ALPHA & OMEGA SEMICONDUCTOR, INC.

July 2003

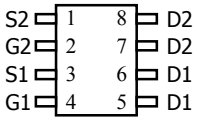
# AO4609
# Complementary Enhancement Mode Field Effect Transistor

## General Description

The AO4609 uses advanced trench technology MOSFETs to provide excellent $R_{DS(ON)}$ and low gate charge. The complementary MOSFETs may be used to form a level shifted high side switch, and for a host of other applications.

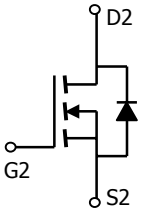
## Features

| n-channel | p-channel |
|---|---|
| $V_{DS}$ (V) = 30V | -30V |
| $I_D$ = 8.5A | -3A |
| $R_{DS(ON)}$ | $R_{DS(ON)}$ |
| < 18mΩ ($V_{GS}$=10V) | < 130mΩ ($V_{GS}$ = 10V) |
| < 28mΩ ($V_{GS}$=4.5V) | < 180mΩ ($V_{GS}$ = 4.5V) |
| | < 260mΩ ($V_{GS}$ = 2.5V) |

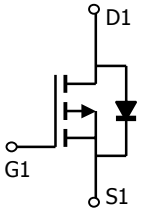



SOIC-8






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 | | $V_{DS}$ | 30 | -30 | V |
| Gate-Source Voltage | | $V_{GS}$ | ±20 | ±12 | V |
| Continuous Drain Current [A] | $T_A$=25°C | $I_D$ | 8.5 | -3 | A |
| | $T_A$=70°C | | 6.6 | -2.4 | |
| Pulsed Drain Current [B] | | $I_{DM}$ | 40 | -6 | |
| Power Dissipation | $T_A$=25°C | $P_D$ | 2 | 2 | W |
| | $T_A$=70°C | | 1.28 | 1.28 | |
| Junction and Storage Temperature Range | | $T_J$, $T_{STG}$ | -55 to 150 | -55 to 150 | °C |

**Thermal Characteristics: n-channel and p-channel**

| Parameter | | Symbol | Device | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Maximum Junction-to-Ambient [A] | t ≤ 10s | $R_{\theta JA}$ | n-ch | 48 | 62.5 | °C/W |
| Maximum Junction-to-Ambient [A] | Steady-State | | n-ch | 74 | 110 | °C/W |
| Maximum Junction-to-Lead [C] | Steady-State | $R_{\theta JL}$ | n-ch | 35 | 40 | °C/W |
| Maximum Junction-to-Ambient [A] | t ≤ 10s | $R_{\theta JA}$ | p-ch | 56 | 62.5 | °C/W |
| Maximum Junction-to-Ambient [A] | Steady-State | | p-ch | 81 | 110 | °C/W |
| Maximum Junction-to-Lead [C] | Steady-State | $R_{\theta JL}$ | p-ch | 40 | 48 | °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 | 30 | | | V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$=24V, $V_{GS}$=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 | 1.8 | 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, $I_D$=8.5A | | 15.5 | 18 | mΩ |
| | | $T_J$=125°C | | 22.3 | 27 | |
| | | $V_{GS}$=4.5V, $I_D$=6A | | 23 | 28 | mΩ |
| $g_{FS}$ | Forward Transconductance | $V_{DS}$=5V, $I_D$=8.5A | | 23 | | S |
| $V_{SD}$ | Diode Forward Voltage | $I_S$=1A,$V_{GS}$=0V | | 0.75 | 1 | V |
| $I_S$ | Maximum Body-Diode Continuous Current | | | | 3 | A |
| **DYNAMIC PARAMETERS** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{GS}$=0V, $V_{DS}$=15V, f=1MHz | | 1040 | | pF |
| $C_{oss}$ | Output Capacitance | | | 180 | | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | | 110 | | pF |
| $R_g$ | Gate resistance | $V_{GS}$=0V, $V_{DS}$=0V, f=1MHz | | 0.7 | | Ω |
| **SWITCHING PARAMETERS** | | | | | | |
| $Q_g$(10V) | Total Gate Charge | $V_{GS}$=10V, $V_{DS}$=15V, $I_D$=8.5A | | 19.2 | | nC |
| $Q_g$(4.5V) | Total Gate Charge | | | 9.36 | | nC |
| $Q_{gs}$ | Gate Source Charge | | | 2.6 | | nC |
| $Q_{gd}$ | Gate Drain Charge | | | 4.2 | | nC |
| $t_{D(on)}$ | Turn-On DelayTime | $V_{GS}$=10V, $V_{DS}$=15V, $R_L$=1.8Ω, $R_{GEN}$=3Ω | | 5.2 | | ns |
| $t_r$ | Turn-On Rise Time | | | 4.4 | | ns |
| $t_{D(off)}$ | Turn-Off DelayTime | | | 17.3 | | ns |
| $t_f$ | Turn-Off Fall Time | | | 3.3 | | ns |
| $t_{rr}$ | Body Diode Reverse Recovery Time | $I_F$=8.5A, dI/dt=100A/μs | | 16.7 | | ns |
| $Q_{rr}$ | Body Diode Reverse Recovery Charge | $I_F$=8.5A, dI/dt=100A/μs | | 6.7 | | nC |

A: The value of $R_{\theta JA}$ 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 a given application depends on the user's specific board design. The current rating is based on the t≤ 10s thermal resistance rating.

B: Repetitive rating, pulse width limited by junction temperature.

C. The $R_{\theta JA}$ is the sum of the thermal impedence from junction to lead $R_{\theta JL}$ and lead to ambient.

D. The static characteristics in Figures 1 to 6 are obtained using 80μs pulses, duty cycle 0.5% max.

E. 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. The SOA curve provides a single pulse rating.

## 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 | -30 | | | V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$=-24V, $V_{GS}$=0V | | | -1 | µA |
| | | $T_J$=55°C | | | -5 | |
| $I_{GSS}$ | Gate-Body leakage current | $V_{DS}$=0V, $V_{GS}$=±12V | | | ±100 | nA |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS}$=$V_{GS}$ $I_D$=-250µA | -0.6 | -1 | -1.4 | V |
| $I_{D(ON)}$ | On state drain current | $V_{GS}$=-4.5V, $V_{DS}$=-5V | -10 | | | A |
| $R_{DS(ON)}$ | Static Drain-Source On-Resistance | $V_{GS}$=-10V, $I_D$=-3A | | 102 | 130 | mΩ |
| | | $T_J$=125°C | | 154 | 200 | |
| | | $V_{GS}$=-4.5V, $I_D$=-2A | | 128 | 180 | mΩ |
| | | $V_{GS}$=-2.5V, $I_D$=-1A | | 187 | 260 | mΩ |
| $g_{FS}$ | Forward Transconductance | $V_{DS}$=-5V, $I_D$=-3A | 3 | 4.5 | | S |
| $V_{SD}$ | Diode Forward Voltage | $I_S$=-1A,$V_{GS}$=0V | | -0.85 | -1 | V |
| $I_S$ | Maximum Body-Diode Continuous Current | | | | -2 | A |
| **DYNAMIC PARAMETERS** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{GS}$=0V, $V_{DS}$=-15V, f=1MHz | | 409 | | pF |
| $C_{oss}$ | Output Capacitance | | | 55 | | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | | 42 | | pF |
| $R_g$ | Gate resistance | $V_{GS}$=0V, $V_{DS}$=0V, f=1MHz | | 12 | | Ω |
| **SWITCHING PARAMETERS** | | | | | | |
| $Q_g$ | Total Gate Charge | $V_{GS}$=-4.5V, $V_{DS}$=-15V, $I_D$=-3A | | 4.4 | | nC |
| $Q_{gs}$ | Gate Source Charge | | | 0.8 | | nC |
| $Q_{gd}$ | Gate Drain Charge | | | 1.32 | | nC |
| $t_{D(on)}$ | Turn-On DelayTime | $V_{GS}$=-10V, $V_{DS}$=-15V, $R_L$=5Ω, $R_{GEN}$=3Ω | | 5.3 | | ns |
| $t_r$ | Turn-On Rise Time | | | 4.4 | | ns |
| $t_{D(off)}$ | Turn-Off DelayTime | | | 31.5 | | ns |
| $t_f$ | Turn-Off Fall Time | | | 8 | | ns |
| $t_{rr}$ | Body Diode Reverse Recovery Time | $I_F$=-3A, dI/dt=100A/µs | | 15.8 | | ns |
| $Q_{rr}$ | Body Diode Reverse Recovery Charge | $I_F$=-3A, dI/dt=100A/µs | | 8 | | nC |

A: The value of $R_{\theta JA}$ 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 a given application depends on the user's specific board design. The current rating is based on the t≤ 10s thermal resistance rating.

B: Repetitive rating, pulse width limited by junction temperature.

C. The $R_{\theta JA}$ is the sum of the thermal impedence from junction to lead $R_{\theta JL}$ and lead to ambient.

D. The static characteristics in Figures 1 to 6,12,14 are obtained using 80µs pulses, duty cycle 0.5% max.

E. 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. The SOA curve provides a single pulse rating.

## N-CHANNEL: TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

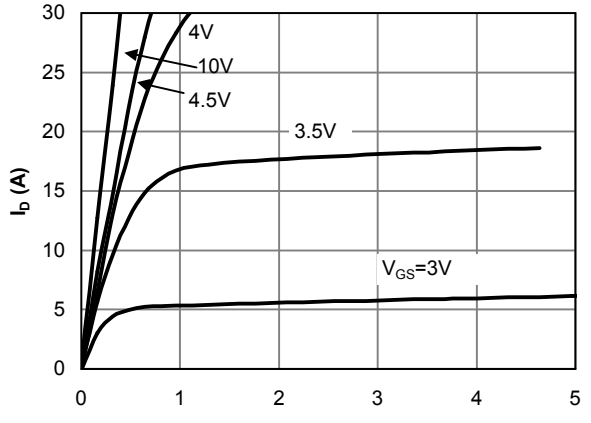



**Fig 1: On-Region Characteristics**

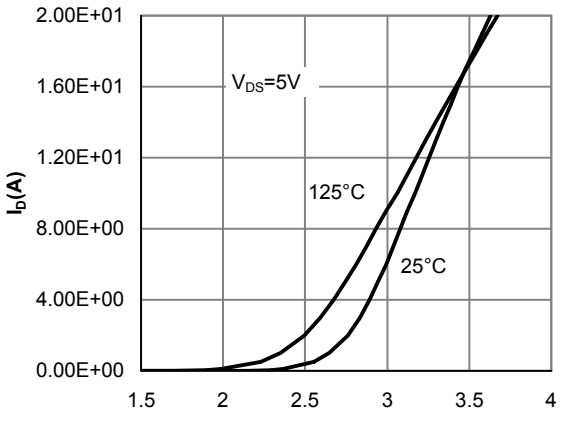



**Figure 2: Transfer Characteristics**

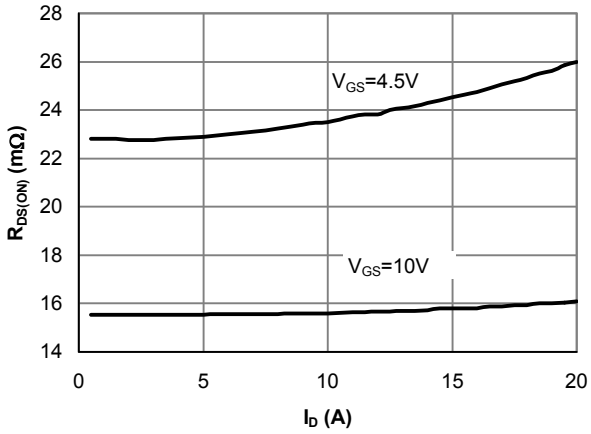



**Figure 3: On-Resistance vs. Drain Current and Gate Voltage**

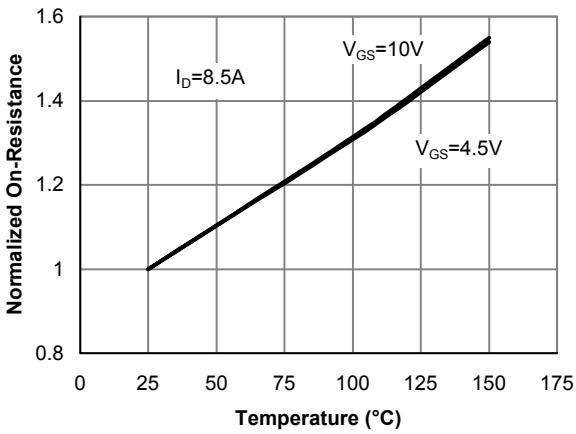



**Figure 4: On-Resistance vs. Junction Temperature**

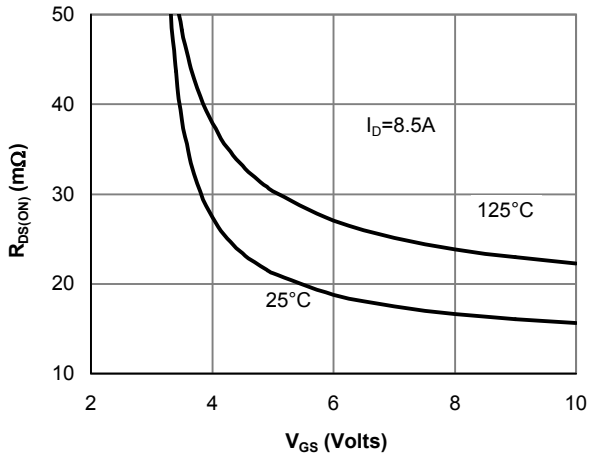



**Figure 5: On-Resistance vs. Gate-Source Voltage**

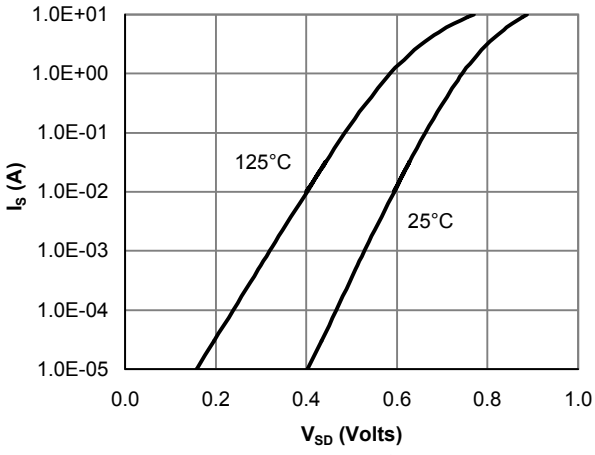



**Figure 6: Body-Diode Characteristics**

## N-CHANNEL: TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

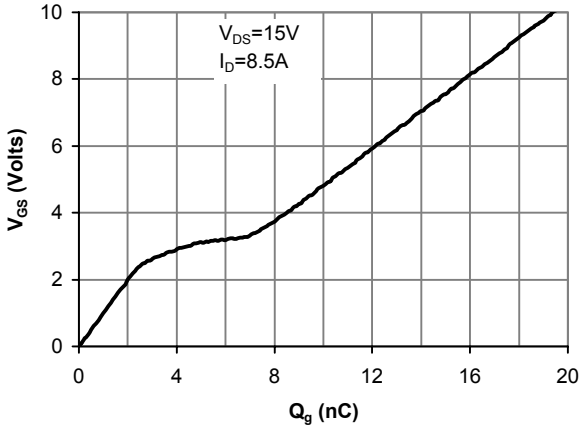



**Figure 7: Gate-Charge Characteristics**

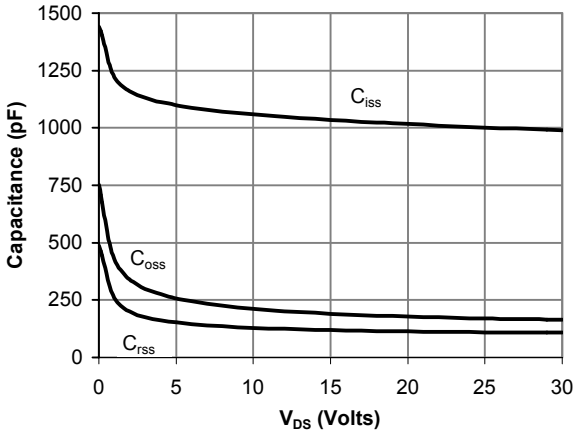



**Figure 8: Capacitance Characteristics**

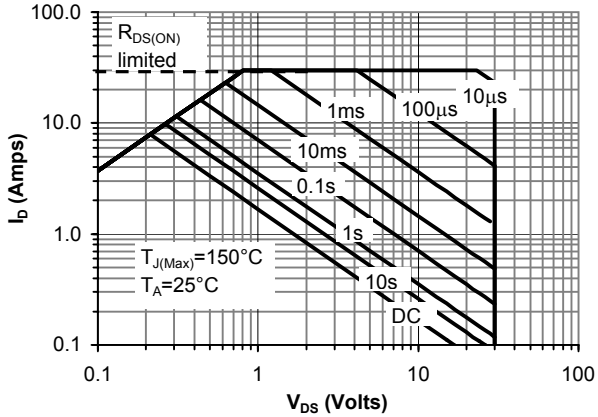



**Figure 9: Maximum Forward Biased Safe Operating Area (Note E)**

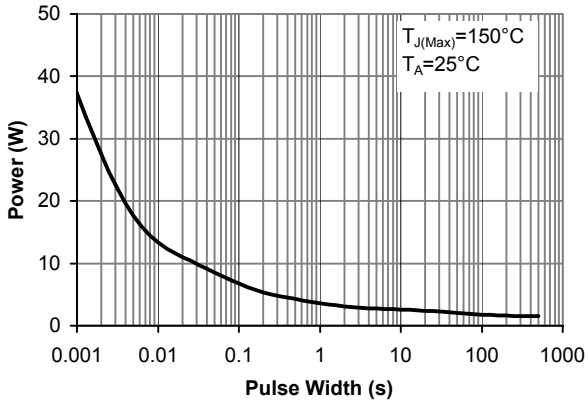



**Figure 10: Single Pulse Power Rating Junction-to-Ambient (Note E)**

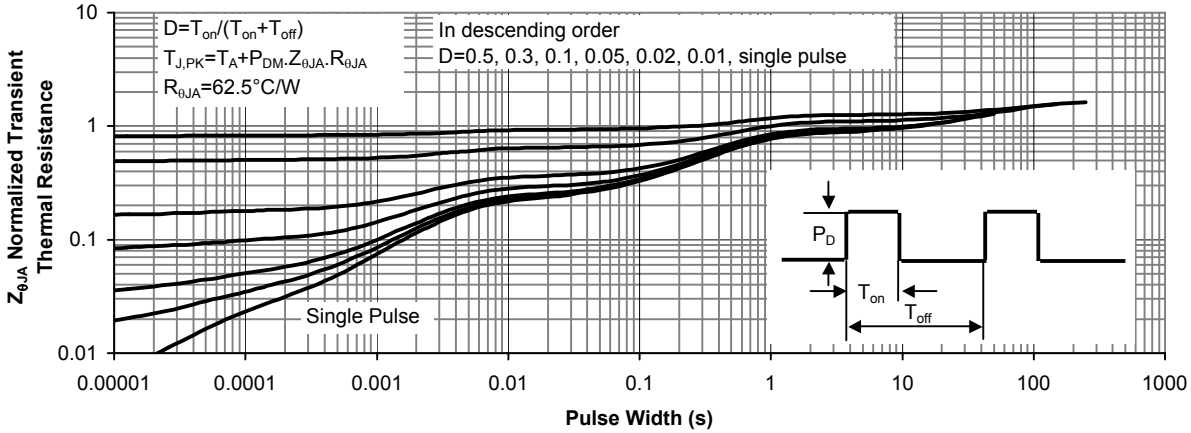
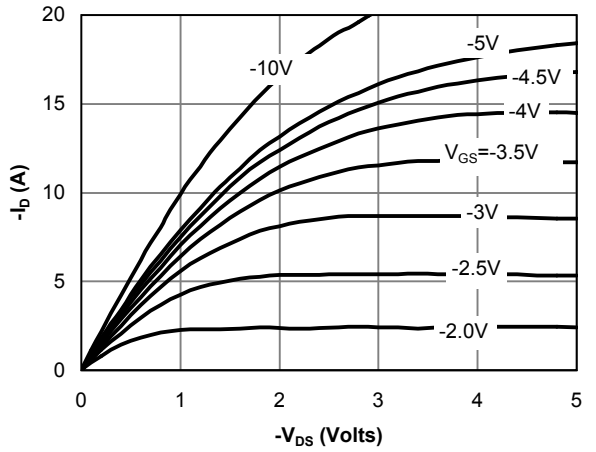



**Figure 11: Normalized Maximum Transient Thermal Impedance**

## P-CHANNEL TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

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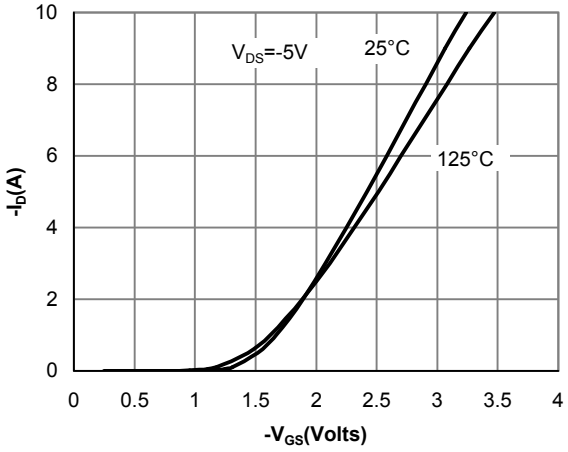



Figure 2: Transfer Characteristics

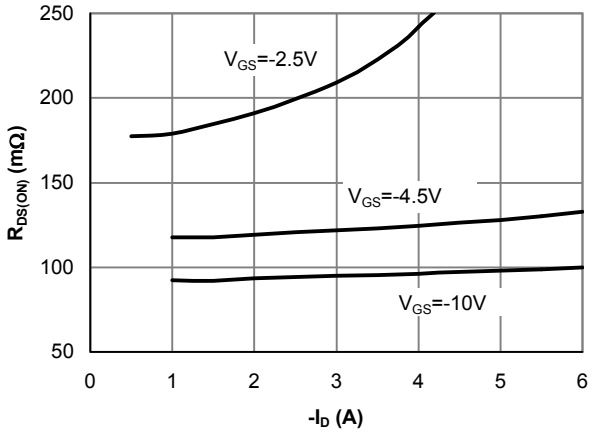



Figure 3: On-Resistance vs. Drain Current and Gate Voltage

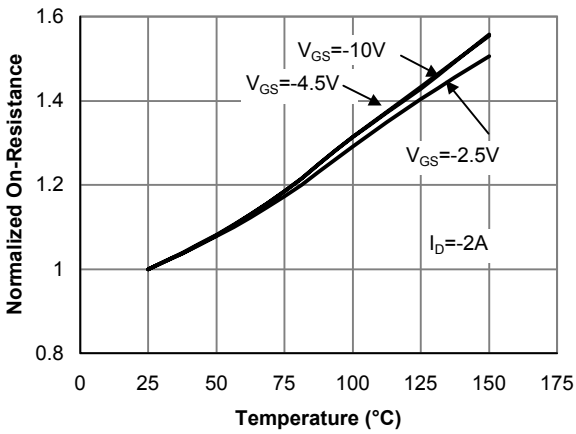



Figure 4: On-Resistance vs. Junction Temperature

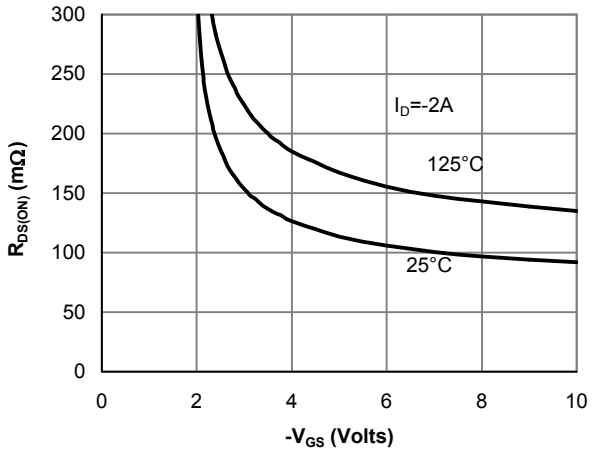



Figure 5: On-Resistance vs. Gate-Source Voltage

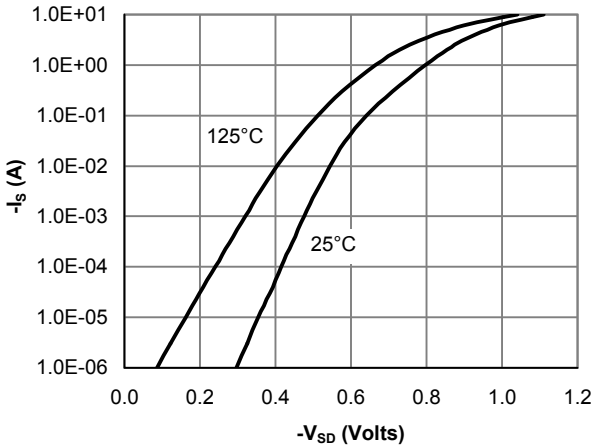



Figure 6: Body-Diode Characteristics

## P-CHANNEL TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

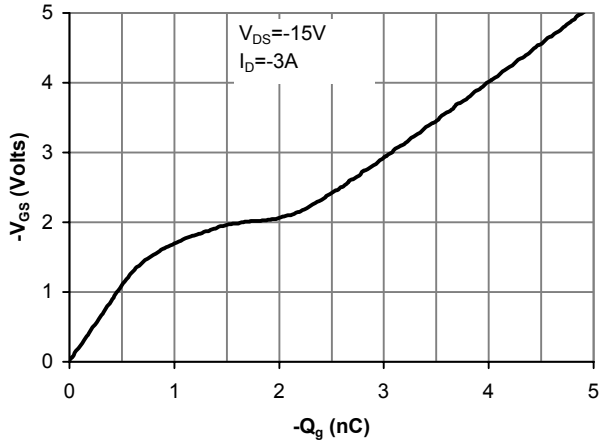



**Figure 7: Gate-Charge Characteristics**

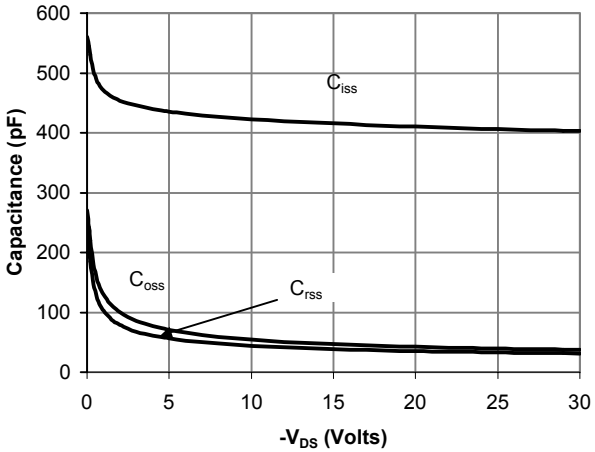



**Figure 8: Capacitance Characteristics**

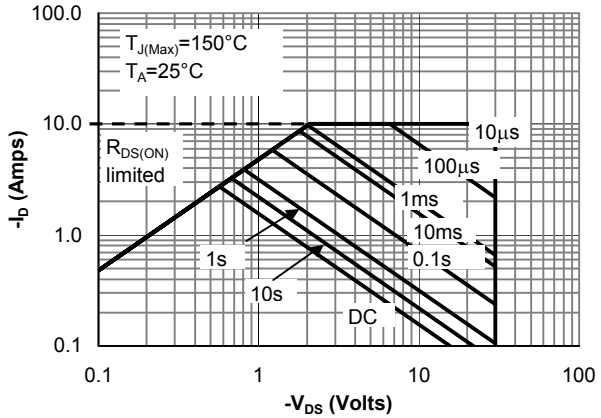



**Figure 9: Maximum Forward Biased Safe Operating Area (Note E)**

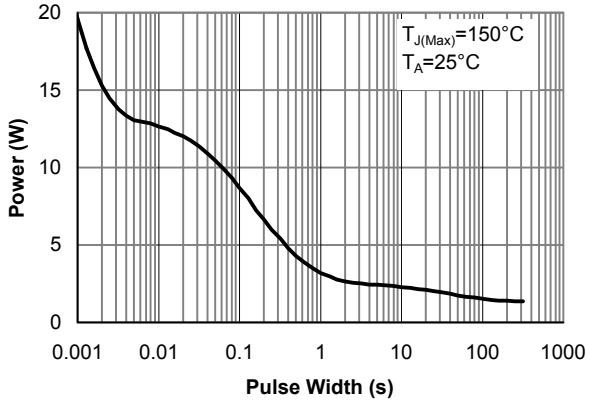



**Figure 10: Single Pulse Power Rating Junction-to-Ambient (Note E)**

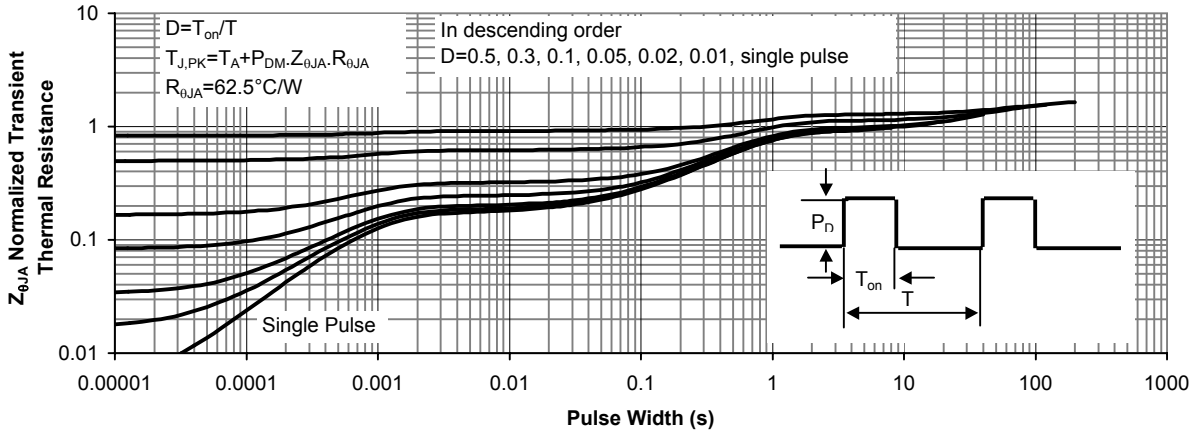
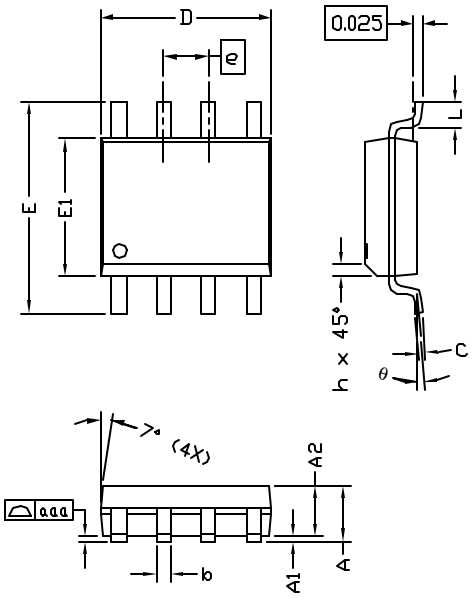



**Figure 11: Normalized Maximum Transient Thermal Impedance**

**ALPHA & OMEGA**
*SEMICONDUCTOR, INC.*

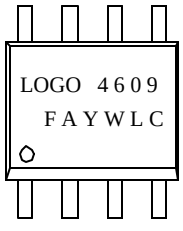
# SO-8 Package Data




| SYMBOLS | DIMENSIONS IN MILLIMETERS | | | DIMENSIONS IN INCHES | | |
|---|---|---|---|---|---|---|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 1.45 | 1.50 | 1.55 | 0.057 | 0.059 | 0.061 |
| A1 | 0.00 | —— | 0.10 | 0.000 | —— | 0.004 |
| A2 | —— | 1.45 | —— | —— | 0.057 | —— |
| b | 0.33 | —— | 0.51 | 0.013 | —— | 0.020 |
| c | 0.19 | —— | 0.25 | 0.007 | —— | 0.010 |
| D | 4.80 | —— | 5.00 | 0.189 | —— | 0.197 |
| E1 | 3.80 | —— | 4.00 | 0.150 | —— | 0.157 |
| e | 1.27 BSC | | | 0.050 BSC | | |
| E | 5.80 | —— | 6.20 | 0.228 | —— | 0.244 |
| h | 0.25 | —— | 0.50 | 0.010 | —— | 0.020 |
| L | 0.40 | —— | 1.27 | 0.016 | —— | 0.050 |
| aaa | —— | —— | 0.10 | —— | —— | 0.004 |
| θ | 0° | —— | 8° | 0° | —— | 8° |

NOTE:
1. LEAD FINISH: 150 MICROINCHES ( 3.8 um) MIN. THICKNESS OF Tin/Lead (SOLDER) PLATED ON LEAD
2. TOLERANCE ±0.10 mm (4 mil) UNLESS OTHERWISE SPECIFIED
3. COPLANARITY : 0.10 mm
4. DIMENSION L IS MEASURED IN GAGE PLANE

## PACKAGE MARKING DESCRIPTION

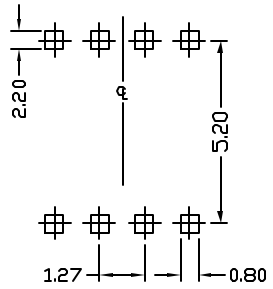



NOTE:
LOGO - AOS LOGO
4609 - PART NUMBER CODE.
F - FAB LOCATION
A - ASSEMBLY LOCATION
Y - YEAR CODE
W - WEEK CODE.
L C - ASSEMBLY LOT CODE

SO-8 PART NO. CODE

| PART NO. | CODE |
|---|---|
| AO4609 | 4609 |

## RECOMMENDED LAND PATTERN




UNIT: mm

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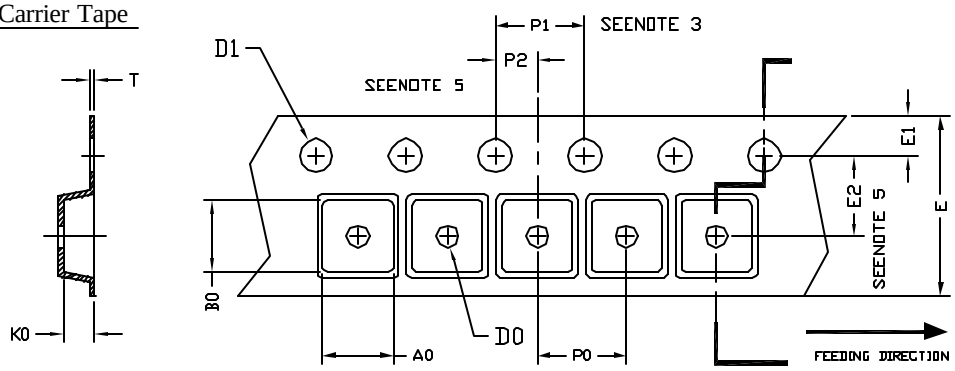
# SO-8 Tape and Reel Data

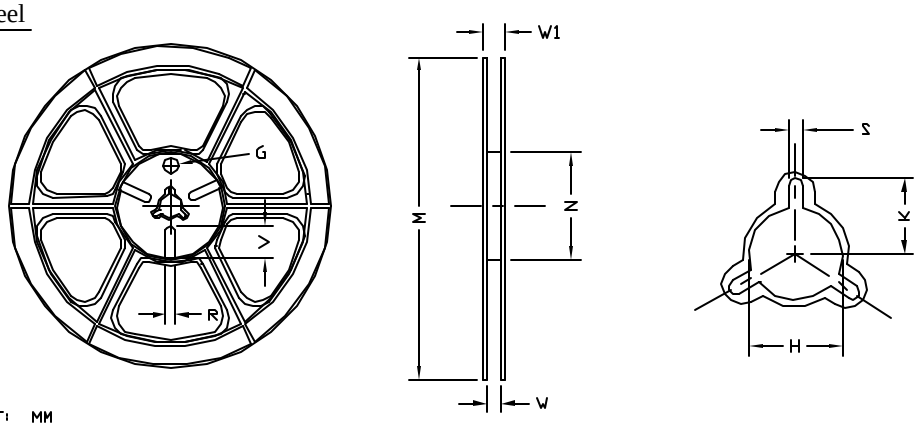
## SO-8 Carrier Tape




UNIT: MM

| PACKAGE | A0 | B0 | K0 | D0 | D1 | E | E1 | E2 | P0 | P1 | P2 | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SO-8 (12 mm) | 6.40 ±0.10 | 5.20 ±0.10 | 2.10 ±0.10 | 1.60 ±0.10 | 1.50 +0.10 | 12.00 ±0.30 | 1.75 ±0.10 | 5.50 ±0.05 | 8.00 ±0.10 | 4.00 ±0.10 | 2.00 ±0.05 | 0.25 ±0.05 |

## SO-8 Reel

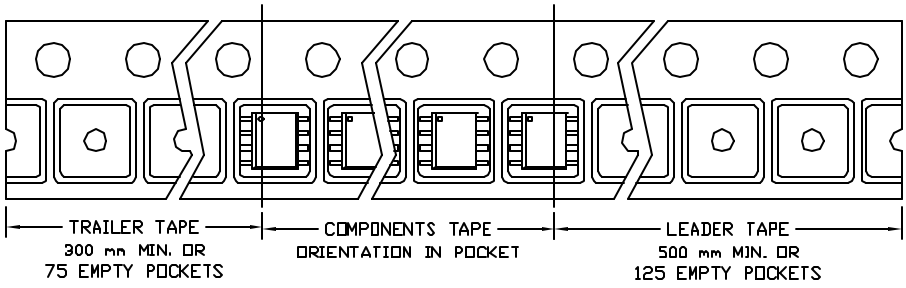



UNIT: MM

| TAPE SIZE | REEL SIZE | M | N | W | W1 | H | K | S | G | R | V |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 mm | ø330 | ø330.00 ±0.50 | ø97.00 ±0.10 | 13.00 ±0.30 | 17.40 ±1.00 | ø13.00 +0.50 -0.20 | 10.60 | 2.00 ±0.50 | --- | --- | --- |

## SO-8 Tape

Leader / Trailer & Orientation



| Document No. | PD-00064 |
|---|---|
| Version | rev C |
| Title | AO4609 Marking Description |

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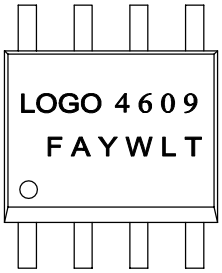
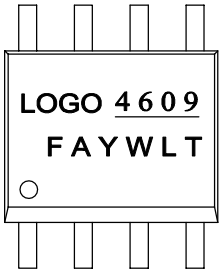
# SO-8 PACKAGE MARKING DESCRIPTION



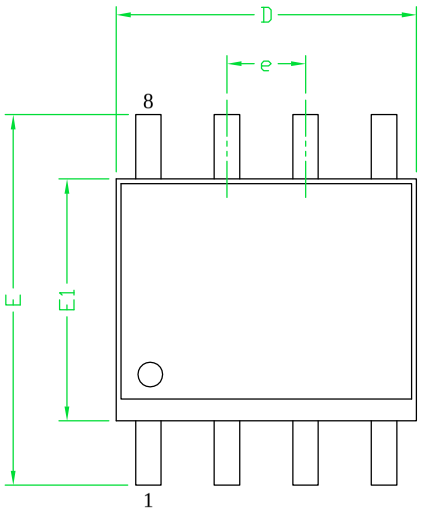

Standard product

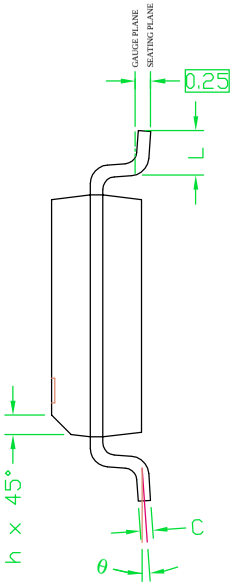


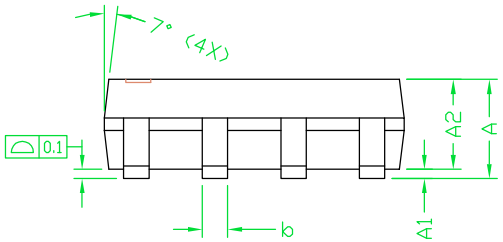

Green product

NOTE:
LOGO - AOS LOGO
4609 - PART NUMBER CODE.
F&A - FOUNDRY AND ASSEMBLY LOCATION
Y - YEAR CODE
W - WEEK CODE.
L T - ASSEMBLY LOT CODE

| PART NO. | DESCRIPTION | CODE |
|---|---|---|
| AO4609 | Standard product | 4609 |
| AO4609L | Green product | 4609 |



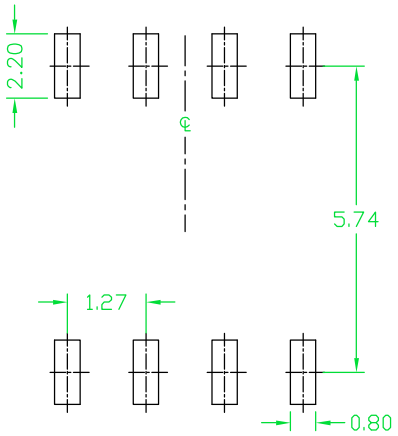




NOTE
1. ALL DIMENSIONS ARE IN MILLMETERS.
2.DIMENSIONS ARE INCLUSIVE OF PLATING.
3.PACKAGE BODY SIZES EXCLUDE MOLD FLASH AND GATE BURRS.
4. DIMENSION L IS MEASURED IN GAUGE PLANE.
5. CONTROLLING DIMENSION IS MILLIMETER. CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.

| SYMBOLS | DIMENSIONS IN MILLIMETERS | | | DIMENSIONS IN INCHES | | |
|---|---|---|---|---|---|---|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 1.35 | 1.65 | 1.75 | 0.053 | 0.065 | 0.069 |
| A1 | 0.10 | —— | 0.25 | 0.004 | —— | 0.010 |
| A2 | 1.25 | 1.50 | 1.65 | 0.049 | 0.059 | 0.065 |
| b | 0.31 | —— | 0.51 | 0.012 | —— | 0.020 |
| c | 0.17 | —— | 0.25 | 0.007 | —— | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | 1.27 BSC | | | 0.050 BSC | | |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| h | 0.25 | —— | 0.50 | 0.010 | —— | 0.020 |
| L | 0.40 | —— | 1.27 | 0.016 | —— | 0.050 |
| θ | 0° | —— | 8° | 0° | —— | 8° |

## RECOMMENDED LAND PATTERN




UNIT: mm

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DECIMAL ANGULAR
X.X ± ±
X.XX ±
X.XXX ±
INTERPRET DIM AND TOL PER ASME Y14.5M – 1994
PRINTING IS SCALED TO FIT DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

ALPHA & OMEGA SEMICONDUCTOR, LTD.

| | |
|---|---|
| Document No. | PD–00004 |
| Version | rev D |
| Title | SO–8 PACKAGE OUTLINE |

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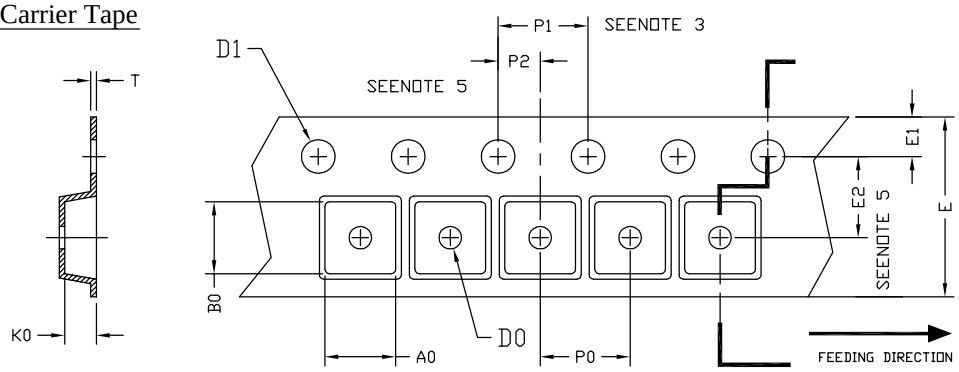
# SO-8 Tape and Reel Data

## SO-8 Carrier Tape




UNIT: MM

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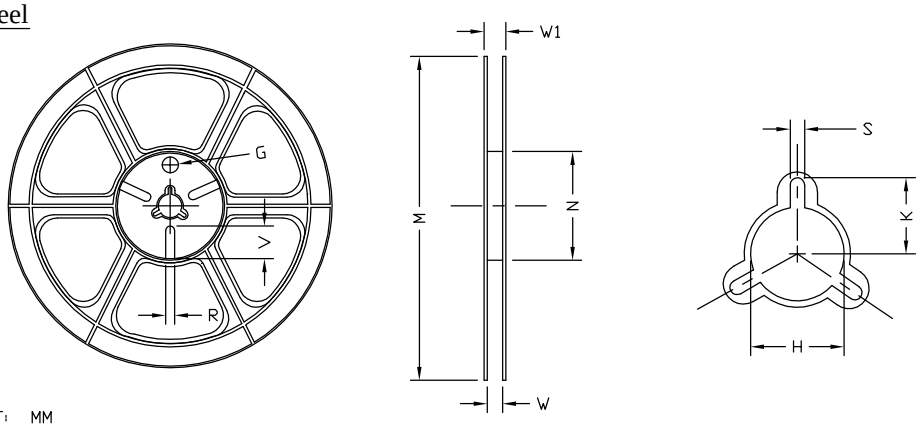
## SO-8 Reel




UNIT: MM

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## SO-8 Tape

Leader / Trailer & Orientation