



# LC<sup>2</sup>MOS 4-/8-Channel High Performance Analog Multiplexers

## ADG408/ADG409

### FEATURES

- 44 V Supply Maximum Ratings
- V<sub>SS</sub> to V<sub>DD</sub> Analog Signal Range
- Low On Resistance (100 Ω max)
- Low Power (I<sub>SUPPLY</sub> < 75 μA)
- Fast Switching
- Break-Before-Make Switching Action
- Plug-in Replacement for DG408/DG409

### APPLICATIONS

- Audio and Video Routing
- Automatic Test Equipment
- Data Acquisition Systems
- Battery Powered Systems
- Sample and Hold Systems
- Communication Systems

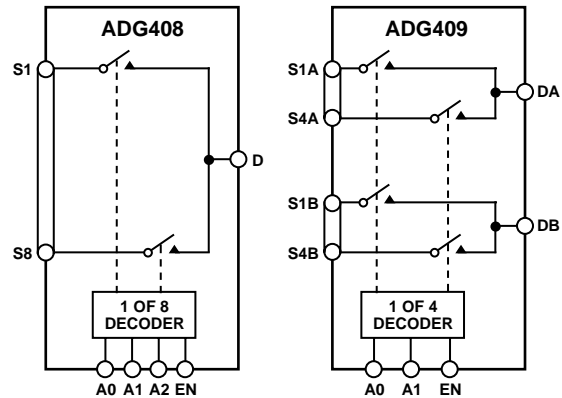
### GENERAL DESCRIPTION

The ADG408 and ADG409 are monolithic CMOS analog multiplexers comprising eight single channels and four differential channels respectively. The ADG408 switches one of eight inputs to a common output as determined by the 3-bit binary address lines A0, A1 and A2. The ADG409 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.

The ADG408/ADG409 are designed on an enhanced LC<sup>2</sup>MOS process which 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 that 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.

The ADG408/ADG409 are improved replacements for the DG408/DG409 Analog Multiplexers.

### FUNCTIONAL BLOCK DIAGRAMS



### PRODUCT HIGHLIGHTS

1. Extended Signal Range  
The ADG408/ADG409 are fabricated on an enhanced LC<sup>2</sup>MOS process giving an increased signal range that extends to the supply rails.
2. Low Power Dissipation
3. Low R<sub>ON</sub>
4. Single Supply Operation  
For applications where the analog signal is unipolar, the ADG408/ADG409 can be operated from a single rail power supply. The parts are fully specified with a single +12 V power supply and will remain functional with single supplies as low as +5 V.

### REV. A

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# ADG408/ADG409—SPECIFICATIONS

**DUAL SUPPLY<sup>1</sup>** ( $V_{DD} = +15\text{ V}$ ,  $V_{SS} = -15\text{ V}$ ,  $GND = 0\text{ V}$ , unless otherwise noted)

Parameter	B Version -40°C to +85°C		T Version -55°C to +125°C		Units	Test Conditions/Comments
	+25°C		+25°C			
<b>ANALOG SWITCH</b>						
Analogue Signal Range		$V_{SS}$ to $V_{DD}$		$V_{SS}$ to $V_{DD}$	V	
$R_{ON}$	40 100		40 100	125	$\Omega$ typ $\Omega$ max	$V_D = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$
$\Delta R_{ON}$	15		15		$\Omega$ max	$V_D = +10\text{ V}$ , $-10\text{ V}$
<b>LEAKAGE CURRENTS</b>						
Source OFF Leakage $I_S$ (OFF)	$\pm 0.5$	$\pm 50$	$\pm 0.5$	$\pm 50$	nA max	$V_D = \pm 10\text{ V}$ , $V_S = \mp 10\text{ V}$ ; Test Circuit 2
Drain OFF Leakage $I_D$ (OFF)						$V_D = \pm 10\text{ V}$ ; $V_S = \mp 10\text{ V}$ ; Test Circuit 3
ADG408	$\pm 1$	$\pm 100$	$\pm 1$	$\pm 100$	nA max	
ADG409	$\pm 1$	$\pm 50$	$\pm 1$	$\pm 50$	nA max	
Channel ON Leakage $I_D$ , $I_S$ (ON)						$V_S = V_D = \pm 10\text{ V}$ ; Test Circuit 4
ADG408	$\pm 1$	$\pm 100$	$\pm 1$	$\pm 100$	nA max	
ADG409	$\pm 1$	$\pm 50$	$\pm 1$	$\pm 50$	nA max	
<b>DIGITAL INPUTS</b>						
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 $I_{INH}$		$\pm 10$		$\pm 10$	$\mu\text{A}$ max	$V_{IN} = 0$ or $V_{DD}$
$C_{IN}$ , Digital Input Capacitance	8		8		pF typ	$f = 1\text{ MHz}$
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>						
$t_{TRANSITION}$		120 250		120 250	ns typ ns max	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_{S1} = \pm 10\text{ V}$ , $V_{SS} = \mp 10\text{ V}$ ; Test Circuit 5
$t_{OPEN}$	10	10	10	10	ns min	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 6
$t_{ON}$ (EN)	85 150	125 225	85 150	125 225	ns typ ns max	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 7
$t_{OFF}$ (EN)		65 150		65 150	ns typ ns max	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 7
Charge Injection	20		20		pC typ	$V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 10\text{ nF}$ ; Test Circuit 8
OFF Isolation	-75		-75		dB typ	$R_L = 1\text{ k}\Omega$ , $f = 100\text{ kHz}$ ; $V_{EN} = 0\text{ V}$ ; Test Circuit 9
Channel-to-Channel Crosstalk	85		85		dB typ	$R_L = 1\text{ k}\Omega$ , $f = 100\text{ kHz}$ ; Test Circuit 10
$C_S$ (OFF)	11		11		pF typ	$f = 1\text{ MHz}$
$C_D$ (OFF)						$f = 1\text{ MHz}$
ADG408	40		40		pF typ	
ADG409	20		20		pF typ	
$C_D$ , $C_S$ (ON)						$f = 1\text{ MHz}$
ADG408	54		54		pF typ	
ADG409	34		34		pF typ	
<b>POWER REQUIREMENTS</b>						
$I_{DD}$		1 5		1 5	$\mu\text{A}$ typ $\mu\text{A}$ max	$V_{IN} = 0\text{ V}$ , $V_{EN} = 0\text{ V}$
$I_{SS}$		1 5		1 5	$\mu\text{A}$ typ $\mu\text{A}$ max	
$I_{DD}$	100 200		100 200	500	$\mu\text{A}$ typ $\mu\text{A}$ max	$V_{IN} = 0\text{ V}$ , $V_{EN} = 2.4\text{ V}$

## NOTES

<sup>1</sup>Temperature ranges are as follows: B Version: -40°C to +85°C; T Version: -55°C to +125°C.

<sup>2</sup>Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

## SINGLE SUPPLY<sup>1</sup> ( $V_{DD} = +12\text{ V}$ , $V_{SS} = 0\text{ V}$ , $GND = 0\text{ V}$ , unless otherwise noted)

Parameter	B Version		T Version		Units	Test Conditions/Comments
	+25°C	-40°C to +85°C	+25°C	-55°C to +125°C		
<b>ANALOG SWITCH</b>						
Analog Signal Range		0 to $V_{DD}$		0 to $V_{DD}$	V	
$R_{ON}$	90		90		$\Omega$ typ	$V_D = +3\text{ V}$ , $+10\text{ V}$ , $I_S = -1\text{ mA}$
<b>LEAKAGE CURRENTS</b>						
Source OFF Leakage $I_S$ (OFF)	$\pm 0.5$	$\pm 50$	$\pm 0.5$	$\pm 50$	nA max	$V_D = 8\text{ V}/0\text{ V}$ , $V_S = 0\text{ V}/8\text{ V}$ ; Test Circuit 2
Drain OFF Leakage $I_D$ (OFF)					nA max	$V_D = 8\text{ V}/0\text{ V}$ , $V_S = 0\text{ V}/8\text{ V}$ ; Test Circuit 3
ADG408	$\pm 1$	$\pm 100$	$\pm 1$	$\pm 100$	nA max	
ADG409	$\pm 1$	$\pm 50$	$\pm 1$	$\pm 50$	nA max	
Channel ON Leakage $I_D$ , $I_S$ (ON)					nA max	$V_S = V_D = 8\text{ V}/0\text{ V}$ ; Test Circuit 4
ADG408	$\pm 1$	$\pm 100$	$\pm 1$	$\pm 100$	nA max	
ADG409	$\pm 1$	$\pm 50$	$\pm 1$	$\pm 50$	nA max	
<b>DIGITAL INPUTS</b>						
Input High Voltage, $V_{INH}$		2.4		2.4	V min	
Input Low Voltage, $V_{INL}$		0.8		0.8	V max	
Input Current					$\mu\text{A}$ max	$V_{IN} = 0$ or $V_{DD}$
$I_{INL}$ or $I_{INH}$		$\pm 10$		$\pm 10$	$\mu\text{A}$ max	$f = 1\text{ MHz}$
$C_{IN}$ , Digital Input Capacitance	8		8		pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>						
$t_{TRANSITION}$	130		130		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_{S1} = 8\text{ V}/0\text{ V}$ , $V_{SS} = 0\text{ V}/8\text{ V}$ ; Test Circuit 5
$t_{OPEN}$	10		10		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 6
$t_{ON}$ (EN)	140		140		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 7
$t_{OFF}$ (EN)	60		60		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ ; $V_S = +5\text{ V}$ ; Test Circuit 7
Charge Injection	5		5		pC typ	$V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 10\text{ nF}$ ; Test Circuit 8
OFF Isolation	-75		-75		dB typ	$R_L = 1\text{ k}\Omega$ , $f = 100\text{ kHz}$ ; $V_{EN} = 0\text{ V}$ ; Test Circuit 9
Channel-to-Channel Crosstalk	85		85		dB typ	$R_L = 1\text{ k}\Omega$ , $f = 100\text{ kHz}$ ; Test Circuit 10
$C_S$ (OFF)	11		11		pF typ	$f = 1\text{ MHz}$
$C_D$ (OFF)					pF typ	$f = 1\text{ MHz}$
ADG408	40		40		pF typ	
ADG409	20		20		pF typ	
$C_D$ , $C_S$ (ON)					pF typ	$f = 1\text{ MHz}$
ADG408	54		54		pF typ	
ADG409	34		34		pF typ	
<b>POWER REQUIREMENTS</b>						
$I_{DD}$		1		1	$\mu\text{A}$ typ	$V_{IN} = 0\text{ V}$ , $V_{EN} = 0\text{ V}$
		5		5	$\mu\text{A}$ max	
$I_{DD}$	100		100		$\mu\text{A}$ typ	$V_{IN} = 0\text{ V}$ , $V_{EN} = 2.4\text{ V}$
	200	500	200	500	$\mu\text{A}$ max	

### NOTES

<sup>1</sup>Temperature ranges are as follows: B Version: -40°C to +85°C; T Version: -55°C to +125°C.

<sup>2</sup>Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

# ADG408/ADG409

## ABSOLUTE MAXIMUM RATINGS<sup>1</sup>

(T<sub>A</sub> = +25°C unless otherwise noted)

V <sub>DD</sub> to V <sub>SS</sub> .....	+44 V
V <sub>DD</sub> to GND .....	-0.3 V to +25 V
V <sub>SS</sub> to GND .....	+0.3 V to -25 V
Analog, Digital Inputs <sup>2</sup> .....	V <sub>SS</sub> -2 V to V <sub>DD</sub> +2 V or 20 mA, Whichever Occurs First
Continuous Current, S or D .....	20 mA
Peak Current, S or D (Pulsed at 1 ms, 10% Duty Cycle max) .....	40 mA
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
Cerdip Package, Power Dissipation .....	900 mW
θ <sub>JA</sub> , Thermal Impedance .....	76°C/W
Lead Temperature, Soldering (10 sec) .....	+300°C
Plastic Package, Power Dissipation .....	470 mW
θ <sub>JA</sub> , Thermal Impedance .....	117°C/W
Lead Temperature, Soldering (10 sec) .....	+260°C
TSSOP Package, Power Dissipation .....	450 mW
θ <sub>JA</sub> , Thermal Impedance .....	155°C/W
θ <sub>JC</sub> , Thermal Impedance .....	50°C/W
SOIC Package, Power Dissipation .....	600 mW
θ <sub>JA</sub> , Thermal Impedance .....	77°C/W
Lead Temperature, Soldering	
Vapor Phase (60 sec) .....	+215°C
Infrared (15 sec) .....	+220°C

### NOTES

<sup>1</sup>Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; 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.

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

## CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADG408/ADG409 feature proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

## ORDERING INFORMATION

Model <sup>1</sup>	Temperature Range	Package Option <sup>2</sup>
ADG408BN	-40°C to +85°C	N-16
ADG408BR	-40°C to +85°C	R-16A
ADG408BRU	-40°C to +85°C	RU-16
ADG408TQ	-55°C to +125°C	Q-16
ADG409BN	-40°C to +85°C	N-16
ADG409BR	-40°C to +85°C	R-16A
ADG409TQ	-55°C to +125°C	Q-16

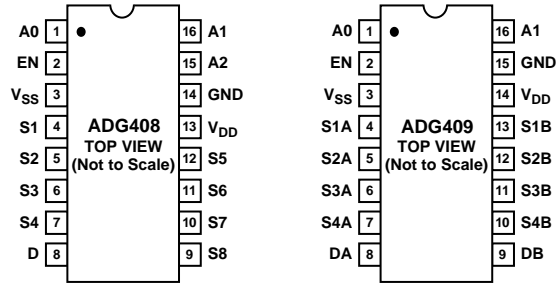
### NOTES

<sup>1</sup>To order MIL-STD-883, Class B processed parts, add /883B to T grade part numbers.

<sup>2</sup>N = Plastic DIP; Q = Cerdip; R = 0.15" Small Outline IC (SOIC);  
RU = Think Shrink Small Outline Package (TSSOP).



## PIN CONFIGURATIONS (DIP/SOIC/TSSOP)



**ADG408 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

**ADG409 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

## 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.
$\Delta R_{ON}$	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% point 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.

# ADG408/ADG409

## Typical Performance Characteristics

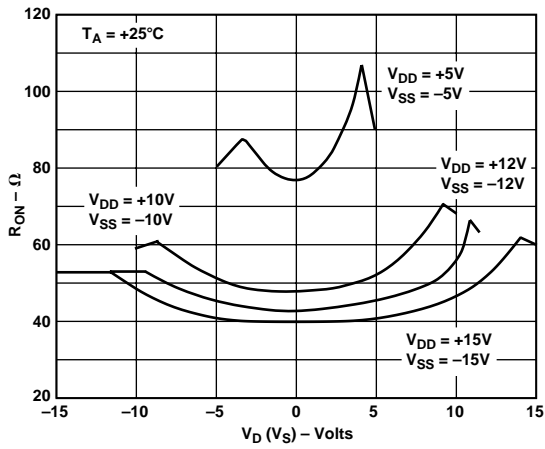


Figure 1.  $R_{ON}$  as a Function of  $V_D$  ( $V_S$ ): Dual Supply Voltage

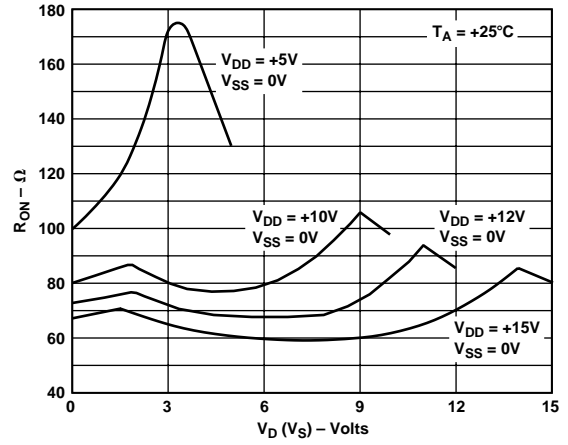


Figure 4.  $R_{ON}$  as a Function of  $V_D$  ( $V_S$ ): Single Supply Voltage

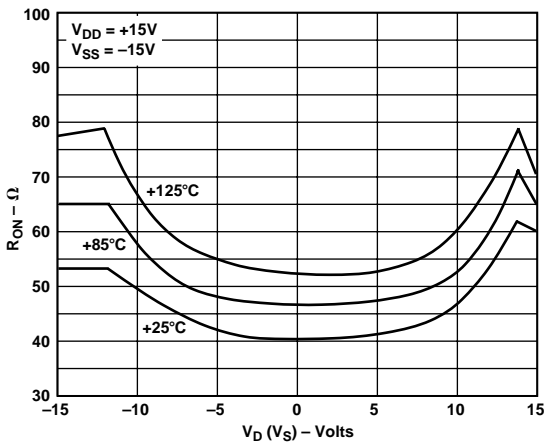


Figure 2.  $R_{ON}$  as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures

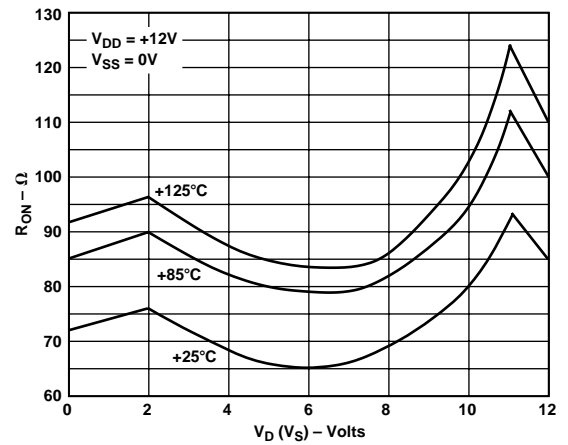


Figure 5.  $R_{ON}$  as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures

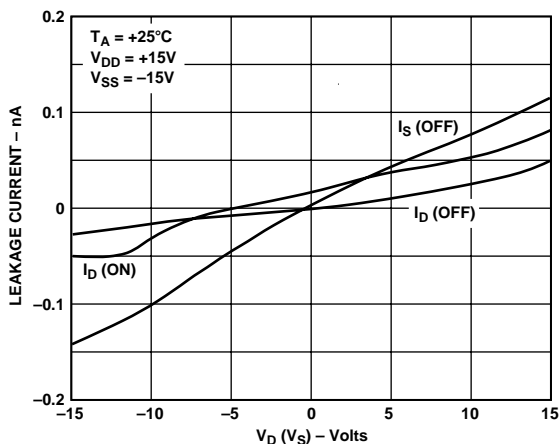


Figure 3. Leakage Currents as a Function of  $V_D$  ( $V_S$ )

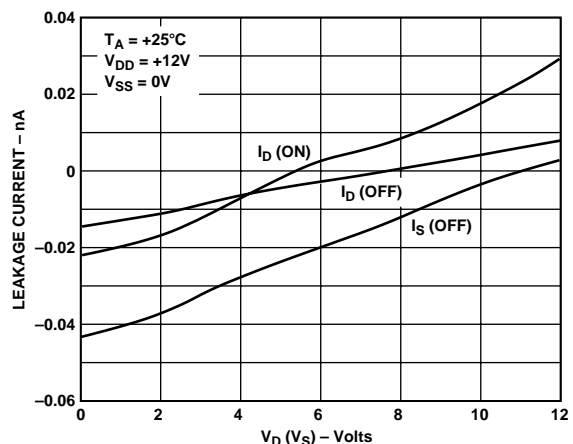


Figure 6. Leakage Currents as a Function of  $V_D$  ( $V_S$ )

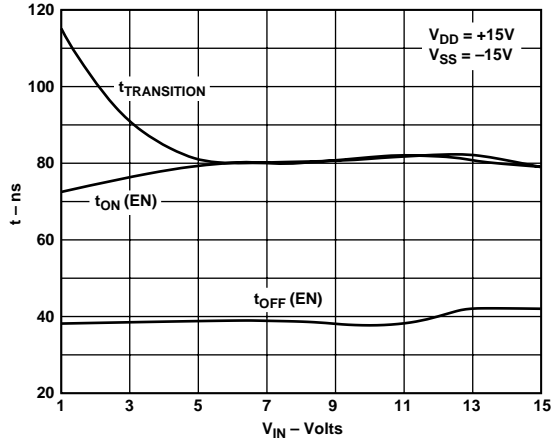


Figure 7. Switching Time vs.  $V_{IN}$  (Bipolar Supply)

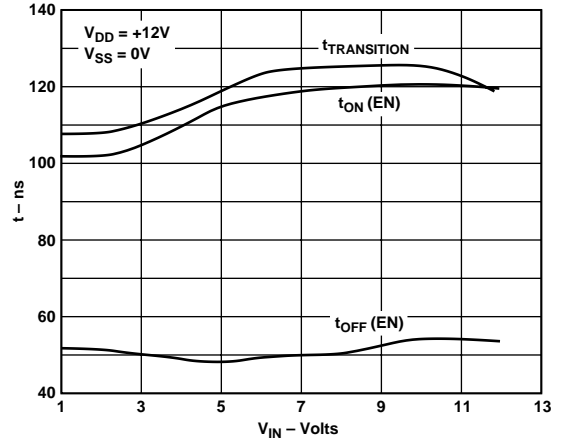


Figure 10. Switching Time vs.  $V_{IN}$  (Single Supply)

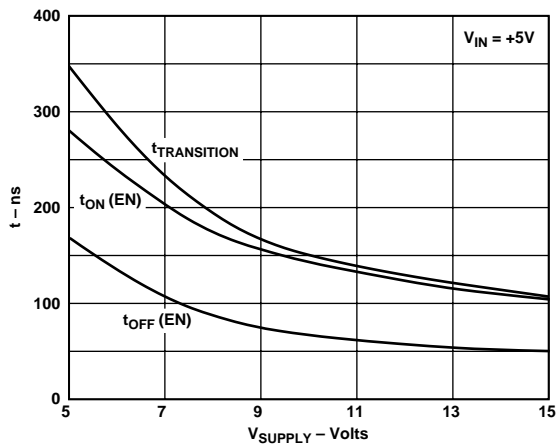


Figure 8. Switching Time vs. Single Supply

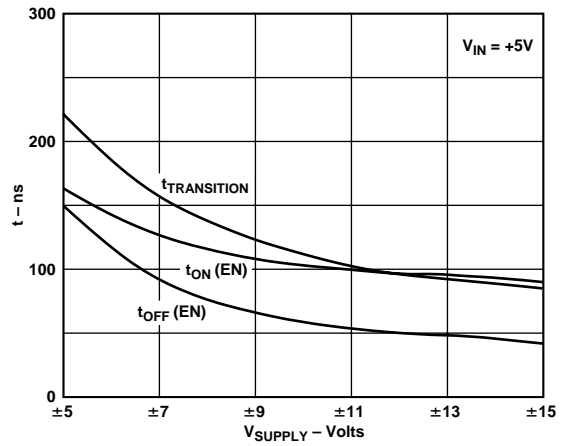


Figure 11. Switching Time vs. Bipolar Supply

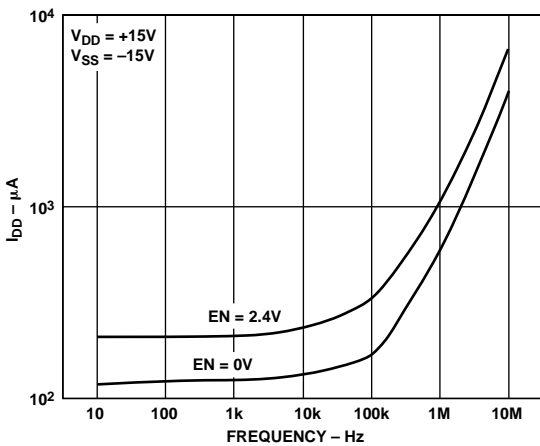


Figure 9. Positive Supply Current vs. Switching Frequency

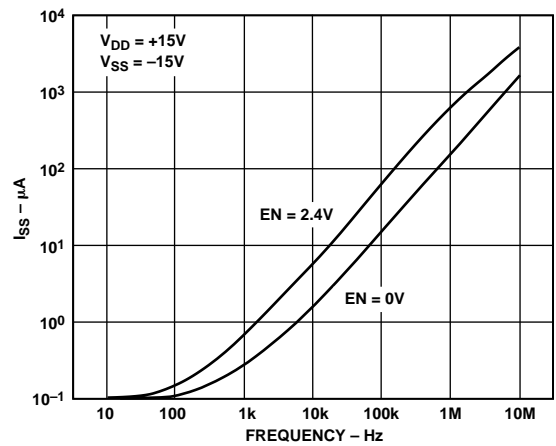


Figure 12. Negative Supply Current vs. Switching Frequency

# ADG408/ADG409

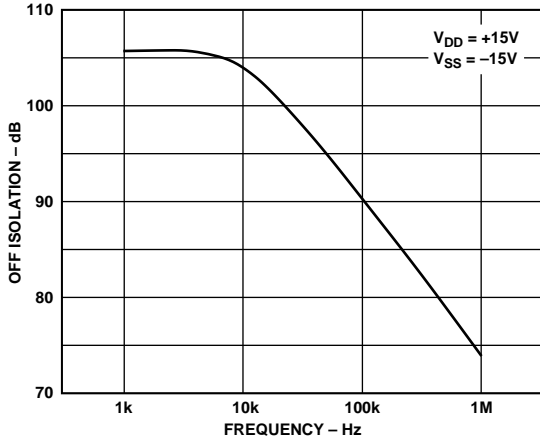


Figure 13. Off Isolation vs. Frequency

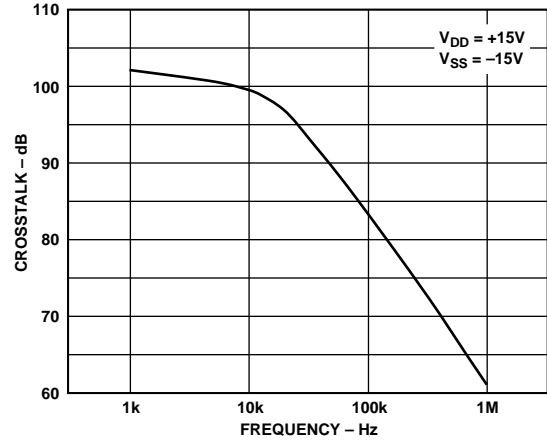
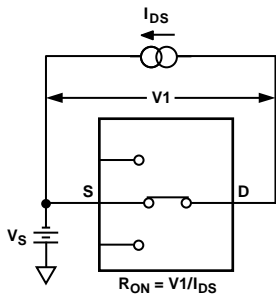
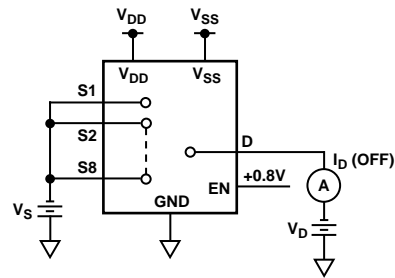


Figure 14. Crosstalk vs. Frequency

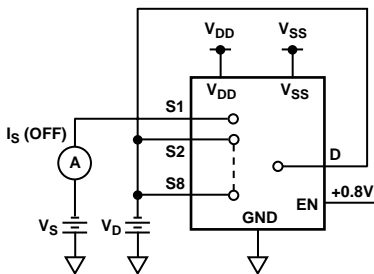
## Test Circuits



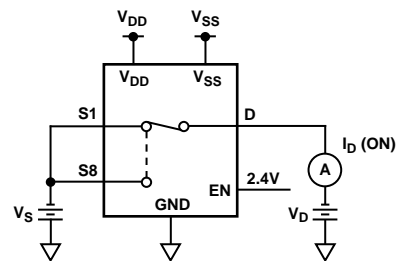
Test Circuit 1. On Resistance



Test Circuit 3.  $I_D$  (OFF)

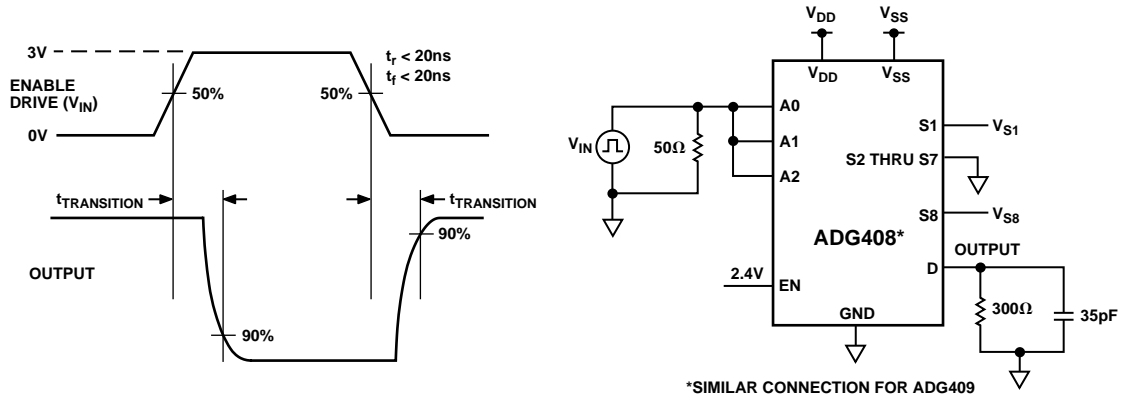


Test Circuit 2.  $I_S$  (OFF)

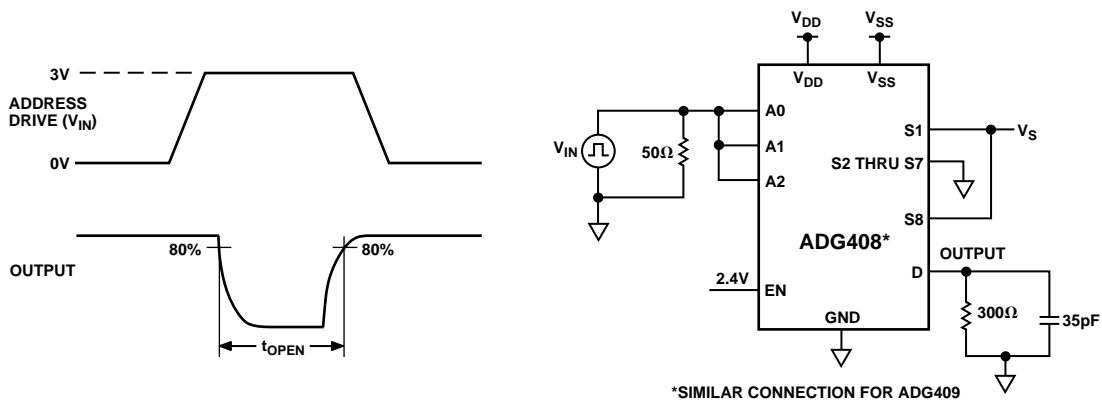


Test Circuit 4.  $I_D$  (ON)

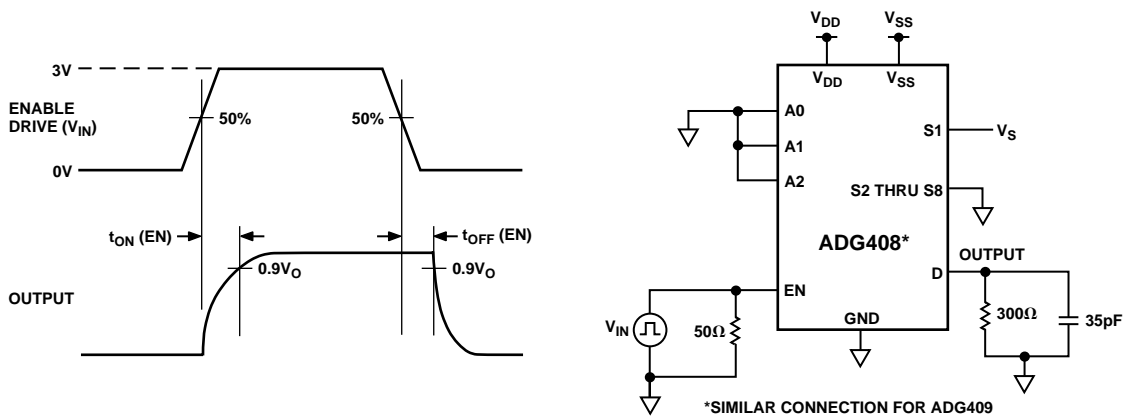




*Test Circuit 5. Switching Time of Multiplexer,  $t_{\text{TRANSITION}}$*

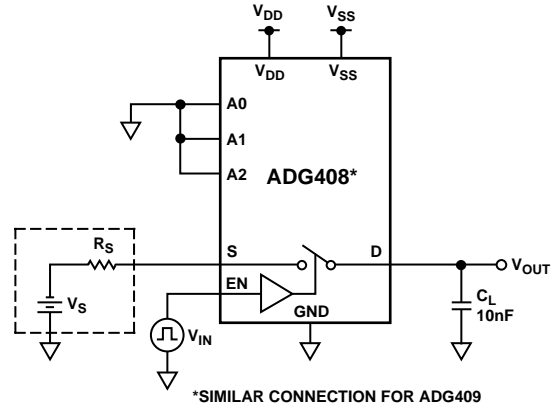
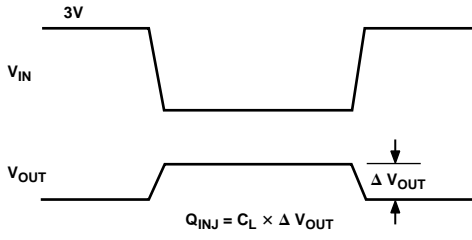


*Test Circuit 6. Break-Before-Make Delay,  $t_{\text{OPEN}}$*

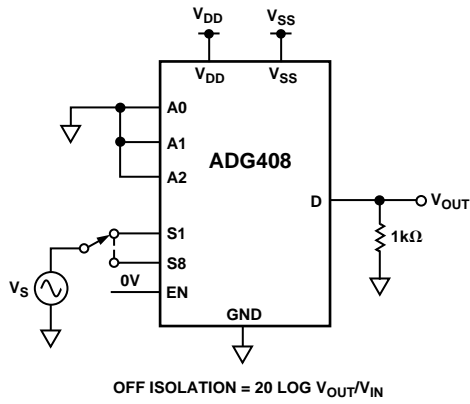


*Test Circuit 7. Enable Delay,  $t_{\text{ON}}(\text{EN})$ ,  $t_{\text{OFF}}(\text{EN})$*

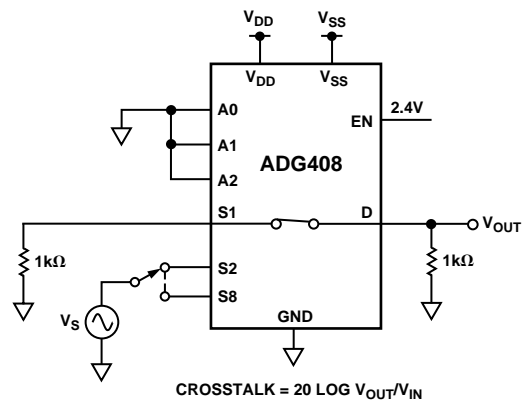
# ADG408/ADG409



Test Circuit 8. Charge Injection



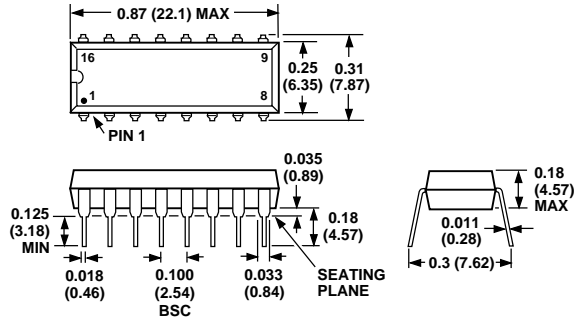
Test Circuit 9. OFF Isolation



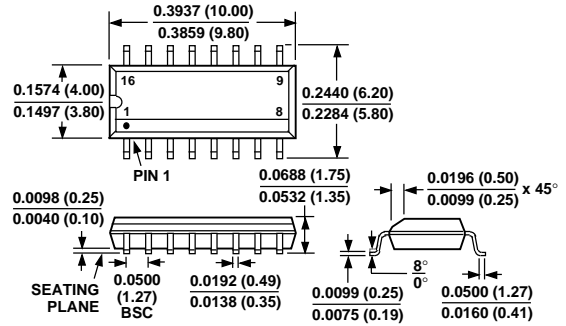
Test Circuit 10. Channel-to-Channel Crosstalk

**OUTLINE DIMENSIONS**  
Dimensions shown in inches and (mm).

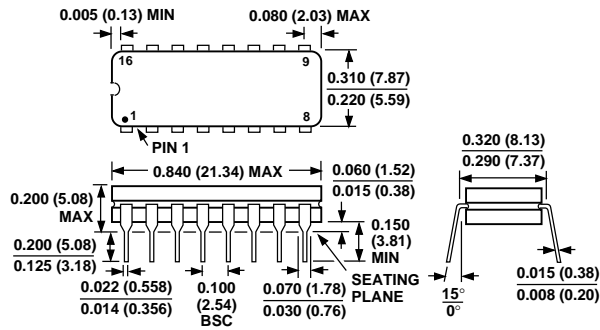
**Plastic DIP (N-16)**



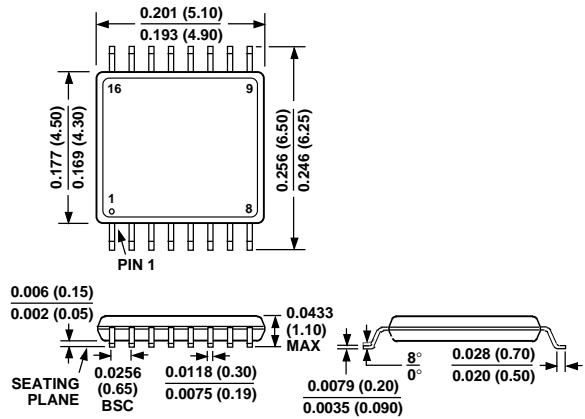
**SO (Narrow Body) (R-16A)**



**Cerdip (Q-16)**



**Thin Shrink Small Outline Package (TSSOP) (RU-16)**



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