

III. Result of Reliability Stress for AO6405

Test Item	Test Condition	Time Point	Lot Attribution	Total Sample size	Number of Failures	Standard
MSL Precondition	168hr 85℃ /85%RH +3 cycle reflow@260℃	-	7 lots	1100pcs	0	JESD22-A113
HTGB	Temp = 150 °c, Vgs=100% of Vgsmax	168hrs 500 hrs 1000 hrs	3 lots 1lot 1 lot (Note A*)	385pcs 77pcs / lot	0	JESD22-A108
HTRB	Temp = 150 °c, Vds=80% of Vdsmax	168hrs 500 hrs 1000 hrs	3 lots 1lot 1 lot (Note A*)	385pcs 77pcs / lot	0	JESD22-A108
HAST	130 +/- 2°c, 85%RH, 33.3 psi, Vgs = 80% of Vgs max	100 hrs	6 lots (Note A*)	330pcs 55 pcs / lot	0	JESD22-A110
Pressure Pot	121°c, 29.7psi, RH=100%	96 hrs	7 lots (Note A*)	385pcs 55 pcs / lot	0	JESD22-A102
Temperature Cycle	-65°c to 150°c, air to air	250 / 500 cycles	7 lots (Note A*)	385pcs 55 pcs / lot	0	JESD22-A104

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

IV. Reliability Evaluation

FIT rate (per billion): 12
MTTF = 9934 years

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size of the selected product (AO6405). Failure Rate Determination is based on JEDEC Standard JESD 85. FIT means one failure per billion hours.

Failure Rate = Chi^2 x 10^9 / **[**2 (N) (H) (Af)**]**

= 1.83 x 10^9 / **[**2 x (2x3x77x168+2x77x500+2x77x1000) x 258**]** = 12

MTTF = 10^9 / FIT = 8.70 x 10^7 hrs = 9934 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℃)
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 X 10-5eV / K