

**PRECISION P-CHANNEL ENHANCEMENT MODE  
EPAD® MATCHED PAIR MOSFET ARRAY**

**V<sub>GS(th)</sub> = -0.40V**

**GENERAL DESCRIPTION**

The ALD310704A/ALD310704 high precision monolithic P-Channel MOSFET array is matched at the factory using ALD's proven EPAD® CMOS technology. This device is available in a quad and dual version and is a member of the EPAD® Matched Pair MOSFET Family. The ALD310704A/ALD310704 is a P-channel version of the popular ALD110804A/ALD110804 Precision Threshold device. Together, these two MOSFET series enable complementary precision N-Channel and P-Channel MOSFET array based circuits.

Intended for low voltage and low power small signal applications, the ALD310704A/ALD310704 features precision -0.40V Gate Threshold Voltage, which enables circuit designs with very low operating voltages such as < +1.0V power supplies where the circuits operate below the threshold voltage of the ALD310704A/ALD310704. This feature also enhances input/output signal operating ranges, especially in very low operating voltage environments. With these low threshold precision devices, a circuit with multiple cascading stages can be constructed to operate at extremely low supply or bias voltage levels. ALD310704A/ALD310704 also features high input impedance ( $2.5 \times 10^{10}\Omega$ ) and high DC current gain ( $>10^8$ ).

ALD310704A/ALD310704 MOSFETs are designed for exceptional matching of device electrical characteristics. The Gate Threshold Voltage  $V_{GS(th)}$  is set precisely at -0.40V  $\pm 0.02V$ , featuring a typical offset voltage of only  $\pm 0.001V$  (1mV). As these devices are on the same monolithic chip, they also exhibit excellent temperature tracking characteristics. They are versatile design components for a broad range

(Continued on next page)

**FEATURES & BENEFITS**

- Precision matched Gate Threshold Voltages
- Precision offset voltages ( $V_{OS}$ ):  
ALD310704A: 2mV max.  
ALD310704: 10mV max.
- Sub-threshold voltage operation
- Low min. operating voltage of less than 0.4V
- Ultra low min. operating current of less than 1nA
- Nano-power operation
- Wide dynamic operating current ranges
- Exponential operating current ranges
- Matched transconductance and output conductance
- Matched and tracked temperature characteristics
- Tight lot-to-lot parametric control
- Positive, zero, and negative  $V_{GS(th)}$  tempco bias currents
- Low input capacitance
- Low input/output leakage currents

**ORDERING INFORMATION** ("L" suffix denotes lead-free (RoHS))

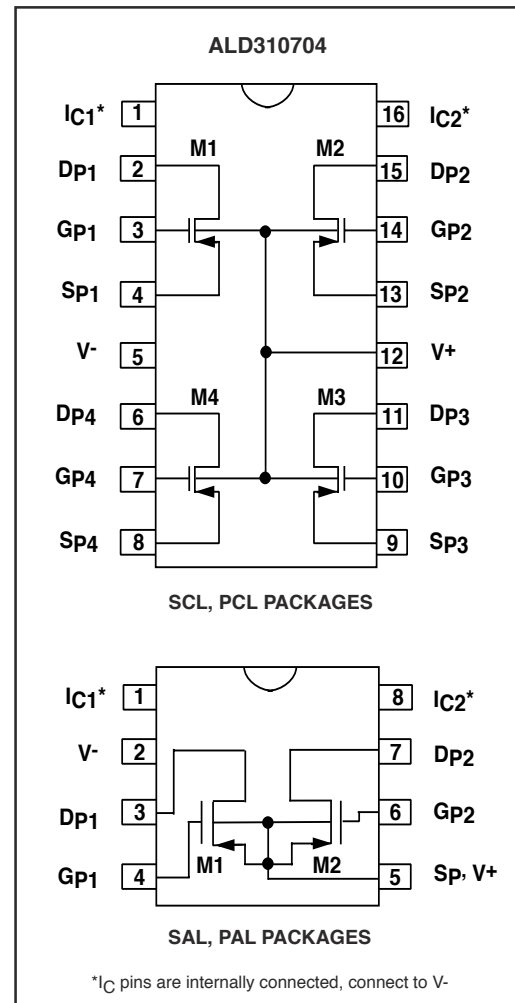
Operating Temperature Range * 0°C to +70°C	
16-Pin SOIC Package	16-Pin Plastic Dip Package
ALD310704ASCL ALD310704SCL	ALD310704APCL ALD310704PCL
8-Pin SOIC Package	8-Pin Plastic Dip Package
ALD310704ASAL ALD310704SAL	ALD310704APAL ALD310704PAL

\*Contact factory for industrial temp. range or user-specified threshold voltage values.

**APPLICATIONS**

- 0.5% precision current mirrors and current sources
- Low Tempco ( $\leq 50\text{ppm}/^\circ\text{C}$ ) current mirrors/sources
- Energy harvesting circuits
- Very low voltage analog and digital circuits
- Backup battery circuits & power failure detectors
- Precision low level voltage-clamps
- Low level zero-crossing detector
- Source followers and buffers
- Precision capacitive probes and sensor interfaces
- Precision charge detectors and charge integrators
- Discrete differential amplifier input stage
- Peak-detectors and level-shifters
- High-side switches and Sample-and-Hold switches
- Precision current multipliers
- Discrete analog switches / multiplexers
- Discrete voltage comparators

**PIN CONFIGURATION**



## GENERAL DESCRIPTION (cont.)

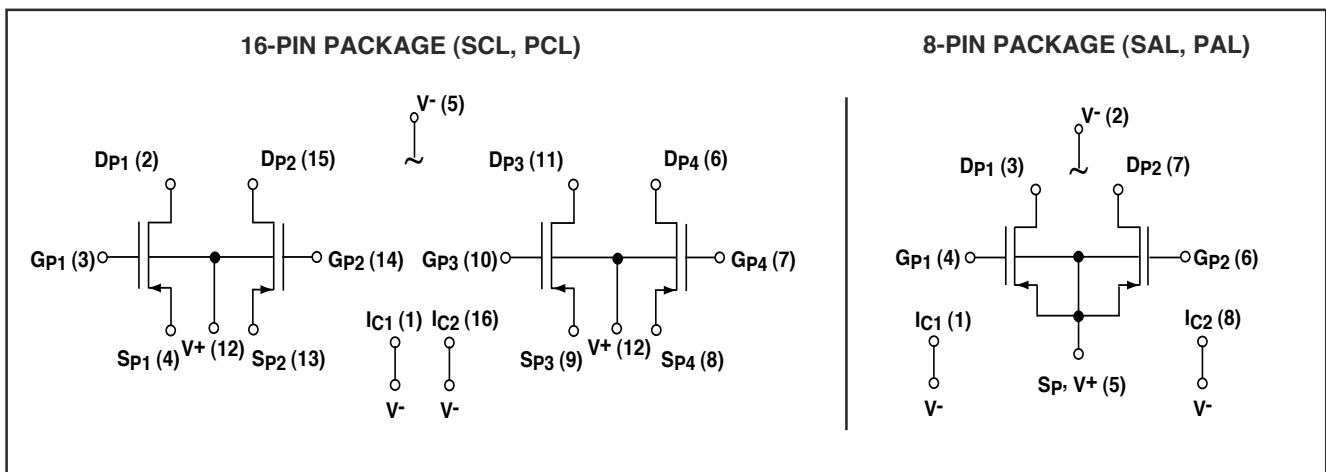
of precision analog applications such as basic building blocks for current mirrors, matching circuits, current sources, differential amplifier input stages, transmission gates, and multiplexers. These devices also excel in limited operating voltage applications such as very low level precision voltage-clamps. In addition to matched pair electrical characteristics, each individual MOSFET exhibits individual well controlled manufacturing characteristics, enabling the user to depend on tight design limits from different production batches.

These devices are built to offer minimum offset voltage and differential thermal response, and they can also be used for switching and amplifying applications in  $-0.40\text{V}$  to  $-8.0\text{V}$  ( $\pm 0.20\text{V}$  to  $\pm 4.0\text{V}$ ) powered systems where low input bias current, low input capacitance, and fast switching speed are desired. These devices, exhibiting well controlled turn-off and sub-threshold characteristics, operate the same as standard enhancement mode P-Channel MOSFETs.

However, the precision of the Gate Threshold Voltage enable two key additional characteristics, or operating features. First, the operating current level varies exponentially with gate bias voltage at or below the Gate Threshold Voltage (subthreshold region). Second, the circuit can be biased and operated in the subthreshold region with nA of bias current and nW of power dissipation.

For most general applications, connect the  $V+$  pin to the most positive voltage and the  $V-$  and IC (internally-connected) pins to the most negative voltage in the system. All other pins must have voltages within these voltage limits at all times. Standard ESD protection facilities and procedures for static sensitive devices are required when handling these devices.

## BLOCK DIAGRAMS



## ABSOLUTE MAXIMUM RATINGS

Drain-Source voltage,  $V_{DS}$  \_\_\_\_\_ -8.0V  
 Gate-Source voltage,  $V_{GS}$  \_\_\_\_\_ -8.0V  
 Operating Current \_\_\_\_\_ 80mA  
 Power dissipation \_\_\_\_\_ 500mW  
 Operating temperature range SCL, PCL SAL, PAL \_\_\_\_\_ 0°C to +70°C  
 Storage temperature range \_\_\_\_\_ -65°C to +150°C  
 Lead temperature, 10 seconds \_\_\_\_\_ +260°C

**CAUTION: ESD Sensitive Device. Use static control procedures in ESD controlled environment.**

## OPERATING ELECTRICAL CHARACTERISTICS

$V^+ = +5V$   $V^- = GND$   $T_A = 25^\circ C$  unless otherwise specified

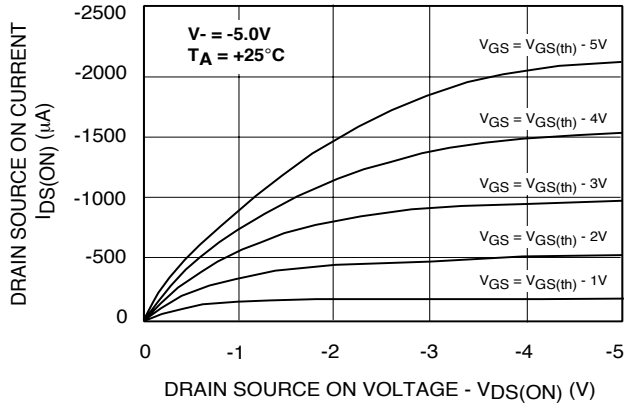
Parameter	Symbol	ALD310704A			ALD310704			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Gate Threshold Voltage	$V_{GS(th)}$	-0.42	-0.40	-0.38	-0.42	-0.40	-0.38	V	$I_{DS} = -1\mu A, V_{DS} = -0.1V$
Offset Voltage	VOS		1	2		2	10	mV	$V_{GS(th)M1} - V_{GS(th)M2}$ or $V_{GS(th)M3} - V_{GS(th)M4}$
Gate Threshold Temperature	$TCV_{GS(th)}$		-2			-2		mV/°C	
Drain Source On Current	$I_{DS(ON)}$		-1.83			-1.83		mA	$V_{GS} = V_{DS} = -5.0V$
Transconductance Current <sup>2</sup>	$G_{FS}$		570			570		$\mu A/V$	$V_{GS} = V_{DS} = -5.0V$
Transconductance Mismatch	$\Delta G_{FS}$		1			1		%	$V_{GS} = V_{DS} = -5.0V$
Output Conductance <sup>2</sup>	$G_{OS}$		48			48		$\mu A/V$	$V_{GS(th)} = -4.0V,$ $V_{DS} = -5.0V$
Drain Source On Resistance	$R_{DS(ON)}$		1.20			1.20		K $\Omega$	$V_{GS} = -5.0V,$ $V_{DS} = -0.1V$
Drain Source On Resistance Mismatch	$\Delta R_{DS(ON)}$		1			1		%	
Drain Source Breakdown	$BV_{DSX}$	-8.0			-8.0			V	
Drain Source Leakage Current <sup>1</sup>	$I_{DS(OFF)}$			400			400	pA	
Gate Leakage Current	$I_{GSS}$			200			200	pA	
Input Capacitance <sup>2</sup>	$C_{ISS}$		2.5			2.5		pF	

Notes: <sup>1</sup> Consists of junction leakage currents

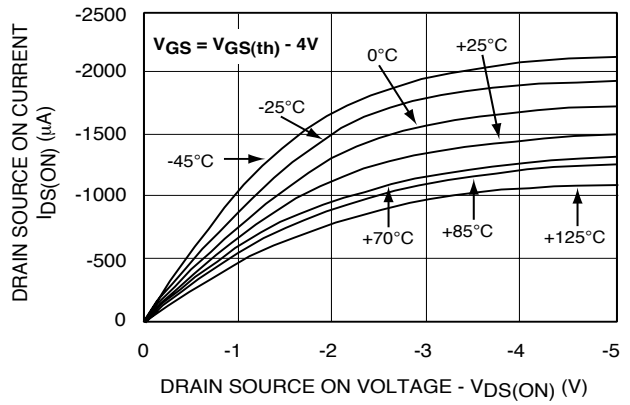
<sup>2</sup> Sample tested parameters

# TYPICAL PERFORMANCE CHARACTERISTICS

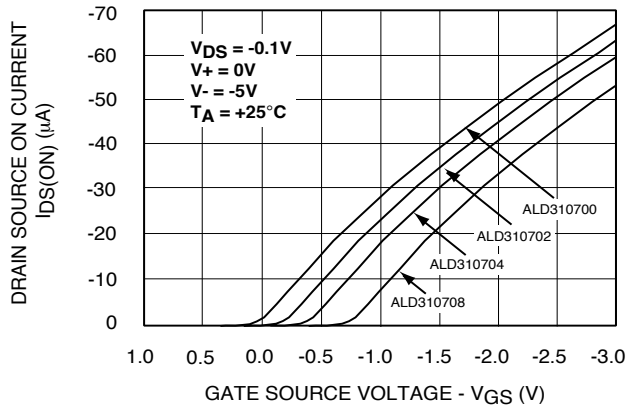
## OUTPUT CHARACTERISTICS



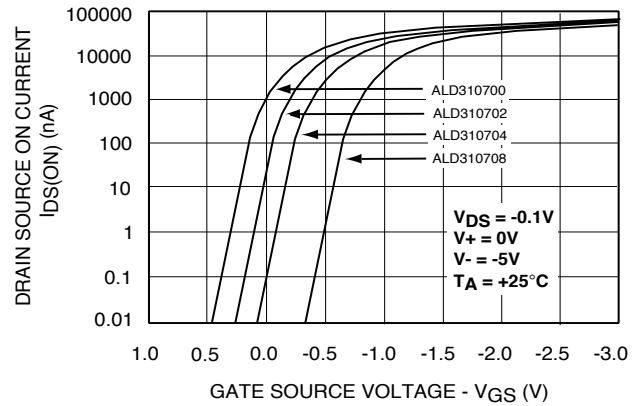
## OUTPUT CHARACTERISTICS



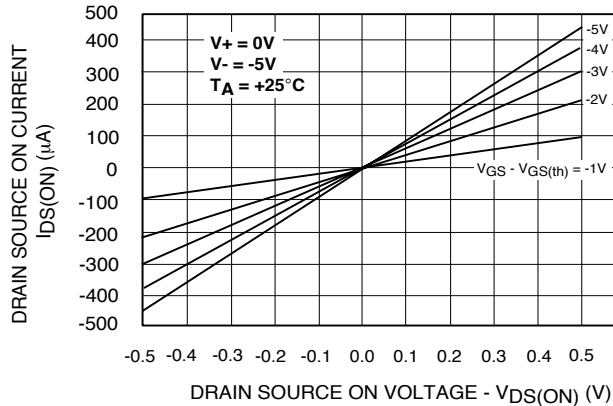
## FORWARD TRANSFER CHARACTERISTICS



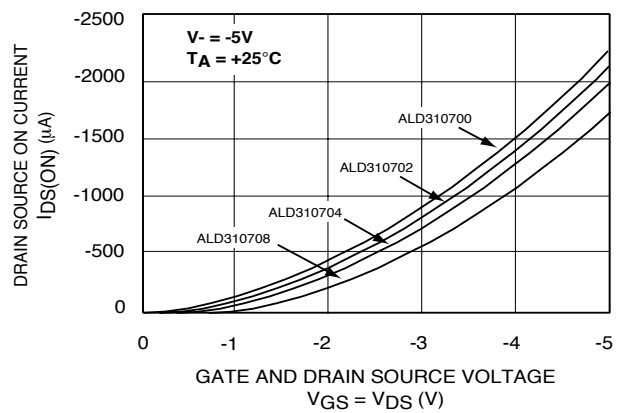
## FORWARD TRANSFER CHARACTERISTICS (SUBTHRESHOLD)



## LOW VOLTAGE OUTPUT CHARACTERISTICS

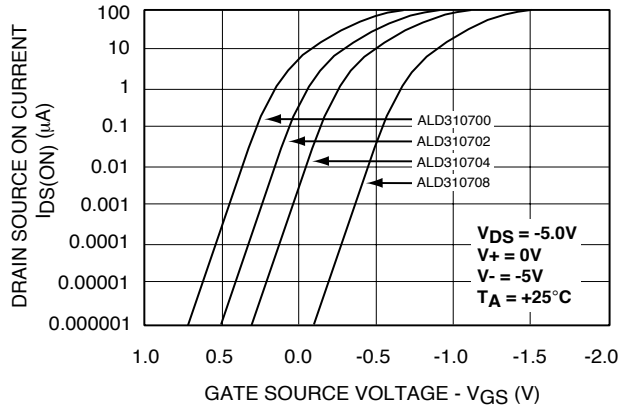


## DRAIN SOURCE ON CURRENT vs. GATE AND DRAIN SOURCE VOLTAGE

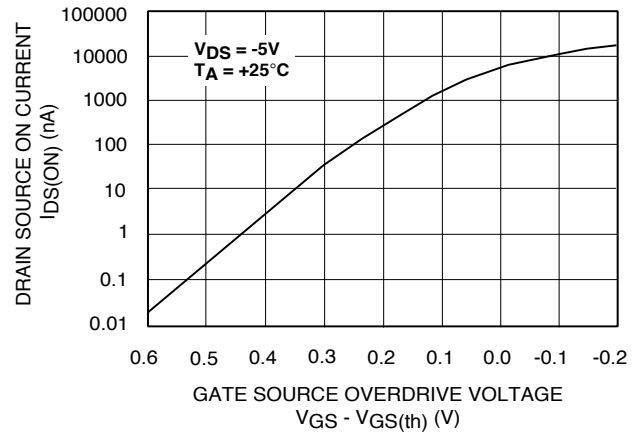


## TYPICAL PERFORMANCE CHARACTERISTICS (cont.)

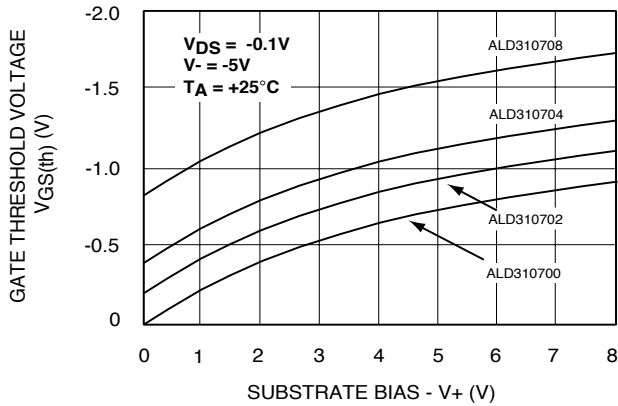
**FORWARD TRANSFER CHARACTERISTICS EXPANDED (SUBTHRESHOLD)**



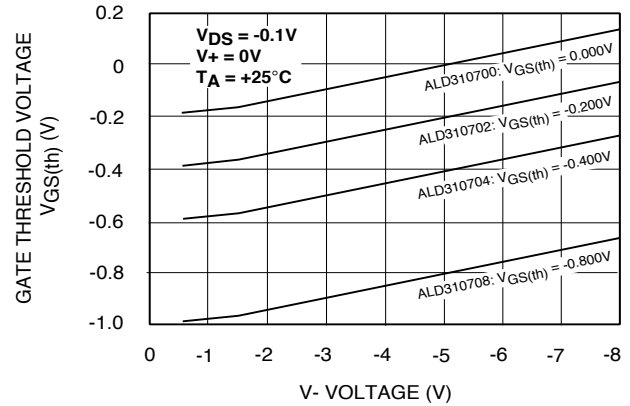
**FORWARD TRANSFER CHARACTERISTICS FURTHER EXPANDED (SUBTHRESHOLD)**



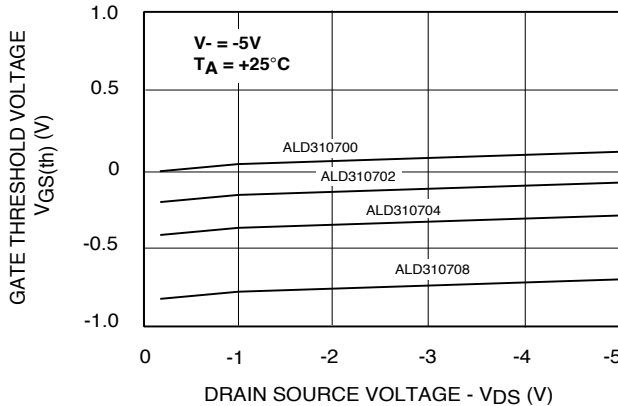
**GATE THRESHOLD VOLTAGE vs. SUBSTRATE BIAS**



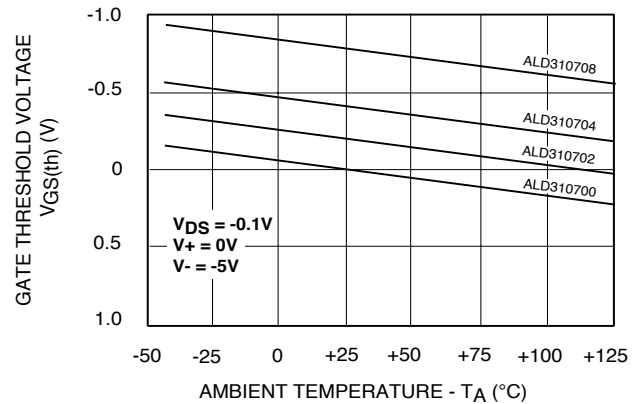
**GATE THRESHOLD VOLTAGE vs. V- VOLTAGE**



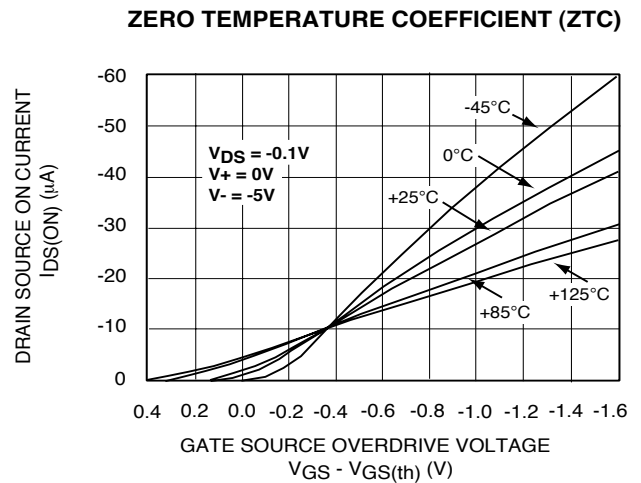
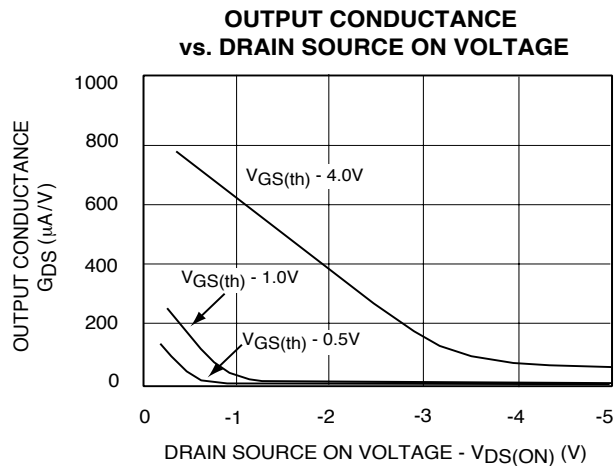
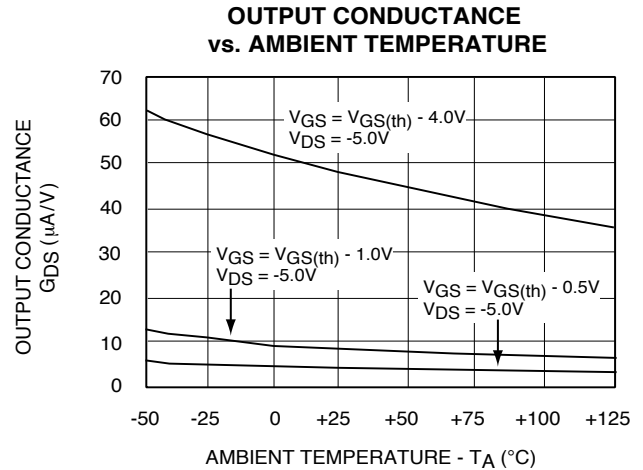
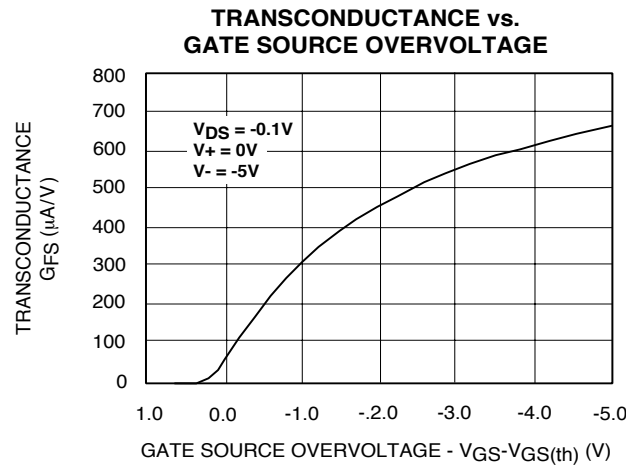
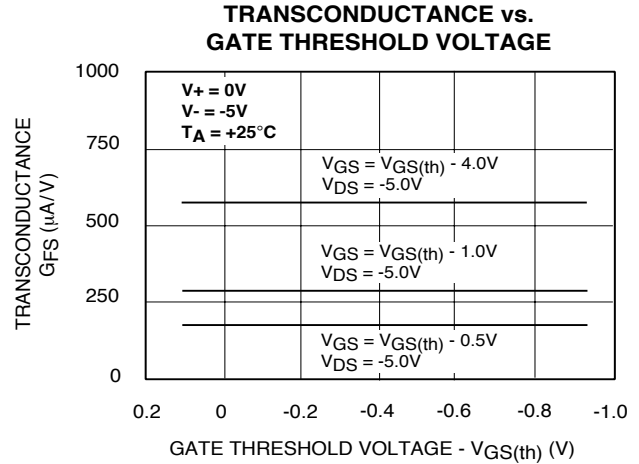
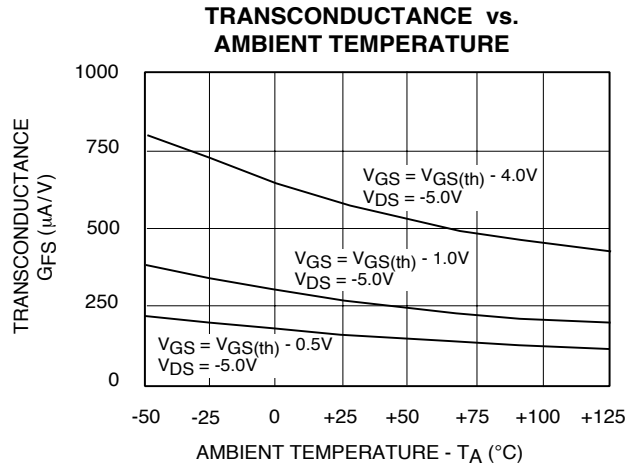
**GATE THRESHOLD VOLTAGE vs. DRAIN SOURCE VOLTAGE**



**GATE THRESHOLD VOLTAGE vs. AMBIENT TEMPERATURE**

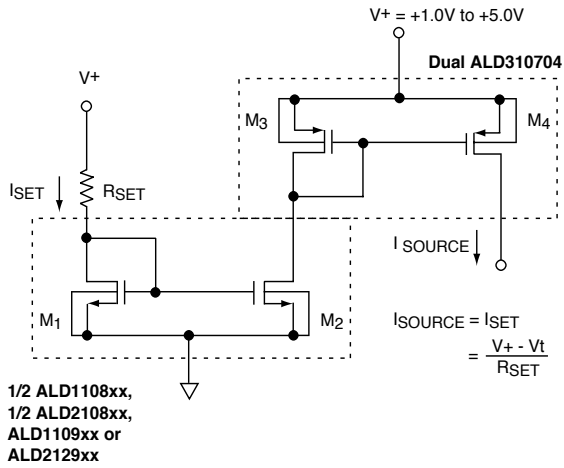


## TYPICAL PERFORMANCE CHARACTERISTICS (cont.)



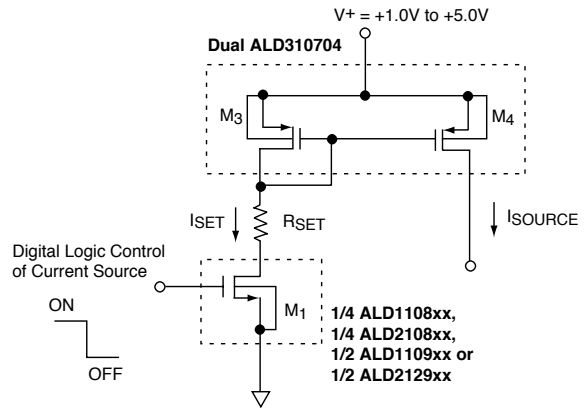
## TYPICAL APPLICATIONS

### LOW VOLTAGE CURRENT SOURCE MIRROR



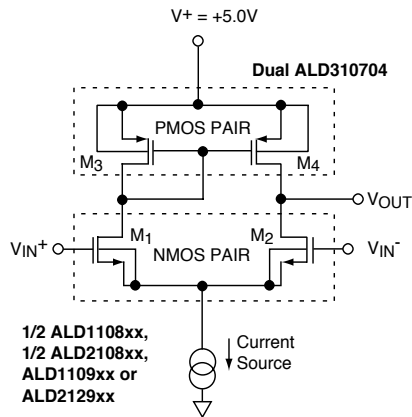
M1, M2: N-Channel MOSFET  
M3, M4: P-Channel MOSFET

### LOW VOLTAGE CURRENT SOURCE W/ GATE CONTROL



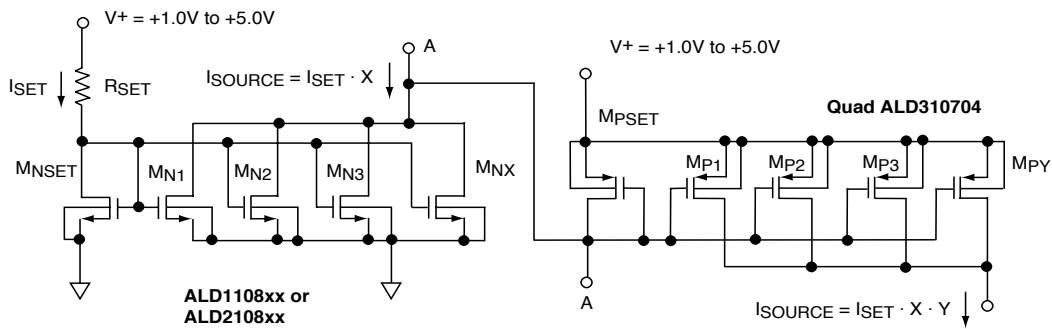
M1 : N-Channel MOSFET  
M3, M4: P-Channel MOSFET

### LOW VOLTAGE DIFFERENTIAL AMPLIFIER



M1, M2: N-Channel MOSFET  
M3, M4: P-Channel MOSFET

### 0.5% PRECISION LOW VOLTAGE CURRENT SOURCE MULTIPLICATION

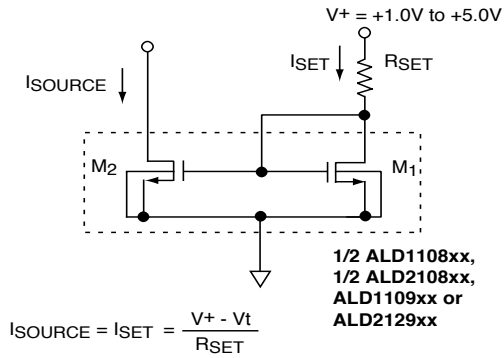


MNSET: MN1, MN2..MNX: N-Channel MOSFET

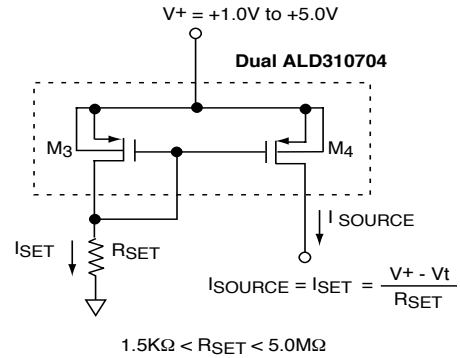
MPSET: MP1, MP2..MPY: P-Channel MOSFET

## TYPICAL APPLICATIONS (cont.)

### 0.5% LOW VOLTAGE PRECISION CURRENT MIRRORS

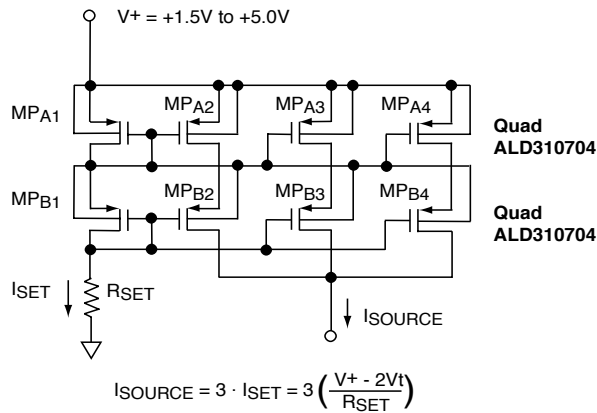


M<sub>1</sub>, M<sub>2</sub>: N-Channel MOSFET



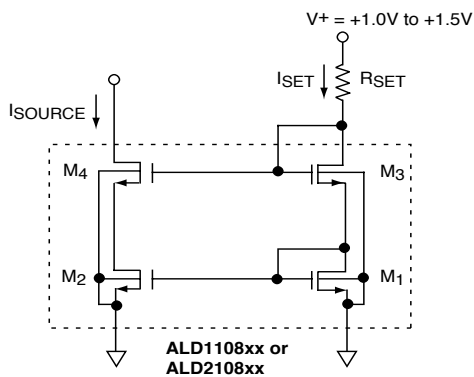
M<sub>3</sub>, M<sub>4</sub>: P-Channel MOSFET

### 0.5% PRECISION LOW VOLTAGE CASCODE CURRENT SOURCES

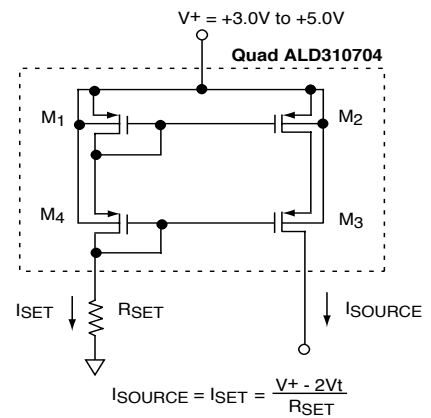


MPA<sub>1</sub>...MPA<sub>4</sub>: ALD310704 P-Channel MOSFET (1st individual pkg)  
MPB<sub>1</sub>...MPB<sub>4</sub>: ALD310704 P-Channel MOSFET (2nd individual pkg)

### 0.5% PRECISION LOW TEMPCO CASCODE CURRENT SOURCES



M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub>, M<sub>4</sub>: N-Channel MOSFET

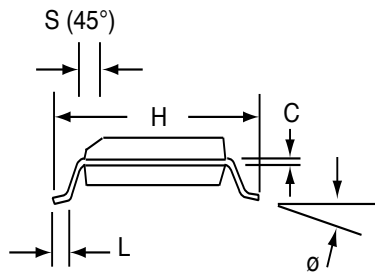
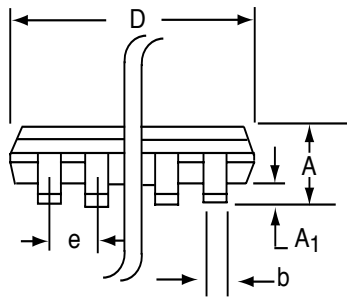
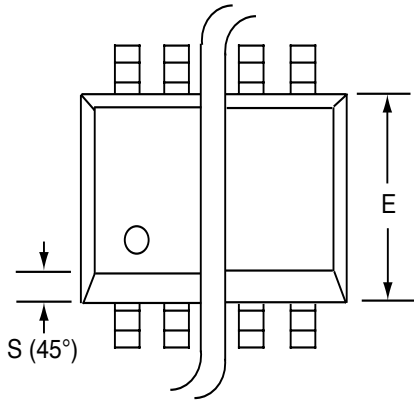


M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub>, M<sub>4</sub>: P-Channel MOSFET



# SOIC-16 PACKAGE DRAWING

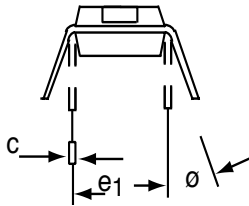
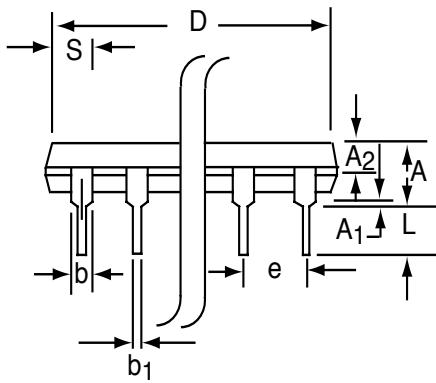
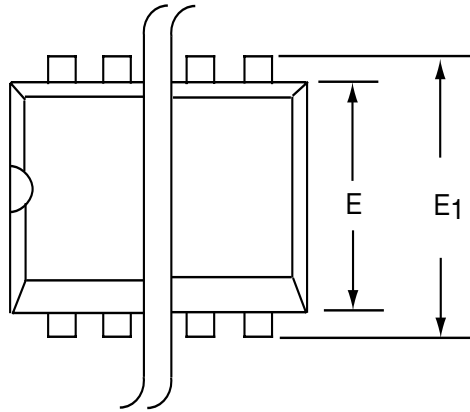
## 16 Pin Plastic SOIC Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
<b>A</b>	1.35	1.75	0.053	0.069
<b>A<sub>1</sub></b>	0.10	0.25	0.004	0.010
<b>b</b>	0.35	0.45	0.014	0.018
<b>C</b>	0.18	0.25	0.007	0.010
<b>D-16</b>	9.80	10.00	0.385	0.394
<b>E</b>	3.50	4.05	0.140	0.160
<b>e</b>	1.27 BSC		0.050 BSC	
<b>H</b>	5.70	6.30	0.224	0.248
<b>L</b>	0.60	0.937	0.024	0.037
<b>∅</b>	0°	8°	0°	8°
<b>S</b>	0.25	0.50	0.010	0.020

# PDIP-16 PACKAGE DRAWING

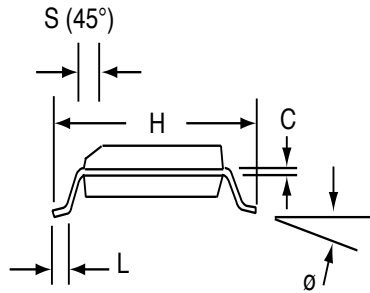
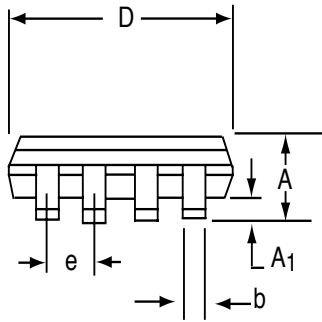
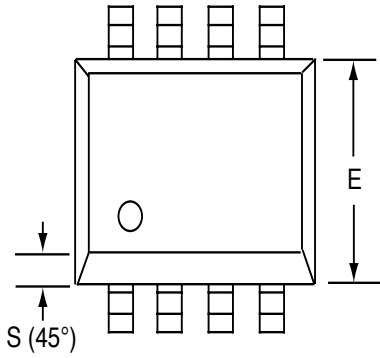
## 16 Pin Plastic DIP Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.105	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>A<sub>2</sub></b>	1.27	2.03	0.050	0.080
<b>b</b>	0.89	1.65	0.035	0.065
<b>b<sub>1</sub></b>	0.38	0.51	0.015	0.020
<b>c</b>	0.20	0.30	0.008	0.012
<b>D-16</b>	18.93	21.33	0.745	0.840
<b>E</b>	5.59	7.11	0.220	0.280
<b>E<sub>1</sub></b>	7.62	8.26	0.300	0.325
<b>e</b>	2.29	2.79	0.090	0.110
<b>e<sub>1</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>S-16</b>	0.38	1.52	0.015	0.060
<b><math>\theta</math></b>	0°	15°	0°	15°

# SOIC-8 PACKAGE DRAWING

## 8 Pin Plastic SOIC Package

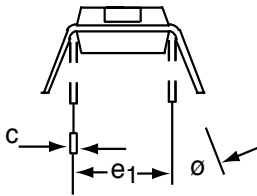
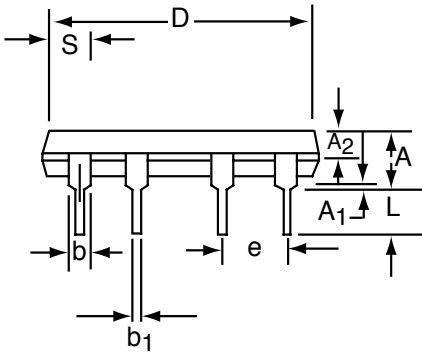
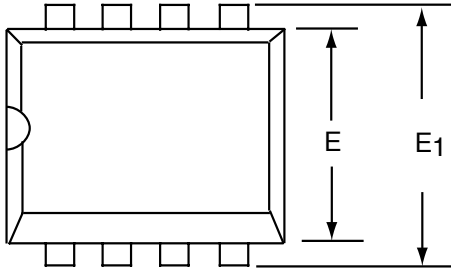


Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.25	0.004	0.010
b	0.35	0.45	0.014	0.018
C	0.18	0.25	0.007	0.010
D-8	4.69	5.00	0.185	0.196
E	3.50	4.05	0.140	0.160
e	1.27 BSC		0.050 BSC	
H	5.70	6.30	0.224	0.248
L	0.60	0.937	0.024	0.037
∅	0°	8°	0°	8°
S	0.25	0.50	0.010	0.020

□

# PDIP-8 PACKAGE DRAWING

## 8 Pin Plastic DIP Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.105	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>A<sub>2</sub></b>	1.27	2.03	0.050	0.080
<b>b</b>	0.89	1.65	0.035	0.065
<b>b<sub>1</sub></b>	0.38	0.51	0.015	0.020
<b>c</b>	0.20	0.30	0.008	0.012
<b>D-8</b>	9.40	11.68	0.370	0.460
<b>E</b>	5.59	7.11	0.220	0.280
<b>E<sub>1</sub></b>	7.62	8.26	0.300	0.325
<b>e</b>	2.29	2.79	0.090	0.110
<b>e<sub>1</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>S-8</b>	1.02	2.03	0.040	0.080
<b>ø</b>	0°	15°	0°	15°