

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

V_{GS(th)} = -0.20V

GENERAL DESCRIPTION

The ALD310702A/ALD310702 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 ALD310702A/ALD310702 is a P-channel version of the popular ALD110802A/ALD110802 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 ALD310702A/ALD310702 features precision -0.80V Gate Threshold Voltage, which enables circuit designs with very low operating voltages such as < +0.5V power supplies where the circuits operate below the threshold voltage of the ALD310702A/ALD310702. 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. ALD310702A/ALD310702 also features high input impedance ($2.5 \times 10^{10}\Omega$) and high DC current gain ($>10^8$).

ALD310702A/ALD310702 MOSFETs are designed for exceptional matching of device electrical characteristics. The Gate Threshold Voltage $V_{GS(th)}$ is set precisely at -0.20V +/-0.02V, featuring a typical offset voltage of only +/-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}):
ALD310702A: 2mV max.
ALD310702: 10mV max.
- Sub-threshold voltage operation
- Low min. operating voltage of less than 0.2V
- 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))

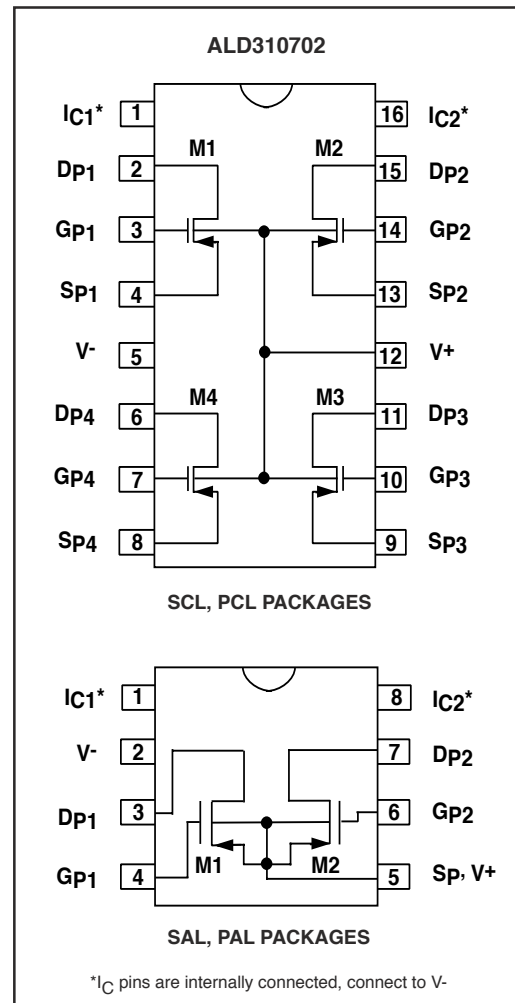
Operating Temperature Range * 0°C to +70°C	
16-Pin SOIC Package	16-Pin Plastic Dip Package
ALD310702ASCL ALD310702SCL	ALD310702APCL ALD310702PCL
8-Pin SOIC Package	8-Pin Plastic Dip Package
ALD310702ASAL ALD310702SAL	ALD310702APAL ALD310702PAL

*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.)

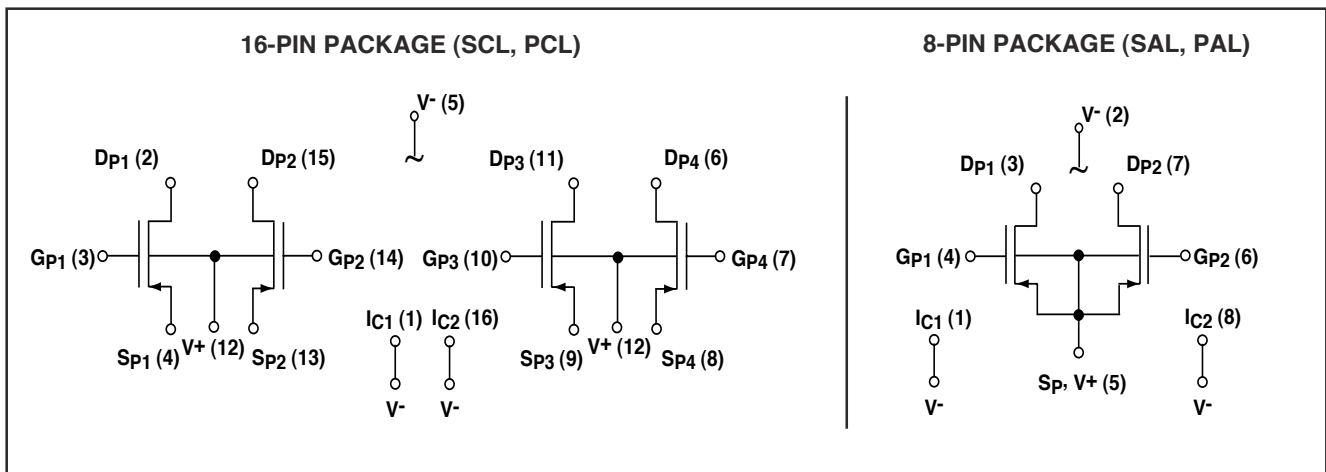
of precision analog applications such as basic building blocks for current mirrors, matching circuits, current sources, differential amplifier input stages, transmission gates, and multiplexers. These devices also excel in limited operating voltage applications such as very low level precision voltage-clamps. 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 -0.40V to -8.0V ($\pm 0.20\text{V}$ 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

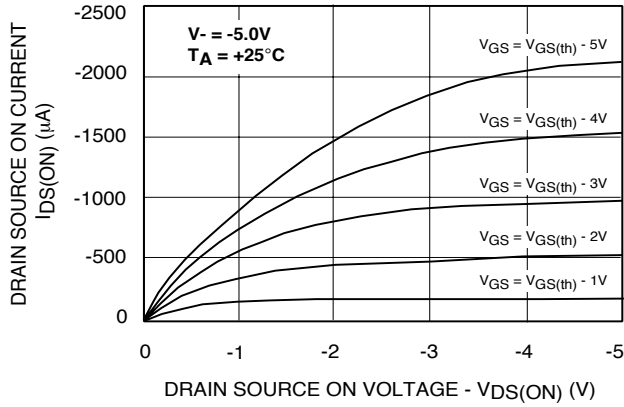
Parameter	Symbol	ALD310702A			ALD310702			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Gate Threshold Voltage	$V_{GS(th)}$	-0.22	-0.20	-0.18	-0.22	-0.20	-0.18	V	$I_{DS} = -1\mu A$, $V_{DS} = -0.1V$
Offset Voltage	V_{OS}		1	2		2	10	mV	$V_{GS(th)M1} - V_{GS(th)M2}$ or $V_{GS(th)M3} - V_{GS(th)M4}$
Gate Threshold Temperature	$TCV_{GS(th)}$		-2			-2		mV/°C	
Drain Source On Current	$I_{DS(ON)}$		-2.03			-2.03		mA	$V_{GS} = V_{DS} = -5.0V$
Transconductance Current ²	G_{FS}		570			570		$\mu A/V$	$V_{GS} = V_{DS} = -5.0V$
Transconductance Mismatch	ΔG_{FS}		1			1		%	$V_{GS} = V_{DS} = -5.0V$
Output Conductance ²	G_{OS}		48			48		$\mu A/V$	$V_{GS(th)} = -4.0V$, $V_{DS} = -5.0V$
Drain Source On Resistance	$R_{DS(ON)}$		1.14			1.14		K Ω	$V_{GS} = -5.0V$, $V_{DS} = -0.1V$
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 ¹	$I_{DS(OFF)}$			400			400	pA	
Gate Leakage Current	I_{GSS}			200			200	pA	
Input Capacitance ²	C_{ISS}		2.5			2.5		pF	

Notes: ¹ Consists of junction leakage currents

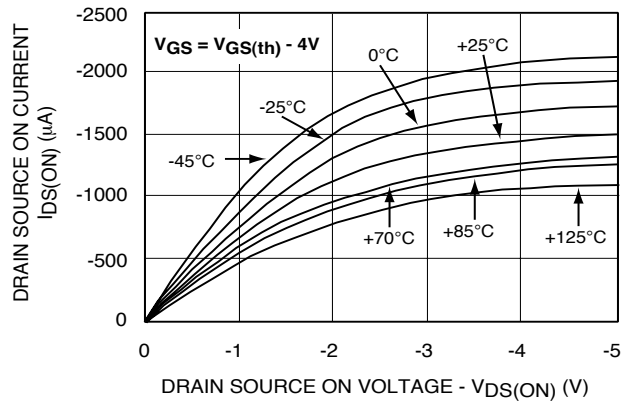
² Sample tested parameters

TYPICAL PERFORMANCE CHARACTERISTICS

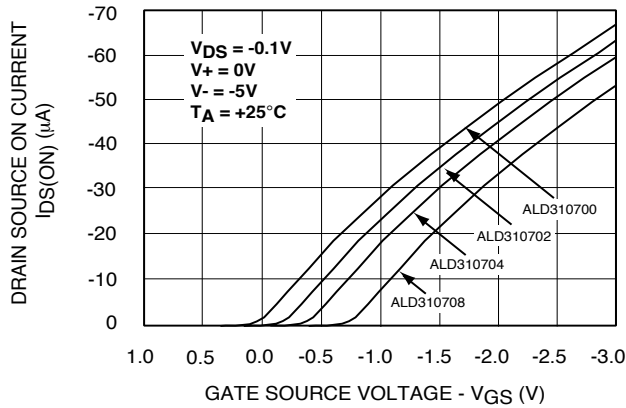
OUTPUT CHARACTERISTICS



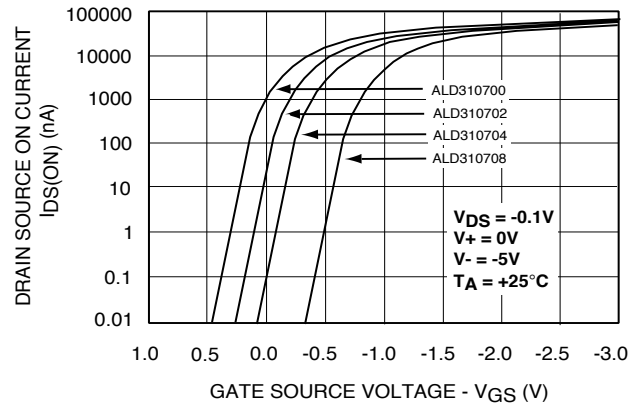
OUTPUT CHARACTERISTICS



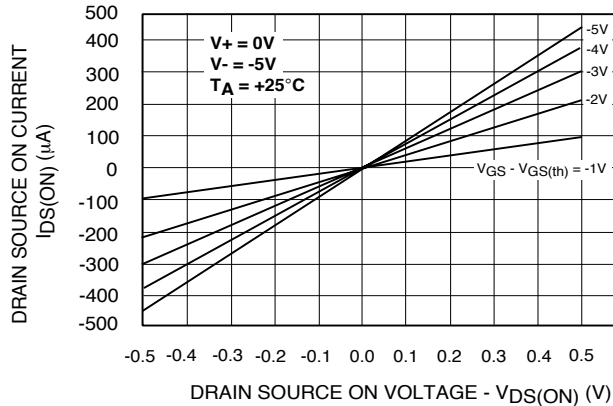
FORWARD TRANSFER CHARACTERISTICS



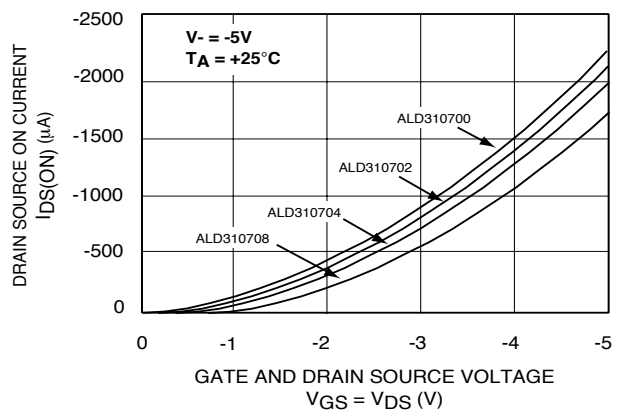
FORWARD TRANSFER CHARACTERISTICS (SUBTHRESHOLD)



LOW VOLTAGE OUTPUT CHARACTERISTICS

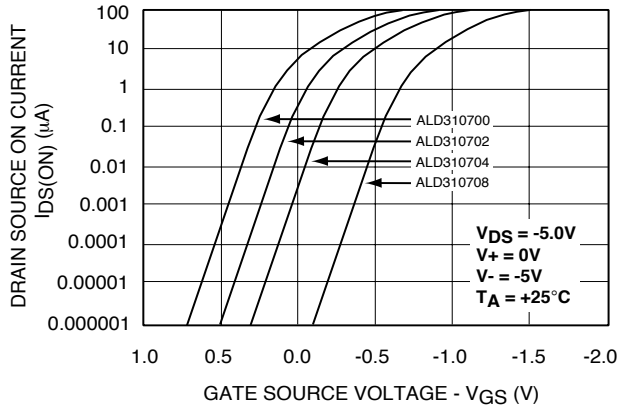


DRAIN SOURCE ON CURRENT vs. GATE AND DRAIN SOURCE VOLTAGE

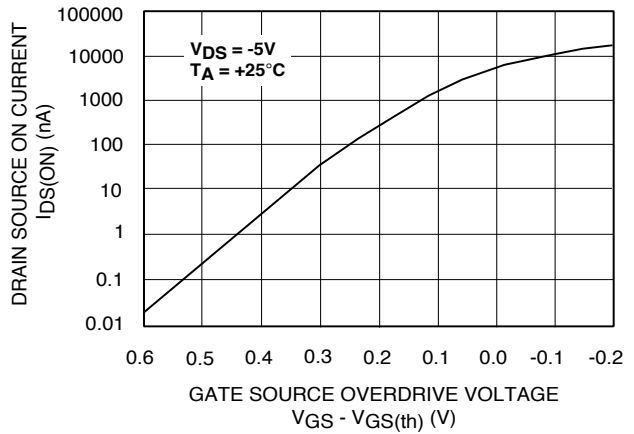


TYPICAL PERFORMANCE CHARACTERISTICS (cont.)

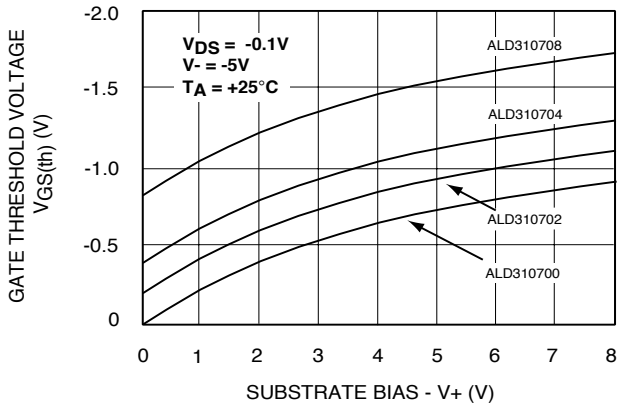
FORWARD TRANSFER CHARACTERISTICS EXPANDED (SUBTHRESHOLD)



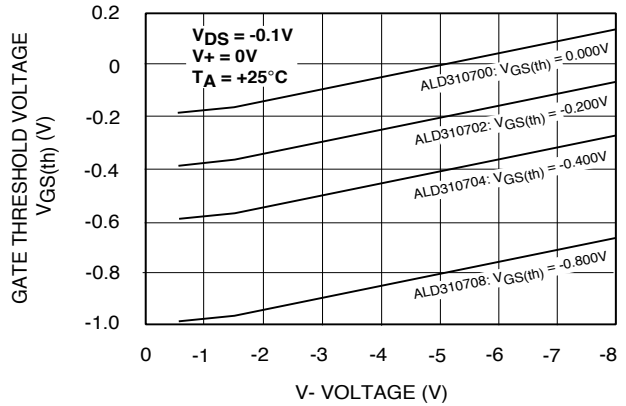
FORWARD TRANSFER CHARACTERISTICS FURTHER EXPANDED (SUBTHRESHOLD)



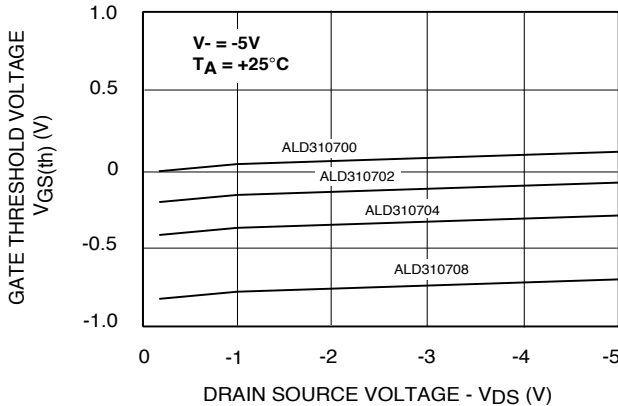
GATE THRESHOLD VOLTAGE vs. SUBSTRATE BIAS



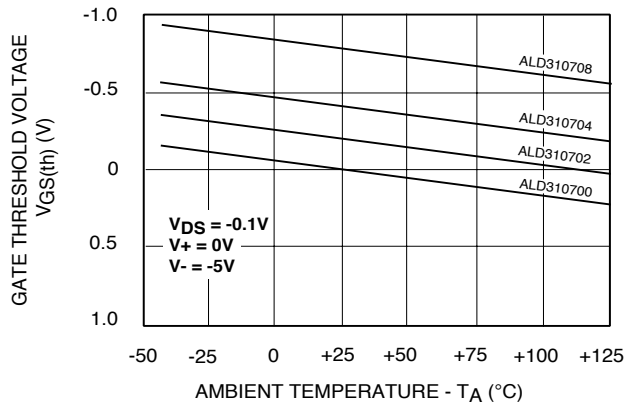
GATE THRESHOLD VOLTAGE vs. V- VOLTAGE



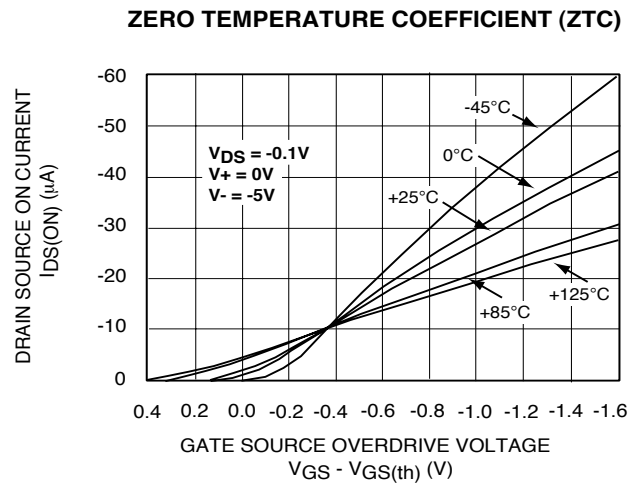
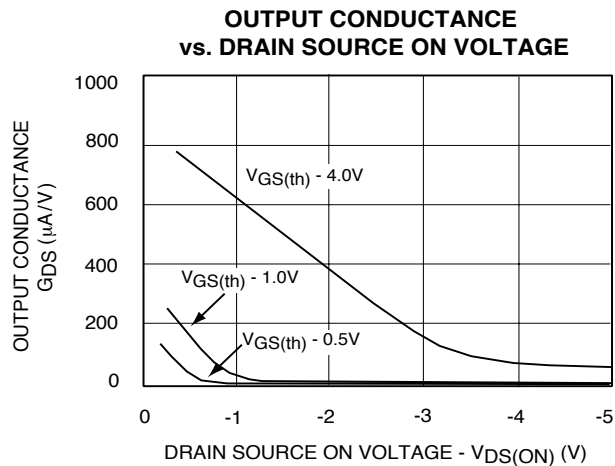
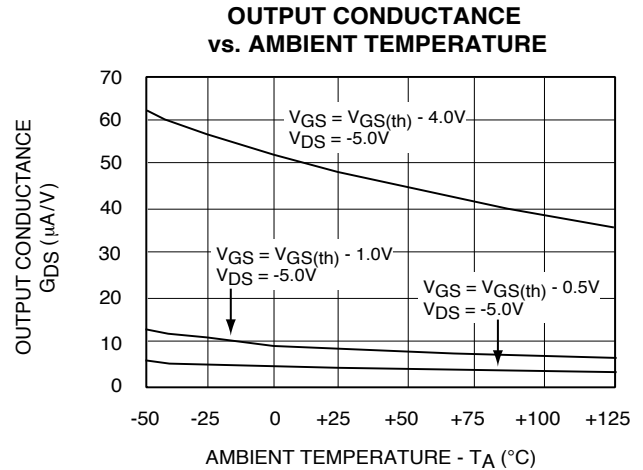
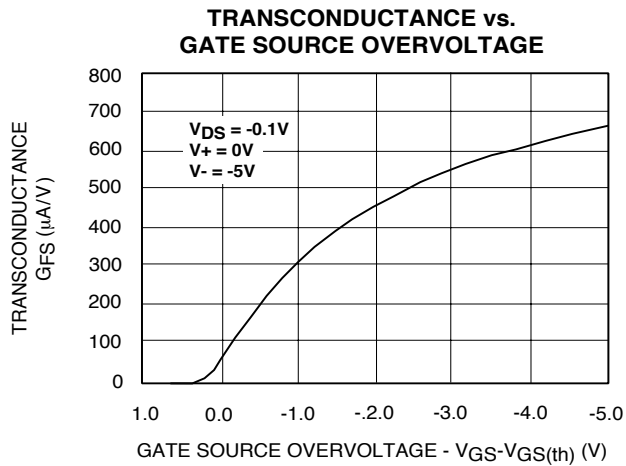
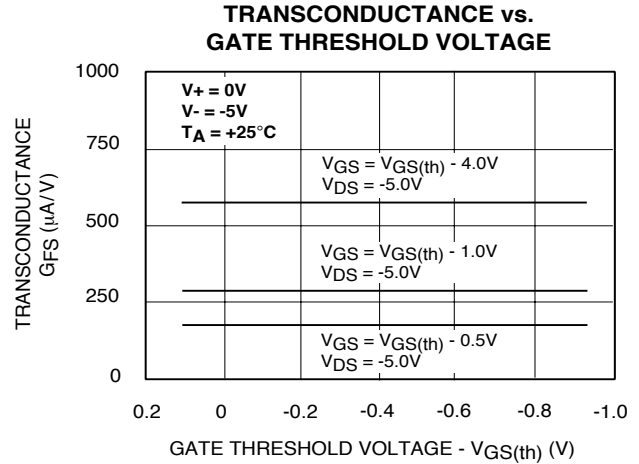
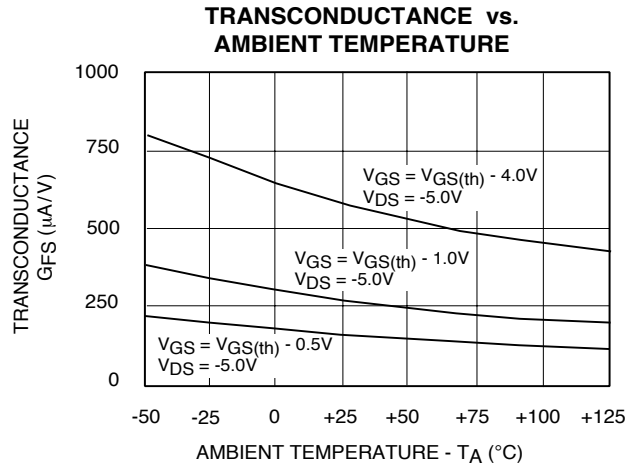
GATE THRESHOLD VOLTAGE vs. DRAIN SOURCE VOLTAGE



GATE THRESHOLD VOLTAGE vs. AMBIENT TEMPERATURE

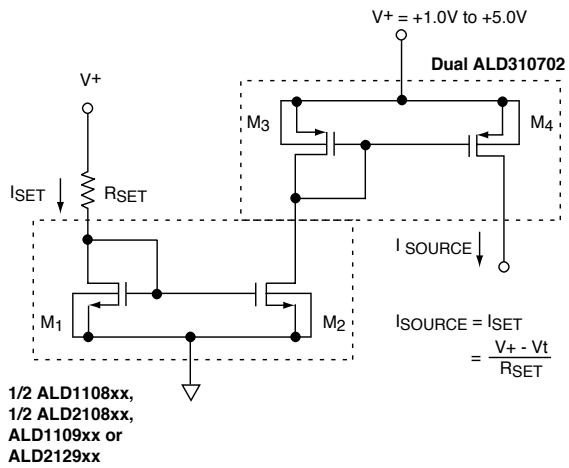


TYPICAL PERFORMANCE CHARACTERISTICS (cont.)



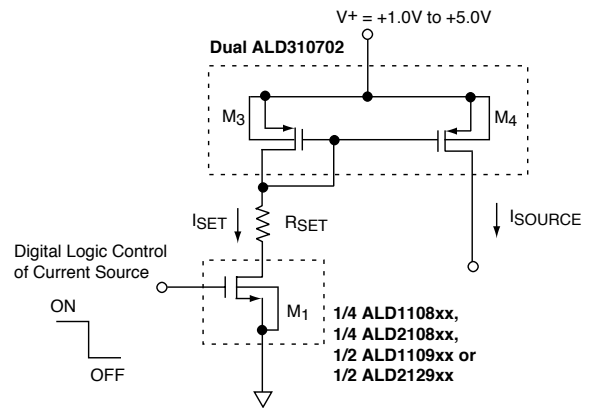
TYPICAL APPLICATIONS

LOW VOLTAGE CURRENT SOURCE MIRROR



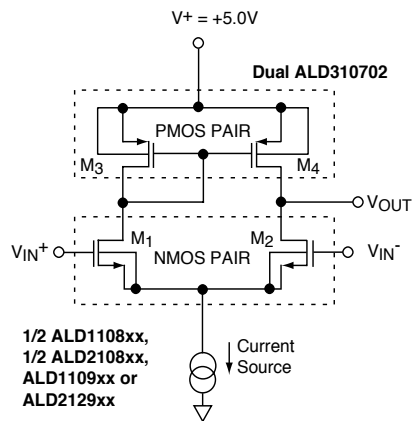
M₁, M₂: N-Channel MOSFET
M₃, M₄: P-Channel MOSFET

LOW VOLTAGE CURRENT SOURCE W/ GATE CONTROL



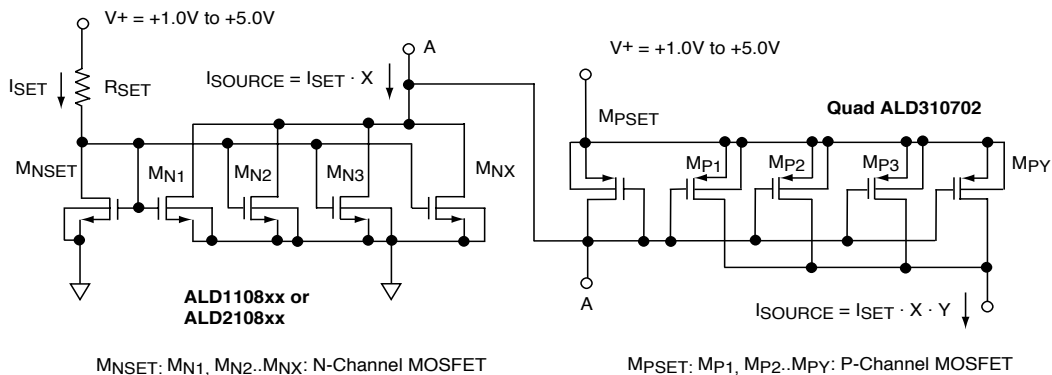
M₁ : N-Channel MOSFET
M₃, M₄: P-Channel MOSFET

LOW VOLTAGE DIFFERENTIAL AMPLIFIER



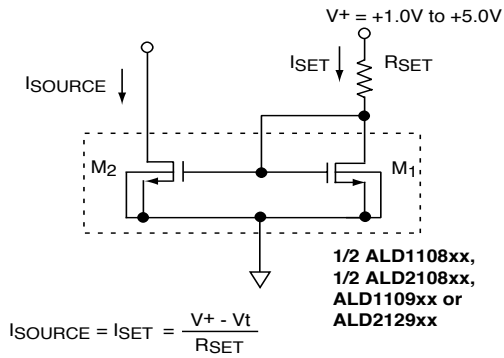
M₁, M₂: N-Channel MOSFET
M₃, M₄: P-Channel MOSFET

0.5% PRECISION LOW VOLTAGE CURRENT SOURCE MULTIPLICATION

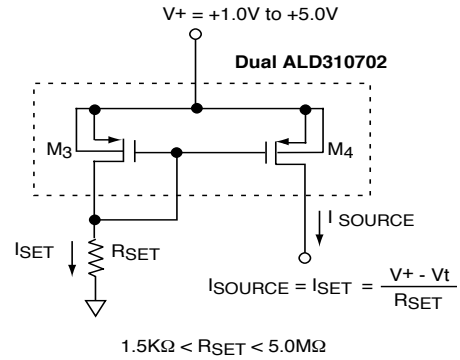


TYPICAL APPLICATIONS (cont.)

0.5% LOW VOLTAGE PRECISION CURRENT MIRRORS

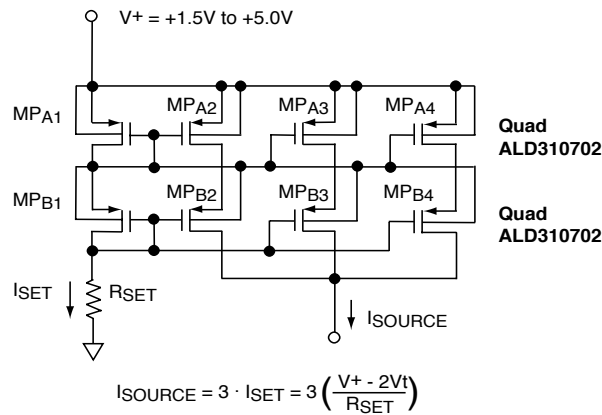


M₁, M₂: N-Channel MOSFET



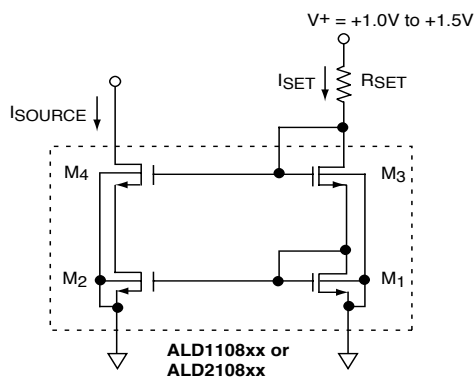
M₃, M₄: P-Channel MOSFET

0.5% PRECISION LOW VOLTAGE CASCODE CURRENT SOURCES

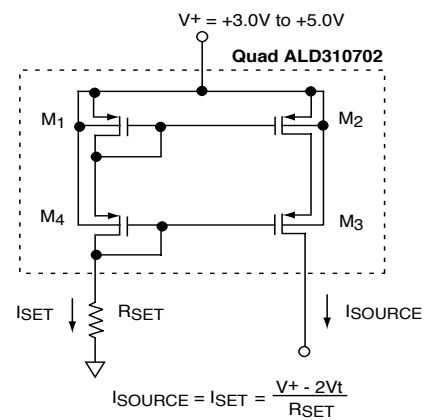


MPA1...MPA4: ALD310702 P-Channel MOSFET (1st individual pkg)
MPB1...MPB4: ALD310702 P-Channel MOSFET (2nd individual pkg)

0.5% PRECISION LOW TEMP CO CASCODE CURRENT SOURCES



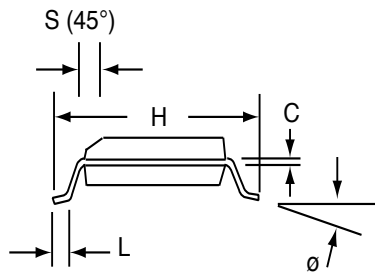
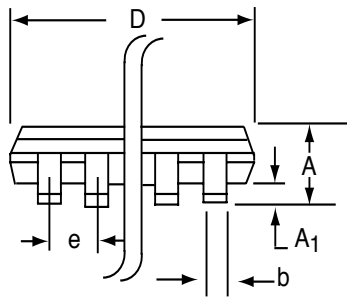
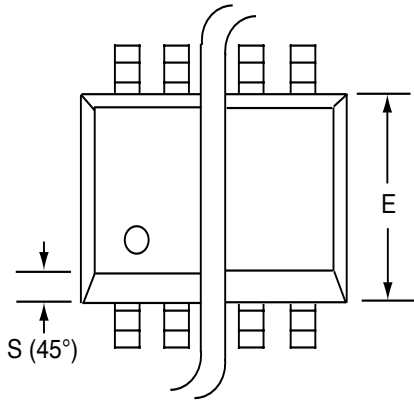
M₁, M₂, M₃, M₄: N-Channel MOSFET



M₁, M₂, M₃, M₄: P-Channel MOSFET

SOIC-16 PACKAGE DRAWING

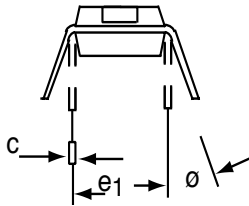
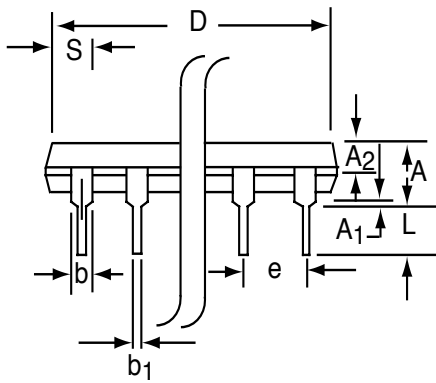
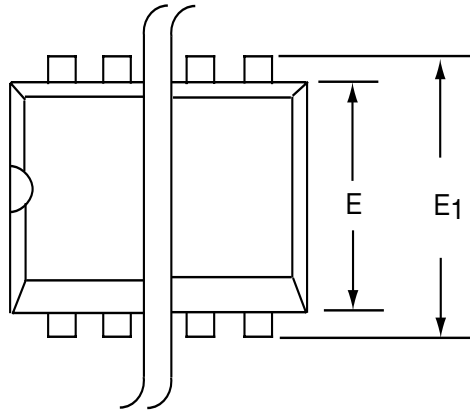
16 Pin Plastic SOIC Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A₁	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-16	9.80	10.00	0.385	0.394
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
Ø	0°	8°	0°	8°
S	0.25	0.50	0.010	0.020

PDIP-16 PACKAGE DRAWING

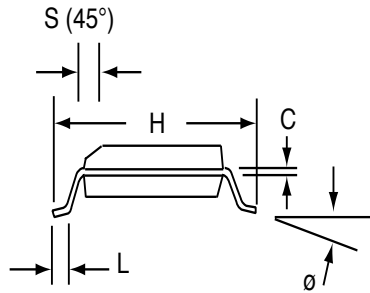
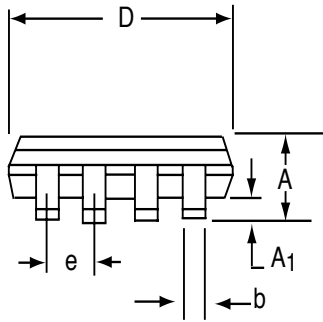
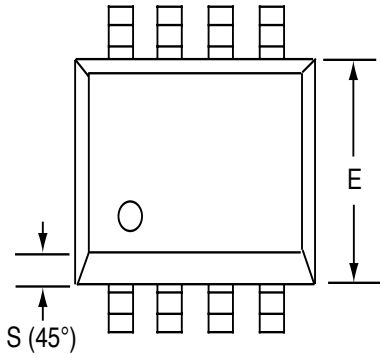
16 Pin Plastic DIP Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	3.81	5.08	0.105	0.200
A₁	0.38	1.27	0.015	0.050
A₂	1.27	2.03	0.050	0.080
b	0.89	1.65	0.035	0.065
b₁	0.38	0.51	0.015	0.020
c	0.20	0.30	0.008	0.012
D-16	18.93	21.33	0.745	0.840
E	5.59	7.11	0.220	0.280
E₁	7.62	8.26	0.300	0.325
e	2.29	2.79	0.090	0.110
e₁	7.37	7.87	0.290	0.310
L	2.79	3.81	0.110	0.150
S-16	0.38	1.52	0.015	0.060
θ	0°	15°	0°	15°

SOIC-8 PACKAGE DRAWING

8 Pin Plastic SOIC Package

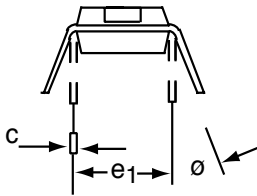
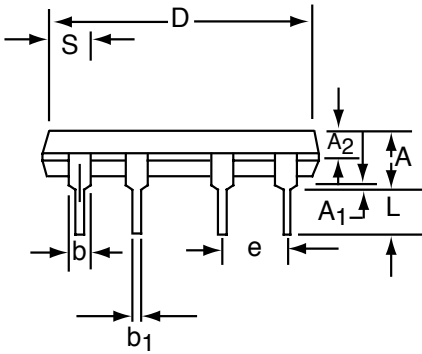
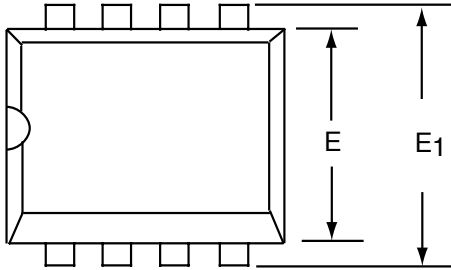


Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A₁	0.10	0.25	0.004	0.010
b	0.35	0.45	0.014	0.018
C	0.18	0.25	0.007	0.010
D-8	4.69	5.00	0.185	0.196
E	3.50	4.05	0.140	0.160
e	1.27 BSC		0.050 BSC	
H	5.70	6.30	0.224	0.248
L	0.60	0.937	0.024	0.037
∅	0°	8°	0°	8°
S	0.25	0.50	0.010	0.020

□

PDIP-8 PACKAGE DRAWING

8 Pin Plastic DIP Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	3.81	5.08	0.105	0.200
A₁	0.38	1.27	0.015	0.050
A₂	1.27	2.03	0.050	0.080
b	0.89	1.65	0.035	0.065
b₁	0.38	0.51	0.015	0.020
c	0.20	0.30	0.008	0.012
D-8	9.40	11.68	0.370	0.460
E	5.59	7.11	0.220	0.280
E₁	7.62	8.26	0.300	0.325
e	2.29	2.79	0.090	0.110
e₁	7.37	7.87	0.290	0.310
L	2.79	3.81	0.110	0.150
S-8	1.02	2.03	0.040	0.080
ø	0°	15°	0°	15°