



3 V/5 V, 4/8 Channel High Performance Analog Multiplexers

ADG608/ADG609

FEATURES

+3 V, +5 V, ± 5 V Power Supplies
 V_{SS} to V_{DD} Analog Signal Range
Low On Resistance (30 Ω max)
Fast Switching Times
 t_{ON} 75 ns max
 t_{OFF} 45 ns max
Low Power Dissipation (1.5 μ W max)
Break-Before-Make Construction
ESD > 5000 V as per Military Standard 3015.7
TTL and CMOS Compatible Inputs

APPLICATIONS

Automatic Test Equipment
Data Acquisition Systems
Communication Systems
Avionics and Military Systems
Microprocessor Controlled Analog Systems
Medical Instrumentation
Battery Powered Instruments
Remote Powered Equipment
Compatible with ± 5 V DACs and ADCs such as AD7840/8, AD7870/1/2/4/5/6/8

GENERAL DESCRIPTION

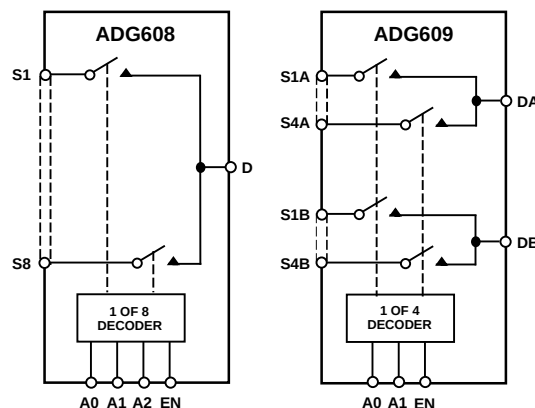
The ADG608 and ADG609 are monolithic CMOS analog multiplexers comprising eight single channels and four differential channels respectively, fully specified for ± 5 V, +5 V and +3 V power supplies. The ADG608 switches one of eight inputs to a common output as determined by the 3-bit binary address lines A0, A1 and A2. The ADG609 switches one of four differential inputs to a common differential output as determined by the 2-bit binary address lines A0 and A1. An EN input on both devices is used to enable or disable the device. When disabled, all channels are switched OFF. All the address and enable inputs are TTL compatible over the full specified operating temperature range, making the parts suitable for bus-controlled systems such as data acquisition systems, process controls, avionics and ATEs since the TTL compatible address inputs simplify the digital interface design and reduce the board space requirements.

The ADG608/ADG609 are designed on an enhanced LC²MOS process that provides low power dissipation yet gives high switching speed and low on resistance. Each channel conducts equally well in both directions when ON and has an input signal range which extends to the supplies. In the OFF condition, signal levels up to the supplies are blocked. All channels exhibit break-before-make switching action preventing momentary shorting when switching channels. Inherent in the design is low charge injection for minimum transients when switching the digital inputs.

REV. A

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FUNCTIONAL BLOCK DIAGRAMS



The ability to operate from single +3 V, +5 V or ± 5 V bipolar supplies makes the ADG608 and ADG609 perfect for use in battery operated instruments and with the new generation of DACs and ADCs from Analog Devices. The use of 5 V supplies and reduced operating currents gives much lower power dissipation than devices operating from ± 15 V supplies.

PRODUCT HIGHLIGHTS

1. Extended Signal Range
The ADG608/ADG609 are fabricated on an enhanced LC²MOS process giving an increased signal range which extends to the supplies.
2. Low Power Dissipation
3. Low R_{ON}
4. Fast Switching Times
5. Break-Before-Make Switching
Switches are guaranteed break-before-make so that input signals are protected against momentary shorting.
6. Single/Dual Supply Operation

ORDERING GUIDE

Model	Temperature Range	Package Option*
ADG608BN	-40°C to +85°C	N-16
ADG608BR	-40°C to +85°C	R-16A
ADG608BRU	-40°C to +85°C	RU-16
ADG608TRU	-55°C to +125°C	RU-16
ADG609BN	-40°C to +85°C	N-16
ADG609BR	-40°C to +85°C	R-16A
ADG609BRU	-40°C to +85°C	RU-16

*N = Plastic DIP; RU = Thin Shrink Small Outline Package (TSSOP);
R = 0.15" Small Outline IC (SOIC).

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ADG608/ADG609—SPECIFICATIONS

DUAL SUPPLY¹ ($V_{DD} = +5\text{ V} \pm 10\%$, $V_{SS} = -5\text{ V} \pm 10\%$, $GND = 0\text{ V}$, unless otherwise noted)

Parameter	B Version +25°C −40°C to +85°C		T Version +25°C −55°C to +125°C		Units	Test Conditions/ Comments	
ANALOG SWITCH							
Analog Signal Range	V _{SS} to V _{DD}		V _{SS} to V _{DD}		V	−3.5 V ≤ V _S ≤ +3.5 V, I _S = −1 mA; V _{DD} = +4.5 V, V _{SS} = −4.5 V; Test Circuit 1	
R _{ON}	22 30		22 30		Ω typ Ω max		
ΔR _{ON}	5	6	5	6	Ω max		
R _{ON} Match	2	3	2	3	Ω max		
LEAKAGE CURRENTS							
Source OFF Leakage I _S (OFF)	±0.05 ±0.5	±2	±0.05 ±0.5	±10	nA typ nA max	V _{DD} = +5.5 V, V _{SS} = −5.5 V V _D = ±4.5 V, V _S = ∓4.5 V; Test Circuit 2	
Drain OFF Leakage I _D (OFF)	±0.05		±0.05		nA typ	V _D = ±4.5 V, V _S = ∓4.5 V; Test Circuit 3	
ADG608	±0.5	±2	±0.5	±10	nA max		
ADG609	±0.5	±1	±0.5	±5	nA max		
Channel ON Leakage I _D , I _S (ON)	±0.05		±0.05		nA typ	V _S = V _D = ±4.5 V; Test Circuit 4	
ADG608	±0.5	±3	±0.5	±20	nA max		
ADG609	±0.5	±1.5	±0.5	±10	nA max		
DIGITAL INPUTS							
Input High Voltage, V _{INH}	2.4		2.4		V min	V _{IN} = 0 or V _{DD}	
Input Low Voltage, V _{INL}	0.8		0.8		V max		
Input Current I _{INL} or I _{INH}	±1		±1		μA max		
C _{IN} , Digital Input Capacitance	5		5		pF typ		
DYNAMIC CHARACTERISTICS²							
t _{TRANSITION}	50 75	90	50 75	100	ns typ ns max	R _L = 300 Ω, C _L = 35 pF; V _{S1} = ±3.5 V, V _{S8} = ∓3.5 V; Test Circuit 5 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 6 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 7 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 7 V _S = 0 V, R _S = 0 Ω, C _L = 1 nF; Test Circuit 8 R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz; V _S = 3 V rms; Test Circuit 9 R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz; Test Circuit 10	
t _{OPEN}	10		10		ns min		
t _{ON} (EN)	50 75	90	50 75	100	ns typ ns max		
t _{OFF} (EN)	30 45	60	30 45	75	ns typ ns max		
Charge Injection	6		6		pC typ		
OFF Isolation	85		85		dB typ		
Channel-to-Channel Crosstalk	85		85		dB typ		
C _S (OFF)	9		9		pF typ		
C _D (OFF)							
ADG608	40		40		pF typ		
ADG609	20		20		pF typ		
C _D (ON)							
ADG608	54		54		pF typ		
ADG609	34		34		pF typ		
POWER REQUIREMENTS							
I _{DD}	0.05 0.2	0.2 2	0.05 0.2	0.2 2	μA typ μA max		V _{IN} = 0 V or V _{DD}
I _{SS}	0.01 0.1	0.1 1	0.01 0.1	0.1 1	μA typ μA max		

NOTES

¹Temperature ranges are as follows: B Version: -40°C to $+85^\circ\text{C}$; T Version: -55°C to $+125^\circ\text{C}$.

²Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

SINGLE SUPPLY¹ ($V_{DD} = +5\text{ V} \pm 10\%$, $V_{SS} = 0\text{ V}$, $GND = 0\text{ V}$, unless otherwise noted)

Parameter	B Version +25°C −40°C to +85°C		T Version +25°C −55°C to +125°C		Units	Test Conditions/ Comments	
ANALOG SWITCH							
Analog Signal Range	0 to V _{DD}		0 to V _{DD}		V	V _S = +3.5 V, I _S = −1 mA; V _{DD} = +4.5 V; Test Circuit 1 +1 V ≤ V _S ≤ +3 V, I _{DS} = −1 mA; V _{DD} = +5 V V _S = 0 V, I _{DS} = −1 mA; V _{DD} = +5 V	
R _{ON}	40 50	60	40 50	70	Ω typ Ω max		
ΔR _{ON}	5	6	5	6	Ω max		
R _{ON} Match	2	3	2	3	Ω max		
LEAKAGE CURRENTS							
Source OFF Leakage I _S (OFF)	±0.05 ±0.5	±2	±0.05 ±0.5	±10	nA typ nA max	V _{DD} = +5.5 V V _D = 4.5 V/0.1 V, V _S = 0.1 V/4.5 V; Test Circuit 2	
Drain OFF Leakage I _D (OFF)	±0.05		±0.05		nA typ		
ADG608	±0.5	±2	±0.5	±10	nA max	V _D = 4.5 V/0.1 V, V _S = 0.1 V/4.5 V; Test Circuit 3	
ADG609	±0.5	±1	±0.5	±5	nA max		
Channel ON Leakage I _D , I _S (ON)	±0.05		±0.05		nA typ	V _S = V _D = 4.5 V/0.1 V; Test Circuit 4	
ADG608	±0.5	±3	±0.5	±20	nA max		
ADG609	±0.5	±1.5	±0.5	±10	nA max		
DIGITAL INPUTS							
Input High Voltage, V _{INH}	2.4		2.4		V min	V _{IN} = 0 or V _{DD}	
Input Low Voltage, V _{INL}	0.8		0.8		V max		
Input Current							
I _{INL} or I _{INH}	±1		±1		μA max		
C _{IN} , Digital Input Capacitance	5		5		pF typ		
DYNAMIC CHARACTERISTICS ²							
t _{TRANSITION}	80 100	130	80 100	150	ns typ ns max	R _L = 300 Ω, C _L = 35 pF; V _{S1} = 3.5 V/0 V, V _{S8} = 0 V/3.5 V; Test Circuit 5 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 6 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 7 R _L = 300 Ω, C _L = 35 pF; V _S = +3.5 V; Test Circuit 7 V _S = 0 V, R _S = 0 Ω, C _L = 1 nF; Test Circuit 8 R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz; V _S = 1.5 V rms; Test Circuit 9 R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz; Test Circuit 10	
t _{OPEN}	10		10		ns min		
t _{ON} (EN)	80 100	130	80 100	150	ns typ ns max		
t _{OFF} (EN)	40 50	60	40 50	75	ns typ ns max		
Charge Injection	0.5 3		0.5 3		pC typ pC max		
OFF Isolation	85		85		dB typ		
Channel-to-Channel Crosstalk	85		85		dB typ		
C _S (OFF)	9		9		pF typ		
C _D (OFF)							
ADG608	40		40		pF typ		
ADG609	20		20		pF typ		
C _D (ON)							
ADG608	54		54		pF typ		
ADG609	34		34		pF typ		
POWER REQUIREMENTS							
I _{DD}	0.05 0.2	0.2 2	0.05 0.2	0.2 2	μA typ μA max	V _{IN} = 0 V or V _{DD}	

NOTES

¹Temperature ranges are as follows: B Version: -40°C to $+85^\circ\text{C}$; T Version: -55°C to $+125^\circ\text{C}$.²Guaranteed by design, not subject to production test.

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ADG608/ADG609—SPECIFICATIONS

SINGLE SUPPLY¹ ($V_{DD} = +3.3 \text{ V} \pm 10\%$, $V_{SS} = 0 \text{ V}$, $GND = 0 \text{ V}$, unless otherwise noted)

Parameter	B Version +25°C −40°C to +85°C		T Version +25°C −55°C to +125°C		Units	Test Conditions/ Comments
ANALOG SWITCH						
Analog Signal Range		0 to V _{DD}		0 to V _{DD}	V	
R _{ON}	60		60		Ω typ	V _S = +1.5 V, I _S = −1 mA;
	90	100	90	120	Ω max	V _{DD} = +3 V; Test Circuit 1
R _{ON} Match	3	3	3	3	Ω max	V _S = 0 V, I _{DS} = −1 mA, V _{DD} = +3.3 V
LEAKAGE CURRENTS						
Source OFF Leakage I _S (OFF)	±0.05		±0.05		nA typ	V _{DD} = +3.6 V
	±0.5	±2	±0.5	±10	nA max	V _D = 2.6 V/0.1 V, V _S = 0.1 V/2.6 V;
Drain OFF Leakage I _D (OFF)	±0.05		±0.05		nA typ	Test Circuit 2
ADG608	±0.5	±2	±0.5	±10	nA max	V _D = 2.6 V/0.1 V, V _S = 0.1 V/2.6 V;
ADG609	±0.5	±1	±0.5	±5	nA max	Test Circuit 3
Channel ON Leakage I _D , I _S (ON)	±0.05		±0.05		nA typ	V _S = V _D = 2.6 V/0.1 V;
ADG608	±0.5	±3	±0.5	±20	nA max	Test Circuit 4
ADG609	±0.5	±1.5	±0.5	±10	nA max	
DIGITAL INPUTS						
Input High Voltage, V _{INH}		2.4		2.4	V min	
Input Low Voltage, V _{INL}		0.8		0.8	V max	
Input Current						
I _{INL} or I _{INH}		±1		±1	μA max	V _{IN} = 0 or V _{DD}
C _{IN} , Digital Input Capacitance	5		5		pF typ	
DYNAMIC CHARACTERISTICS²						
t _{TRANSITION}	120		120		ns typ	R _L = 300 Ω, C _L = 35 pF;
	170	225	170	250	ns max	V _{S1} = 1.5 V/0 V, V _{S8} = 0 V/1.5 V;
						Test Circuit 5
t _{OPEN}	10		10		ns min	R _L = 300 Ω, C _L = 35 pF;
						V _S = +1.5 V; Test Circuit 6
t _{ON} (EN)	120		120		ns typ	R _L = 300 Ω, C _L = 35 pF;
	170	225	170	250	ns max	V _S = +1.5 V; Test Circuit 7
t _{OFF} (EN)	40		40		ns typ	R _L = 300 Ω, C _L = 35 pF;
	60	75	60	90	ns max	V _S = +1.5 V; Test Circuit 7
Charge Injection	0.5		0.5		pC typ	V _S = 0 V, R _S = 0 Ω, C _L = 1 nF;
	3		3		pC max	Test Circuit 8
OFF Isolation	85		85		dB typ	R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz;
						V _S = 1 V rms; Test Circuit 9
Channel-to-Channel Crosstalk	85		85		dB typ	R _L = 1 kΩ, C _L = 15 pF, f = 100 kHz;
						Test Circuit 10
C _S (OFF)	9		9		pF typ	
C _D (OFF)						
ADG608	40		40		pF typ	
ADG609	20		20		pF typ	
C _D (ON)						
ADG608	54		54		pF typ	
ADG609	34		34		pF typ	
POWER REQUIREMENTS						
I _{DD}	0.05	0.2	0.05	0.2	μA typ	V _{IN} = 0 V or V _{DD}
	0.2	2	0.2	2	μA max	

NOTES

¹Temperature ranges are as follows: B Version: −40°C to +85°C; T Version: −55°C to +125°C.

²Guaranteed by design, not subject to production test.

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ABSOLUTE MAXIMUM RATINGS¹

(T_A = +25°C unless otherwise noted)

V _{DD} to V _{SS}	+13 V
V _{DD} to GND	−0.3 V to +6.5 V
V _{SS} to GND	+0.3 V to −6.5 V
Analog, Digital Inputs ²	−0.3 V to V _{DD} + 2 V or 20 mA, Whichever Occurs First
Continuous Current, S or D	20 mA
Peak Current, S or D	40 mA (Pulsed at 1 ms, 10% Duty Cycle Max)
Operating Temperature Range	
Industrial (B Version)	−40°C to +85°C
Extended (T Version)	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Junction Temperature	+150°C
Plastic DIP Package	
θ _{JA} , Thermal Impedance	117°C/W
Lead Temperature, Soldering (10 sec)	+260°C

SOIC Package

θ _{JA} , Thermal Impedance	77°C/W
Lead Temperature, Soldering	
Vapor Phase (60 sec)	+215°C
Infrared (15 sec)	+220°C

TSSOP Package

θ _{JA} , Thermal Impedance	158°C/W
Lead Temperature, Soldering	
Vapor Phase (60 sec)	+215°C
Infrared (15 sec)	+220°C

ESD Rating >5000 V

NOTES

¹Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Only one absolute maximum rating may be applied at any one time.

²Overvoltages at A, S, D or EN will be clamped by internal diodes. Current should be limited to the maximum ratings given.

Table I. ADG608 Truth Table

A2	A1	A0	EN	ON SWITCH
X	X	X	0	NONE
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

X = Don't Care

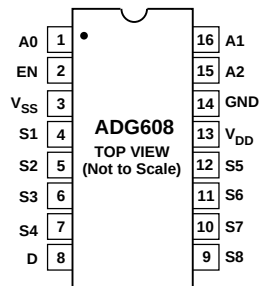
Table II. ADG609 Truth Table

A1	A0	EN	ON SWITCH PAIR
X	X	0	NONE
0	0	1	1
0	1	1	2
1	0	1	3
1	1	1	4

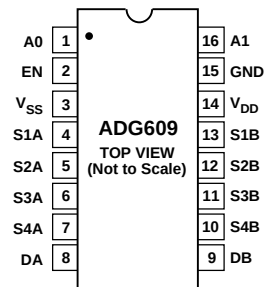
X = Don't Care

PIN CONFIGURATIONS

DIP/SOIC/TSSOP



DIP/SOIC/TSSOP



ADG608/ADG609—Typical Performance Characteristics

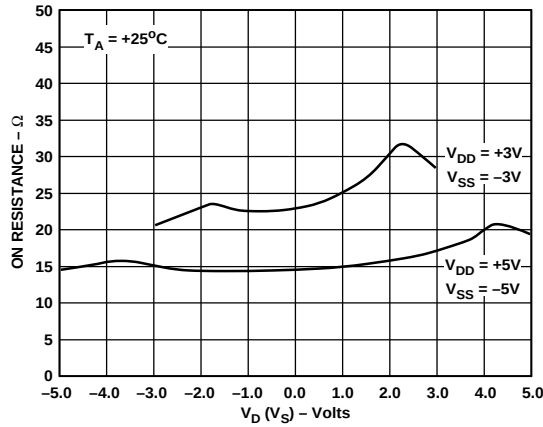


Figure 1. R_{ON} as a Function of V_D (V_S): Dual Supply Voltage

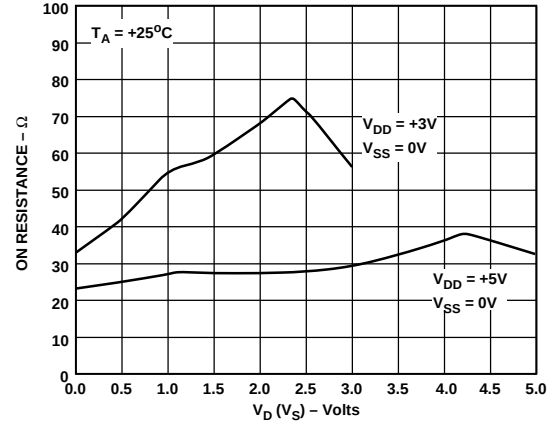


Figure 4. R_{ON} as a Function of V_D (V_S): Single Supply Voltage

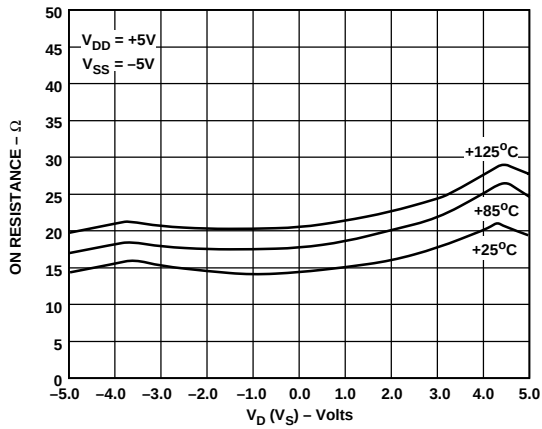


Figure 2. R_{ON} as a Function of V_D (V_S) for Different Temperatures

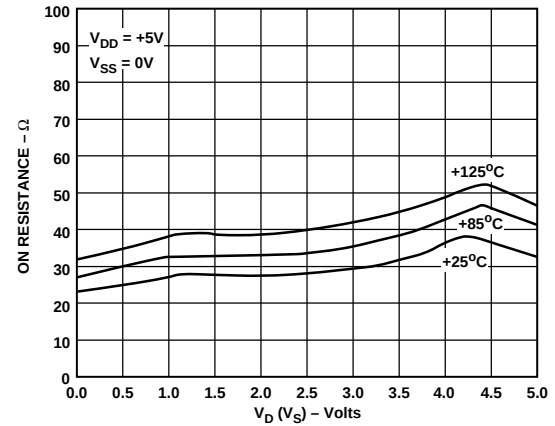


Figure 5. R_{ON} as a Function of V_D (V_S) for Different Temperatures

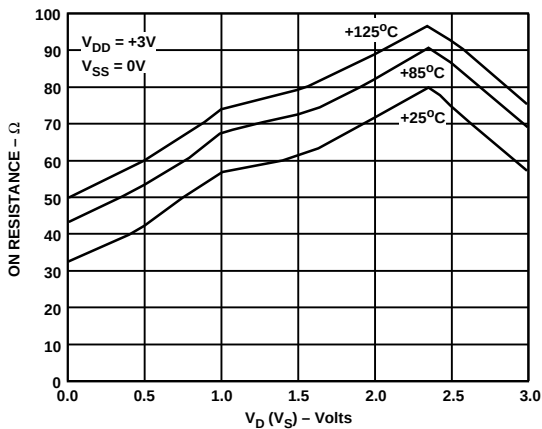


Figure 3. R_{ON} as a Function of V_D (V_S) for Different Temperatures

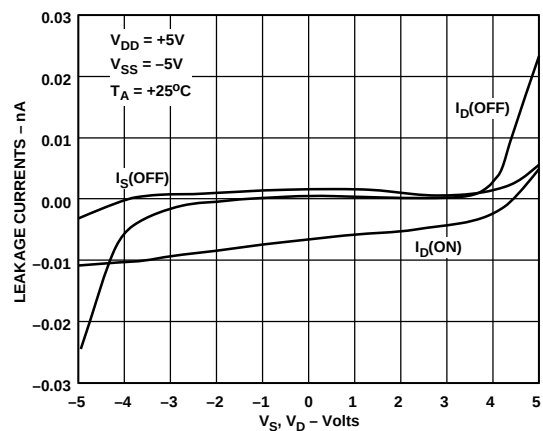


Figure 6. Leakage Currents as a Function of V_D (V_S)

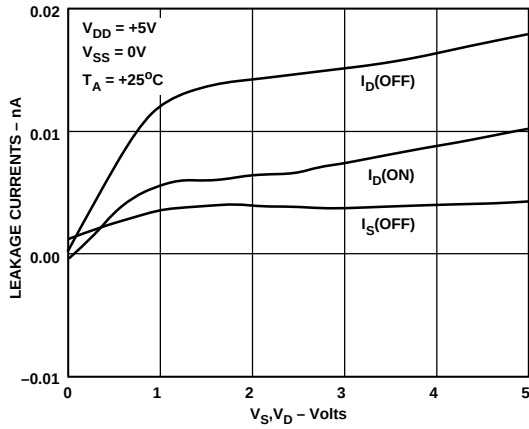


Figure 7. Leakage Currents as a Function of V_D (V_S)

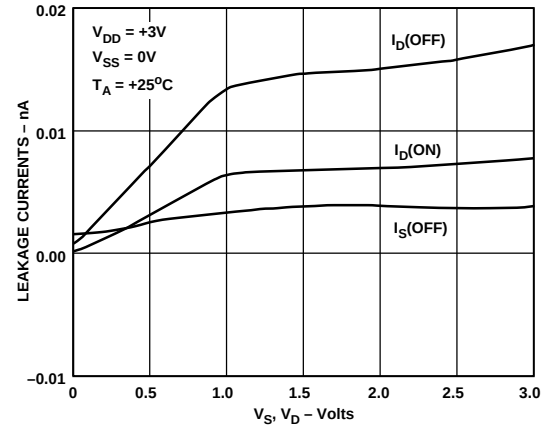


Figure 10. Leakage Currents as a Function of V_D (V_S)

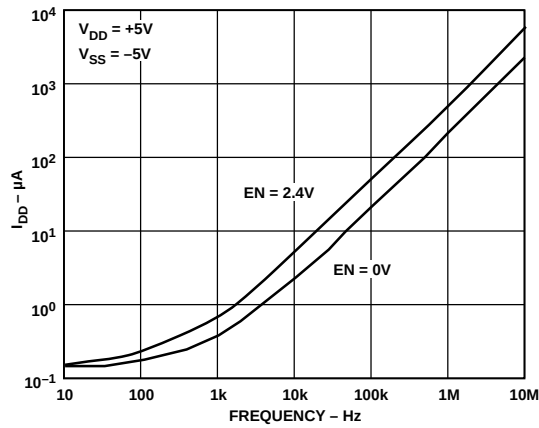


Figure 8. Positive Supply Current vs. Switching Frequency

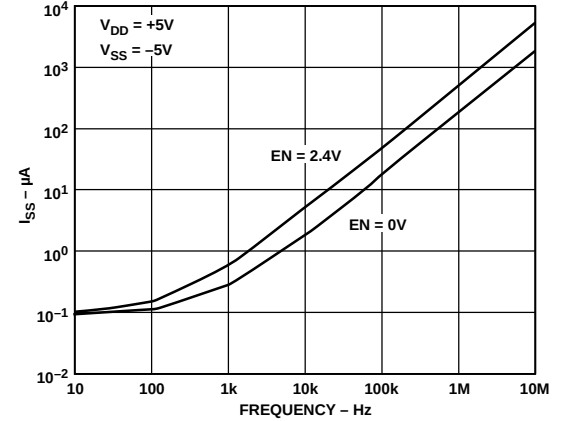


Figure 11. Negative Supply Current vs. Switching Frequency

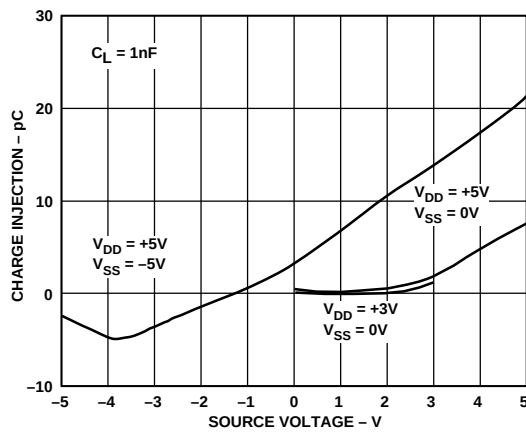


Figure 9. Charge Injection vs. Analog Voltage V_S

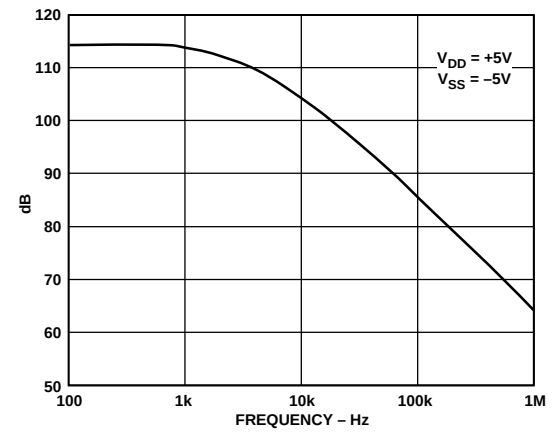
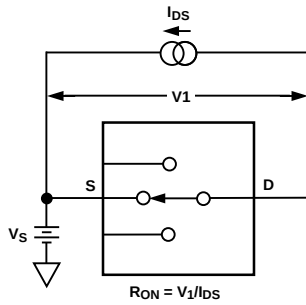


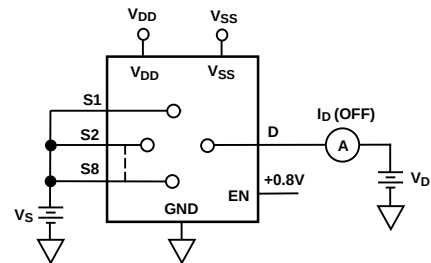
Figure 12. Crosstalk and Off Isolation vs. Frequency

ADG608/ADG609

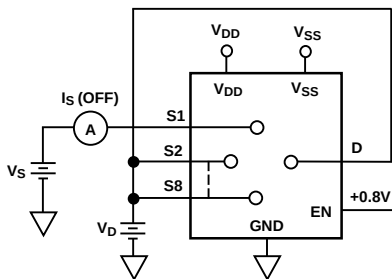
Test Circuits



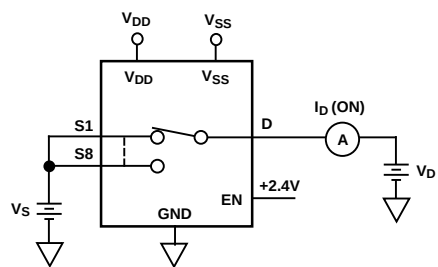
Test Circuit 1. On Resistance



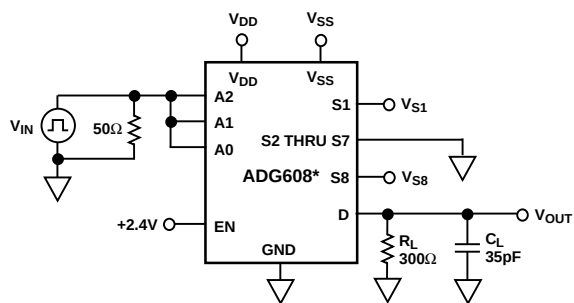
Test Circuit 3. I_D (OFF)



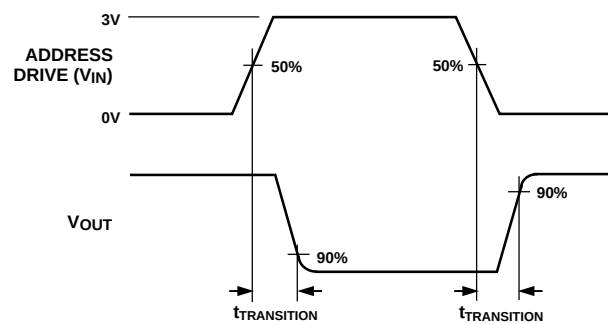
Test Circuit 2. I_S (OFF)



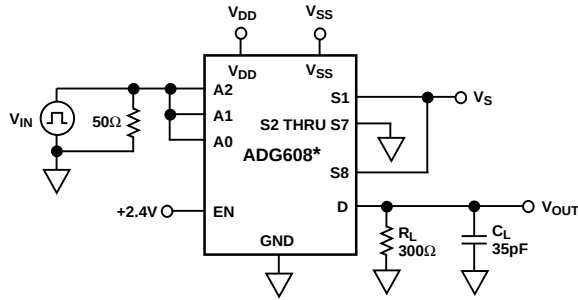
Test Circuit 4. I_D (ON)



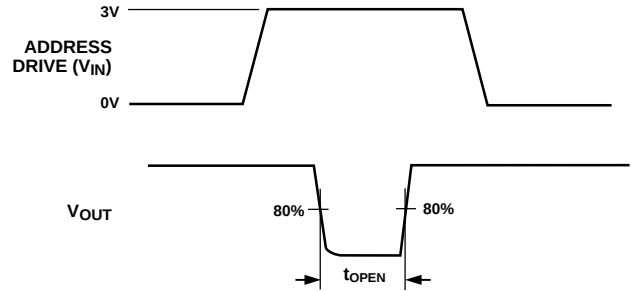
* SIMILAR CONNECTION FOR ADG609



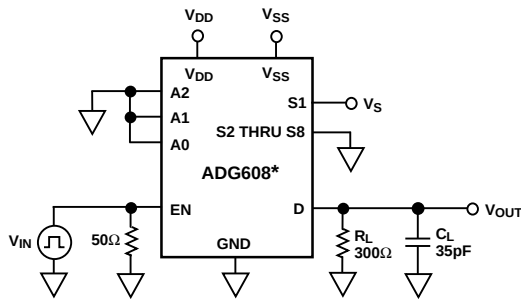
Test Circuit 5. Switching Time of Multiplexer, $t_{TRANSITION}$



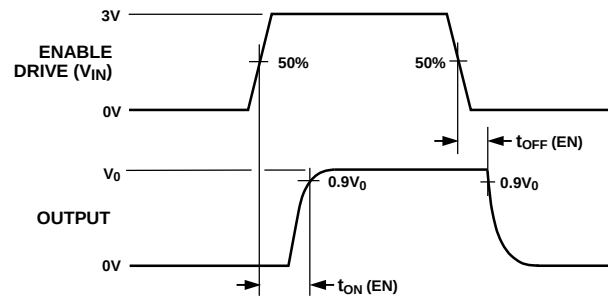
* SIMILAR CONNECTION FOR ADG609



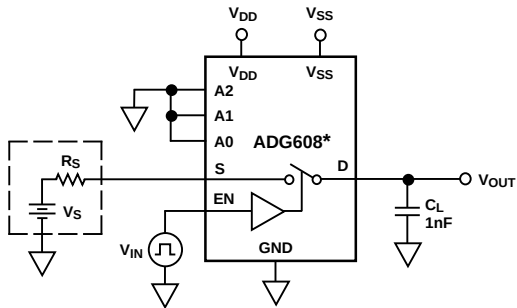
Test Circuit 6. Break-Before-Make Delay, t_{OPEN}



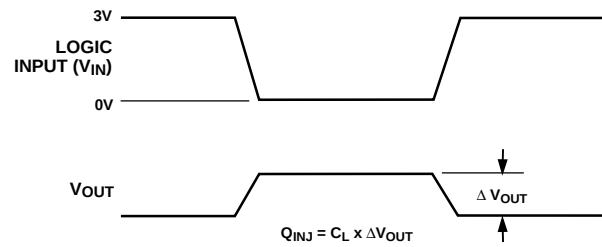
* SIMILAR CONNECTION FOR ADG609



Test Circuit 7. Enable Delay, $t_{ON} (EN)$, $t_{OFF} (EN)$

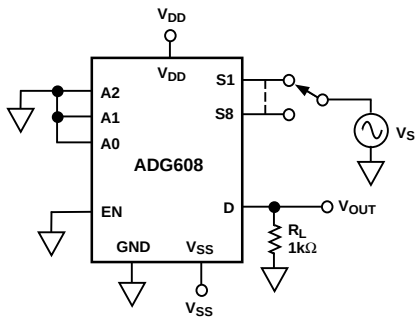


* SIMILAR CONNECTION FOR ADG609

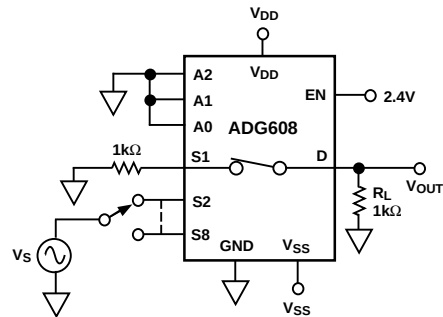


Test Circuit 8. Charge Injection

ADG608/ADG609



Test Circuit 9. OFF Isolation



Test Circuit 10. Channel-to-Channel Crosstalk

TERMINOLOGY

V_{DD}	Most positive power supply potential.
V_{SS}	Most negative power supply potential in dual supplies. In single supply applications, it may be connected to ground.
GND	Ground (0 V) reference.
R_{ON}	Ohmic resistance between D and S.
ΔR_{ON}	R_{ON} variation due to a change in the analog input voltage with a constant load current.
R_{ON} Match	Difference between the R_{ON} of any two channels.
I_S (OFF)	Source leakage current when the switch is off.
I_D (OFF)	Drain leakage current when the switch is off.
I_D, I_S (ON)	Channel leakage current when the switch is on.
V_D, V_S	Analog voltage on terminals D, S.
C_S (OFF)	Channel input capacitance for “OFF” condition.
C_D (OFF)	Channel output capacitance for “OFF” condition.
C_D, C_S (ON)	“ON” switch capacitance.
C_{IN}	Digital input capacitance.
t_{ON} (EN)	Delay time between the 50% and 90% points of the digital input and switch “ON” condition.

t_{OFF} (EN)	Delay time between the 50% and 90% points of the digital input and switch “OFF” condition.
$t_{TRANSITION}$	Delay time between the 50% and 90% points of the digital inputs and the switch “ON” condition when switching from one address state to another.
t_{OPEN}	“OFF” time measured between the 80% points of both switches when switching from one address state to another.
V_{INL}	Maximum input voltage for logic “0.”
V_{INH}	Minimum input voltage for logic “1.”
I_{INL} (I_{INH})	Input current of the digital input.
Crosstalk	A measure of unwanted signal which is coupled through from one channel to another as a result of parasitic capacitance.
Off Isolation	A measure of unwanted signal coupling through an “OFF” channel.
Charge Injection	A measure of the glitch impulse transferred from the digital input to the analog output during switching.
I_{DD}	Positive supply current.
I_{SS}	Negative supply current.

Dimensions shown in inches and (mm).

The drawing shows the mechanical specifications for the BSC package. The top view is a square with pins on all four sides. The side view shows the package's profile with a maximum height of 0.433 mm (0.017 in) and a seating plane at 0.0256 mm (0.001 in) from the base. The package is designed to be seated at an 8° angle.

Dimension	Value (mm)	Value (in)
Top Width	0.201	(5.10)
Pin Pitch (Top)	0.193	(4.90)
Left Height	0.177	(4.50)
Pin Pitch (Left)	0.169	(4.30)
Right Height	0.256	(6.50)
Pin Pitch (Right)	0.246	(6.25)
Bottom Width	0.006	(0.15)
Pin Pitch (Bottom)	0.002	(0.05)
Seating Plane	0.0256	(0.65)
BSC	0.0118	(0.30)
MAX	0.0075	(0.19)
8°	0.0079	(0.20)
0°	0.0035	(0.090)
0.028	0.028	(0.70)
0.020	0.020	(0.50)

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
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- Поставка сложных, дефицитных, либо снятых с производства позиций;
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- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
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- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

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JONHON

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Разъемы специального, военного и аэрокосмического назначения:

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«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели,
кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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