QUAD/DUAL ELECTRICALLY PROGRAMMABLE ANALOG DEVICE (EPAD™)

FEATURES

- Operates from 2V, 3V, 5V to 10V
- Flexible basic circuit building block and design element
- Very high resolution -- average programmable voltage resolution of 0.1mV
- Wide dynamic range -- current levels from 0.1µA to 3000µA
- Voltage adjustment range from 1.000V to 3.000V in 0.1mV steps
- Proven, non-volatile CMOS technology
- Typical 10 years drift of less than 2mV
- Usable in voltage mode or current mode
- High input impedance -- $10^{12}\Omega$
- Very high DC current gain -- greater than 10^9
- Device operating current has positive temperature coefficient range and negative temperature coefficient range with cross-over zero temperature coefficient current level at 68µA
- Tight matching and tracking of on-resistance between different devices with programming
- Very low input currents and leakage currents
- Low cost, monolithic technology
- Application-specific or in-system programming modes
- User programmable software-controlled automation
- User programmability of any standard/custom configuration
- Micropower operation
- Available in standard PDIP, SOIC and hermetic CDIP packages
- Suitable for matched-pair balanced circuit configuration
- Suitable for both coarse and fine trimming applications

ORDERING INFORMATION

Operating Temperature Range*		
-55°C to +125°C	0°C to +70°C	0°C to +70°C
16-Pin CERDIP Package	16-Pin Plastic Dip Package	16-Pin SOIC Package
ALD1108E DC	ALD1108E PC	ALD1108E SC

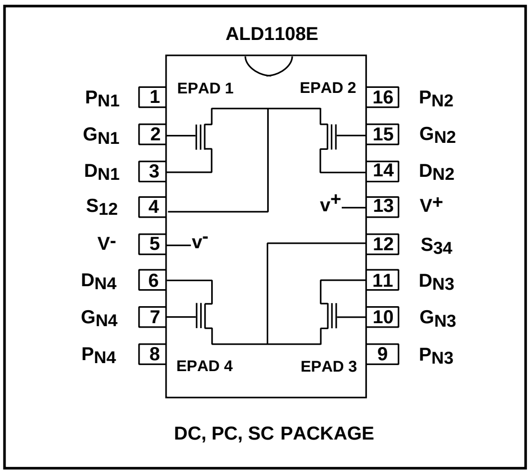
Operating Temperature Range*		
-55°C to +125°C	0°C to +70°C	0°C to +70°C
8-Pin CERDIP Package	8-Pin Plastic Dip Package	8-Pin SOIC Package
ALD1110E DA	ALD1110E PA	ALD1110E SA

* Contact factory for industrial temperature range

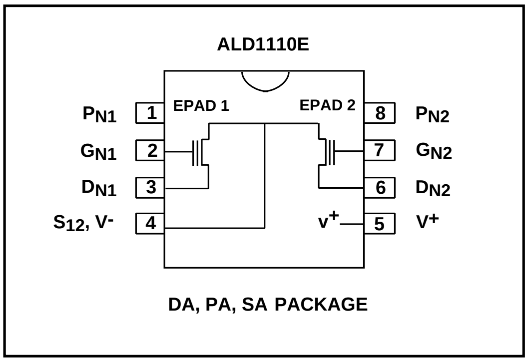
BENEFITS

- Simple, elegant single-chip solution to trimming voltage/current values
- Direct in-circuit active element operation and programming
- Remotely and electrically trim parameters on circuits that are physically inaccessible
- Usable in environmentally sealed circuits
- No system overhead or active circuitry required
- No mechanical moving parts -- high G-shock tolerance
- Improved reliability, dependability, dust and moisture resistance
- Cost and labor savings
- Small footprint for high board density applications
- Fully automated test and trimming environment

PIN CONFIGURATION



PIN CONFIGURATION



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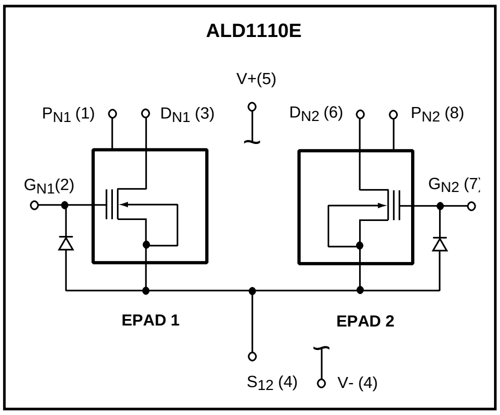
APPLICATIONS

- Precision PC-based electronic calibration
- Automated voltage trimming or setting
- Remote voltage or current adjustment of inaccessible nodes
- PCMCIA based instrumentation trimming
- Electrically adjusted resistive load
- Temperature compensated current sources and current mirrors
- Electrically trimmed/calibrated current sources
- Permanent precision preset voltage level shifter
- Low temperature coefficient voltage and/or current bias circuits
- Multiple preset voltage bias circuits
- Multiple channel resistor pull-up or pull-down circuits
- Microprocessor based process control systems
- Portable data acquisition systems
- Battery operated terminals and instruments
- Remote telemetry systems
- Programmable gain amplifiers
- Low level signal conditioning
- Sensor and transducer bias currents
- Neural networks

BLOCK DIAGRAM



GENERAL DESCRIPTION

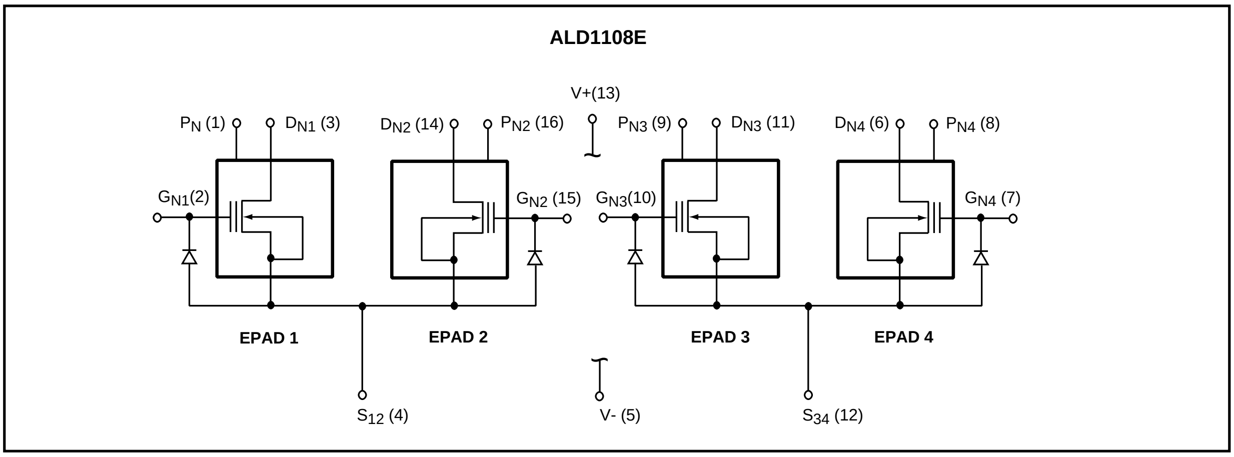
ALD1108E/ALD1110E are monolithic quad/dual EPADs (Electrically Programmable Analog Device) that utilize CMOS MOSFET with electrically programmable threshold voltage. For a given input voltage, changing the threshold turn-on voltage of a MOSFET device precisely changes its drain on-current, resulting in an on-resistance characteristic that can be precisely set and controlled. Used as an in-circuit element for trimming or setting a combination of voltage and/or current characteristics, it can be programmed via a Personal Computer remotely and automatically via software control. Once programmed and set, the set voltage and current levels are stored indefinitely inside the device as a precisely controlled nonvolatile stored charge, which is not affected during normal operation of the device, even after power has been turned off.

The ALD1108E/ALD1110E are devices built with ALD's EPAD technology, an electrically programmable device technology refined for analog applications. The ALD1108E/ALD1110E functions like a regular MOSFET transistor except with precise user preset threshold voltage. Using the ALD1108E/ALD1110E is simple and straight forward. The device is extremely versatile as a circuit element and design component. It presents the user with a wealth of possible applications, limited only by the imagination of the user and the many ways an analog MOSFET device can be used as a circuit design element. The ALD1108E/ ALD1110E do not need other active circuitry for functionality.

The basic device is a monotonically adjustable device which means the device can normally be programmed to increase in threshold voltage and to decrease in drain-on current as a function of a given input bias voltage. Once adjusted, the voltage and current conditions are permanent and not reversible. However, a given EPAD device can be adjusted many times to continually increase the threshold voltage. A pair of EPAD devices can also be connected such that one device is used to adjust a parameter in one direction and the other device is used to adjust the same parameter in the other direction.

The ALD1108E/ALD1110E can be pre-programmed with the ALD EPAD programmer to obtain the desired voltage and current levels. Or, they can be programmed as an active in-system element in a user system, via user designed interface circuitry. For more information, see Application Note AN1108.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Supply voltage, V^+ referenced to V^-		-0.3V to +13.2V
Supply voltage, V_S referenced to V^-		±6.6V
Differential input voltage range		0.3V to V^+ +0.3V
Power dissipation		600 mW
Operating temperature range	PA, SA, PC, SC package	0°C to +70°C
	DA, DC package	-55°C to +125°C
Storage temperature range		-65°C to +150°C
Lead temperature, 10 seconds		+260°C

OPERATING ELECTRICAL CHARACTERISTICS
T_A = 25°C V^+ = +5.0V unless otherwise specified

Parameter	Symbol	ALD1108E Min	ALD1108E Typ	ALD1108E Max	ALD1110E Min	ALD1110E Typ	ALD1110E Max	Unit	Test Conditions
Supply Voltage	V^+	1.2		10.0	1.2		10.0	V	
Initial Threshold Voltage	$V_{t\,i}$	0.990	1.000	1.010	0.990	1.000	1.010	V	I_{DS} = 1μA T_A = 21°C
Programmable Vt Range	V_t	1.000		3.000	1.000		3.000	V	
Drain - Gate Connected Voltage Tempco	TCV_{DS}		-1.6 -0.3 0.0 +2.7			-1.6 -0.3 0.0 +2.7		mV/°C mV/°C mV/°C mV/°C	I_D = 5μA I_D = 50μA I_D = 68μA I_D = 500μA
Initial Offset Voltage	$V_{OS\,i}$		1	5		1	5	mV	
Tempco of V_{OS}	TCV_{OS}		5			5		μV/°C	$V_{DS1} = V_{DS2}$
Differential Threshold Voltage	DV_t			2.000			2.000	V	
Tempco of Differential Threshold Voltage	$TCDV_t$		0.033			0.033		mV/°C	
Long Term Drift	$\Delta V_t/\Delta t$		-0.02	-0.05		-0.02	-0.05	mV	1000 Hours
Long Term Drift Match	$\Delta V_t/\Delta t$		-5			-5		μV	1000 Hours
Drain Source On Current	$I_{DS(ON)}$		3.0			3.0		mA	$V_G = V_D$ = 5V V_S = 0V V_t = 1.0
Drain Source On Current	$I_{DS(ON)}$		0.8			0.8		mA	$V_G = V_D$ = 5V V_S = 0V V_t = 3.0
Initial Zero Tempco Voltage	$V_{ZTC\,i}$		1.52			1.52		V	V_t = 1.000V
Zero Tempco Current	I_{ZTC}		68			68		μA	
Initial On-Resistance	$R_{ON\,i}$		500			500		Ω	$V_{GS\,i}$ = 5V V_{DS} = 0.1V
On-Resistance Match	ΔR_{ON}		0.5			0.5		%	

OPERATING ELECTRICAL CHARACTERISTICS (cont'd)
T_A = 25°C V^+ = +5.0V unless otherwise specified

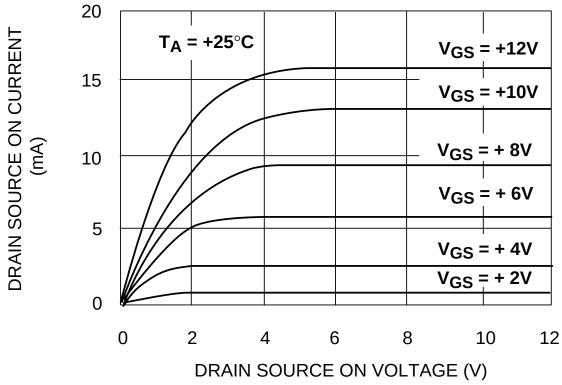
Parameter	Symbol	ALD1108E Min	ALD1108E Typ	ALD1108E Max	ALD1110E Min	ALD1110E Typ	ALD1110E Max	Unit	Test Conditions
Transconductance	gm		1.4			1.4		mA/V	V_D = 10V, V_G = V_t + 4.0
Transconductance Match	Δgm		25			25		μA/V	V_D = 10V, V_G = V_t + 4.0
Low Level Output Conductance	g_{OL}		6			6		μA/V	V_G = V_t +0.5V
High Level Output Conductance	g_{OH}		68			68		μA/V	V_G = V_t +4.0V
Drain Off Leakage Current	$I_{D(OFF)}$		5	400 4		5	400 4	pA nA	 T_A = 125°C
Gate Leakage Current	I_{GSS}		10	100 1		10	100 1	pA nA	 T_A = 125°C
Input Capacitance	C_{ISS}		25			25		pF	
Cross Talk			60			60		dB	f = 100KHz
Relaxation Time Constant	t_{RLX}		2			2		Hours	
Relaxation Voltage	V_{RLX}		-0.3			-0.3		%	1.0V ≤ V_t ≤ 3.0V

PROGRAMMING CHARACTERISTICS
T_A = 25°C V^+ = +5.0V unless otherwise specified

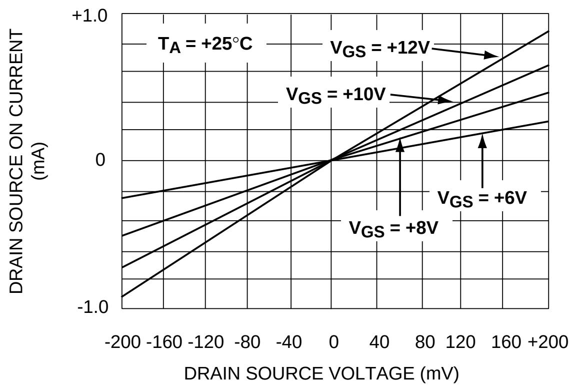
Parameter	Symbol	ALD1108E Min	ALD1108E Typ	ALD1108E Max	ALD1110E Min	ALD1110E Typ	ALD1110E Max	Unit	Test Conditions
Programmable V_t Range	V_t	1.000		3.000	1.000		3.000	V	
Resolution of V_t Programming	RV_t		0.1	1		0.1	1	mV	
Change in V_t Per Programming Pulse	ΔV_t / N		0.5 0.05			0.5 0.05		mV/ pulse	V_t = 1.0V V_t = 2.5V
Programming Voltage	Vp	11.75	12.00	12.25	11.75	12.00	12.25	V	
Programming Current	Ip		2			2		mA	
Pulse Frequency	ƒ pulse		50			50		KHz	

TYPICAL PERFORMANCE CHARACTERISTICS

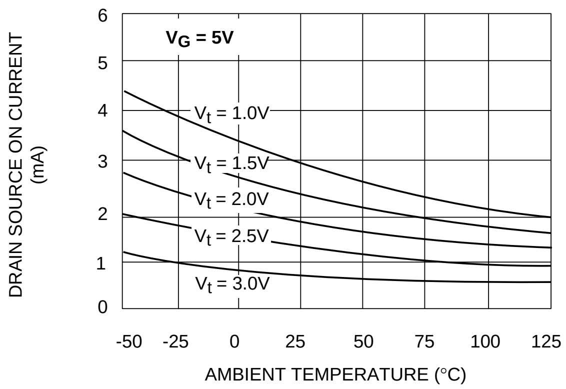
OUTPUT CHARACTERISTICS



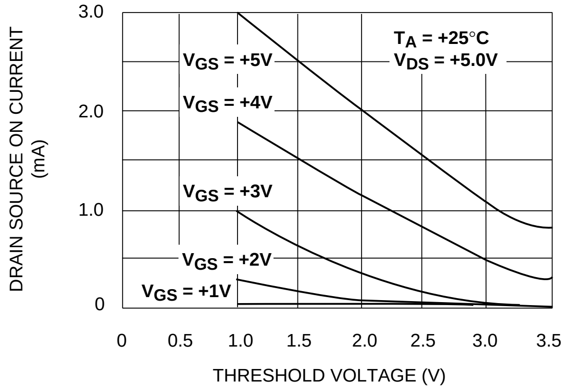
OUTPUT CHARACTERISTICS



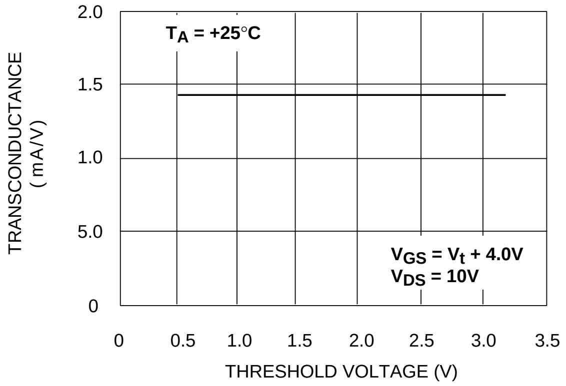
DRAIN SOURCE ON CURRENT vs. AMBIENT TEMPERATURE



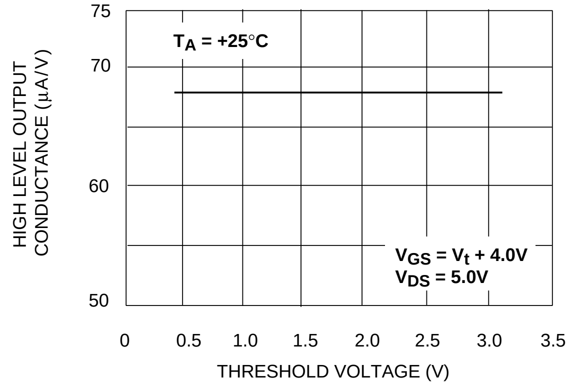
DRAIN SOURCE ON CURRENT vs. THRESHOLD VOLTAGE



TRANSCONDUCTANCE vs. THRESHOLD VOLTAGE

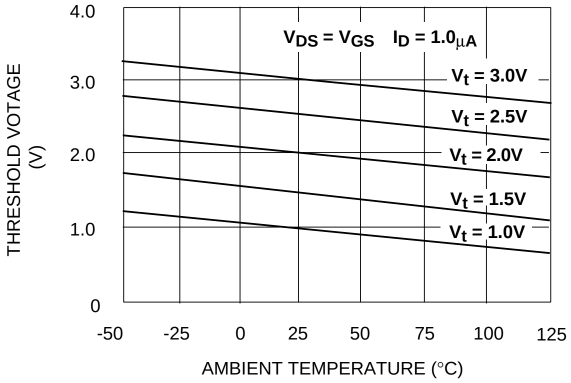


HIGH LEVEL OUTPUT CONDUCTANCE vs.THRESHOLD VOLTAGE

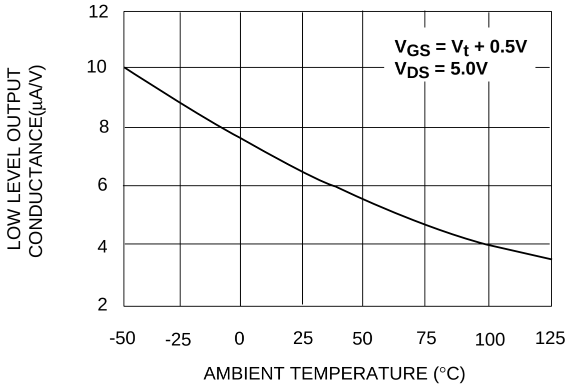


TYPICAL PERFORMANCE CHARACTERISTICS

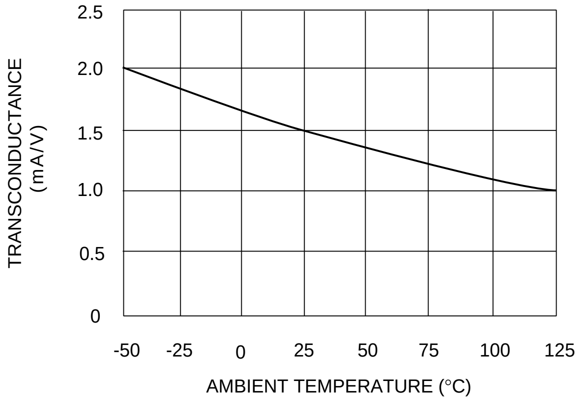
THRESHOLD VOLTAGE vs. AMBIENT TEMPERATURE



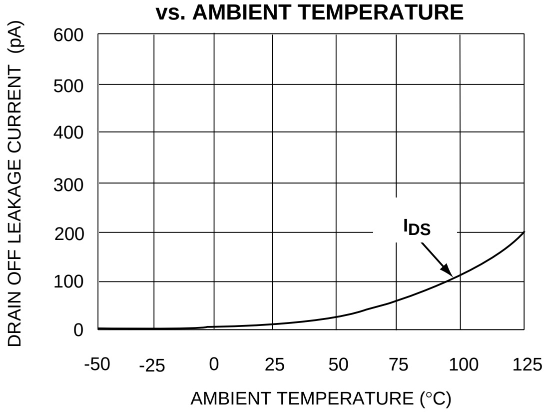
LOW LEVEL OUTPUT CONDUCTANCE vs. AMBIENT TEMPERATURE



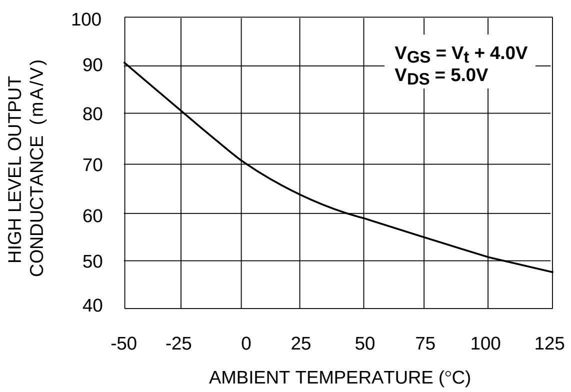
TRANSCONDUCTANCE vs. AMBIENT TEMPERATURE



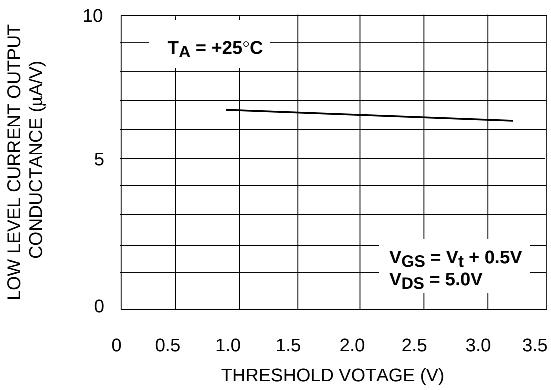
DRAIN OFF LEAKAGE CURRENT I_{DS} vs. AMBIENT TEMPERATURE



HIGH LEVEL OUTPUT CONDUCTANCE vs. AMBIENT TEMPERATURE

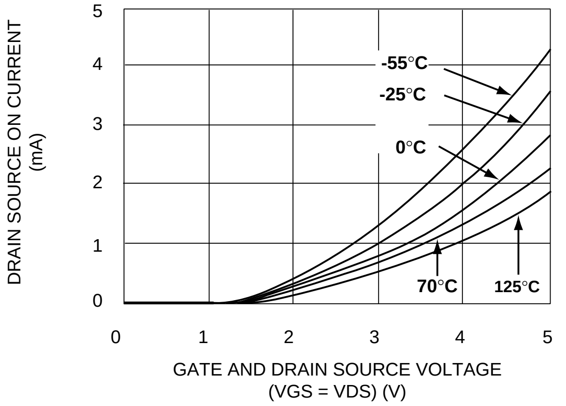


LOW LEVEL OUTPUT CONDUCTANCE vs. THRESHOLD VOLTAGE

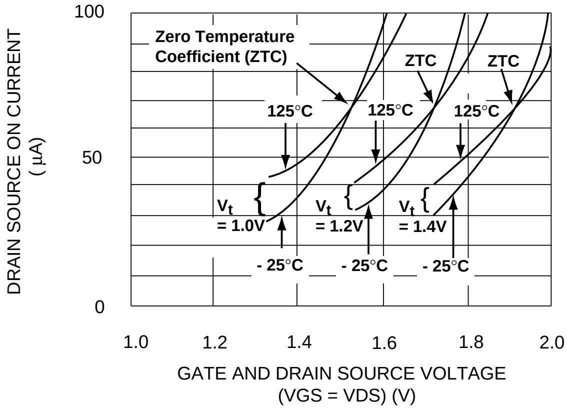


TYPICAL PERFORMANCE CHARACTERISTICS

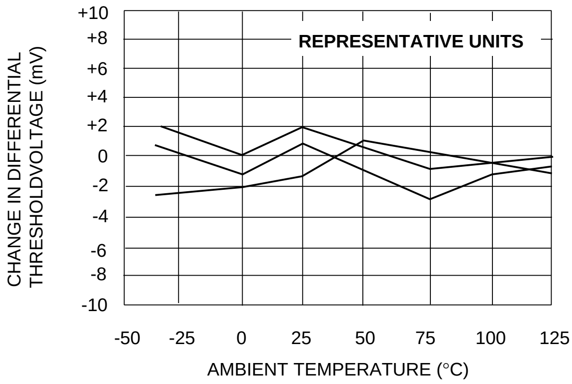
DRAIN SOURCE ON CURRENT, BIAS CURRENT vs. AMBIENT TEMPERATURE



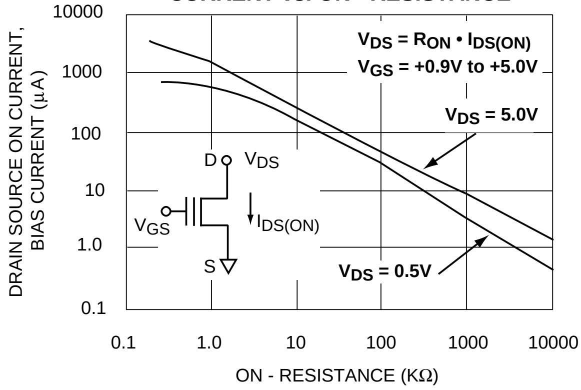
DRAIN SOURCE ON CURRENT, BIAS CURRENT vs. AMBIENT TEMPERATURE



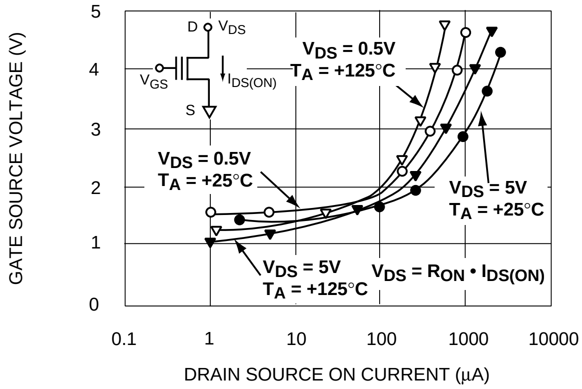
CHANGE IN DIFFERENTIAL THRESHOLD VOLTAGE vs. AMBIENT TEMPERATURE



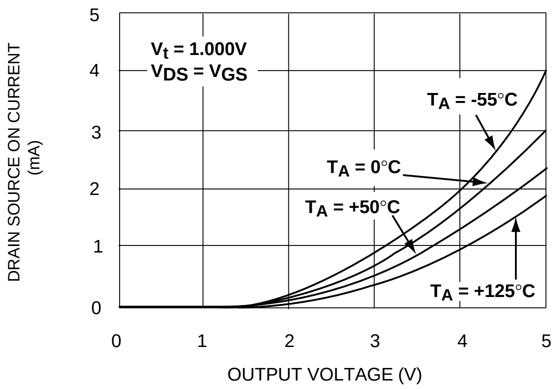
DRAIN SOURCE ON CURRENT, BIAS CURRENT vs. ON - RESISTANCE



GATE SOURCE VOLTAGE vs. DRAIN SOURCE ON CURRENT

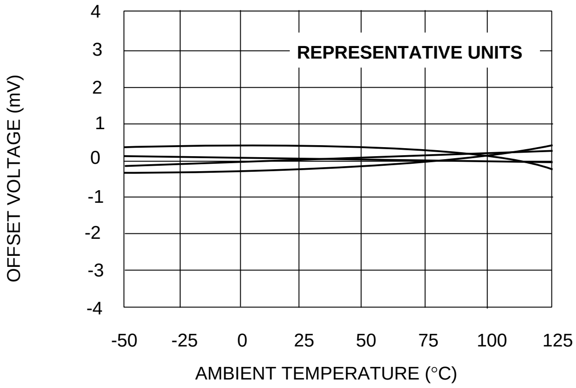


DRAIN SOURCE ON CURRENT vs. OUTPUT VOLTAGE

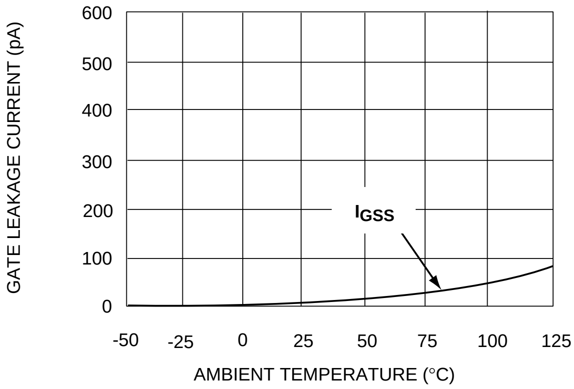


TYPICAL PERFORMANCE CHARACTERISTICS

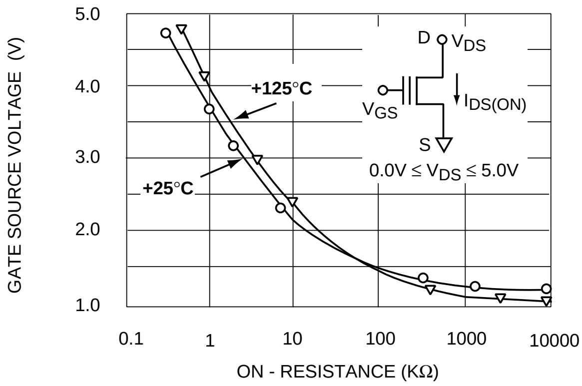
OFFSET VOLTAGE vs. AMBIENT TEMPERATURE



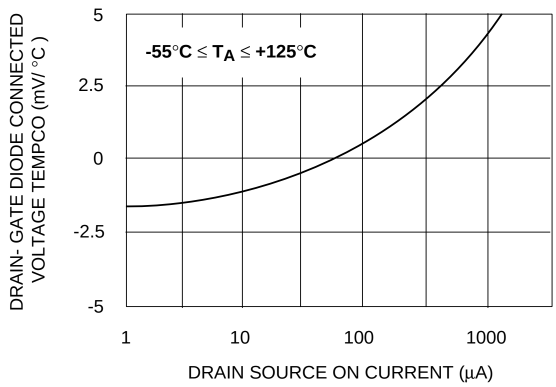
GATE LEAKAGE CURRENT vs. AMBIENT TEMPERATURE



GATE SOURCE VOLTAGE vs. ON - RESISTANCE



DRAIN - GATE DIODE CONNECTED VOLTAGE TEMPCO vs. DRAIN SOURCE ON CURRENT



DEFINITION OF TERMS

Bias Voltage (V_{BIAS})

Bias Voltage of an EPAD is the voltage across Gate and Source terminals with Gate and Drain connected at a specified Drain to Source Current, I_{DS}. When $I_{DS} = 1\mu A$, Bias Voltage is identical to Threshold Voltage. Input Bias Voltage of an EPAD is the voltage across Gate and Source terminals, V_{GS}. Output Bias Voltage of an EPAD is the voltage across Drain and Source terminals V_{DS} at a specified Drain to Source Current, I_{DS}.

Change in Threshold Voltage Per Programming Pulse ($\Delta V_t / N$)

This is the voltage change in Threshold Voltage while the EPAD is being programmed with an electrical voltage pulse. This voltage change can be very small as it varies as an exponential function of Vt. Typical initial values range from 0.1 mV/step to 1.0mV/step when Vt = 1 Volt and decreases to 10µV/step or lower at higher Vt values.

Delta Threshold Voltage (ΔVt)

Delta Threshold Voltage is a change in the threshold voltage of the same EPAD device after programming.

Differential Threshold Voltage (DVt)

Differential Threshold Voltage is the difference of Vt between the two EPAD devices, each electrically programmed to a different Vt value. This is also a fixed relative voltage that tracks with temperature, with tempco value of TC DVt for 1 volt relative Vt between two EPADs.

EPAD™

Electrically Programmable Analog Device is an Integrated Circuit that utilizes CMOS FET with electrically programmable Threshold Voltage. Once programmed, the set Threshold Voltage is retained indefinitely, even when power is off.

Initial Threshold Voltage ($V_{t\,i}$)

The initial Vt of a device before being electrically programmed to a new Vt value.

Initial Zero Tempco Voltage (V_{ZTCi})

Initial Drain Voltage at which the Temperature Coefficient of the Drain-Gate connected Voltage, relative to the Source Voltage, is at zero, when the initial Vt is at 1.000 volt.

Long Term Drift ($\Delta Vt / \Delta t$)

Long Term Drift is the nominal change in threshold voltage of an EPAD for a time period of 1,000 hours.

Long Term Drift Match ($\Delta Vt / \Delta t$)

Long Term Drift Match is the nominal match in long term drift between two EPADs, for a time period of 1,000 hours.

Monotonic Adjustment of Vt

Vt Adjustment can be changed in one direction only.

Offset Voltage (V_{OS})

Offset Voltage is the small difference in Vt between two EPAD devices when the two devices have the same initial electrically programmed Vt values.

Programming Voltage (Vp)

The voltage at which programming of the threshold voltage of the EPAD occurs. This voltage, the control of timing of this voltage and the impedance of the voltage source is critical to the way the EPAD is programmed and its subsequent device performance. The user is advised to use an ALD EPAD programmer which has been specifically designed and developed for this task.

Relaxation Time Constant (t_{RLX})

Relaxation Time Constant is the time constant associated with the Relaxation Voltage drop after an EPAD has been programmed.

Relaxation Voltage (V_{RLX})

After programming, an EPAD threshold voltage will " relax " a small amount, which corresponds to a small loss of interface charge. This is a small, fixed voltage step and decreases at a Relaxation Time Constant. The Relaxation Voltage is the voltage change (voltage drop) after three Relaxation Time Constants. To compensate for this, an initial relaxation voltage, expressed as a percentage of the programmed Vt, can be added to the initial desired target voltage.

Tempco of Differential Threshold Voltage ($TCDV_t$)

Temperature Coefficient of Differential Threshold Voltage is the change in difference between two EPAD threshold voltages per degree C change in temperature when the two devices initially have 1V relative electrically programmed Vt difference.

Tempco of Threshold Voltage (TCV_t)

Temperature Coefficient of the Vt is the change in the Threshold Voltage per degree C change in temperature.

Threshold Voltage (V_t)

Threshold Voltage of an EPAD is the voltage across Gate and Source when 1μA is forced into the Drain terminal as the Drain and Gate are connected together.

Tempco of V_{OS} (TCV_{OS})

Temperature Coefficient of Offset Voltage is the change in difference between two EPAD threshold voltages per degree Centigrade change in temperature when the two devices have the same initial electrically programmed Vt values.

Zero Tempco Current (I_{ZTC})

The Drain current of an EPAD device at which Temperature Coefficient of the Drain-Gate Connected Voltage, relative to the Source Voltage, is at zero.