

FEATURES

5 Ω max on resistance
 0.5 Ω max on resistance flatness
 33 V supply maximum ratings
 Fully specified at ± 15 V/ 12 V/ ± 5 V
 3 V logic compatible inputs
 Rail-to-rail operation
 Break-before-make switching action
 16-lead TSSOP and 4 mm \times 4 mm LFCSP packages
 Typical power consumption (< 0.03 μ W)

APPLICATIONS

Relay replacement
 Audio and video routing
 Automatic test equipment
 Data acquisition systems
 Battery-powered systems
 Sample-and-hold systems
 Communication systems
 Relay replacement

GENERAL DESCRIPTION

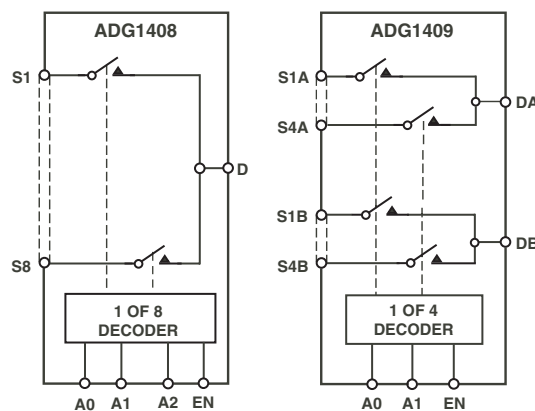
The ADG1408 and ADG1409 are monolithic *i*CMOS analog multiplexers comprising eight single channels and four differential channels, respectively. The ADG1408 switches one of eight inputs to a common output as determined by the 3-bit binary address lines A0, A1, and A2. The ADG1409 switches one of four 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 *i*CMOS (industrial-CMOS) modular manufacturing process combines high-voltage CMOS (complementary metal-oxide semiconductor) and bipolar technologies. It enables the development of a wide range of high performance analog ICs capable of 30-V operation in a footprint that no other generation of high-voltage parts has been able to achieve. Unlike analog ICs using conventional CMOS processes, *i*CMOS components can tolerate high supply voltages, while providing increased performance, dramatically lower power consumption, and reduced package size.

Rev. PrB

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FUNCTIONAL BLOCK DIAGRAMS



SWITCHES SHOWN FOR A "1" LOGIC INPUT

Figure 1.

The ultralow on resistance and on resistance flatness of these switches make them ideal solutions for data acquisition and gain switching applications, where low distortion is critical. *i*CMOS construction ensures ultralow power dissipation, making the parts ideally suited for portable and battery powered instruments

PRODUCT HIGHLIGHTS

1. 5 Ω max on resistance.
2. 0.5 Ω max on resistance flatness.
3. 3 V logic compatible digital input $V_{IH} = 2.0$ V, $V_{IL} = 0.8$ V.
4. 16-lead TSSOP and 4 mm \times 4 mm LFCSP package.

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REVISION HISTORY

SPECIFICATIONS

DUAL SUPPLY¹

$V_{DD} = +15\text{ V} \pm 10\%$, $V_{SS} = -15\text{ V} \pm 10\%$, $GND = 0\text{ V}$, unless otherwise noted.

Table 1.

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			V_{SS} to V_{DD}	V	
R_{ON}	3			Ω typ	$V_D = \pm 10\text{ V}$, $I_S = -10\text{ mA}$
	4	5	5	Ω max	
R_{ON} Flatness				Ω typ	$V_D = +10\text{ V}$, -10 V
	0.5			Ω max	
ΔR_{ON}	0.5			Ω typ	$V_D = +10\text{ V}$, -10 V
				Ω max	
LEAKAGE CURRENTS					
Source OFF Leakage I_S (OFF)	± 0.01			nA typ	$V_D = \pm 10\text{ V}$, $V_S = -10\text{ V}$; Test Circuit 2
	± 0.5	± 2.5	± 50	nA max	± 0.5
Drain OFF Leakage I_D (OFF)					$V_D = \pm 10\text{ V}$; $V_S = \pm 10\text{ V}$; Test Circuit 3
ADG1408	± 1	± 100	± 100	nA max	
ADG1409	± 1	± 50	± 50	nA max	
Channel ON Leakage I_D , I_S (ON)					$V_S = V_D = \pm 10\text{ V}$; Test Circuit 4
ADG1408	± 1	± 100	± 100	nA max	
ADG1409	± 1	± 50	± 50	nA max	
DIGITAL INPUTS					
Input High Voltage, V_{INH}		2.0	2.0	V min	
Input Low Voltage, V_{INL}		0.8	0.8	V max	
Input Current					
I_{INL} or I_{INH}	± 0.005			μA max	$V_{IN} = V_{INL}$ or V_{INH}
		± 0.5	± 0.5	μA max	
C_{IN} , Digital Input Capacitance	5			pF typ	
DYNAMIC CHARACTERISTICS²					
$t_{TRANSITION}$	80	120	120	ns typ	$R_L = 300\ \Omega$, $C_L = 35\text{ pF}$; $V_{S1} = \pm 10\text{ V}$, $V_{S8} = \pm 10\text{ V}$; Test Circuit 5
		250	250	ns max	
T_{BBM}	10	10	10	ns typ	$R_L = 300\ \Omega$, $C_L = 35\text{ pF}$; $V_S = 10\text{ V}$; Test Circuit 6
			1	ns min	
$t_{ON}(EN)$	85	125	125	ns typ	$R_L = 300\ \Omega$, $C_L = 35\text{ pF}$; $V_S = 5\text{ V}$; Test Circuit 7
	150	225	225	ns max	
$t_{OFF}(EN)$	40	65	65	ns typ	$R_L = 300\ \Omega$, $C_L = 35\text{ pF}$; $V_S = 5\text{ V}$; Test Circuit 7
		150	150	ns max	
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			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			dB typ	$R_L = 1\text{ k}\Omega$, $f = 100\text{ kHz}$; Test Circuit 10
Total Harmonic Distortion, THD + N	0.002			% typ	$R_L = 600\ \Omega$, 5 V rms ; $f = 20\text{ Hz}$ to 20 kHz
-3 dB Bandwidth	50			MHz typ	$R_L = 300\ \Omega$, $C_L = 5\text{ pF}$; Test Circuit 10
C_S (OFF)	15			pF typ	Test Circuit 10 $f = 1\text{ MHz}$

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS ²					
C_D (OFF)					$f = 1 \text{ MHz}$
ADG1408	100			pF typ	
ADG1409	50			pF typ	
C_D, C_S (ON)					$f = 1 \text{ MHz}$
ADG1408	150			pF typ	
ADG1409	75			pF typ	
POWER REQUIREMENTS					
I_{DD}	0.001			μA typ	$V_{DD} = +16.5 \text{ V}, V_{SS} = -16.5 \text{ V}$ Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{DD}	150			μA typ	Digital inputs= 5 V
			300	μA max	
I_{SS}	0.001			μA typ	Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{GND}	0.001			μA typ	Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{GND}	150			μA typ	Digital inputs= 5 V
		5	300	μA max	

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

² Guaranteed by design, not subject to production test.

SINGLE SUPPLY¹

$V_{DD} = 12 \text{ V} \pm 10\%$, $V_{SS} = 0 \text{ V}$, $GND = 0 \text{ V}$, unless otherwise noted.

Table 2.

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			0 to V_{DD}	V	
R_{ON}	6			Ω typ	$V_D = 3 \text{ V}, 10 \text{ V}, I_S = -1 \text{ mA}$
	7	8	9	Ω max	
R_{ON} Flatness				Ω typ	$V_D = 3 \text{ V}, 10 \text{ V}, I_S = -1 \text{ mA}$
	1.5			Ω max	
ΔR_{ON}	0.5			Ω typ	$V_D = 3 \text{ V}, 10 \text{ V}, I_S = -1 \text{ mA}$
				Ω max	
Channel ON Leakage I_D, I_S (ON)					$V_S = V_D = 8 \text{ V}/0 \text{ V};$ Test Circuit 4
ADG1408	± 1	± 100	± 100	nA max	
ADG1409	± 1	± 50	± 50	nA max	
DIGITAL INPUTS					
Input High Voltage, V_{INH}		2.0	2.0	V min	
Input Low Voltage, V_{INL}		0.8	0.8	V max	
Input Current					
I_{INL} or I_{INH}		± 10	± 10	μA max	$V_{IN} = 0 \text{ or } V_{DD}$
C_{IN} , Digital Input Capacitance	8			pF typ	$f = 1 \text{ MHz}$
DYNAMIC CHARACTERISTICS ²					
$t_{TRANSITION}$	130			ns typ	$R_L = 300 \Omega, C_L = 35 \text{ pF};$ $V_{S1} = 8 \text{ V}/0 \text{ V}, V_{S8} = 0 \text{ V}/8 \text{ V};$ Test Circuit 5
T_{BBM}	10			ns typ	$R_L = 300 \Omega, C_L = 35 \text{ pF};$ $V_S = 5 \text{ V};$ Test Circuit 6
			1	ns min	
t_{ON} (EN)	140			ns typ	$R_L = 300 \Omega, C_L = 35 \text{ pF};$ $V_S = 5 \text{ V};$ Test Circuit 7

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS²					
t _{OFF} (EN)	60			ns typ	R _L = 300 Ω, C _L = 35 pF; V _S = 5 V; Test Circuit 7
Charge Injection	5			pC typ	V _S = 0 V, R _S = 0 Ω, C _L = 10 nF; Test Circuit 8
OFF Isolation	-75			dB typ	R _L = 1 kΩ f = 100 kHz; V _{EN} = 0 V; Test Circuit 9
Channel-to-Channel Crosstalk	85			dB typ	R _L = 1 kΩ, f = 100 kHz; Test Circuit 10
Total Harmonic Distortion, THD + N	0.002			% typ	R _L = 600 Ω, 5 V rms; f=20 Hz to 20 kHz
-3 dB Bandwidth	50			MHz typ	R _L = 300 Ω, C _L = 5 pF; Test Circuit 10
C _S (OFF)	15			pF typ	f = 1 MHz
C _D (OFF)					f = 1 MHz
ADG1408	100			pF typ	
ADG1409	50			pF typ	
C _D , C _S (ON)					f = 1 MHz
ADG1408	150			pF typ	
ADG1409	75			pF typ	
POWER REQUIREMENTS					
I _{DD}		1	1	μA typ	V _{DD} = 13.2 V Digital inputs= 0 V or V _{DD}
		5	5	μA max	
I _{DD}	150			μA typ	Digital inputs= 5
			300	μA max	

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

² Guaranteed by design, not subject to production test.

DUAL SUPPLY¹

V_{DD} = 5 V ± 10%, V_{SS} = -5 V ± 10%, GND = 0 V, unless otherwise noted.

Table 3.

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			V _{SS} to V _{DD}	V	
R _{ON}	6			Ω typ	V _D = ±3.3 V, I _S = -10 mA
	7	8	10	Ω max	
ΔR _{ON}	0.5			Ω max	V _D = +3.3 V, -3.3 V
LEAKAGE CURRENTS					
Source OFF Leakage I _S (OFF)	±0.01			nA typ	V _D = ±3.3 V, V _S = -3.3 V; Test Circuit 2
	±0.5	±2.5	±50	nA max	
Drain OFF Leakage I _D (OFF)					V _D = ±3.3 V; V _S = ±3.3 V;
ADG1408	±1	±100	±100	nA max	Test Circuit 3
ADG1409	±1	±50	±50	nA max	
Channel ON Leakage I _D , I _S (ON)					V _S = V _D = ±3.3 V;
ADG1408	±1	±100	±100	nA max	Test Circuit 4
ADG1409	±1	±50	±50	nA max	

Parameter	+25°C	-40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
DIGITAL INPUTS					
Input High Voltage, V_{INH}		2.0	2.0	V min	
Input Low Voltage, V_{INL}		0.8	0.8	V max	
Input Current I_{INL} or I_{INH}	± 0.005	± 0.5	± 0.5	μA max μA max	$V_{IN} = V_{INL}$ or V_{INH}
C_{IN} , Digital Input Capacitance	5			pF typ	
DYNAMIC CHARACTERISTICS²					
$t_{TRANSITION}$		120	120	ns typ	$R_L = 300 \Omega$, $C_L = 35$ pF; $V_{S1} = \pm 10$ V, $V_{S8} = \pm 10$ V; Test Circuit 5
		250	250	ns max	
T_{BBM}				ns typ	$R_L = 300 \Omega$, $C_L = 35$ pF;
			1	ns min	$V_S = 5$ V; Test Circuit 6
$t_{ON}(EN)$	85	125	125	ns typ	$R_L = 300 \Omega$, $C_L = 35$ pF;
	150	225	225	ns max	$V_S = 5$ V; Test Circuit 7
$t_{OFF}(EN)$		65	65	ns typ	$R_L = 300 \Omega$, $C_L = 35$ pF;
		150	150	ns max	$V_S = 5$ V; Test Circuit 7
Charge Injection	20			pC typ	$V_S = 0$ V, $R_S = 0 \Omega$, $C_L = 10$ nF; Test Circuit 8
OFF Isolation	-75		-75	dB typ	$R_L = 1$ k Ω , $f = 100$ kHz; $V_{EN} = 0$ V; Test Circuit 9
Channel-to-Channel Crosstalk	85		85	dB typ	$R_L = 1$ k Ω , $f = 100$ kHz; Test Circuit 10
Total Harmonic Distortion, THD + N	0.002			% typ	$R_L = 600 \Omega$, 5 V rms; $f = 20$ Hz to 20 kHz
-3dB Bandwidth	50			MHz typ	$R_L = 300 \Omega$, $C_L = 5$ pF; Test Circuit 10 Test Circuit 10
C_S (OFF)	15			pF typ	$f = 1$ MHz
C_D (OFF)					$f = 1$ MHz
ADG1408	100			pF typ	
ADG1409	50			pF typ	
C_D , C_S (ON)					$f = 1$ MHz
ADG1408	150			pF typ	
ADG1409	75			pF typ	
POWER REQUIREMENTS					
I_{DD}	0.001			μA typ	$V_{DD} = +16.5$ V, $V_{SS} = -16.5$ V Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{DD}	150			μA typ	Digital inputs= 5 V
			300	μA max	
I_{SS}	0.001			μA typ	Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{GND}	0.001			μA typ	Digital inputs= 0 V or V_{DD}
		5	5	μA max	
I_{GND}	150			μA typ	Digital inputs= 5 V
		5	300	μA max	

¹ Temperature ranges are as follows: B Version: -40°C to +85°C; Y Version: -40°C to +125°C.

² Guaranteed by design, not subject to production test.

ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings $T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 4.

Parameter	Rating
V_{DD} to V_{SS}	36 V
V_{DD} to GND	-0.3 V to +25 V
V_{SS} to GND	+0.3 V to -25 V
Analog, Digital Inputs ¹	$V_{SS} - 0.3$ V to $V_{DD} + 0.3$ V or 20 mA, whichever occurs first
Continuous Current, S or D	30 mA
Peak Current, S or D (Pulsed at 1 ms, 10% Duty Cycle max)	100 mA
Operating Temperature Range	
Industrial (B Version)	-40° C to +85°C
Automotive (Y Version)	-40° C to +125°C
Storage Temperature Range	-65° C to +150°C
Junction Temperature	150°C
TSSOP Package, Power Dissipation	450 mW
θ_{JA} , Thermal Impedance	150.4°C/W
θ_{JC} , Thermal Impedance	50°C/W
Lead Temperature, Soldering	
Vapor Phase (60 sec)	215°C
Infrared (15 sec)	220°C

¹ Overvoltages at A, EN, S, or D are clamped by internal diodes. Current should be limited to the maximum ratings given

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.

ESD 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 this product features 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.



PIN CONFIGURATIONS

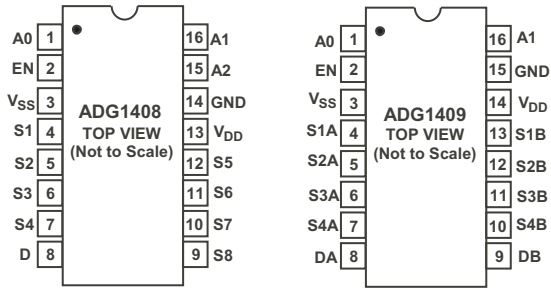


Figure 2. Pin Configurations—TSSOP

Table 5. ADG1408 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

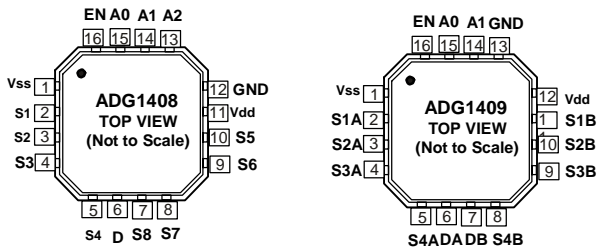


Figure 3. Pin Configurations – 4mm x4mm LFCSP

Table 6. ADG1409 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

Table 7.

Mnemonic	Description
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}	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.
I_{DD}	Positive supply current.
I_{SS}	Negative supply current.
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.
Bandwidth	The frequency at which the output is attenuated by 3dBs.
On Response	The frequency response of the "ON" switch.
THD + N	The ratio of the harmonic amplitude plus noise of the signal to the fundamental.

TYPICAL PERFORMANCE CHARACTERISTICS

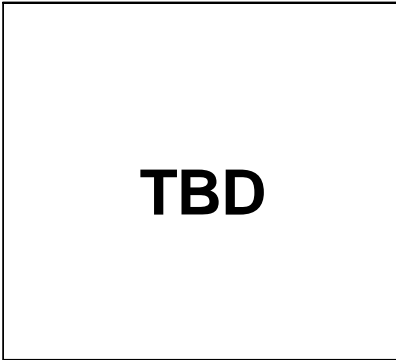


Figure 4. On Resistance as a Function of $V_D(V_S)$ for Single Supply

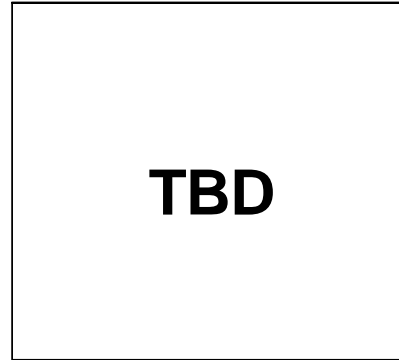


Figure 7. On Resistance as a Function of $V_D(V_S)$ for Different Temperatures, Single Supply

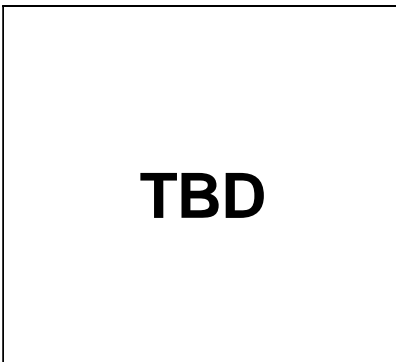


Figure 5. On Resistance as a Function of $V_D(V_S)$ for Dual Supply

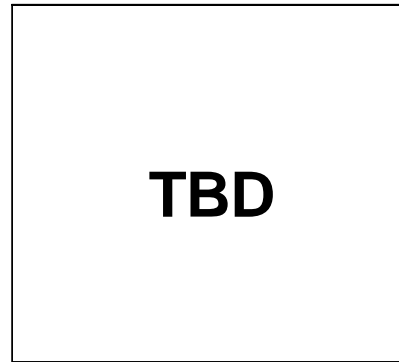


Figure 8. On Resistance as a Function of $V_D(V_S)$ for Different Temperatures, Dual Supply

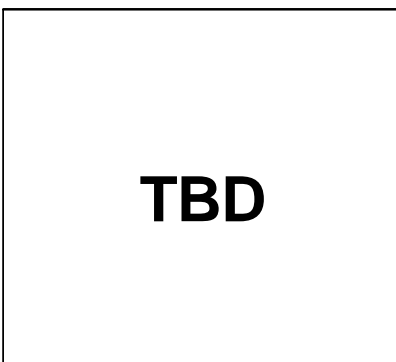


Figure 6. On Resistance as a Function of $V_D(V_S)$ for Different Temperatures, Single Supply

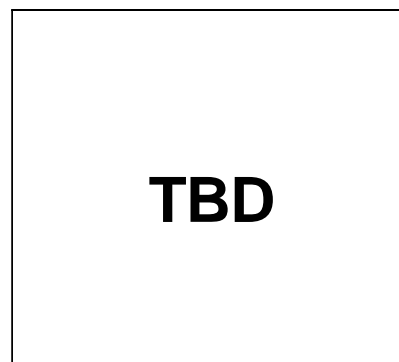


Figure 9. Leakage Currents as a Function of $V_D(V_S)$

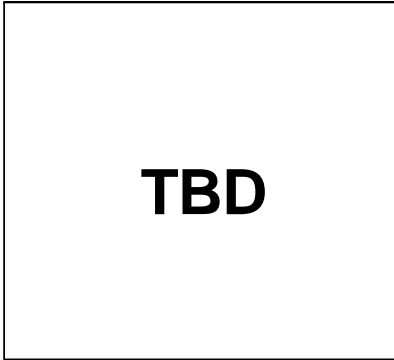


Figure 10. Leakage Currents as a function of Temperature

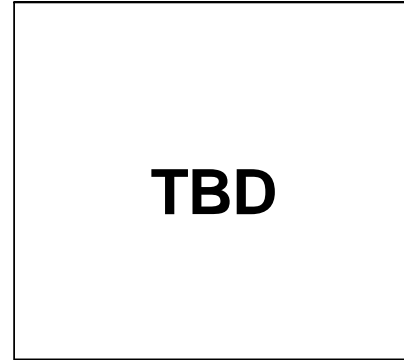


Figure 14. Off Isolation vs. Frequency

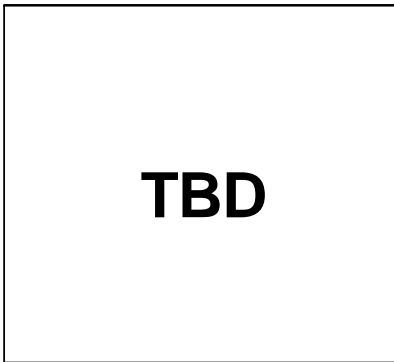


Figure 11. Supply Currents vs. Input Switching Frequency

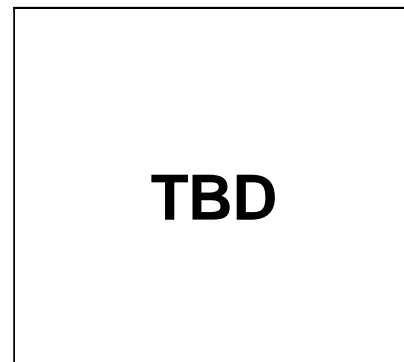


Figure 15. Crosstalk vs. Frequency

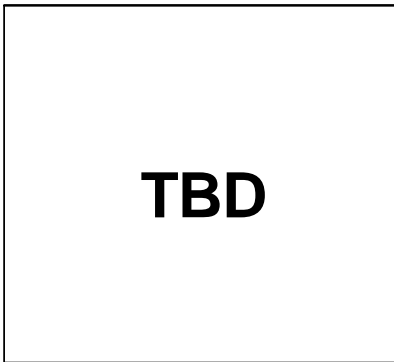


Figure 12. Charge Injection vs. Source Voltage

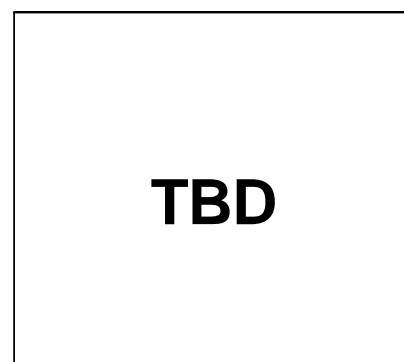


Figure 16. On Response vs. Frequency

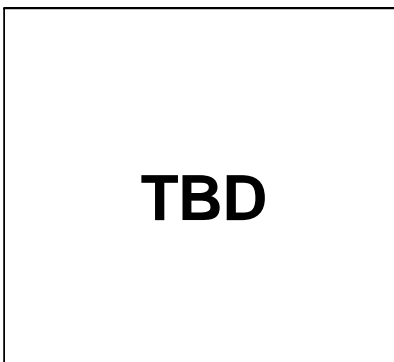


Figure 13. TON/TOFF Times vs. Temperature

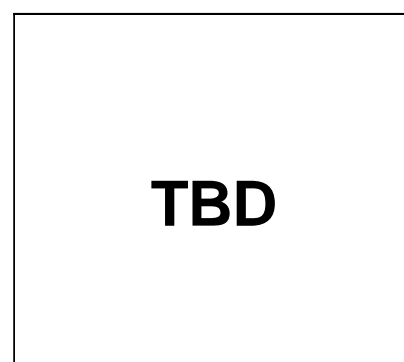


Figure 17. THD + N vs. Frequency

TEST CIRCUITS

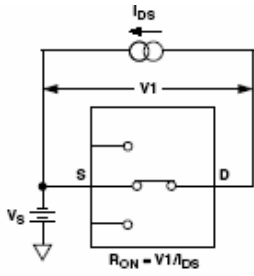


Figure 18. Test Circuit 1. On Resistance

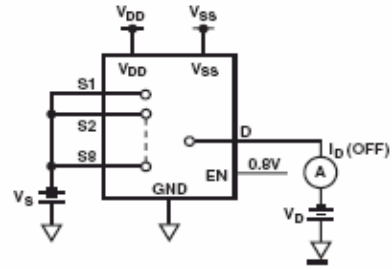


Figure 20. Test Circuit 3. I_D (OFF)

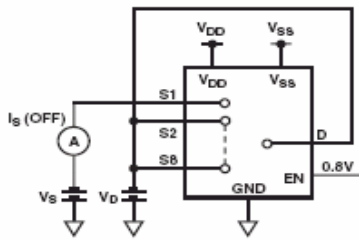


Figure 19. Test Circuit 2. I_S (OFF)

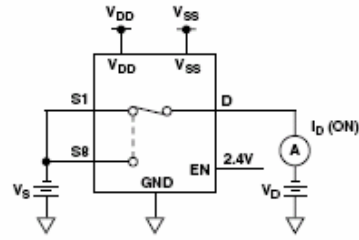


Figure 21. Test Circuit 4. I_D (ON)

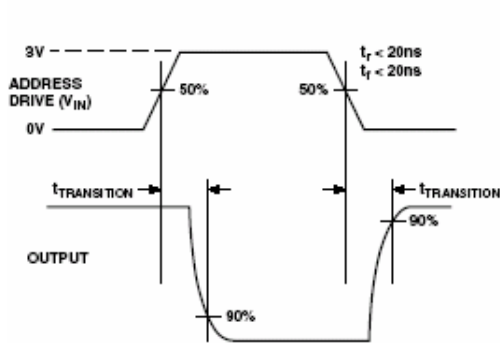
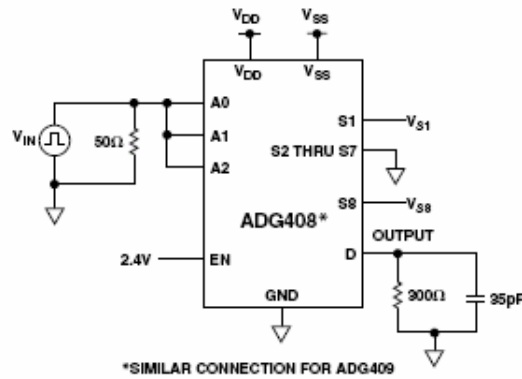


Figure 22. Test Circuit 5. Switching Time of Multiplexer, $t_{TRANSITION}$



*SIMILAR CONNECTION FOR ADG409

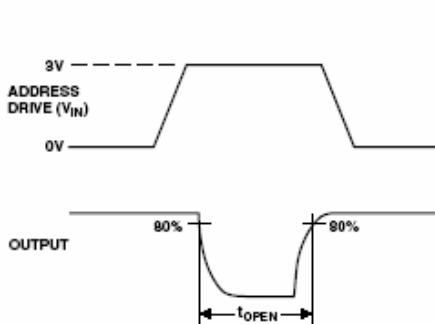
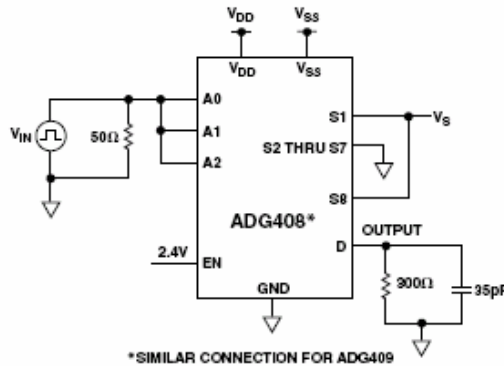


Figure 23. Test Circuit 6. Break-Before-Make Delay, t_{OPEN}



*SIMILAR CONNECTION FOR ADG409

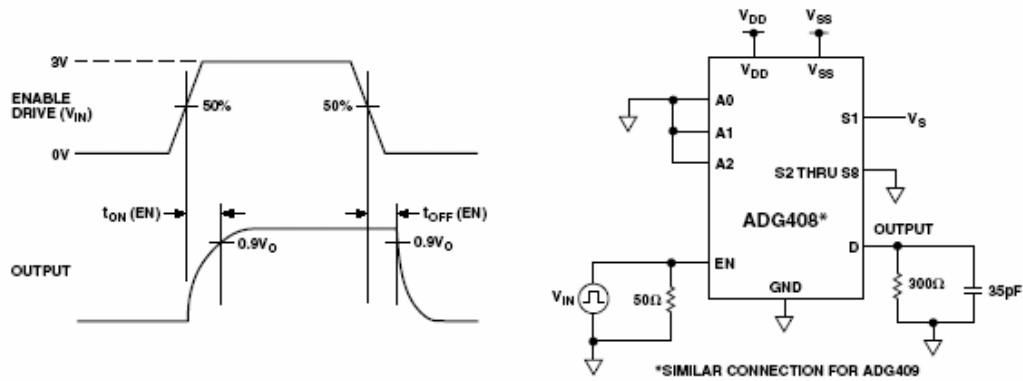


Figure 24. Test Circuit 7. Enable Delay, $t_{ON}(EN)$, $t_{OFF}(EN)$

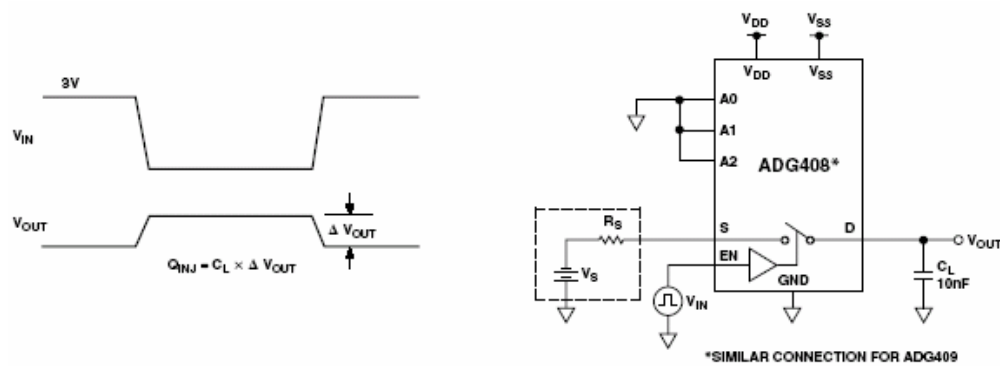


Figure 25. Test Circuit 8. Charge Injection

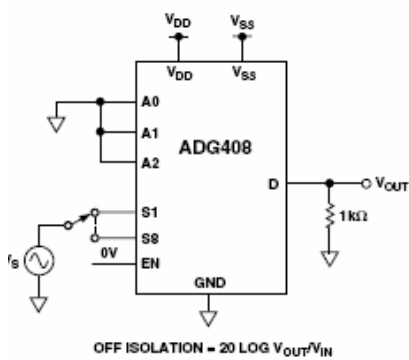


Figure 26. Test Circuit 9. OFF Isolation

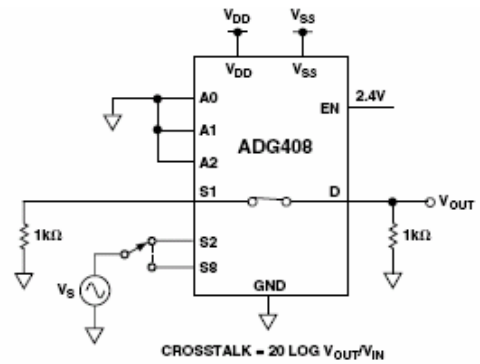


Figure 27. Test Circuit 10. Channel-to-Channel Crosstalk

OUTLINE DIMENSIONS

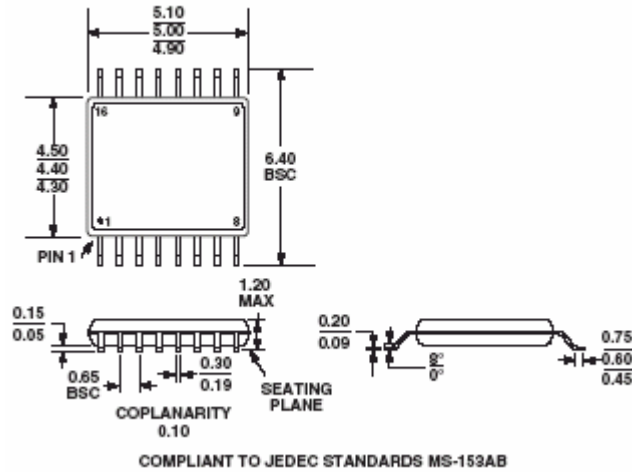


Figure 28. 16-Lead Thin Shrink Small Outline Package [TSSOP] (RU-16)

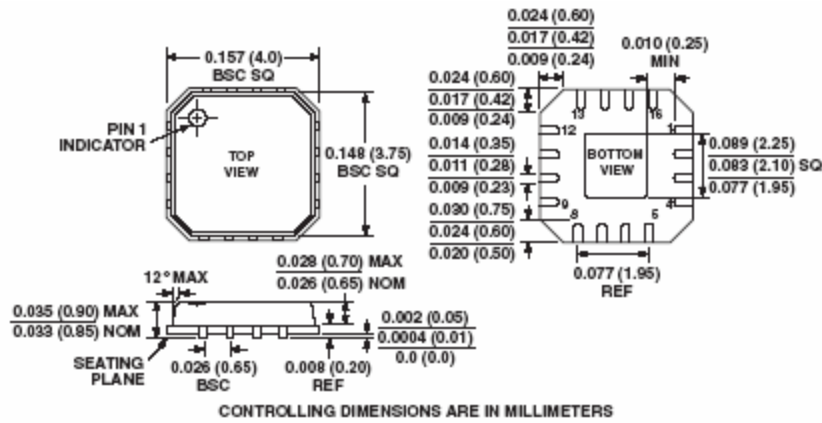


Figure 29. 16-Lead Lead Frame Chip Scale Package [LF CSP]
4mm x 4mm (CP-16)
Dimensions shown in inches and (millimeters)

ORDERING GUIDE

Model	Temperature Range	Description	Package Option
ADG1408YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG1409YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG1409YCP	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	CP-16
ADG1409YCP	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	CP-16

NOTES

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