



**ALPHA & OMEGA**  
SEMICONDUCTOR



## AO5401E

### P-Channel Enhancement Mode Field Effect Transistor

#### General Description

The AO5401E/L uses advanced trench technology to provide excellent  $R_{DS(ON)}$ , low gate charge and operation with gate voltages as low as 1.8V. This device is suitable for use as a load switch or in PWM applications. AO5401E and AO5401EL are electrically identical.

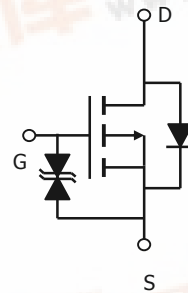
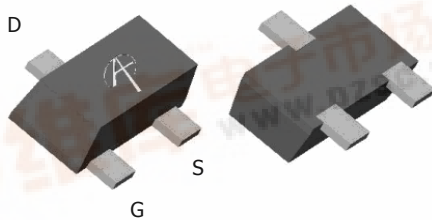
- RoHS compliant
- AO5401EL is Halogen Free

#### Features

- $V_{DS}$  (V) = -20V
- $I_D$  = -0.5 A ( $V_{GS}$  = -4.5V)
- $R_{DS(ON)} < 0.8\Omega$  ( $V_{GS}$  = -4.5V)
- $R_{DS(ON)} < 1\Omega$  ( $V_{GS}$  = -2.5V)
- $R_{DS(ON)} < 1.3\Omega$  ( $V_{GS}$  = -1.8V)

**ESD PROTECTED!**

**SC89-3L**  
Top View



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

| Parameter                              | Symbol                 | 10 Sec     | Steady State | Units            |
|----------------------------------------|------------------------|------------|--------------|------------------|
| Drain-Source Voltage                   | $V_{DS}$               | -20        |              | V                |
| Gate-Source Voltage                    | $V_{GS}$               | $\pm 8$    |              | V                |
| Continuous Drain Current <sup>AF</sup> | $T_A=25^\circ\text{C}$ | -0.5       | -0.5         | A                |
|                                        | $T_A=70^\circ\text{C}$ | -0.45      | -0.40        |                  |
| Pulsed Drain Current <sup>B</sup>      | $I_{DM}$               | -1         |              |                  |
| Power Dissipation <sup>A</sup>         | $T_A=25^\circ\text{C}$ | 0.38       | 0.28         | W                |
|                                        | $T_A=70^\circ\text{C}$ | 0.24       | 0.18         |                  |
| 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> | $R_{\theta JA}$ | 275 | 330 | $^\circ\text{C/W}$ |
| Maximum Junction-to-Ambient <sup>A</sup> |                 | 360 | 450 | $^\circ\text{C/W}$ |
| Maximum Junction-to-Lead <sup>C</sup>    | $R_{\theta JL}$ | 300 | 350 | $^\circ\text{C/W}$ |

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

| Symbol               | Parameter                             | Conditions                                                                                  | Min  | Typ          | Max         | Units |
|----------------------|---------------------------------------|---------------------------------------------------------------------------------------------|------|--------------|-------------|-------|
| STATIC PARAMETERS    |                                       |                                                                                             |      |              |             |       |
| BV <sub>DSS</sub>    | Drain-Source Breakdown Voltage        | I <sub>D</sub> =-250μA, V <sub>GS</sub> =0V                                                 | -20  |              |             | V     |
| I <sub>DSS</sub>     | Zero Gate Voltage Drain Current       | V <sub>DS</sub> =-20V, V <sub>GS</sub> =0V<br>T <sub>J</sub> =55°C                          |      |              | 1<br>5      | μA    |
| I <sub>GSS</sub>     | Gate-Body leakage current             | V <sub>DS</sub> =10V, V <sub>GS</sub> =±4.5V<br>V <sub>DS</sub> =10V, V <sub>GS</sub> =±8V  |      |              | ±1<br>±10   | μA    |
| V <sub>GS(th)</sub>  | Gate Threshold Voltage                | V <sub>DS</sub> =V <sub>GS</sub> I <sub>D</sub> =-250μA                                     | -0.4 | -0.5         | -0.9        | V     |
| I <sub>D(ON)</sub>   | On state drain current                | V <sub>GS</sub> =-4.5V, V <sub>DS</sub> =-5V                                                | -1   |              |             | A     |
| R <sub>DS(ON)</sub>  | Static Drain-Source On-Resistance     | V <sub>GS</sub> =-4.5V, I <sub>D</sub> =-0.5A<br>T <sub>J</sub> =125°C                      |      | 0.53<br>0.75 | 0.8<br>0.95 | Ω     |
|                      |                                       | V <sub>GS</sub> =-2.5V, I <sub>D</sub> =-0.5A                                               |      | 0.72         | 1           | Ω     |
|                      |                                       | V <sub>GS</sub> =-1.8V, I <sub>D</sub> =-0.3A                                               |      | 0.95         | 1.3         | Ω     |
| g <sub>FS</sub>      | Forward Transconductance              | V <sub>DS</sub> =-5V, I <sub>D</sub> =-0.5A                                                 |      | 0.9          |             | S     |
| V <sub>SD</sub>      | Diode Forward Voltage                 | I <sub>S</sub> =-0.1A,V <sub>GS</sub> =0V                                                   |      | -0.66        | -1          | V     |
| I <sub>S</sub>       | Maximum Body-Diode Continuous Current |                                                                                             |      |              | -0.5        | A     |
| DYNAMIC PARAMETERS   |                                       |                                                                                             |      |              |             |       |
| C <sub>iss</sub>     | Input Capacitance                     | V <sub>GS</sub> =0V, V <sub>DS</sub> =-10V, f=1MHz                                          |      | 72           | 100         | pF    |
| C <sub>oss</sub>     | Output Capacitance                    |                                                                                             |      | 17           |             | pF    |
| C <sub>rss</sub>     | Reverse Transfer Capacitance          |                                                                                             |      | 9            |             | pF    |
| SWITCHING PARAMETERS |                                       |                                                                                             |      |              |             |       |
| t <sub>D(on)</sub>   | Turn-On DelayTime                     | V <sub>GS</sub> =-4.5V, V <sub>DS</sub> =-10V, R <sub>L</sub> =50Ω,<br>R <sub>GEN</sub> =3Ω |      | 60.5         |             | ns    |
| t <sub>r</sub>       | Turn-On Rise Time                     |                                                                                             |      | 150          |             | ns    |
| t <sub>D(off)</sub>  | Turn-Off DelayTime                    |                                                                                             |      | 612          |             | ns    |
| t <sub>f</sub>       | Turn-Off Fall Time                    |                                                                                             |      | 436          |             | ns    |
| t <sub>rr</sub>      | Body Diode Reverse Recovery Time      | I <sub>F</sub> =-0.5A, dI/dt=100A/μs                                                        |      | 27           | 35          | ns    |
| Q <sub>rr</sub>      | Body Diode Reverse Recovery Charge    | I <sub>F</sub> =-0.5A, dI/dt=100A/μs                                                        |      | 8.3          |             | 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. The current rating is based on the t<sub>θJA</sub> ≤ 10s thermal resistance rating.

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

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

D: The static characteristics in Figures 1 to 6,12,14 are obtained using <300 μs pulses, duty cycle 0.5% max.

E: These tests are performed with the device mounted on 1 in<sup>2</sup> FR-4 board with 2oz. Copper, in a still air environment with T<sub>A</sub>=25°C. The SOA curve provides a single pulse rating.

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## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

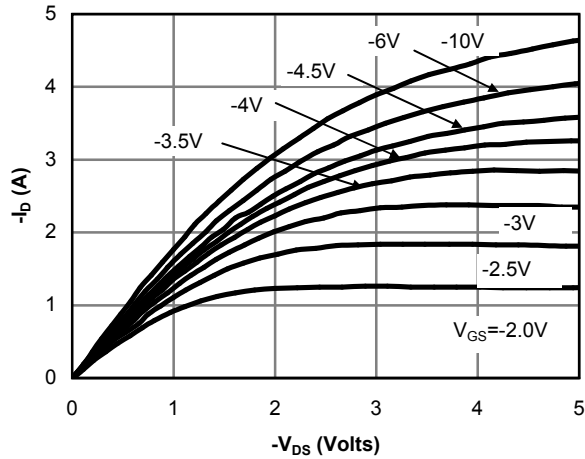


Figure 1: On-Region Characteristics

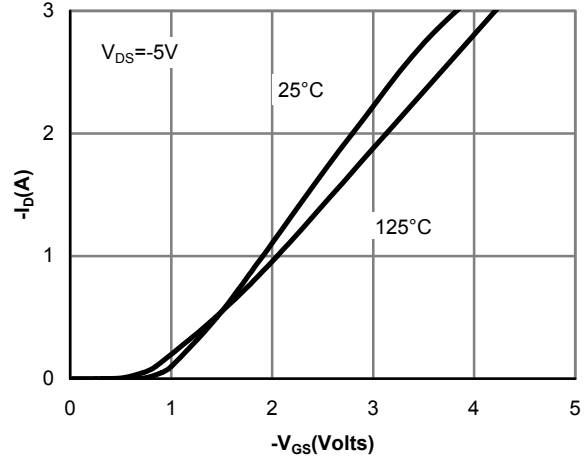


Figure 2: Transfer Characteristics

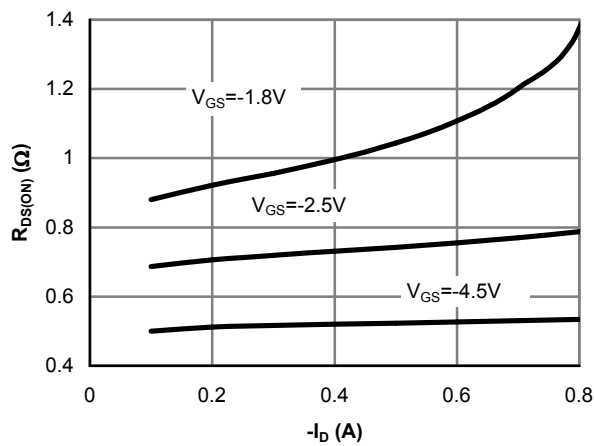


Figure 3: On-Resistance vs. Drain Current and Gate Voltage

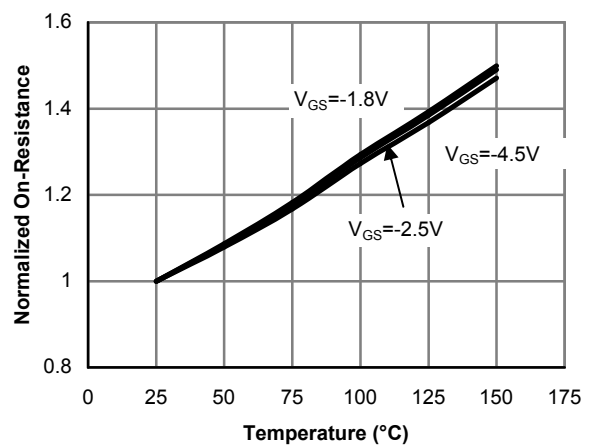


Figure 4: On-Resistance vs. Junction Temperature

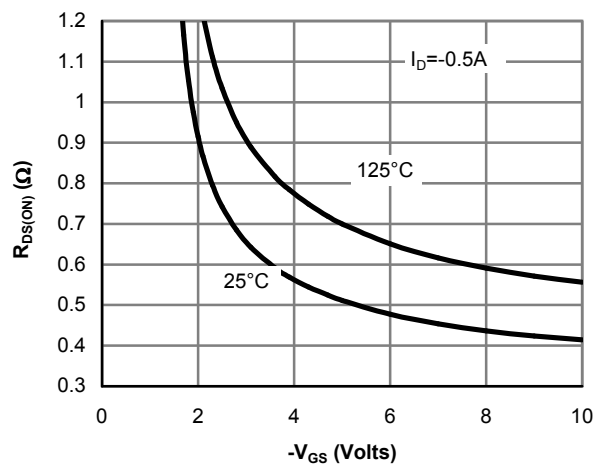


Figure 5: On-Resistance vs. Gate-Source Voltage

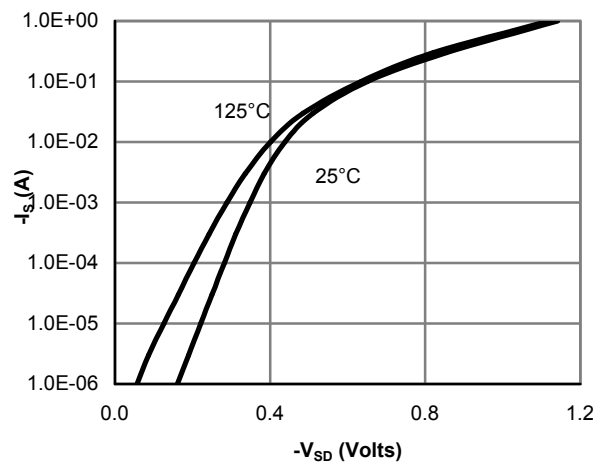


Figure 6: Body-Diode Characteristics

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

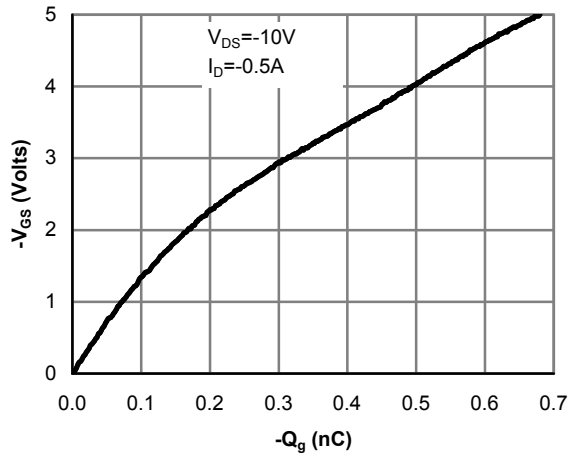


Figure 7: Gate-Charge Characteristics

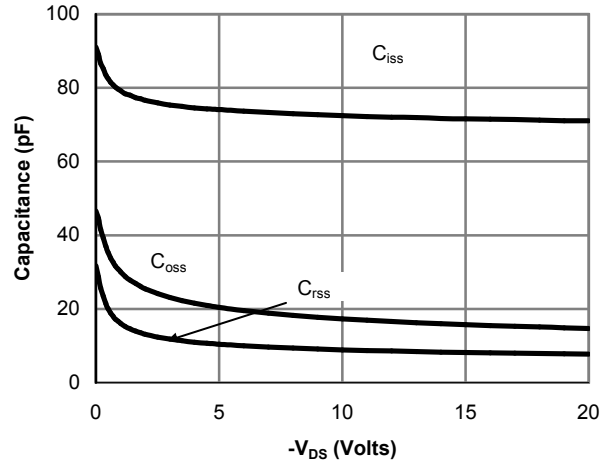


Figure 8: Capacitance Characteristics

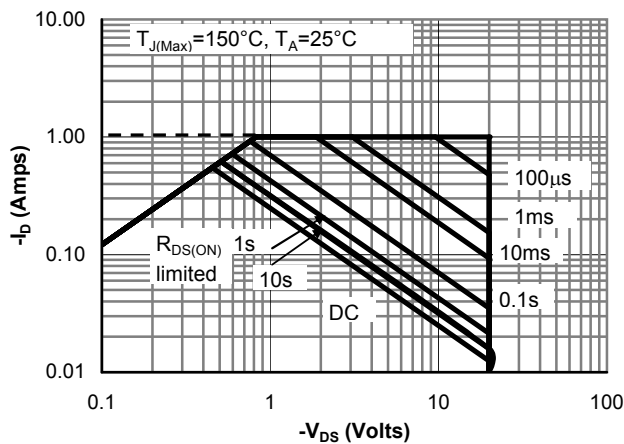


Figure 9: Maximum Forward Biased Safe Operating Area (Note E)

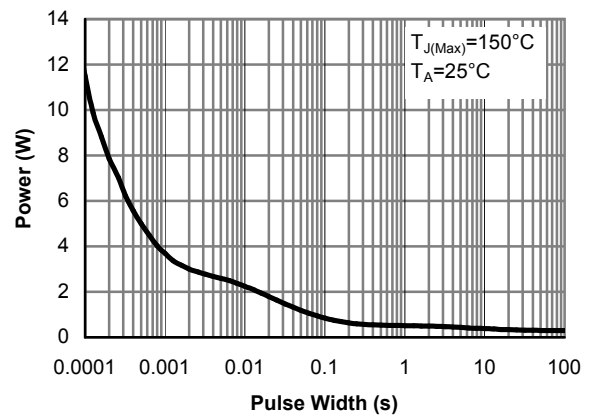


Figure 10: Single Pulse Power Rating Junction-to-Ambient (Note E)

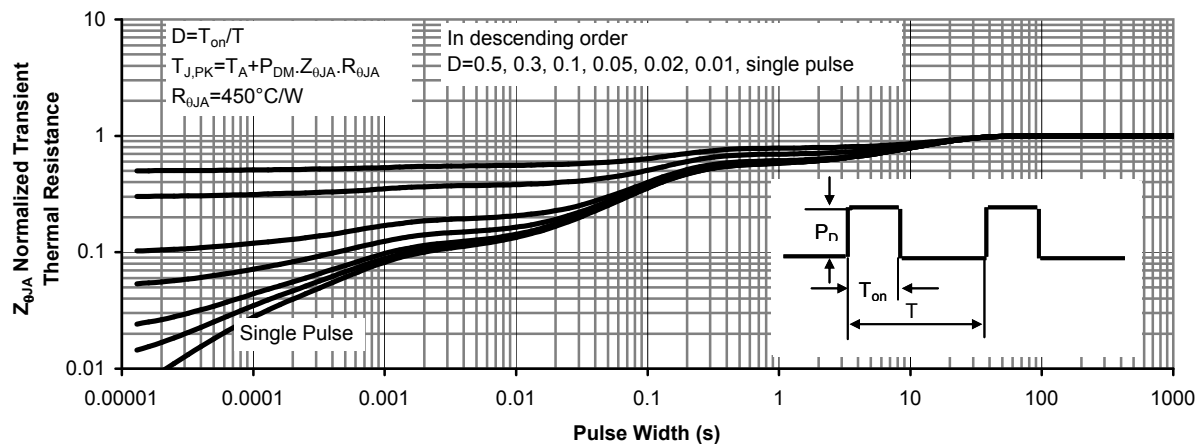
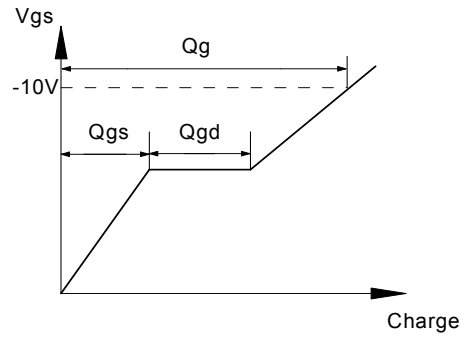
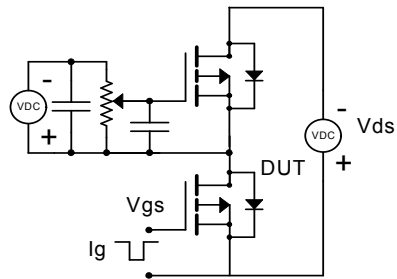
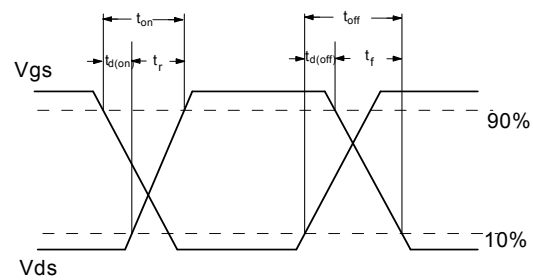
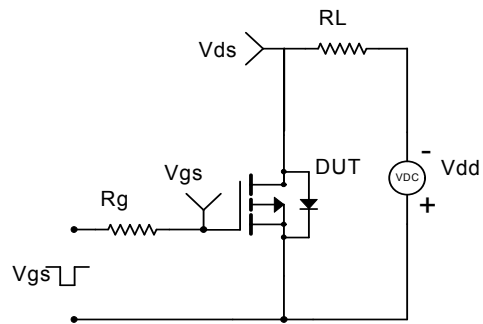


Figure 11: Normalized Maximum Transient Thermal Impedance

Gate Charge Test Circuit &amp; Waveform



Resistive Switching Test Circuit &amp; Waveforms



Diode Recovery Test Circuit &amp; Waveforms

