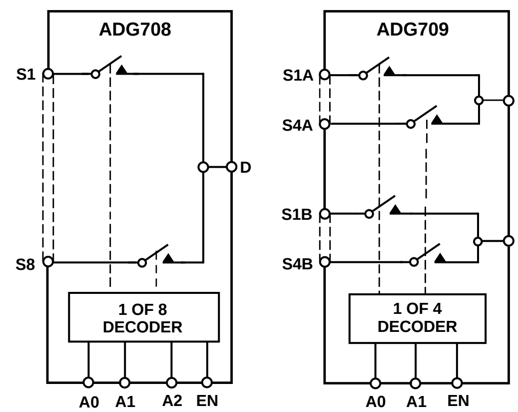
CMOS, 3 Ω Low Voltage 4-/8-Channel Multiplexers

ADG708/ADG709

FEATURES
1.8 V to 5.5 V Single Supply
±3 V Dual Supply
3 Ω On-Resistance
0.75 Ω On-Resistance Flatness
100 pA Leakage Currents
14 ns Switching Times
Single 8-to-1 Multiplexer ADG708
Differential 4-to-1 Multiplexer ADG709
16-Lead TSSOP Package
Low Power Consumption
TTL/CMOS-Compatible Inputs

APPLICATIONS
Data Acquisition Systems
Communication Systems
Relay Replacement
Audio and Video Switching
Battery-Powered Systems

FUNCTIONAL BLOCK DIAGRAMS



GENERAL DESCRIPTION

The ADG708 and ADG709 are low voltage, CMOS analog multiplexers comprising eight single channels and four differential channels respectively. The ADG708 switches one of eight inputs (S1–S8) to a common output, D, as determined by the 3-bit binary address lines A0, A1, and A2. The ADG709 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.

Low power consumption and operating supply range of 1.8 V to 5.5 V make the ADG708 and ADG709 ideal for battery-powered, portable instruments. All channels exhibit break-before-make switching action preventing momentary shorting when switching channels.

These switches are designed on an enhanced submicron process that provides low power dissipation yet gives high switching speed, very low on-resistance and leakage currents. On-resistance is in the region of a few ohms and is closely matched between switches and very flat over the full signal range. These parts can operate equally well as either Multiplexers or Demultiplexers, and have an input signal range that extends to the supplies.

The ADG708 and ADG709 are available in a 16-lead TSSOP package.

PRODUCT HIGHLIGHTS

1. Single/Dual Supply Operation. The ADG708 and ADG709 are fully specified and guaranteed with 3 V and 5 V single supply and ±3 V dual supply rails.
2. Low R_{ON} (3 Ω Typical).
3. Low Power Consumption (<0.01 μW).
4. Guaranteed Break-Before-Make Switching Action.
5. Small 16-Lead TSSOP Package.

REV. 0

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ADG708/ADG709–SPECIFICATIONS[1] (V_{DD} = 5 V ± 10%, V_{SS} = 0 V, GND = 0 V, unless otherwise noted)

Parameter	B Version +25°C	B Version –40°C to +85°C	C Version +25°C	C Version –40°C to +85°C	Unit	Test Conditions/Comments
ANALOG SWITCH						
Analog Signal Range		0 V to V_{DD}		0 V to V_{DD}	V	
On-Resistance (R_{ON})	3		3		Ω typ	V_S = 0 V to V_{DD}, I_{DS} = 10 mA;
	4.5	5	4.5	5	Ω max	Test Circuit 1
On-Resistance Match Between		0.4		0.4	Ω typ	
Channels (ΔR_{ON})		0.8		0.8	Ω max	V_S = 0 V to V_{DD}, I_{DS} = 10 mA
On-Resistance Flatness ($R_{FLAT(ON)}$)	0.75		0.75		Ω typ	V_S = 0 V to V_{DD}, I_{DS} = 10 mA
		1.2		1.2	Ω max	
LEAKAGE CURRENTS						V_{DD} = 5.5 V
Source OFF Leakage I_S (OFF)	±0.01		±0.01		nA typ	V_D = 4.5 V/1 V, V_S = 1 V/4.5 V;
		±20	±0.1	±0.3	nA max	Test Circuit 2
Drain OFF Leakage I_D (OFF)	±0.01		±0.01		nA typ	V_D = 4.5 V/1 V, V_S = 1 V/4.5 V;
		±20	±0.1	±0.75	nA max	Test Circuit 3
Channel ON Leakage I_D, I_S (ON)	±0.01		±0.01		nA typ	V_D = V_S = 1 V, or 4.5 V, Test Circuit 4
		±20	±0.1	±0.75	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}	0.005		0.005		µA typ	V_{IN} = V_{INL} or V_{INH}
		±0.1		±0.1	µA max	
C_{IN}, Digital Input Capacitance	2		2		pF typ	
DYNAMIC CHARACTERISTICS[2]						
$t_{TRANSITION}$	14		14		ns typ	R_L = 300 Ω, C_L = 35 pF, Test Circuit 5
		25		25	ns max	V_{S1} = 3 V/0 V, V_{S8} = 0 V/3 V
Break-Before-Make Time Delay, t_D	8		8		ns typ	R_L = 300 Ω, C_L = 35 pF
		1		1	ns min	V_S = 3 V, Test Circuit 6
t_{ON}(EN)	14		14		ns typ	R_L = 300 Ω, C_L = 35 pF
		25		25	ns max	V_S = 3 V, Test Circuit 7
t_{OFF}(EN)	7		7		ns typ	R_L = 300 Ω, C_L = 35 pF
		12		12	ns max	V_S = 3 V, Test Circuit 7
Charge Injection	±3		±3		pC typ	V_S = 2.5 V, R_S = 0 Ω, C_L = 1 nF; Test Circuit 8
Off Isolation	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 9
Channel-to-Channel Crosstalk	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 10
–3 dB Bandwidth	55		55		MHz typ	R_L = 50 Ω, C_L = 5 pF, Test Circuit 9
C_S (OFF)	13		13		pF typ	
C_D (OFF)						
ADG708	85		85		pF typ	
ADG709	42		42		pF typ	
C_D, C_S (ON)						
ADG708	96		96		pF typ	
ADG709	48		48		pF typ	
POWER REQUIREMENTS						V_{DD} = 5.5 V
I_{DD}	0.001		0.001		µA typ	Digital Inputs = 0 V or 5.5 V
		1.0		1.0	µA max	

NOTES
[1]Temperature range is as follows: B and C Versions: –40°C to +85°C.
[2]Guaranteed by design, not subject to production test.
Specifications subject to change without notice.

SPECIFICATIONS[1] (V_{DD} = 3 V ± 10%, V_{SS} = 0 V, GND = 0 V, unless otherwise noted)

Parameter	B Version +25°C	B Version –40°C to +85°C	C Version +25°C	C Version –40°C to +85°C	Unit	Test Conditions/Comments
ANALOG SWITCH						
Analog Signal Range		0 V to V_{DD}		0 V to V_{DD}	V	
On-Resistance (R_{ON})	8		8		Ω typ	V_S = 0 V to V_{DD}, I_{DS} = 10 mA;
	11	12	11	12	Ω max	Test Circuit 1
On-Resistance Match Between		0.4		0.4	Ω typ	V_S = 0 V to V_{DD} , I_{DS} = 10 mA
Channels (ΔR_{ON})		1.2		1.2	Ω max	
LEAKAGE CURRENTS						V_{DD} = 3.3 V
Source OFF Leakage I_S (OFF)	±0.01		±0.01		nA typ	V_S = 3 V/1 V, V_D = 1 V/3 V;
		±20	±0.1	±0.3	nA max	Test Circuit 2
Drain OFF Leakage I_D (OFF)	±0.01		±0.01		nA typ	V_S = 3 V/1 V, V_D = 1 V/3 V;
		±20	±0.1	±0.75	nA max	Test Circuit 3
Channel ON Leakage I_D, I_S (ON)	±0.01		±0.01		nA typ	V_S = V_D = 1 V or 3 V, Test Circuit 4
		±20	±0.1	±0.75	nA max	
DIGITAL INPUTS						
Input High Voltage, V_{INH}		2.0		2.0	V min	
Input Low Voltage, V_{INL}		0.4		0.4	V max	
Input Current						
I_{INL} or I_{INH}	0.005		0.005		µA typ	V_{IN} = V_{INL} or V_{INH}
		±0.1		±0.1	µA max	
C_{IN}, Digital Input Capacitance	2		2		pF typ	
DYNAMIC CHARACTERISTICS[2]						
$t_{TRANSITION}$	18		18		ns typ	R_L = 300 Ω, C_L = 35 pF, Test Circuit 5
		30		30	ns max	V_{S1} = 2 V/0 V, V_{S2} = 0 V/2 V
Break-Before-Make Time Delay, t_D	8		8		ns typ	R_L = 300 Ω, C_L = 35 pF
		1		1	ns min	V_S = 2 V, Test Circuit 6
t_{ON}(EN)	18		18		ns typ	R_L = 300 Ω, C_L = 35 pF
		30		30	ns max	V_S = 2 V, Test Circuit 7
t_{OFF}(EN)	8		8		ns typ	R_L = 300 Ω, C_L = 35 pF
		15		15	ns max	V_S = 2 V, Test Circuit 7
Charge Injection	±3		±3		pC typ	V_S = 1.5 V, R_S = 0 Ω, C_L = 1 nF; Test Circuit 8
Off Isolation	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 9
Channel-to-Channel Crosstalk	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 10
–3 dB Bandwidth	55		55		MHz typ	R_L = 50 Ω, C_L = 5 pF, Test Circuit 9
C_S (OFF)	13		13		pF typ	
C_D (OFF)						
ADG708	85		85		pF typ	
ADG709	42		42		pF typ	
C_D, C_S (ON)						
ADG708	96		96		pF typ	
ADG709	48		48		pF typ	
POWER REQUIREMENTS						V_{DD} = 3.3 V
I_{DD}	0.001		0.001		µA typ	Digital Inputs = 0 V or 3.3 V
		1.0		1.0	µA max	

NOTES

[1]Temperature ranges are as follows: B and C Versions: –40°C to +85°C.

[2]Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

ADG708/ADG709–SPECIFICATIONS[1]

DUAL SUPPLY (V_{DD} = +3 V ± 10%, V_{SS} = –3 V ± 10%, GND = 0 V)

Parameter	B Version +25°C	B Version –40°C to +85°C	C Version +25°C	C Version –40°C to +85°C	Unit	Test Conditions/Comments
ANALOG SWITCH						
Analog Signal Range		V_{SS} to V_{DD}		V_{SS} to V_{DD}	V	
On-Resistance (R_{ON})	2.5		2.5		Ω typ	$V_S = V_{SS}$ to V_{DD}, I_{DS} = 10 mA;
	4.5	5	4.5	5	Ω max	Test Circuit 1
On-Resistance Match Between		0.4		0.4	Ω typ	
Channels (ΔR_{ON})		0.8		0.8	Ω max	$V_S = V_{SS}$ to V_{DD}, I_{DS} = 10 mA
On-Resistance Flatness ($R_{FLAT(ON)}$)	0.6		0.6		Ω typ	$V_S = V_{SS}$ to V_{DD}, I_{DS} = 10 mA
		1.0		1.0	Ω max	
LEAKAGE CURRENTS						V_{DD} = +3.3 V, V_{SS} = –3.3 V
Source OFF Leakage I_S (OFF)	±0.01		±0.01		nA typ	V_S = +2.25 V/–1.25 V, V_D = –1.25 V/+2.25 V;
		±20	±0.1	±0.3	nA max	Test Circuit 2
Drain OFF Leakage I_D (OFF)	±0.01		±0.01		nA typ	V_S = +2.25 V/–1.25 V, V_D = –1.25 V/+2.25 V;
		±20	±0.1	±0.75	nA max	Test Circuit 3
Channel ON Leakage I_D, I_S (ON)	±0.01		±0.01		nA typ	$V_S = V_D$ = +2.25 V/–1.25 V, Test Circuit 4
		±20	±0.1	±0.75	nA max	
DIGITAL INPUTS						
Input High Voltage, V_{INH}		2.0		2.0	V min	
Input Low Voltage, V_{INL}		0.4		0.4	V max	
Input Current						
I_{INL} or I_{INH}	0.005		0.005		μA typ	$V_{IN} = V_{INL}$ or V_{INH}
		±0.1		±0.1	μA max	
C_{IN}, Digital Input Capacitance	2		2		pF typ	
DYNAMIC CHARACTERISTICS[2]						
$t_{TRANSITION}$	14		14		ns typ	R_L = 300 Ω, C_L = 35 pF, Test Circuit 5
		25		25	ns max	V_S = 1.5 V/0 V, Test Circuit 5
Break-Before-Make Time Delay, t_D	8		8		ns typ	R_L = 300 Ω, C_L = 35 pF
		1		1	ns min	V_S = 1.5 V, Test Circuit 6
t_{ON}(EN)	14		14		ns typ	R_L = 300 Ω, C_L = 35 pF
		25		25	ns max	V_S = 1.5 V, Test Circuit 7
t_{OFF}(EN)	8		8		ns typ	R_L = 300 Ω, C_L = 35 pF
		15		15	ns max	V_S = 1.5 V, Test Circuit 7
Charge Injection	±3		±3		pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF; Test Circuit 8
Off Isolation	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 9
Channel-to-Channel Crosstalk	–60		–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Test Circuit 10
–3 dB Bandwidth	55		55		MHz typ	R_L = 50 Ω, C_L = 5 pF, Test Circuit 9
C_S (OFF)	13		13		pF typ	
C_D (OFF)						
ADG708	85		85		pF typ	
ADG709	42		42		pF typ	
C_D, C_S (ON)						
ADG708	96		96	`	pF typ	
ADG709	48		48		pF typ	
POWER REQUIREMENTS						V_{DD} = 3.3 V
I_{DD}	0.001		0.001		μA typ	Digital Inputs = 0 V or 3.3 V
		1.0		1.0	μA max	
I_{SS}	0.001		0.001		μA typ	V_{SS} = –3.3 V
		1.0		1.0	μA max	Digital Inputs = 0 V or 3.3 V

NOTES

[1]Temperature range is as follows: B and C Versions: –40°C to +85°C.

[2]Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1]

(T_A = 25°C unless otherwise noted)

V_{DD} to V_{SS} . . . . 7 V
V_{DD} to GND . . . . –0.3 V to +7 V
V_{SS} to GND . . . . +0.3 V to –3.5 V
Analog Inputs[2] . . . . V_{SS} – 0.3 V to V_{DD} +0.3 V or 30 mA, Whichever Occurs First
Digital Inputs[2] . . . . –0.3 V to V_{DD} +0.3 V or 30 mA, Whichever Occurs First
Peak Current, S or D . . . . 100 mA
. . . . (Pulsed at 1 ms, 10% Duty Cycle max)
Continuous Current, S or D . . . . 30 mA
Operating Temperature Range
Industrial (B, C Versions) . . . . –40°C to +85°C
Storage Temperature Range . . . . –65°C to +150°C
Junction Temperature . . . . 150°C
TSSOP Package, Power Dissipation . . . . 432 mW
θ_{JA} Thermal Impedance . . . . 150.4°C/W
θ_{JC} Thermal Impedance . . . . 27.6°C/W
Lead Temperature, Soldering
Vapor Phase (60 sec) . . . . 215°C
Infrared (15 sec) . . . . 220°C

NOTES
[1]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.
[2]Overvoltages at IN, 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 ADG708/ADG709 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.

Table I. ADG708 Truth Table

A2	A1	A0	EN	Switch Condition
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

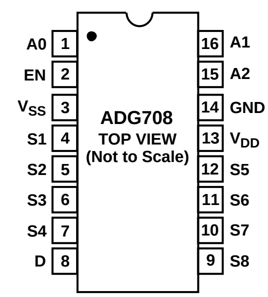
Table II. ADG709 Truth Table

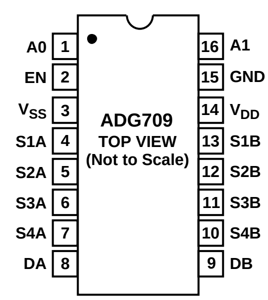
A1	A0	EN	ON Switch Pair
X	X	0	NONE
0	0	1	1
0	1	1	2
1	0	1	3
1	1	1	4

X = Don't Care.

PIN CONFIGURATIONS

TSSOP





ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADG708BRU	–40°C to +85°C	16-Lead Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG709BRU	–40°C to +85°C	16-Lead Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG708CRU	–40°C to +85°C	16-Lead Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG709CRU	–40°C to +85°C	16-Lead Thin Shrink Small Outline Package (TSSOP)	RU-16

TERMINOLOGY

V_{DD}	Most positive power supply potential.
V_{SS}	Most negative power supply in a dual supply application. In single supply applications, this should be tied to ground at the device.
GND	Ground (0 V) Reference.
S	Source Terminal. May be an input or output.
D	Drain Terminal. May be an input or output.
IN	Logic Control Input.
R_{ON}	Ohmic resistance between D and S.
$R_{FLAT(ON)}$	Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.
I_S (OFF)	Source leakage current with the switch "OFF."
I_D (OFF)	Drain leakage current with the switch "OFF."
I_D, I_S (ON)	Channel leakage current with the switch "ON."
V_D (V_S)	Analog voltage on terminals D, S.
C_S (OFF)	"OFF" switch source capacitance. Measured with reference to ground.
C_D (OFF)	"OFF" switch drain capacitance. Measured with reference to ground.
C_D, C_S (ON)	"ON" switch capacitance. Measured with reference to ground.
C_{IN}	Digital Input Capacitance.
$t_{TRANSITION}$	Delay time measured between the 50% and 90% points of the digital inputs and the switch "ON" condition when switching from one address state to another.
t_{ON} (EN)	Delay time between the 50% and 90% points of the EN digital input and the switch "ON" condition.
t_{OFF} (EN)	Delay time between the 50% and 90% points of the EN digital input and the switch "OFF" condition.
t_{OPEN}	"OFF" time measured between the 80% points of both switches when switching from one address state to another.
Off Isolation	A measure of unwanted signal coupling through an "OFF" switch.
Crosstalk	A measure of unwanted signal which is coupled through from one channel to another as a result of parasitic capacitance.
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 3 dBs.
On Response	The frequency response of the "ON" switch.
On Loss	The loss due to the ON resistance of the switch.
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.

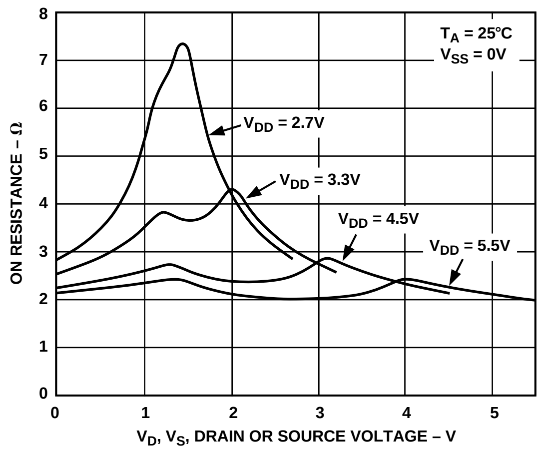


Figure 1. On Resistance as a Function of V_D (V_S) for Single Supply

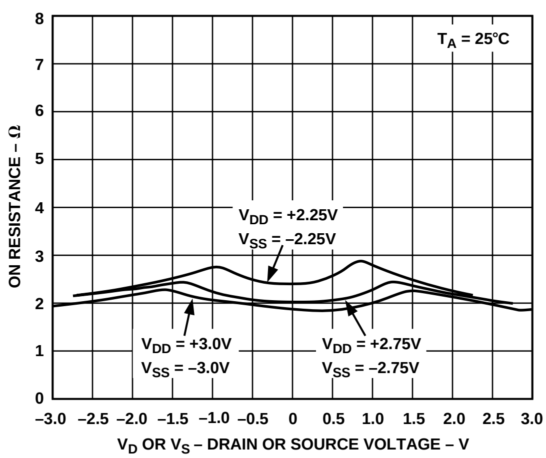


Figure 2. On Resistance as a Function of V_D (V_S) for Dual Supply

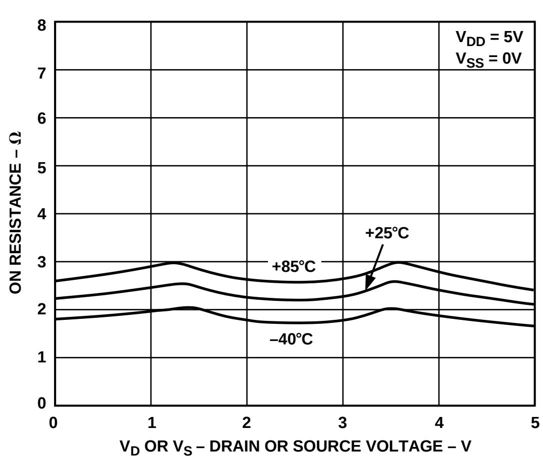


Figure 3. On Resistance as a Function of V_D (V_S) for Different Temperatures, Single Supply

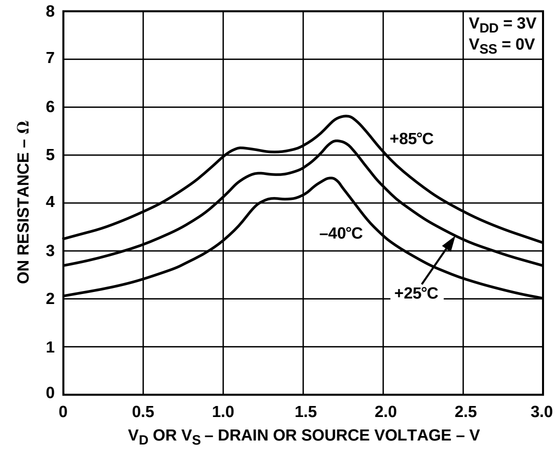


Figure 4. On Resistance as a Function of V_D (V_S) for Different Temperatures, Single Supply

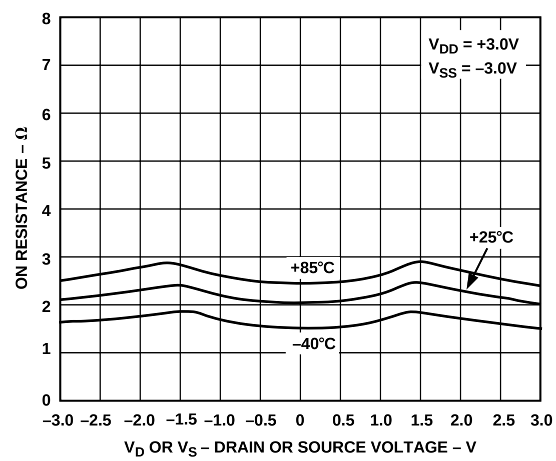


Figure 5. On Resistance as a Function of V_D (V_S) for Different Temperatures, Dual Supply

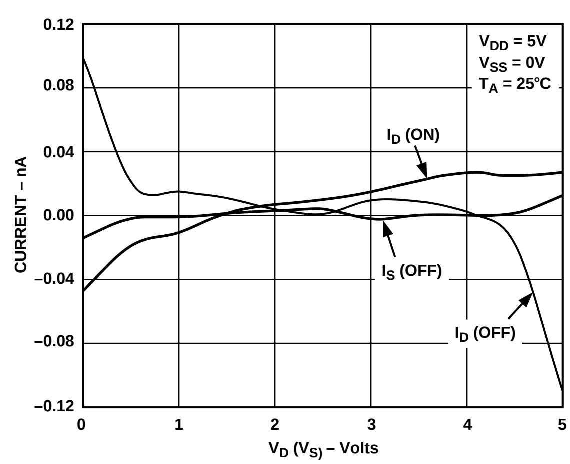


Figure 6. Leakage Currents as a Function of V_D (V_S)

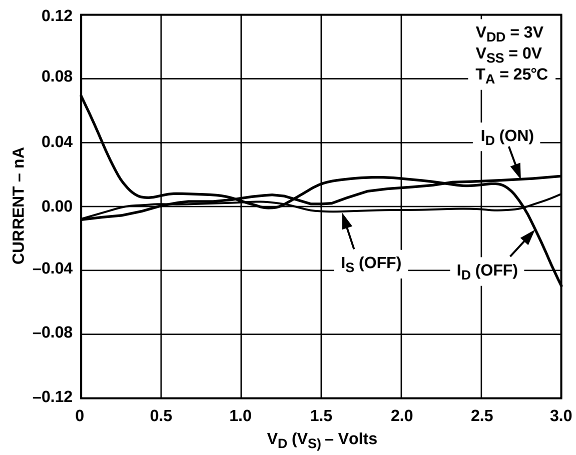


Figure 7. Leakage Currents as a Function of V_D (V_S)

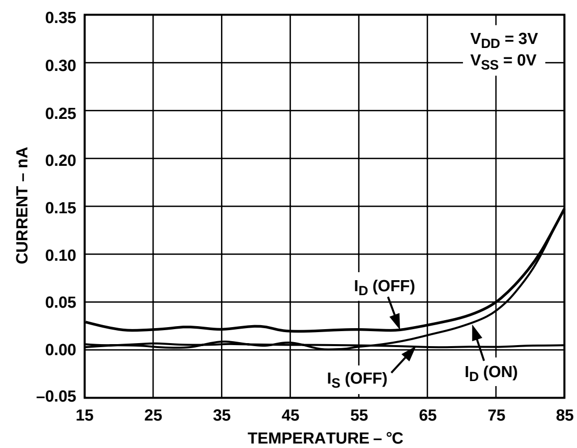


Figure 10. Leakage Currents as a Function of Temperature

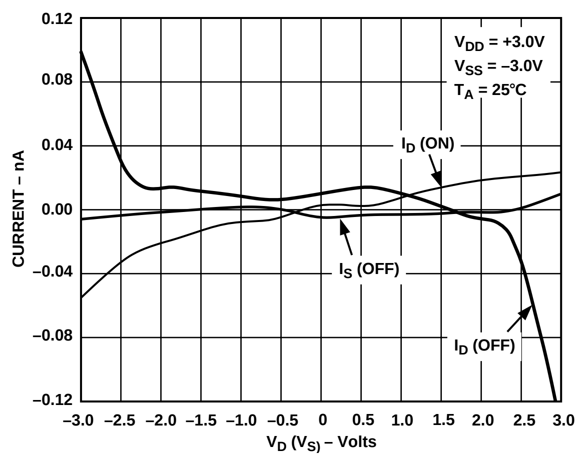


Figure 8. Leakage Currents as a Function of V_D (V_S)

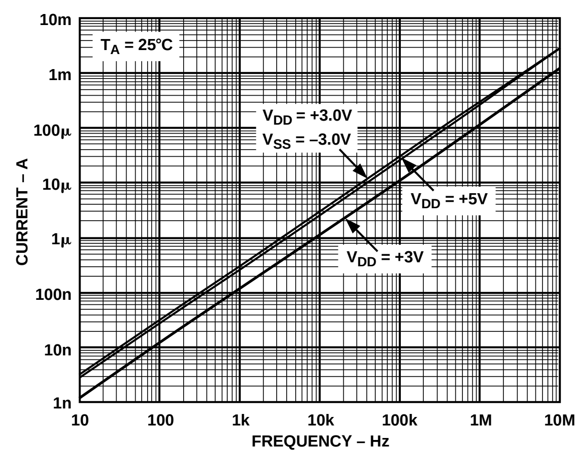


Figure 11. Supply Current vs. Input Switching Frequency

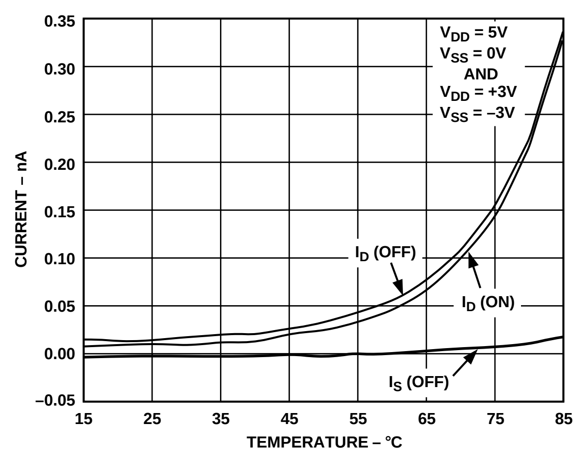


Figure 9. Leakage Currents as a Function of Temperature

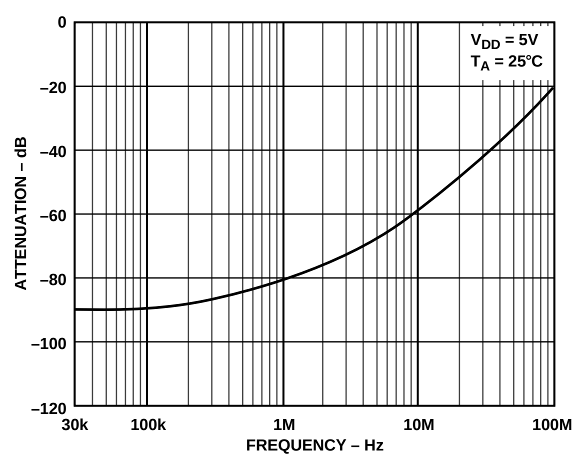


Figure 12. Off Isolation vs. Frequency

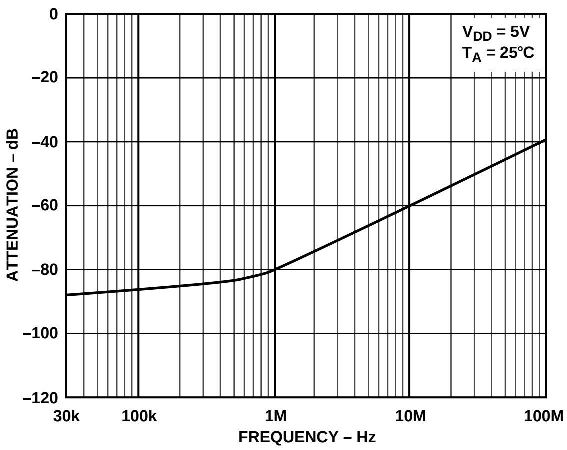


Figure 13. Crosstalk vs. Frequency

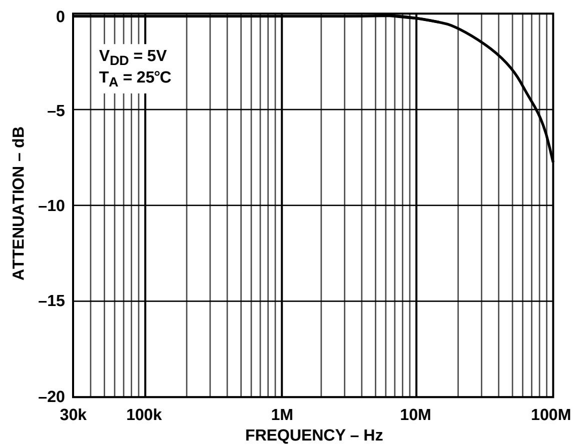


Figure 14. On Response vs. Frequency

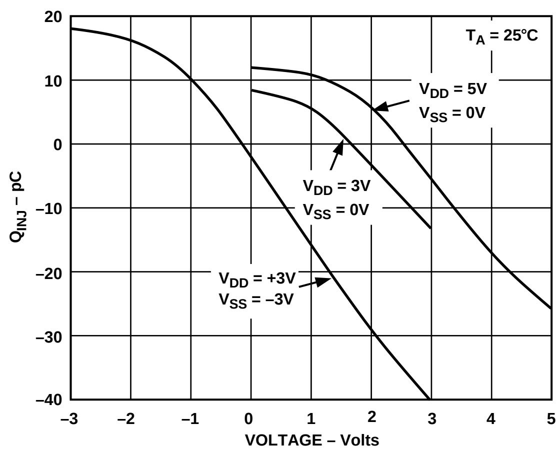
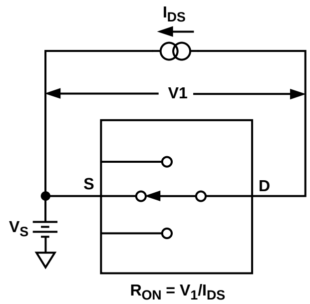
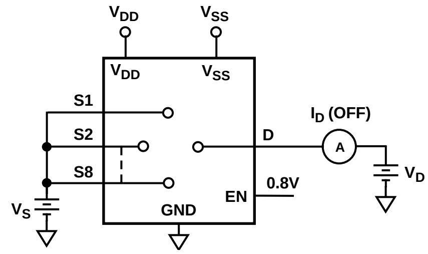


Figure 15. Charge Injection vs. Source Voltage

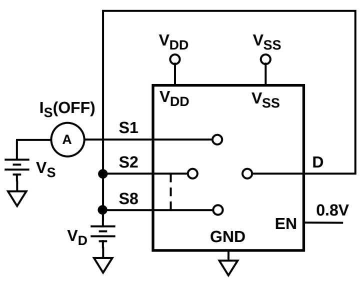
Test Circuits



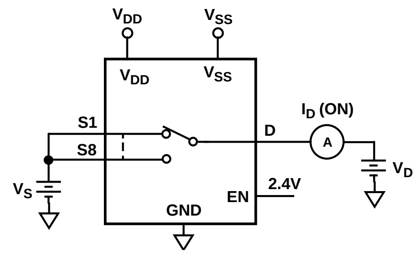
Test Circuit 1. On Resistance



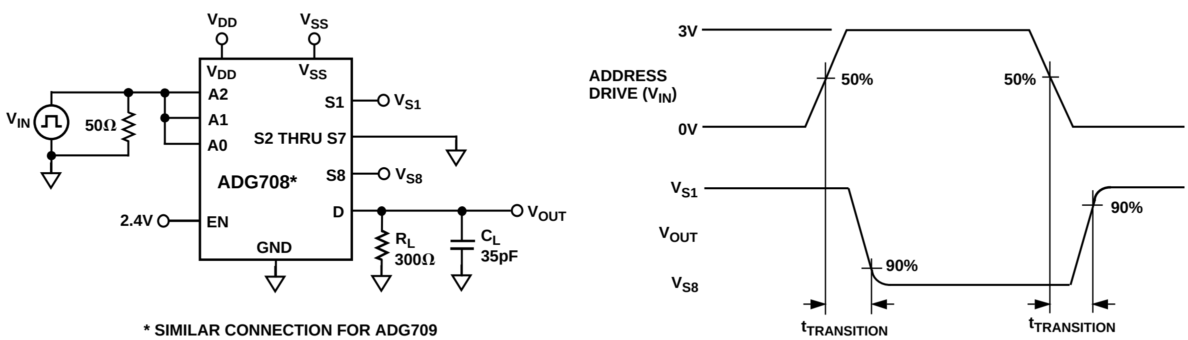
Test Circuit 3. I_D (OFF)



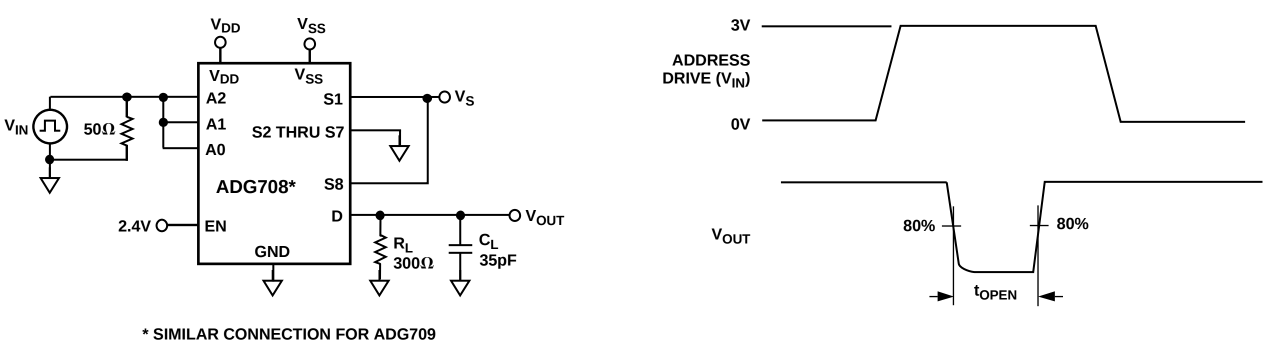
Test Circuit 2. I_S (OFF)



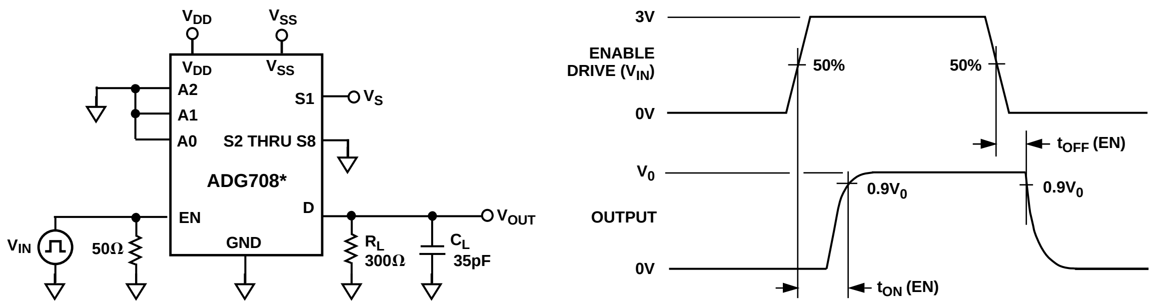
Test Circuit 4. I_D (ON)



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

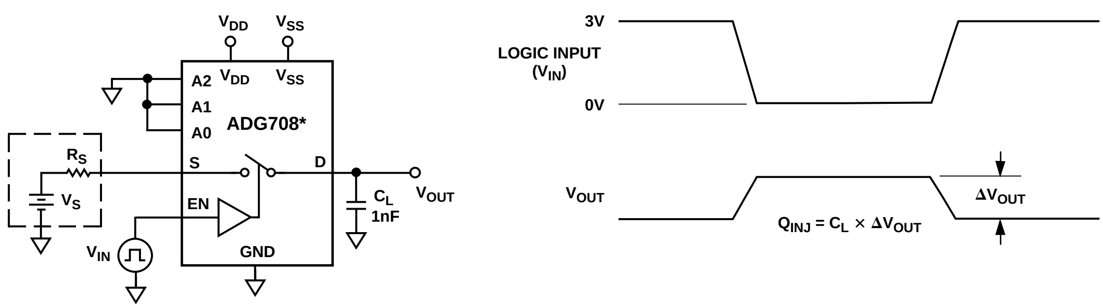


Test Circuit 6. Break-Before-Make Delay, t_{OPEN}



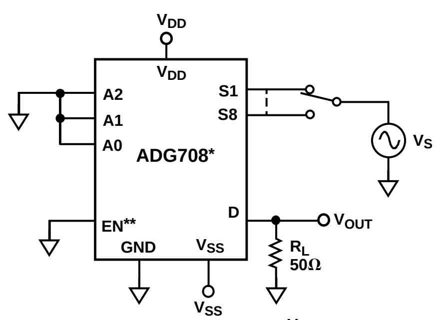
* SIMILAR CONNECTION FOR ADG709

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



*SIMILAR CONNECTION FOR ADG709

Test Circuit 8. Charge Injection

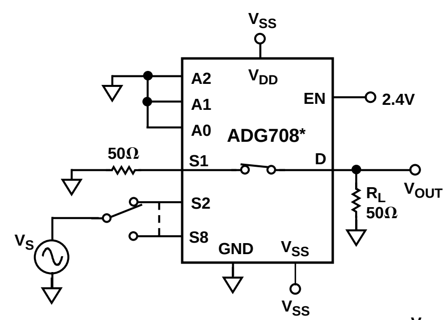


OFF ISOLATION = $20\log_{10}\frac{V_{OUT}}{V_S}$

INSERTION LOSS = $20\log_{10}\left(\frac{V_{OUT}\text{ WITH SWITCH}}{V_{OUT}\text{ WITHOUT SWITCH}}\right)$

* SIMILAR CONNECTION FOR ADG709
** CONNECT TO 2.4V FOR BANDWIDTH MEASUREMENTS

Test Circuit 9. OFF Isolation and Bandwidth



CHANNEL-TO-CHANNEL CROSSTALK = $20\log_{10}\frac{V_{OUT}}{V_S}$

* SIMILAR CONNECTION FOR ADG709

Test Circuit 10. Channel-to-Channel Crosstalk

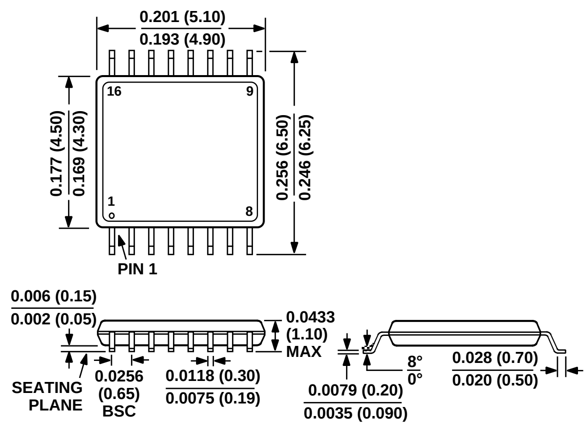
Power-Supply Sequencing

When using CMOS devices, care must be taken to ensure correct power-supply sequencing. Incorrect power-supply sequencing can result in the device being subjected to stresses beyond the maximum ratings listed in the data sheet. Digital and analog inputs should always be applied after power supplies and ground. For single supply operation, V_{SS} should be tied to GND as close to the device as possible.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

16-Lead TSSOP (RU-16)



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