

QUAD/DUAL SUPERCAPACITOR AUTO BALANCING (SAB™) MOSFET ARRAY

GENERAL DESCRIPTION

The ALD810016/ALD910016 are members of the ALD8100xx (quad) and ALD9100xx (dual) family of Supercapacitor Auto Balancing MOSFETs, or SAB™ MOSFETs. SAB MOSFETs are built with production proven EPAD® technology and are designed to address voltage and leakage-current balancing of supercapacitors connected in series. Supercapacitors, also known as ultracapacitors or supercaps, connected in series can be leakage-current balanced by using a combination of one or more devices connected across each supercapacitor stack to prevent over-voltages.

The ALD810016 offers a set of unique, precise operating voltage and current characteristics for each of four SAB MOSFET devices, as shown in its Operating Electrical Characteristics table. It can be used to balance up to four supercapacitors connected in series. The ALD910016 has its own set of unique precision Operating Electrical Characteristics for each of its two SAB MOSFET devices, suitable for up to two series-connected supercapacitors.

Each SAB MOSFET features a precision gate threshold voltage in the V_t mode, which is 1.60V when the gate-drain source terminals (V_{GS} = V_{DS}) are connected together at a drain-source current of $I_{DS(ON)} = 1\mu A$. In this mode, input voltage $V_{IN} = V_{GS} = V_{DS}$. Different V_{IN} produces an Output Current I_{OUT} = I_{DS(ON)} characteristic and results in an effective variable resistor that varies in value exponentially with $V_{\mbox{\scriptsize IN}}.$ This $V_{\mbox{\scriptsize IN}},$ when connected across each supercapacitor in a series, balances each supercapacitor to within its voltage and current limits.

When $V_{IN} = 1.60V$ is applied to an ALD810016/ALD910016, its I_{OUT} is $1\mu A$. For a 100mV increase in V_{IN} , to 1.70V, I_{OUT} increases by about tenfold. For an additional increase in V_{IN} to 1.82V for the ALD910016 (1.84V for the ALD810016), I_{OUT} increases one hundredfold, to $100\mu A$. Conversely, for a 100mV decrease in V_{IN} to 1.50V, IOUT decreases to one tenth of its previous value, to 0.1µA. Another 100mV decrease in input voltage would reduce IOUT to 0.01µA. Hence, when an ALD810016/ALD910016 SAB MOSFET is connected across a supercapacitor that charges to less than 1.40V, it would dissipate essentially no power.

(Continued on next page)

PRODUCT FAMILY SPECIFICATIONS

For more information on supercapacitor balancing, how SAB MOSFETs achieve automatic supercapacitor balancing, the device characteristics of the SAB MOSFET family, product family product selection guide, applications, configurations, and package information, please download from www.aldinc.com the document:

"ALD8100xx/ALD9100xx Family of Supercapacitor Auto Balancing (SAB™) MOSFET ARRAYs

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

	Operating Temperature Range				
Package	0°C to +70°C	-40°C to +85°C			
	(Commercial)	(Industrial)			
16-Pin SOIC	ALD810016SCL	ALD810016SCLI			
8-Pin SOIC	ALD910016SAL	ALD910016SALI			

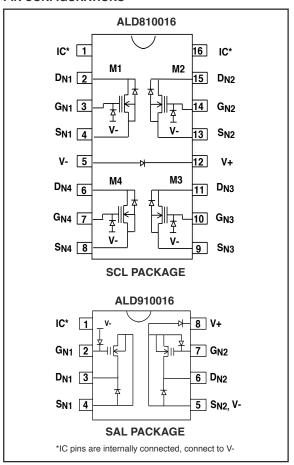
FEATURES & BENEFITS

- · Simple and economical to use
- Precision factory trimmed
- Automatically regulates and balances leakage currents
- Effective for supercapacitor charge-balancing
- Balances up to 4 supercaps with a single IC package
- Balances 2-cell, 3-cell, 4-cell series-connected supercaps
 Scalable to larger supercap stacks and arrays
- Near zero additional leakage currents
- · Zero leakage at 0.3V below rated voltages
- Balances series and/or parallel-connected supercaps
- Leakage currents are exponential function of cell voltages
- Active current ranges from <0.3nA to >1000μA
- Always active. always fast response time
- · Minimizes leakage currents and power dissipation

APPLICATIONS

- · Series-connected supercapacitor cell leakage balancing
- **Energy harvesting**
- · Long term backup battery with supercapacitor outputs
- Zero-power voltage divider at selected voltages
- Matched current mirrors and current sources
- Zero-power mode maximum voltage limiter
- Scaled supercapacitor stacks and arrays

PIN CONFIGURATIONS



GENERAL DESCRIPTION (CONT.)

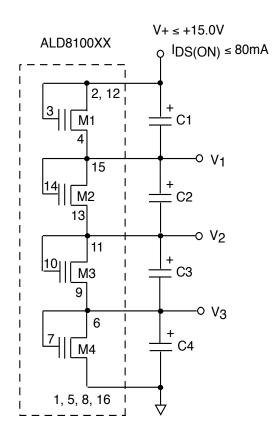
The voltage dependent characteristic of the ALD810016/ ALD910016 on-resistance is effective in controlling excessive voltage rise across a supercapacitor when connected across it. In series-connected supercapacitor stacks, when one supercapacitor voltage rises, the voltage of the other supercapacitors drops, with the ones that have the highest leakage currents having the lowest supercapacitor voltages. The SAB MOSFETs connected across these supercapacitors would exhibit complementary opposing current levels, resulting in little additional leakage currents other than those caused by the supercapacitors themselves.

For technical assistance, please contact ALD technical support at techsupport@aldinc.com.

APPLYING THE ALD810016/ALD910016:

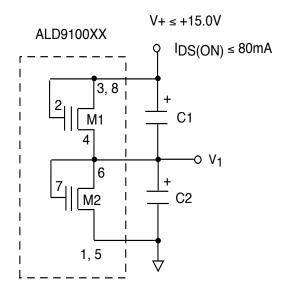
- 1) Select a maximum supercapacitor leakage current limit for any supercapacitor used in the stack. This is the same as output current, I_{OUT} = I_{DS(ON)}, of the ALD810016/ALD910016. Test that each supercapacitor leakage current meets this maximum current limit before use in the stack.
- 2) Determine whether the input voltage V_{IN} ($V_{GS} = V_{DS}$) at that I_{OUT} is acceptable for the intended application. This voltage is the same voltage as the maximum desired operating voltage of the supercapacitor. For example, with the ALD810016, $I_{OUT} = 1000 \mu A$ corresponds to $V_{IN} = 2.12 V$.
- 3) Determine that the operating voltage margin, due to various tolerances and/or temperature effects, is adequate for the intended operating environment of the supercapacitor.

SCHEMATIC DIAGRAM OF A TYPICAL CONNECTION FOR A FOUR-SUPERCAP STACK



1-16 DENOTES PACKAGE PIN NUMBERS C1-C4 DENOTES SUPERCAPACITORS

SCHEMATIC DIAGRAM OF A TYPICAL CONNECTION FOR A TWO-SUPERCAP STACK



1-8 DENOTES PACKAGE PIN NUMBERS C1-C2 DENOTES SUPERCAPACITORS

ABSOLUTE MAXIMUM RATINGS

V+ to V- voltage	15.0V
Drain-Source voltage, V _{DS}	10.6V
Gate-Source voltage, V _{GS}	10.6V
Operating Current	80mA
Power dissipation	500mW
Operating temperature range SCL	0°C to +70°C
Operating temperature range SCLI	-40°C to +85°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, $T_A = 25^{\circ}C$, $V_{IN} = V_{GS} = V_{DS}$, $I_{OUT} = I_{DS}(ON)$ unless otherwise specified

	ALD810016					
Parameter	Symbol	Min	Тур	Max	Unit	Test Conditions
Gate Threshold Voltage	Vt	1.58	1.60	1.62	V	VGS = VDS; IDS(ON) = 1μA
Offset Voltage	Vos		5	20	mV	Vt1 - Vt2 or Vt3 - Vt4
Offset Voltage Tempco	TCVOS		5		μV/C	V _{t1} - V _{t2} or V _{t3} - V _{t4}
Gate Threshold Voltage Tempco	TC _{Vt}		-2.2		mV/C	$V_{GS} = V_{DS}; I_{DS(ON)} = 1\mu A$
Output Current Drain Source On Resistance	IOUT RDS(ON)		0.0001 12000		μA MΩ	V _{IN} = 1.20V
Output Current Drain Source On Resistance	IOUT RDS(ON)		0.001 1300		μA MΩ	V _{IN} = 1.30V
Output Current Drain Source On Resistance	IOUT RDS(ON)		0.01 140		μA MΩ	V _{IN} = 1.40V
Output Current Drain Source On Resistance	IOUT RDS(ON)		0.1 15		μA MΩ	V _{IN} = 1.50V
Output Current Drain Source On Resistance	IOUT RDS(ON)		1 1.6		μA MΩ	V _{IN} = 1.60V
Output Current Drain Source On Resistance	IOUT RDS(ON)		10 0.17		μA MΩ	V _{IN} = 1.70V
Output Current Drain Source On Resistance	IOUT RDS(ON)		100 0.018		μ Α ΜΩ	V _{IN} = 1.84V
Output Current Drain Source On Resistance	IOUT RDS(ON)		300 0.007		μ Α ΜΩ	V _{IN} = 1.94V
Output Current Drain Source On Resistance	IOUT RDS(ON)		1000 0.002		μA MΩ	V _{IN} = 2.12V
Output Current Drain Source On Resistance	IOUT RDS(ON)		3000 0.001		μA MΩ	V _{IN} = 2.42V
Output Current Drain Source On Resistance	IOUT RDS(ON)		10000 0.0003		μ Α ΜΩ	V _{IN} = 3.02V
Drain Source Breakdown Voltage	BVDSX	10.6			V	
Drain Source Leakage Current ¹	IDS(OFF)		10	400	pA nA	V _{IN} = V _{GS} = V _{DS} = V _t - 1.0 V _{IN} = V _{GS} = V _{DS} = V _t - 1.0, T _A = +125°C
Gate Leakage Current ¹	IGSS		5	200	pA nA	VGS = 5.0V, VDS = 0V VGS = 5.0V, VDS = 0V, TA = +125°C
Input Capacitance	CISS		15		pF	V _{GS} = 0V, V _{DS} = 5.0V
Turn-on Delay Time	t _{on}		10		ns	
Turn-off Delay Time	t _{off}		10		ns	
Crosstalk			60		dB	f = 100KHz

ABSOLUTE MAXIMUM RATINGS

V+ to V- voltage	15.0V
Drain-Source voltage, V _{DS}	10.6V
Gate-Source voltage, V _{GS}	10.6V
Operating Current	80mA
Power dissipation	500mW
Operating temperature range SAL	0°C to +70°C
Operating temperature range SALI	40°C to +85°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.

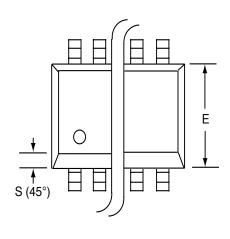
OPERATING ELECTRICAL CHARACTERISTICS

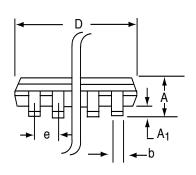
V+ = +5V, V- = GND, $T_A = 25$ °C, $V_{IN} = V_{GS} = V_{DS}$, $I_{OUT} = I_{DS(ON)}$ unless otherwise specified

	ALD910016					
Parameter	Symbol	Min	Тур	Max	Unit	Test Conditions
Gate Threshold Voltage	Vt	1.58	1.60	1.62	V	$V_{GS} = V_{DS}; I_{DS(ON)} = 1\mu A$
Offset Voltage	Vos		5	20	mV	V _{t1} - V _{t2}
Offset Voltage Tempco	TC _{VOS}		5		μV/C	V _{t1} - V _{t2}
Gate Threshold Voltage Tempco	TC _{Vt}		-2.2		mV/C	V _{GS} = V _{DS} ; I _{DS} (ON) = 1μA
Output Current Drain Source On Resistance	IOUT RDS(ON)		0.0001 12000		μ Α ΜΩ	V _{IN} = 1.20V
Output Current Drain Source On Resistance	lout RDS(ON)		0.001 1300		μ Α ΜΩ	V _{IN} = 1.30V
Output Current Drain Source On Resistance	lout RDS(ON)		0.01 140		μ Α ΜΩ	V _{IN} = 1.40V
Output Current Drain Source On Resistance	lout RDS(ON)		0.1 15		μ Α ΜΩ	V _{IN} = 1.50V
Output Current Drain Source On Resistance	lout RDS(ON)		1 1.6		μ Α ΜΩ	V _{IN} = 1.60V
Output Current Drain Source On Resistance	lout RDS(ON)		10 0.17		μ Α ΜΩ	V _{IN} = 1.70V
Output Current Drain Source On Resistance	IOUT RDS(ON)		100 0.018		μ Α ΜΩ	V _{IN} = 1.82V
Output Current Drain Source On Resistance	IOUT RDS(ON)		300 0.007		μ Α ΜΩ	V _{IN} = 1.90V
Output Current Drain Source On Resistance	lout RDS(ON)		1000 0.002		μ Α ΜΩ	V _{IN} = 2.04V
Output Current Drain Source On Resistance	I _{OUT} R _{DS(ON)}		3000 0.001		μ Α ΜΩ	V _{IN} = 2.10V
Output Current Drain Source On Resistance	IOUT RDS(ON)		10000 0.0003		μ Α ΜΩ	V _{IN} = 2.60V
Drain Source Breakdown Voltage	BV _{DSX}	10.6			V	
Drain Source Leakage Current ¹	IDS(OFF)		10	400 4	pA nA	VIN = VGS = VDS = Vt - 1.0 VIN = VGS = VDS = Vt - 1.0, TA = +125°C
Gate Leakage Current ¹	I _{GSS}		5	200	pA nA	V _{GS} = 5.0V, V _{DS} = 0V V _{GS} = 5.0V, V _{DS} = 0V, T _A = +125°C
Input Capacitance	CISS		30		pF	VGS = 0V, VDS = 5.0V
Turn-on Delay Time	ton		10		ns	
Turn-off Delay Time	t _{off}		10		ns	
Crosstalk			60		dB	f = 100KHz
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SOIC-16 PACKAGE DRAWING

16 Pin Plastic SOIC Package





	Millin	neters	Inches		
Dim	Min	Max	Min	Max	
Α	1.35	1.75	0.053	0.069	
A ₁	0.10	0.25	0.004	0.010	
b	0.35	0.45	0.014	0.018	
С	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	
е	1.27	BSC	0.050 BSC		
н	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	

