



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 MSOP Package

Fast Switching Times

t_{ON} 20 ns

t_{OFF} 10 ns

Low Power Consumption (<0.1 μ W)

TTL/CMOS Compatible

APPLICATIONS

USB 1.1 Signal Switching Circuits

Cell Phones

PDA's

Battery-Powered Systems

Communication Systems

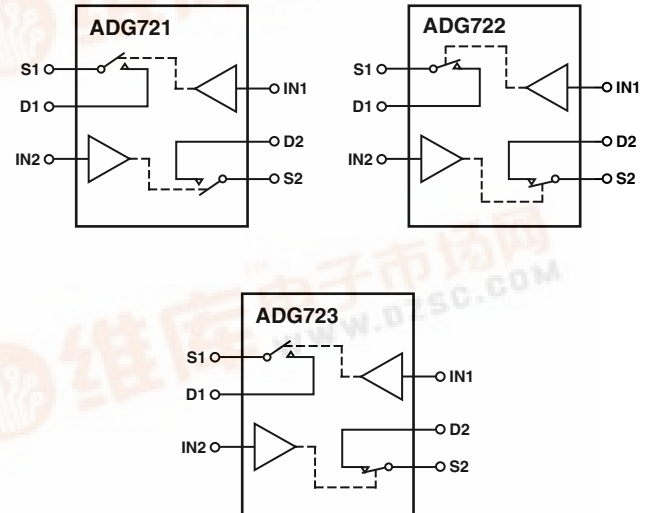
Sample Hold Systems

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 offer high performance, including low on resistance and fast switching times, and are 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 MSOP.

REV. A

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ADG721/ADG722/ADG723—SPECIFICATIONS¹

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

Parameter	B Version		Unit	Test Conditions/Comments
	+25°C	–40°C to +85°C		
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	1.0	Ω typ Ω max	V _S = 0 V to V _{DD} , I _S = –10 mA
On Resistance Flatness (R _{FLAT(ON)})	0.85	1.5	Ω typ Ω max	V _S = 0 V to V _{DD} , I _S = –10 mA
LEAKAGE CURRENTS				
Source OFF Leakage I _S (OFF)	±0.01 ±0.25	±0.35	nA typ nA max	V _{DD} = 5.5 V V _S = 4.5 V/1 V, V _D = 1 V/4.5 V Test Circuit 2
Drain OFF Leakage I _D (OFF)	±0.01 ±0.25	±0.35	nA typ nA max	V _S = 4.5 V/1 V, V _D = 1 V/4.5 V Test Circuit 2
Channel ON Leakage I _D , I _S (ON)	±0.01 ±0.25	±0.35	nA typ nA max	V _S = V _D = 1 V, or V _S = V _D = 4.5 V 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	±0.1	μA typ μA max	V _{IN} = V _{INL} or V _{INH}
DYNAMIC CHARACTERISTICS ²				
t _{ON}	14	20	ns typ ns max	R _L = 300 Ω, C _L = 35 pF V _S = 3 V, Test Circuit 4
t _{OFF}	6	10	ns typ ns max	R _L = 300 Ω, C _L = 35 pF V _S = 3 V, Test Circuit 4
Break-Before-Make Time Delay, t _D (ADG723 Only)	7	1	ns typ ns min	R _L = 300 Ω, C _L = 35 pF, 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 –80		dB typ dB typ	R _L = 50 Ω, C _L = 5 pF, f = 10 MHz R _L = 50 Ω, C _L = 5 pF, f = 1 MHz, Test Circuit 7
Channel-to-Channel Crosstalk	–77 –97		dB typ dB typ	R _L = 50 Ω, C _L = 5 pF, f = 10 MHz 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				
I _{DD}	0.001	1.0	μA typ μA max	V _{DD} = 5.5 V Digital Inputs = 0 V or 5 V

NOTES

¹Temperature range: B Version, –40°C to +85°C.

²Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

SPECIFICATIONS¹

($V_{DD} = 3\text{ V} \pm 10\%$, $GND = 0\text{ V}$. All specifications -40°C to $+85^{\circ}\text{C}$, unless otherwise noted.)

Parameter	B Version		Unit	Test Conditions/Comments
	+25°C	−40°C to +85°C		
ANALOG SWITCH				
Analog Signal Range		0 V to V _{DD}	V	
On Resistance (R _{ON})	6.5	10	Ω typ 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	1.0	Ω typ Ω max	V _S = 0 V to V _{DD} , I _S = −10 mA
On Resistance Flatness (R _{FLAT(ON)})		3.5	Ω typ	V _S = 0 V to V _{DD} , I _S = −10 mA
LEAKAGE CURRENTS				
Source OFF Leakage I _S (OFF)	±0.01 ±0.25	±0.35	nA typ nA max	V _{DD} = 3.3 V V _S = 3 V/1 V, V _D = 1 V/3 V Test Circuit 2
Drain OFF Leakage I _D (OFF)	±0.01 ±0.25	±0.35	nA typ nA max	V _S = 3 V/1 V, V _D = 1 V/3 V Test Circuit 2
Channel ON Leakage I _D , I _S (ON)	±0.01 ±0.25	±0.35	nA typ nA max	V _S = V _D = 1 V, or 3 V 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	±0.1	μA typ μA max	V _{IN} = V _{INL} or V _{INH}
DYNAMIC CHARACTERISTICS ²				
t _{ON}	16	24	ns typ ns max	R _L = 300 Ω, C _L = 35 pF V _S = 2 V, Test Circuit 4
t _{OFF}	7	11	ns typ ns max	R _L = 300 Ω, C _L = 35 pF V _S = 2 V, Test Circuit 4
Break-Before-Make Time Delay, t _D (ADG723 Only)	7	1	ns typ ns min	R _L = 300 Ω, C _L = 35 pF, 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 −80		dB typ dB typ	R _L = 50 Ω, C _L = 5 pF, f = 10 MHz R _L = 50 Ω, C _L = 5 pF, f = 1 MHz, Test Circuit 7
Channel-to-Channel Crosstalk	−77 −97		dB typ dB typ	R _L = 50 Ω, C _L = 5 pF, f = 10 MHz 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				
I _{DD}	0.001	1.0	μA typ μA max	V _{DD} = 3.3 V Digital Inputs = 0 V or 3 V

NOTES

¹Temperature range: B Version, -40°C to $+85^{\circ}\text{C}$.²Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

ADG721/ADG722/ADG723

ABSOLUTE MAXIMUM RATINGS¹

(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
MSOP 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

¹Stresses 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.

²Overvoltages 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

ORDERING GUIDE

Model	Temperature Range	Branding ¹	Package Description	Package Option
ADG721BRM	−40°C to +85°C	S6B	MSOP	RM-8
ADG721BRM-REEL	−40°C to +85°C	S6B	MSOP	RM-8
ADG721BRM-REEL7	−40°C to +85°C	S6B	MSOP	RM-8
ADG721BRMZ ²	−40°C to +85°C	S6B	MSOP	RM-8
ADG721BRMZ-REEL ²	−40°C to +85°C	S6B	MSOP	RM-8
ADG721BRMZ-REEL7 ²	−40°C to +85°C	S6B	MSOP	RM-8
ADG722BRM	−40°C to +85°C	S7B	MSOP	RM-8
ADG722BRM-REEL	−40°C to +85°C	S7B	MSOP	RM-8
ADG722BRM-REEL7	−40°C to +85°C	S7B	MSOP	RM-8
ADG722BRMZ ²	−40°C to +85°C	S7B	MSOP	RM-8
ADG722BRMZ-REEL ²	−40°C to +85°C	S7B	MSOP	RM-8
ADG722BRMZ-REEL7 ²	−40°C to +85°C	S7B	MSOP	RM-8
ADG723BRM	−40°C to +85°C	S8B	MSOP	RM-8
ADG723BRM-REEL	−40°C to +85°C	S8B	MSOP	RM-8
ADG723BRM-REEL7	−40°C to +85°C	S8B	MSOP	RM-8

NOTES

¹Branding = Due to package size limitations, these three characters represent the part number.

²Z = Pb-free part.

CAUTION

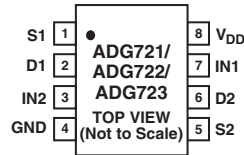
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADG721/ADG722/ADG723 feature proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



ADG721/ADG722/ADG723

PIN CONFIGURATION

8-Lead MSOP (RM-8)



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 that 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.

ADG721/ADG722/ADG723—Typical Performance Characteristics

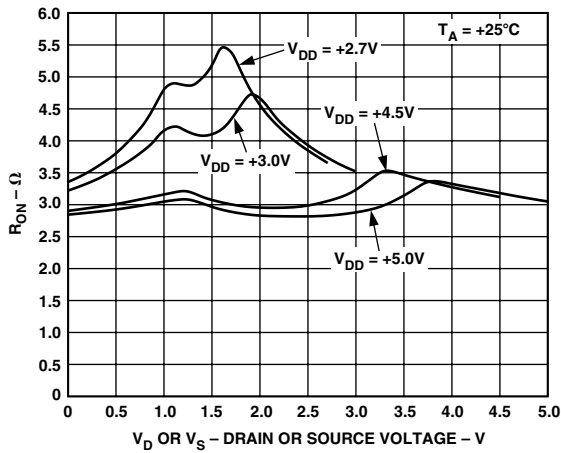


Figure 1. On Resistance as a Function of V_D (V_S) Single Supplies

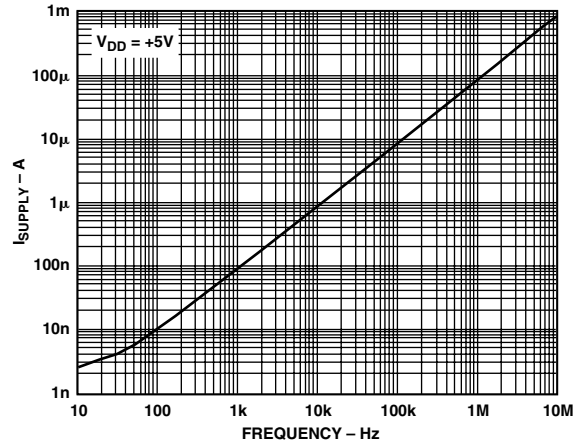


Figure 4. Supply Current vs. Input Switching Frequency

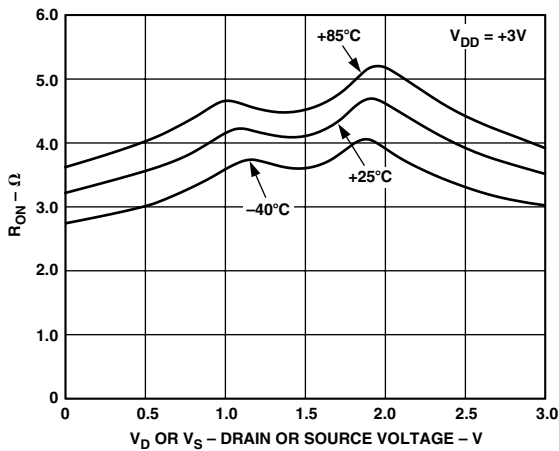


Figure 2. On Resistance as a Function of V_D (V_S) for Different Temperatures, $V_{DD} = 3V$

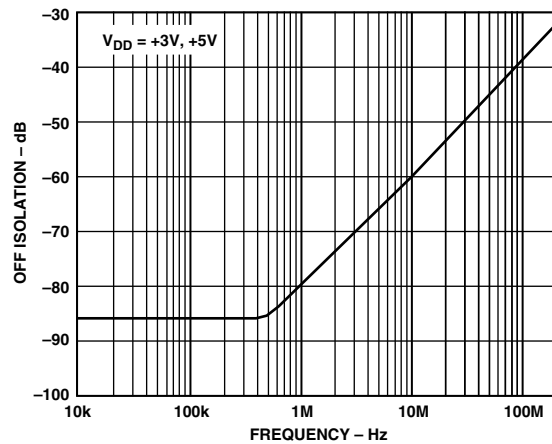


Figure 5. Off Isolation vs. Frequency

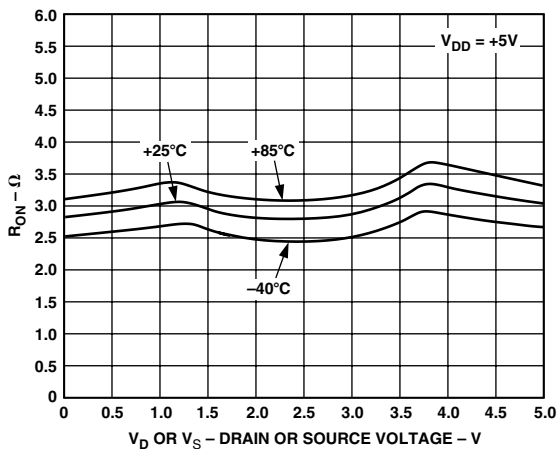


Figure 3. On Resistance as a Function of V_D (V_S) for Different Temperatures, $V_{DD} = 5V$

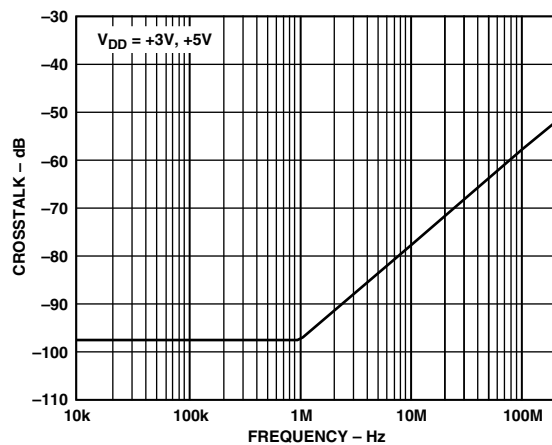


Figure 6. Crosstalk vs. Frequency

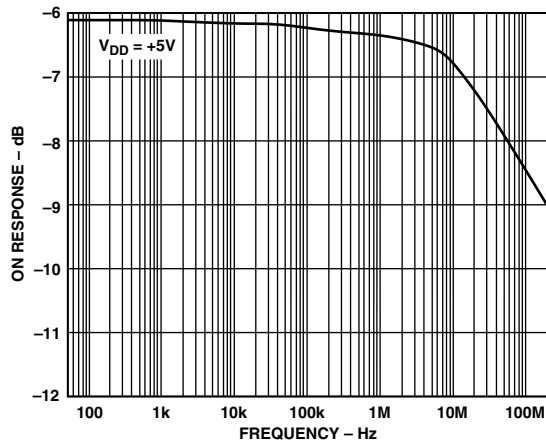
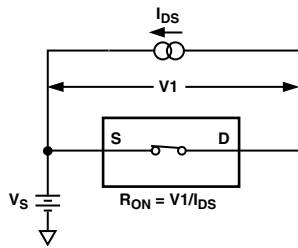
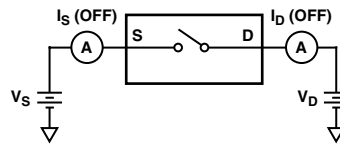


Figure 7. On Response vs. Frequency

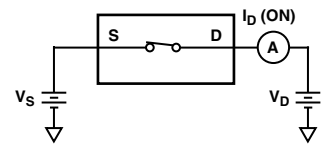
Test Circuits



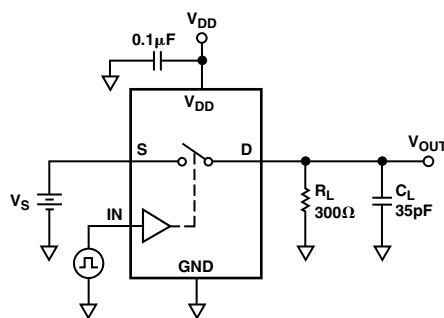
Test Circuit 1. On Resistance



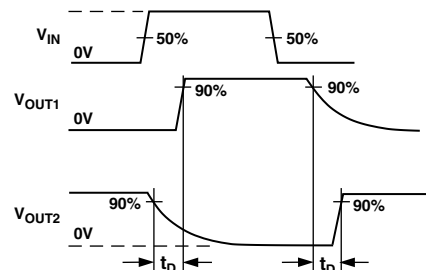
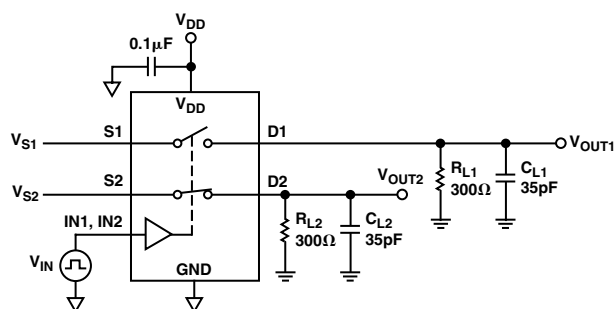
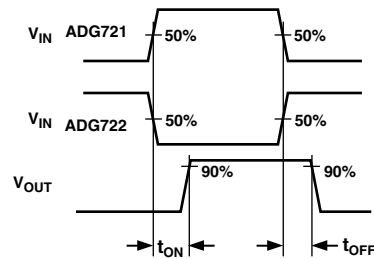
Test Circuit 2. Off Leakage



Test Circuit 3. On Leakage

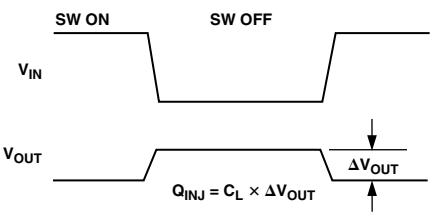
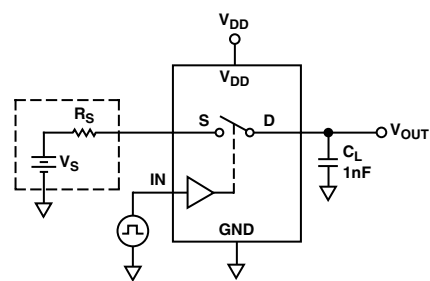


Test Circuit 4. Switching Times

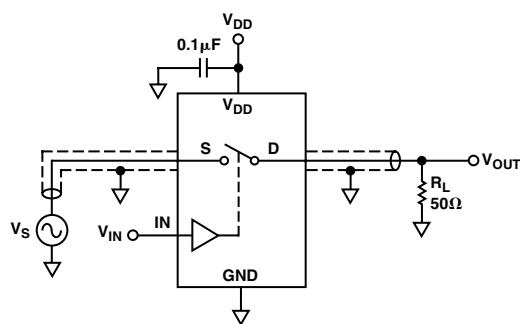


Test Circuit 5. Break-Before-Make Time Delay, t_D (ADG723 Only)

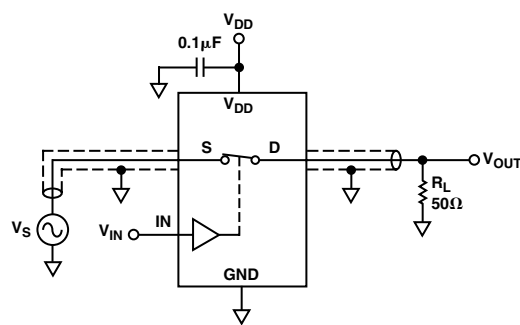
ADG721/ADG722/ADG723



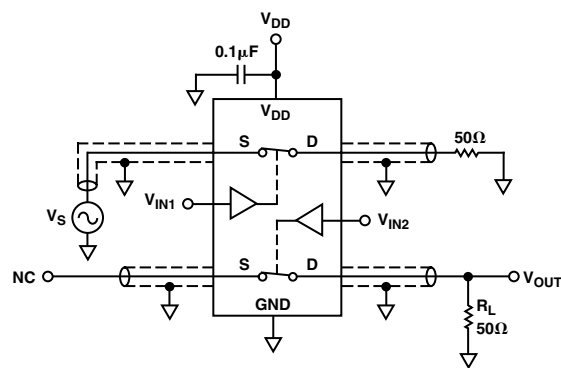
Test Circuit 6. Charge Injection



Test Circuit 7. Off Isolation



Test Circuit 9. Bandwidth



CHANNEL-TO-CHANNEL
CROSSTALK
 $= 20 \times \text{LOG} |V_S/V_{OUT}|$

Test Circuit 8. Channel-to-Channel Crosstalk

APPLICATIONS INFORMATION

The ADG721/ADG722/ADG723 belong to Analog Devices' new family of CMOS switches. This series of general-purpose switches has 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 affects 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 $40\ \Omega$ 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.

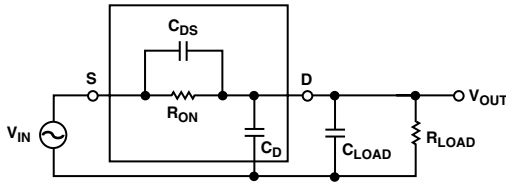


Figure 8. Switch Represented by Equivalent Parasitic Components

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. See 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.

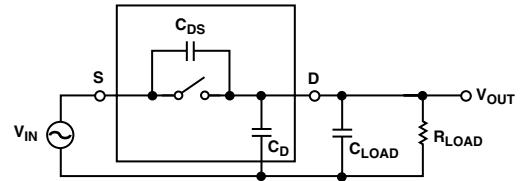


Figure 9. Off Isolation Is Affected by External Load Resistance and Capacitance

The larger the value of C_{DS} , the larger the values of feedthrough that are 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.

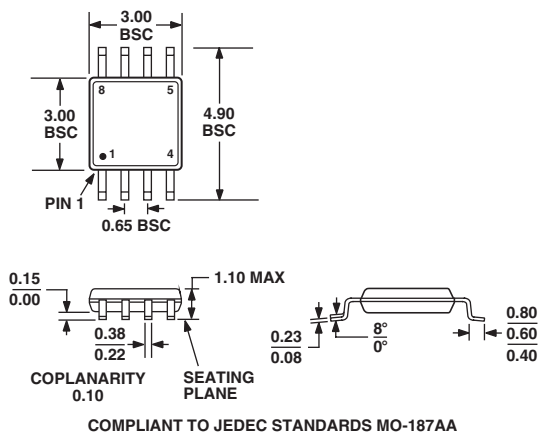
$$A(s) = \left[\frac{s(R_{LOAD} C_{DS})}{s(R_{LOAD})(C_{LOAD} + C_D + C_{DS}) + 1} \right]$$

ADG721/ADG722/ADG723

OUTLINE DIMENSIONS

8-Lead Mini Small Outline Package [MSOP] (RM-8)

Dimensions shown in millimeters



Revision History

Location	Page
3/04—Data Sheet changed from REV. 0 to REV. A.	
Additions to APPLICATIONS	1
Changes to ORDERING GUIDE	4
Updated OUTLINE DIMENSIONS	10

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