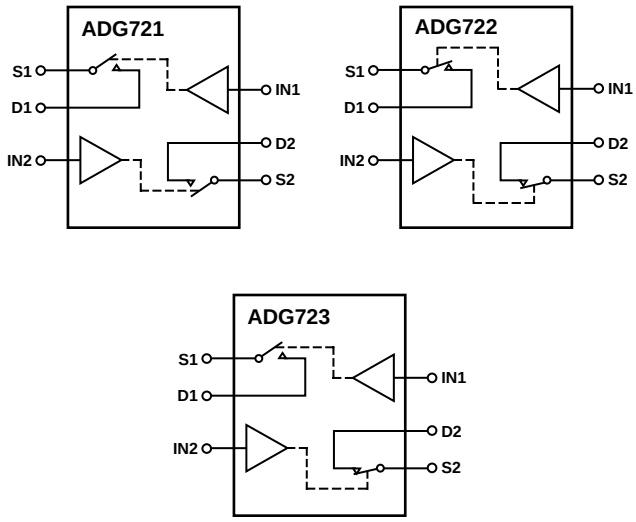
CMOS
Low Voltage 4 Ω Dual SPST Switches

ADG721/ADG722/ADG723

FEATURES
+1.8 V to +5.5 V Single Supply
4 Ω (Max) On Resistance
Low On-Resistance Flatness
–3 dB Bandwidth >200 MHz
Rail-to-Rail Operation
8-Lead μSOIC Package
Fast Switching Times
t_{ON} 20 ns
t_{OFF} 10 ns
Low Power Consumption (<0.1 μW)
TTL/CMOS Compatible

APPLICATIONS
Battery Powered Systems
Communication Systems
Sample Hold Systems
Audio Signal Routing
Video Switching
Mechanical Reed Relay Replacement

FUNCTIONAL BLOCK DIAGRAMS



SWITCHES SHOWN FOR A LOGIC "0" INPUT

GENERAL DESCRIPTION

The ADG721, ADG722 and ADG723 are monolithic CMOS SPST switches. These switches are designed on an advanced submicron process that provides low power dissipation yet gives high switching speed, low On resistance and low leakage currents.

The ADG721, ADG722 and ADG723 are designed to operate from a single +1.8 V to +5.5 V supply, making them ideal for use in battery powered instruments and with the new generation of DACs and ADCs from Analog Devices.

The ADG721, ADG722 and ADG723 contain two independent single-pole/single-throw (SPST) switches. The ADG721 and ADG722 differ only in that both switches are normally open and normally closed respectively. While in the ADG723, Switch 1 is normally open and Switch 2 is normally closed.

Each switch of the ADG721, ADG722 and ADG723 conducts equally well in both directions when on. The ADG723 exhibits break-before-make switching action.

PRODUCT HIGHLIGHTS

1. +1.8 V to +5.5 V Single Supply Operation. The ADG721, ADG722 and ADG723 offers high performance, including low on resistance and fast switching times and is fully specified and guaranteed with +3 V and +5 V supply rails.
2. Very Low R_{ON} (4 Ω max at 5 V, 10 Ω max at 3 V). At 1.8 V operation, R_{ON} is typically 40 Ω over the temperature range.
3. Low On-Resistance Flatness.
4. –3 dB Bandwidth >200 MHz.
5. Low Power Dissipation. CMOS construction ensures low power dissipation.
6. Fast t_{ON}/t_{OFF}.
7. 8-Lead μSOIC.

REV. 0

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ADG721/ADG722/ADG723–SPECIFICATIONS[1]

(V_{DD} = +5 V ± 10%, GND = 0 V. All specifications –40°C to +85°C, unless otherwise noted.)

Parameter	B Version +25°C	B Version –40°C to +85°C	Units	Test Conditions/Comments
ANALOG SWITCH				
Analog Signal Range		0 V to V_{DD}	V	
On Resistance (R_{ON})	4	5	Ω max	V_S = 0 V to V_{DD}, I_S = –10 mA, Test Circuit 1
On Resistance Match Between Channels (ΔR_{ON})	0.3		Ω typ	V_S = 0 V to V_{DD}, I_S = –10 mA
		1.0	Ω max	
On-Resistance Flatness ($R_{FLAT(ON)}$)	0.85		Ω typ	V_S = 0 V to V_{DD}, I_S = –10 mA
		1.5	Ω max	
LEAKAGE CURRENTS				V_{DD} = +5.5 V
Source OFF Leakage I_S (OFF)	±0.01		nA typ	V_S = 4.5 V/1 V, V_D = 1 V/4.5 V
	±0.25	±0.35	nA max	Test Circuit 2
Drain OFF Leakage I_D (OFF)	±0.01		nA typ	V_S = 4.5 V/1 V, V_D = 1 V/4.5 V
	±0.25	±0.35	nA max	Test Circuit 2
Channel ON Leakage I_D, I_S (ON)	±0.01		nA typ	V_S = V_D = 1 V, or V_S = V_D = 4.5 V
	±0.25	±0.35	nA max	Test Circuit 3
DIGITAL INPUTS				
Input High Voltage, V_{INH}		2.4	V min	
Input Low Voltage, V_{INL}		0.8	V max	
Input Current				
I_{INL} or I_{INH}	0.005		µA typ	V_{IN} = V_{INL} or V_{INH}
		±0.1	µA max	
DYNAMIC CHARACTERISTICS[2]				
t_{ON}	14		ns typ	R_L = 300 Ω, C_L = 35 pF
		20	ns max	V_S = 3 V, Test Circuit 4
t_{OFF}	6		ns typ	R_L = 300 Ω, C_L = 35 pF
		10	ns max	V_S = 3 V, Test Circuit 4
Break-Before-Make Time Delay, t_D (ADG723 Only)	7		ns typ	R_L = 300 Ω, C_L = 35 pF,
		1	ns min	V_{S1} = V_{S2} = 3 V, Test Circuit 5
Charge Injection	2		pC typ	V_S = 2 V; R_S = 0 Ω, C_L = 1 nF, Test Circuit 6
Off Isolation	–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, Test Circuit 7
Channel-to-Channel Crosstalk	–77		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–97		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, Test Circuit 8
Bandwidth –3 dB	200		MHz typ	R_L = 50 Ω, C_L = 5 pF, Test Circuit 9
C_S (OFF)	7		pF typ	
C_D (OFF)	7		pF typ	
C_D, C_S (ON)	18		pF typ	
POWER REQUIREMENTS				V_{DD} = +5.5 V Digital Inputs = 0 V or 5 V
I_{DD}	0.001		µA typ	
		1.0	µA max	

NOTES

[1]Temperature ranges are as follows: B Version, –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%, GND = 0 V. All specifications –40°C to +85°C, unless otherwise noted.)

Parameter	B Version +25°C	B Version –40°C to +85°C	Units	Test Conditions/Comments
ANALOG SWITCH				
Analog Signal Range		0 V to V_{DD}	V	
On Resistance (R_{ON})	6.5		Ω typ	V_S = 0 V to V_{DD}, I_S = –10 mA
		10	Ω max	Test Circuit 1
On Resistance Match Between Channels (ΔR_{ON})	0.3		Ω typ	V_S = 0 V to V_{DD}, I_S = –10 mA
		1.0	Ω max	
On-Resistance Flatness ($R_{FLAT(ON)}$)		3.5	Ω typ	V_S = 0 V to V_{DD}, I_S = –10 mA
LEAKAGE CURRENTS				V_{DD} = +3.3 V
Source OFF Leakage I_S (OFF)	±0.01		nA typ	V_S = 3 V/1 V, V_D = 1 V/3 V
	±0.25	±0.35	nA max	Test Circuit 2
Drain OFF Leakage I_D (OFF)	±0.01		nA typ	V_S = 3 V/1 V, V_D = 1 V/3 V
	±0.25	±0.35	nA max	Test Circuit 2
Channel ON Leakage I_D, I_S (ON)	±0.01		nA typ	V_S = V_D = 1 V, or 3 V
	±0.25	±0.35	nA max	Test Circuit 3
DIGITAL INPUTS				
Input High Voltage, V_{INH}		2.0	V min	
Input Low Voltage, V_{INL}		0.4	V max	
Input Current				
I_{INL} or I_{INH}	0.005		µA typ	V_{IN} = V_{INL} or V_{INH}
		±0.1	µA max	
DYNAMIC CHARACTERISTICS[2]				
t_{ON}	16		ns typ	R_L = 300 Ω, C_L = 35 pF
		24	ns max	V_S = 2 V, Test Circuit 4
t_{OFF}	7		ns typ	R_L = 300 Ω, C_L = 35 pF
		11	ns max	V_S = 2 V, Test Circuit 4
Break-Before-Make Time Delay, t_D	7		ns typ	R_L = 300 Ω, C_L = 35 pF,
(ADG723 Only)		1	ns min	V_{S1} = V_{S2} = 2 V, Test Circuit 5
Charge Injection	2		pC typ	V_S = 1.5 V; R_S = 0 Ω, C_L = 1 nF, Test Circuit 6
Off Isolation	–60		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–80		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, Test Circuit 7
Channel-to-Channel Crosstalk	–77		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 10 MHz
	–97		dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, Test Circuit 8
Bandwidth –3 dB	200		MHz typ	R_L = 50 Ω, C_L = 5 pF, Test Circuit 9
C_S (OFF)	7		pF typ	
C_D (OFF)	7		pF typ	
C_D, C_S (ON)	18		pF typ	
POWER REQUIREMENTS				V_{DD} = +3.3 V Digital Inputs = 0 V or 3 V
I_{DD}	0.001		µA typ	
		1.0	µA max	

NOTES

[1]Temperature ranges are as follows: B Version, –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 GND . . . . . –0.3 V to +7 V
Analog, Digital Inputs[2] . . . . . –0.3 V to V_{DD} + 0.3 V or 30 mA, Whichever Occurs First
Continuous Current, S or D . . . . . 30 mA
Operating Temperature Range
Industrial (B Version) . . . . . –40°C to +85°C
Storage Temperature Range . . . . . –65°C to +150°C
Junction Temperature . . . . . +150°C
µSOIC Package, Power Dissipation . . . . . 450 mW
θ_{JA} Thermal Impedance . . . . . 206°C/W
θ_{JC} Thermal Impedance . . . . . 44°C/W
Lead Temperature, Soldering
Vapor Phase (60 sec) . . . . . +215°C
Infrared (15 sec) . . . . . +220°C
ESD . . . . . 2 kV

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.

Table I. Truth Table (ADG721/ADG722)

ADG721 In	ADG722 In	Switch Condition
0	1	OFF
1	0	ON

Table II. Truth Table (ADG723)

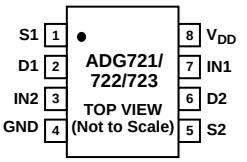
Logic	Switch 1	Switch 2
0	OFF	ON
1	ON	OFF

TERMINOLOGY

V_{DD}	Most Positive Power Supply Potential.
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.
ΔR_{ON}	On resistance match between any two channels i.e., R_{ON} max – R_{ON} min.
$R_{FLAT(ON)}$	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.
C_D (OFF)	"OFF" Switch Drain Capacitance.
C_D, C_S (ON)	"ON" Switch Capacitance.
t_{ON}	Delay between applying the digital control input and the output switching on.
t_{OFF}	Delay between applying the digital control input and the output switching off.
t_D	"OFF" time or "ON" time measured between the 90% points of both switches, When switching from one address state to another. (ADG723 Only)
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" switch.
Charge Injection	A measure of the glitch impulse transferred during switching.

PIN CONFIGURATION

8-Lead µSOIC (RM-8)



ORDERING GUIDE

Model	Temperature Range	Brand*	Package Description	Package Option
ADG721BRM	–40°C to +85°C	S6B	µSOIC	RM-8
ADG722BRM	–40°C to +85°C	S7B	µSOIC	RM-8
ADG723BRM	–40°C to +85°C	S8B	µSOIC	RM-8

*Brand = Due to package size limitations, these three characters represent the part number.

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 ADG721/ADG722/ADG723 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.

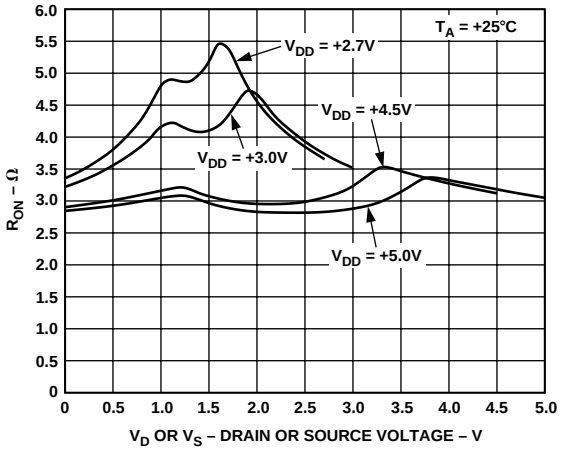


Figure 1. On Resistance as a Function of V_D (V_S) Single Supplies

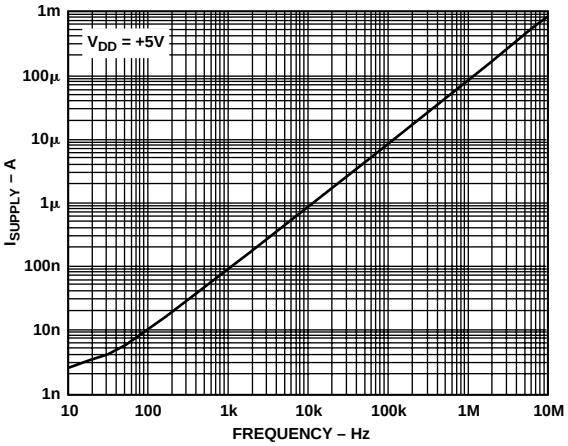


Figure 4. Supply Current vs. Input Switching Frequency

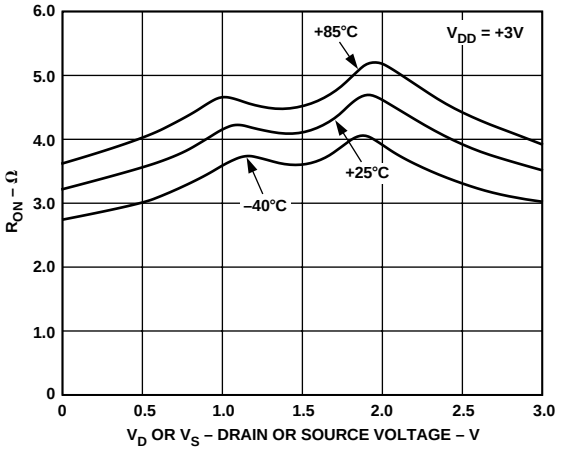


Figure 2. On Resistance as a Function of V_D (V_S) for Different Temperatures V_{DD} = +3 V

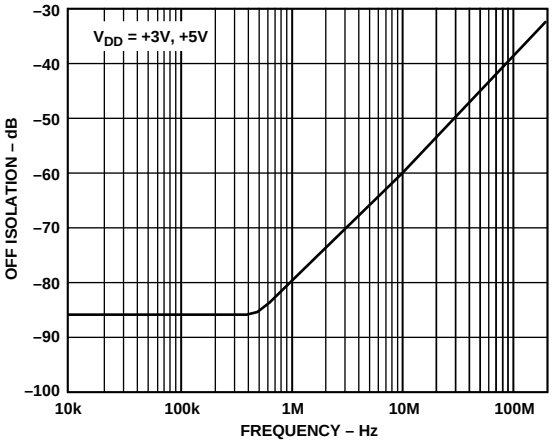


Figure 5. Off Isolation vs. Frequency

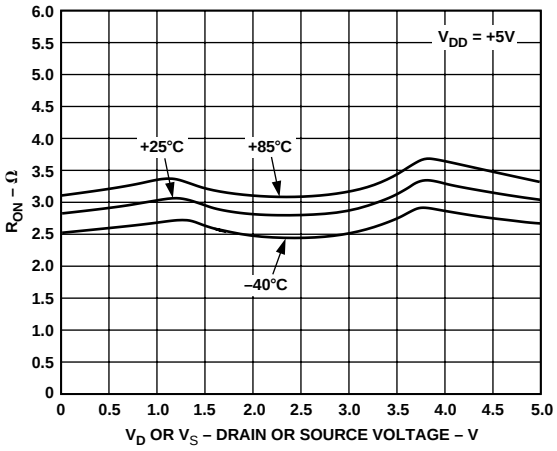


Figure 3. On Resistance as a Function of V_D (V_S) for Different Temperatures V_{DD} = +5 V

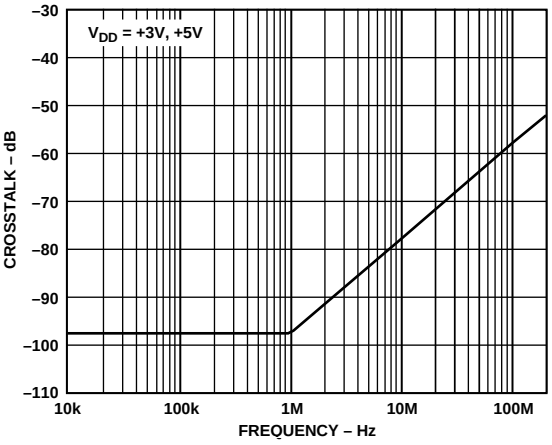


Figure 6. Crosstalk vs. Frequency

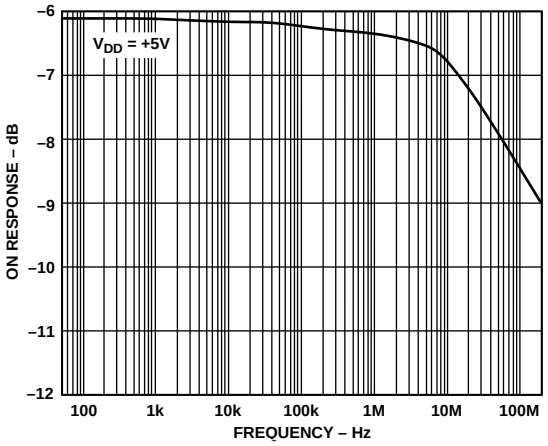
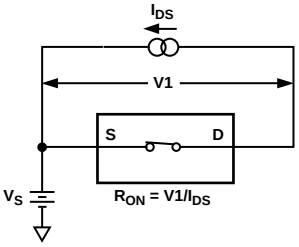
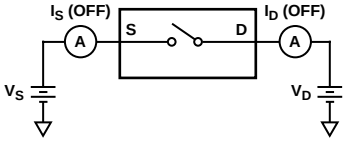


Figure 7. On Response vs. Frequency

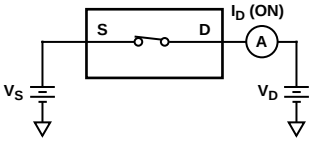
Test Circuits



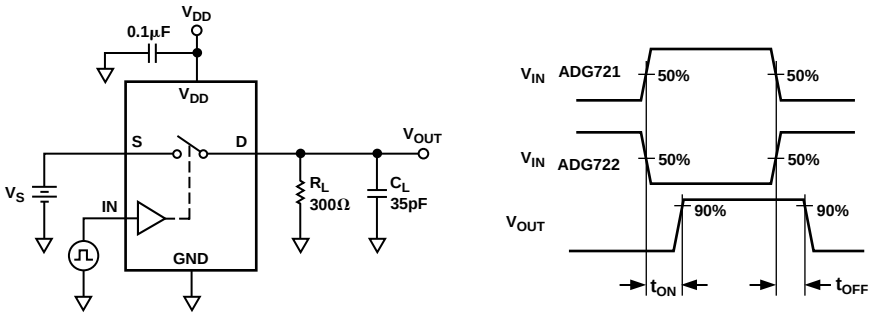
Test Circuit 1. On Resistance



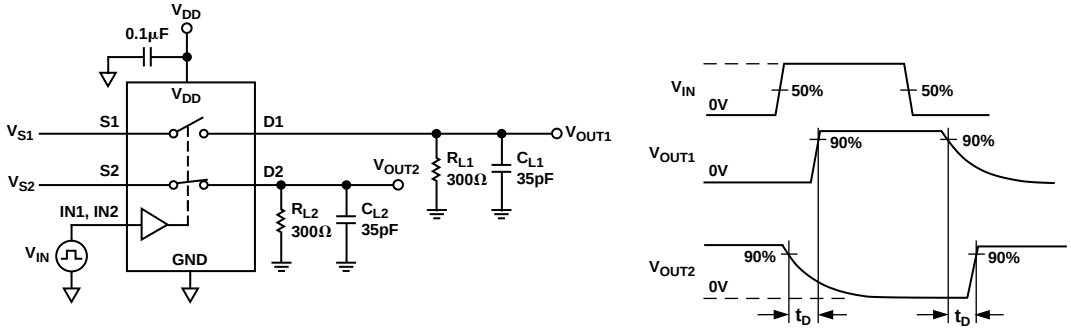
Test Circuit 2. Off Leakage



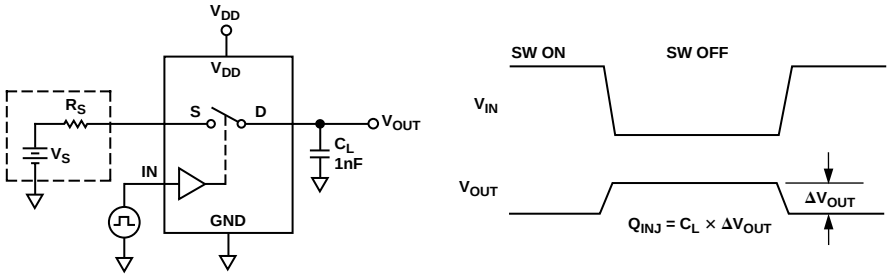
Test Circuit 3. On Leakage



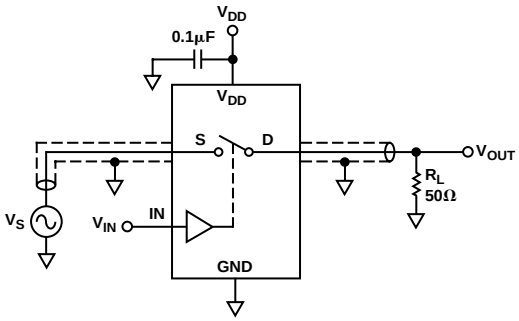
Test Circuit 4. Switching Times



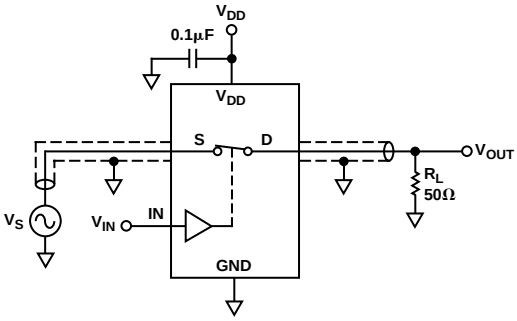
Test Circuit 5. Break-Before-Make Time Delay, t_D (ADG723 Only)



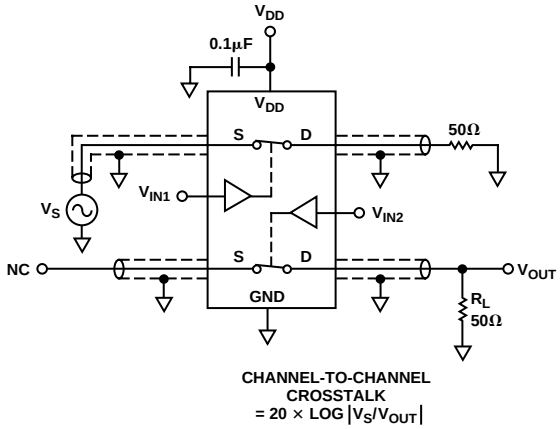
Test Circuit 6. Charge Injection



Test Circuit 7. Off Isolation



Test Circuit 9. Bandwidth



Test Circuit 8. Channel-to-Channel Crosstalk

APPLICATIONS INFORMATION

The ADG721/ADG722/ADG723 belongs to Analog Devices' new family of CMOS switches. This series of general purpose switches have improved switching times, lower on resistance, higher bandwidths, low power consumption and low leakage currents.

ADG721/ADG722/ADG723 Supply Voltages

Functionality of the ADG721/ADG722/ADG723 extends from +1.8 V to +5.5 V single supply, which makes it ideal for battery powered instruments, where important design parameters are power efficiency and performance.

It is important to note that the supply voltage effects the input signal range, the on resistance and the switching times of the part. By taking a look at the typical performance characteristics and the specifications, the effects of the power supplies can be clearly seen.

For V_{DD} = +1.8 V, on resistance is typically 40 Ω over the temperature range.

On Response vs. Frequency

Figure 8 illustrates the parasitic components that affect the ac performance of CMOS switches (the switch is shown surrounded by a box). Additional external capacitances will further degrade some performance. These capacitances affect feedthrough, crosstalk and system bandwidth.

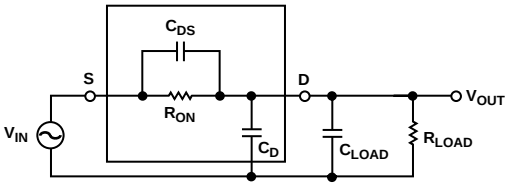


Figure 8. Switch Represented by Equivalent Parasitic Components

The transfer function that describes the equivalent diagram of the switch (Figure 8) is of the form (A)s shown below.

$$A(s) = R_T\left[\frac{s(R_{ON}\ C_{DS})+1}{s(R_{ON}\ C_T\ R_T)+1}\right]$$

where:

$C_T = C_{LOAD} + C_D + C_{DS}$
$R_T = R_{LOAD}/(R_{LOAD} + R_{ON})$

The signal transfer characteristic is dependent on the switch channel capacitance, C_{DS}. This capacitance creates a frequency zero in the numerator of the transfer function A(s). Because the switch on resistance is small, this zero usually occurs at high frequencies. The bandwidth is a function of the switch output capacitance combined with C_{DS} and the load capacitance. The frequency pole corresponding to these capacitances appears in the denominator of A(s).

The dominant effect of the output capacitance, C_D, causes the pole breakpoint frequency to occur first. Therefore, in order to maximize bandwidth a switch must have a low input and output capacitance and low on resistance. The On Response vs. Frequency plot for the ADG721/ADG722/ADG723 can be seen in Figure 7.

Off Isolation

Off isolation is a measure of the input signal coupled through an off switch to the switch output. The capacitance, C_{DS}, couples the input signal to the output load, when the switch is off as shown in Figure 9.

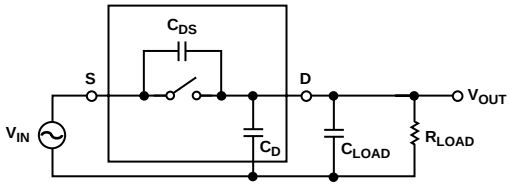


Figure 9. Off Isolation Is Affected by External Load Resistance and Capacitance

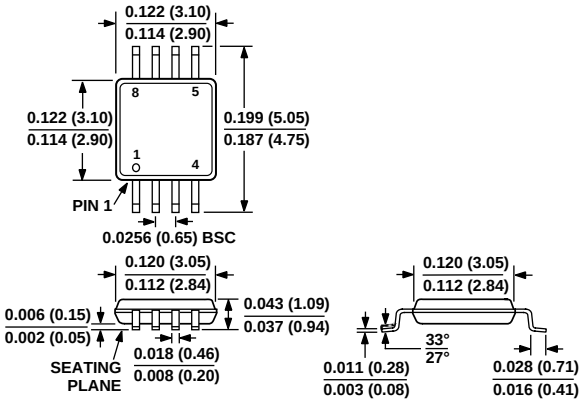
The larger the value of C_{DS}, larger values of feedthrough will be produced. The typical performance characteristic graph of Figure 5 illustrates the drop in off isolation as a function of frequency. From dc to roughly 1 MHz, the switch shows better than –80 dB isolation. Up to frequencies of 10 MHz, the off isolation remains better than –60 dB. As the frequency increases, more and more of the input signal is coupled through to the output. Off isolation can be maximized by choosing a switch with the smallest C_{DS} as possible. The values of load resistance and capacitance also affect off isolation, as they contribute to the coefficients of the poles and zeros in the transfer function of the switch when open.

$$A(s) = \left[\frac{s(R_{LOAD}\ C_{DS})}{s(R_{LOAD})\,(C_{LOAD} + C_D + C_{DS})+1}\right]$$

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

8-Lead μSOIC
(RM-8)



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