



# CMOS Low Voltage 2 $\Omega$ SPST Switches

## ADG701L/ADG702L

### FEATURES

- 1.8 V to 5.5 V single supply
- 2  $\Omega$  (typical) on resistance
- Low on resistance flatness
- Guaranteed leakage specifications up to 85°C
- 3 dB bandwidth > 200 MHz
- Rail-to-rail operation
- Fast switching times
  - $t_{ON}$  18 ns
  - $t_{OFF}$  12 ns
- Typical power consumption < 0.01  $\mu$ W
- TTL/CMOS-compatible

### APPLICATIONS

- Battery-powered systems
- Communication systems
- Sample-and-hold systems
- Audio signal routing
- Video switching
- Mechanical reed relay replacement

### GENERAL DESCRIPTION

The ADG701L/ADG702L are monolithic CMOS SPST switches. These switches are designed using an advanced submicron process that provides low power dissipation, yet offers high switching speed, low on resistance, and low leakage currents. In addition, -3 dB bandwidths of greater than 200 MHz can be achieved.

The ADG701L/ADG702L can operate from a single 1.8 V to 5.5 V supply, making it ideal for use in battery-powered instruments and with the new generation of DACs and ADCs from Analog Devices.

Figure 1 and Figure 2 show that with a logic input of 1, the switch of the ADG701L is closed, while that of the ADG702L is open. Each switch conducts equally well in both directions when on.

The ADG701L/ADG702L are packaged as 5-lead SOT-23, 6-lead SOT-23, and 8-lead MSOP.

### FUNCTIONAL BLOCK DIAGRAMS

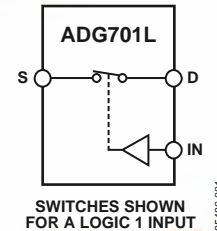


Figure 1.

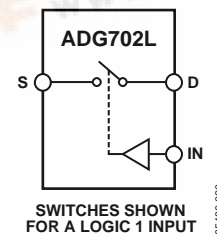


Figure 2.

### PRODUCT HIGHLIGHTS

1. 1.8 V to 5.5 V single-supply operation. The ADG701L/ADG702L offer high performance, including low on resistance and fast switching times. The ADG701L/ADG702L are fully specified and guaranteed with 3 V and 5 V supply rails.
2. Very low  $R_{ON}$  (3  $\Omega$  maximum at 5 V, 5  $\Omega$  maximum at 3 V). At 1.8 V operation,  $R_{ON}$  is typically 40  $\Omega$  over the temperature range.
3. On resistance flatness  $R_{FLAT(ON)}$  (1  $\Omega$  maximum).
4. -3 dB bandwidth > 200 MHz.
5. Low power dissipation. CMOS construction ensures low power dissipation.
6. Fast  $t_{ON}/t_{OFF}$ .



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**REVISION HISTORY**

**11/06—Revision 0: Initial Version**

## SPECIFICATIONS

$V_{DD} = 5\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$ . Temperature range for the B version is  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , unless otherwise noted.

**Table 1.**

Parameter	B Version		Unit	Test Conditions/Comments
	+25°C	-40°C to +85°C		
<b>ANALOG SWITCH</b>				
Analog Signal Range		0 V to $V_{DD}$	V	
On Resistance ( $R_{ON}$ )	2		$\Omega$ typ	$V_S = 0\text{ V to }V_{DD}$ , $I_S = -10\text{ mA}$ ; see Figure 12
	3	4	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	0.5		$\Omega$ typ	$V_S = 0\text{ V to }V_{DD}$ , $I_S = -10\text{ mA}$
		1.0	$\Omega$ max	
<b>LEAKAGE CURRENTS</b>				
Source Off Leakage, $I_S$ (OFF)	$\pm 0.01$		nA typ	$V_{DD} = 5.5\text{ V}$ $V_S = 4.5\text{ V}/1\text{ V}$ , $V_D = 1\text{ V}/4.5\text{ V}$ ; see Figure 13
	$\pm 0.25$	$\pm 0.35$	nA max	
Drain Off Leakage, $I_D$ (OFF)	$\pm 0.01$		nA typ	$V_S = 4.5\text{ V}/1\text{ V}$ , $V_D = 1\text{ V}/4.5\text{ V}$ ; see Figure 13
	$\pm 0.25$	$\pm 0.35$	nA max	
Channel On Leakage, $I_D$ , $I_S$ (ON)	$\pm 0.01$		nA typ	$V_S = V_D = 1\text{ V}$ , or $4.5\text{ V}$ ; see Figure 14
	$\pm 0.25$	$\pm 0.35$	nA max	
<b>DIGITAL INPUTS</b>				
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		$\mu\text{A}$ typ	$V_{IN} = V_{INL}$ or $V_{INH}$
		$\pm 0.1$	$\mu\text{A}$ max	
<b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>				
$t_{ON}$	12		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
		18	ns max	$V_S = 3\text{ V}$ ; see Figure 15
$t_{OFF}$	8		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
		12	ns max	$V_S = 3\text{ V}$ ; see Figure 15
Charge Injection	5		pC typ	$V_S = 2\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; see Figure 16
Off Isolation	-55		dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 10\text{ MHz}$
	-75		dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 17
Bandwidth -3 dB	200		MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 18
$C_S$ (OFF)	17		pF typ	
$C_D$ (OFF)	17		pF typ	
$C_D$ , $C_S$ (ON)	38		pF typ	
<b>POWER REQUIREMENTS</b>				
$I_{DD}$	0.001		$\mu\text{A}$ typ	$V_{DD} = 5.5\text{ V}$ Digital inputs = 0 V or 5 V
		1.0	$\mu\text{A}$ max	

<sup>1</sup> Guaranteed by design, not subject to production test.

# ADG701L/ADG702L

$V_{DD} = 3\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$ . Temperature range for the B version is  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , unless otherwise noted.

**Table 2.**

Parameter	B Version		Unit	Test Conditions/Comments
	+25°C	-40°C to +85°C		
<b>ANALOG SWITCH</b>				
Analog Signal Range		0 V to $V_{DD}$	V	
On Resistance ( $R_{ON}$ )	3.5		$\Omega$ typ	$V_S = 0\text{ V to }V_{DD}$ , $I_S = -10\text{ mA}$ ; see Figure 12
	5	6	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	1.5		$\Omega$ typ	$V_S = 0\text{ V to }V_{DD}$ , $I_S = -10\text{ mA}$
<b>LEAKAGE CURRENTS</b>				
Source Off Leakage $I_S$ (OFF)	$\pm 0.01$		nA typ	$V_{DD} = 3.3\text{ V}$ $V_S = 3\text{ V}/1\text{ V}$ , $V_D = 1\text{ V}/3\text{ V}$ ; see Figure 13
	$\pm 0.25$	$\pm 0.35$	nA max	
Drain Off Leakage $I_D$ (OFF)	$\pm 0.01$		nA typ	$V_S = 3\text{ V}/1\text{ V}$ , $V_D = 1\text{ V}/3\text{ V}$ ; see Figure 13
	$\pm 0.25$	$\pm 0.35$	nA max	
Channel On Leakage $I_D$ , $I_S$ (ON)	$\pm 0.01$		nA typ	$V_S = V_D = 1\text{ V}$ , or $3\text{ V}$ ; see Figure 14
	$\pm 0.25$	$\pm 0.35$	nA max	
<b>DIGITAL INPUTS</b>				
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		$\mu\text{A}$ typ	$V_{IN} = V_{INL}$ or $V_{INH}$
		$\pm 0.1$	$\mu\text{A}$ max	
<b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>				
$t_{ON}$	14		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
		20	ns max	$V_S = 2\text{ V}$ , see Figure 15
$t_{OFF}$	8		ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
		13	ns max	$V_S = 2\text{ V}$ , see Figure 15
Charge Injection	4		pC typ	$V_S = 1.5\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; see Figure 16
Off Isolation	-55		dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 10\text{ MHz}$
	-75		dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 17
Bandwidth -3 dB	200		MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 18
$C_S$ (OFF)	17		pF typ	
$C_D$ (OFF)	17		pF typ	
$C_D$ , $C_S$ (ON)	38		pF typ	
<b>POWER REQUIREMENTS</b>				
$I_{DD}$	0.001		$\mu\text{A}$ typ	$V_{DD} = 3.3\text{ V}$ Digital Inputs = 0 V or 3 V
		1.0	$\mu\text{A}$ max	

<sup>1</sup> Guaranteed by design, not subject to production test.

## ABSOLUTE MAXIMUM RATINGS

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

**Table 3.**

Parameter	Rating
$V_{DD}$ to GND	-0.3 V to +7 V
Analog, Digital Inputs <sup>1</sup>	-0.3 V to $V_{DD} + 0.3$ V or 30 mA, whichever occurs first
Continuous Current, S or D	30 mA
Peak Current, S or D	100 mA, pulsed at 1 ms, 10% duty cycle maximum
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	315 mW
$\theta_{JA}$ Thermal Impedance	206°C/W
$\theta_{JC}$ Thermal Impedance	44°C/W
SOT-23 Package, Power Dissipation	282 mW
$\theta_{JA}$ Thermal Impedance	229.6°C/W
$\theta_{JC}$ Thermal Impedance	91.99°C/W
Lead Temperature, Soldering	
Vapor Phase (60 sec)	215°C
Infrared (15 sec)	220°C
Lead-free Reflow Soldering	
Peak Temperature	260 (+0/-5)°C
Time at Peak Temperature	10 sec to 40 sec
ESD	2 kV

<sup>1</sup> Overvoltages at IN, 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 indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### 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.



# ADG701L/ADG702L

## PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

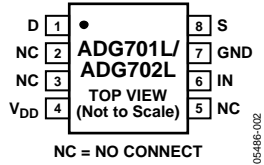


Figure 3. 8-Lead MSOP Pin Configuration

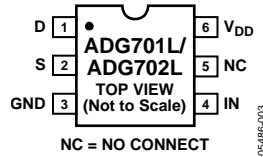


Figure 4. 6-Lead SOT-23 Pin Configuration

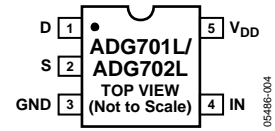


Figure 5. 5-Lead SOT-23 Pin Configuration

Table 4. Pin Function Descriptions

Pin Number			Mnemonic	Description
8-Lead MSOP	6-lead SOT-23	5-lead SOT-23		
1	1	1	D	Drain Terminal. May be an input or output.
2, 3, 5	5	N/A	NC	No Connect.
4	6	5	V <sub>DD</sub>	Most Positive Power Supply Potential.
6	4	4	IN	Logic Control Input.
7	3	3	GND	Ground (0 V) Reference.
8	2	2	S	Source Terminal. May be an input or output.

Table 5. Truth Table

ADG701L In	ADG702L In	Switch Condition
0	1	Off
1	0	On

TYPICAL PERFORMANCE CHARACTERISTICS

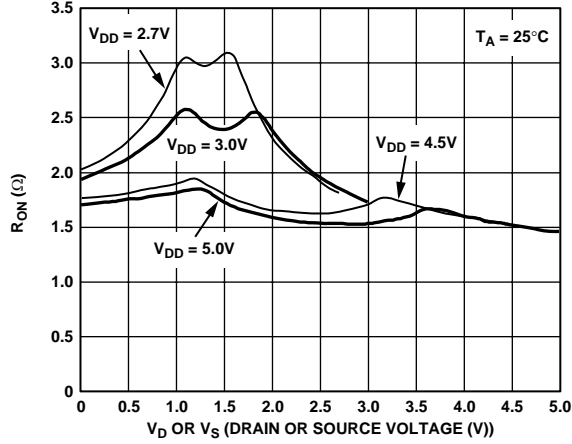


Figure 6. On Resistance as a Function of  $V_D$  ( $V_S$ ) Single Supplies

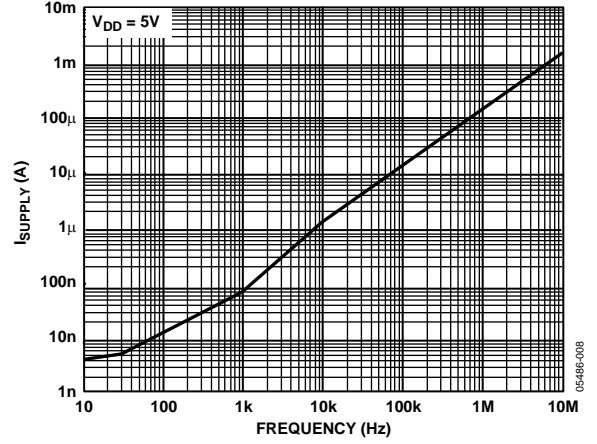


Figure 9. Supply Current vs. Input Switching Frequency

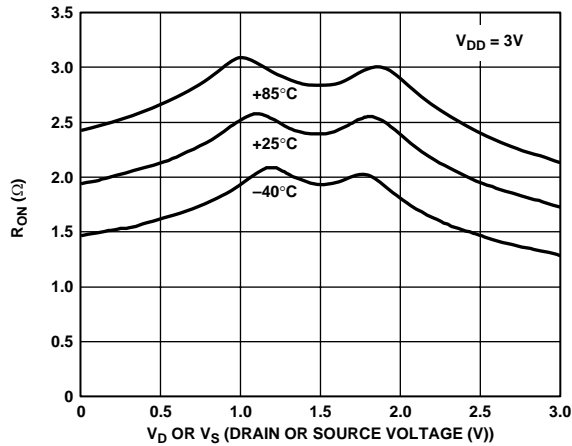


Figure 7. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures  $V_{DD} = 3\text{V}$

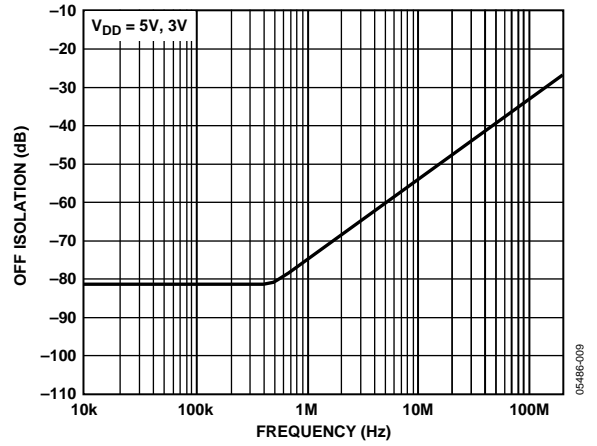


Figure 10. Off Isolation vs. Frequency

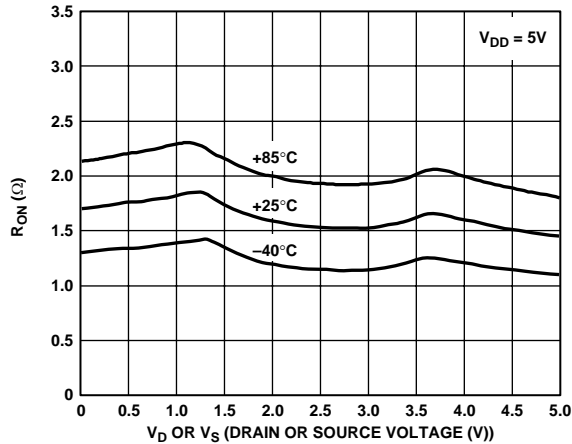


Figure 8. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures  $V_{DD} = 5\text{V}$

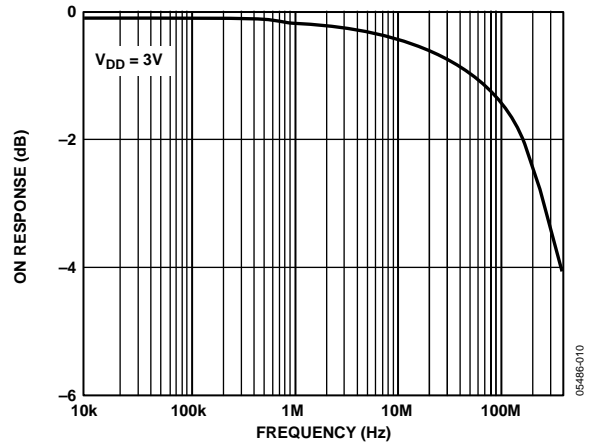


Figure 11. Bandwidth

# ADG701L/ADG702L

## TEST CIRCUITS

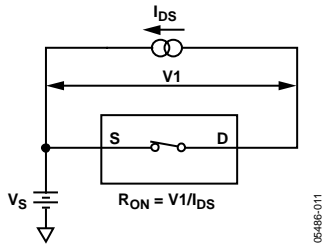


Figure 12. On Resistance

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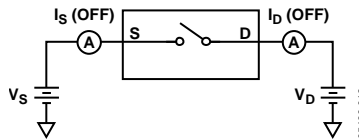


Figure 13. Off Leakage

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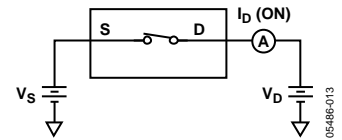
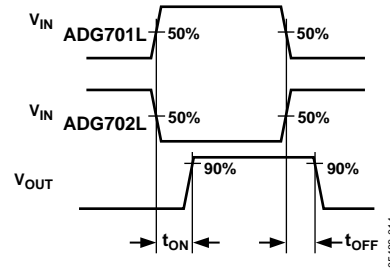
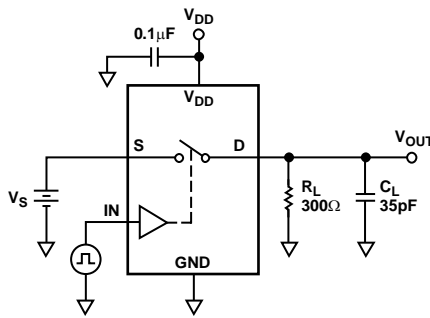


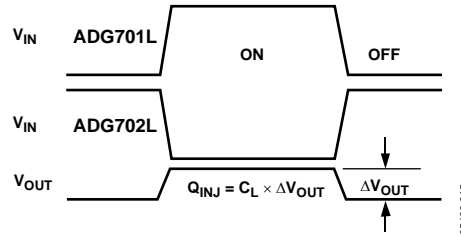
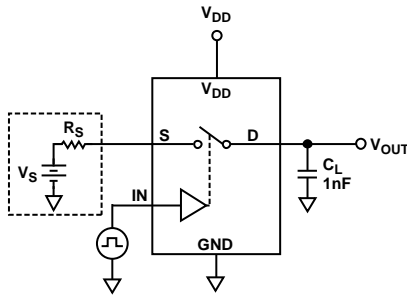
Figure 14. On Leakage

05486-013



05486-014

Figure 15. Switching Times



05486-015

Figure 16. Charge Injection

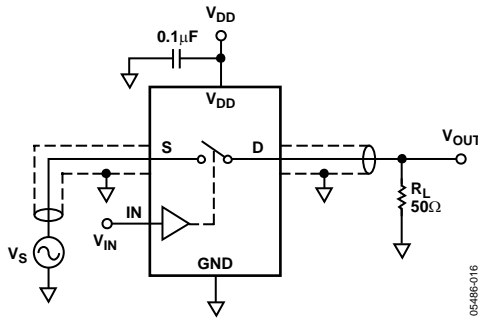


Figure 17. Off Isolation

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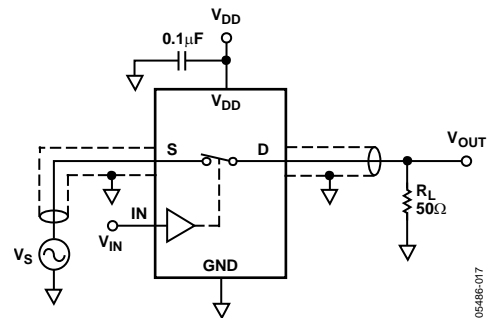


Figure 18. Bandwidth

05486-017



## TERMINOLOGY

**R<sub>ON</sub>**

Ohmic resistance between D and S.

**R<sub>FLAT (ON)</sub>**

Flatness is defined as the difference between the maximum and minimum value of on resistance as measured over the specified analog signal range.

**I<sub>S (OFF)</sub>**

Source leakage current with the switch off.

**I<sub>D (OFF)</sub>**

Drain leakage current with the switch off.

**I<sub>D, I<sub>S</sub> (ON)</sub>**

Channel leakage current with the switch on.

**V<sub>D (V<sub>S</sub>)</sub>**

Analog voltage on Terminal D and Terminal S.

**C<sub>S (OFF)</sub>**

Off switch source capacitance.

**C<sub>D (OFF)</sub>**

Off switch drain capacitance.

**C<sub>D, C<sub>S</sub> (ON)</sub>**

On switch capacitance.

**t<sub>ON</sub>**

Delay between applying the digital control input and the output switching on. See Figure 15.

**t<sub>OFF</sub>**

Delay between applying the digital control input and the output switching off.

**Off Isolation**

A measure of unwanted signal coupling through an off switch.

**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 dB.

**On Response**

The frequency response of the on switch.

**On Loss**

The voltage drop across the on switch, seen in Figure 11 as the number of decibels the signal is away from 0 dB at very low frequencies.

# ADG701L/ADG702L

## APPLICATIONS INFORMATION

The ADG701L/ADG702L belong to the Analog Devices new family of CMOS switches. This series of general-purpose switches have improved switching times, lower on resistance, higher bandwidth, low power consumption, and low leakage currents.

### SUPPLY VOLTAGES

Functionality of the ADG701L/ADG702L extends from 1.8 V to 5.5 V single supply, making the parts ideal for battery-powered instruments where power, efficiency, and performance are important design parameters.

It is important to note that the supply voltage affects the input signal range, the on resistance, and the switching times of the part. The effects of the power supplies can be clearly seen in the Typical Performance Characteristics and the Specifications sections.

For  $V_{DD} = 1.8$  V operation,  $R_{ON}$  is typically 40  $\Omega$  over the temperature range.

### BANDWIDTH

Figure 19 illustrates the parasitic components that affect the ac performance of CMOS switches (a box surrounds the switch). Additional external capacitances further degrade some performance. These capacitances affect feedthrough, crosstalk, and system bandwidth.

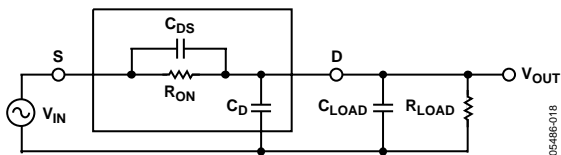


Figure 19. Switch Represented by Equivalent Parasitic Components

The transfer function that describes the equivalent diagram of the switch (see Figure 19) is of the form  $A(s)$ , as shown in the following equation:

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

where  $C_T = C_{LOAD} + C_D + C_{DS}$ .

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. In order to maximize bandwidth, a switch must have a low input and output capacitance and low on resistance. The on response versus frequency for the ADG701L/ADG702L is shown in Figure 11.

### 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 (see Figure 20).

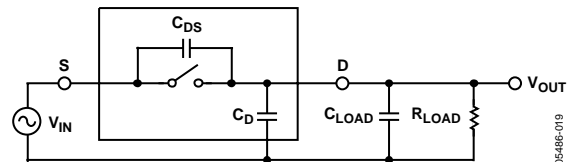
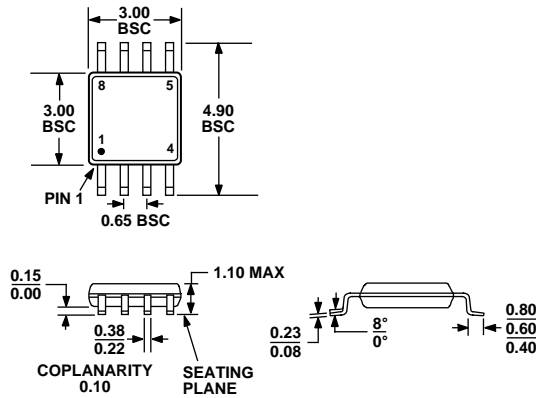


Figure 20. Off Isolation Is Affected by External Load Resistance and Capacitance

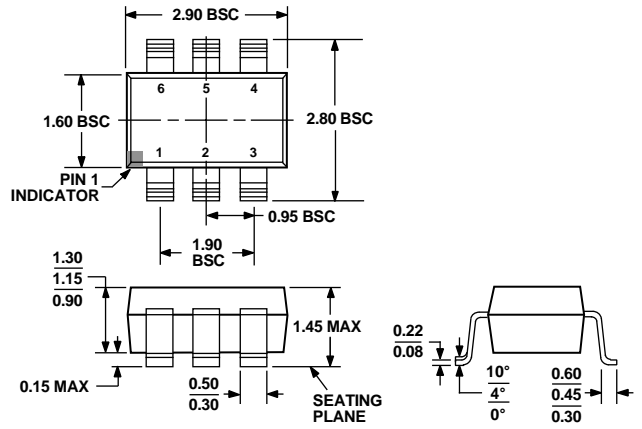
The larger the value of  $C_{DS}$ , the larger the values of feedthrough produced. Figure 10 illustrates the drop in off isolation as a function of frequency. From dc to roughly 1 MHz, the switch shows better than  $-75$  dB isolation. Up to frequencies of 10 MHz, the off isolation remains better than  $-55$  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  $C_{DS}$  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.

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

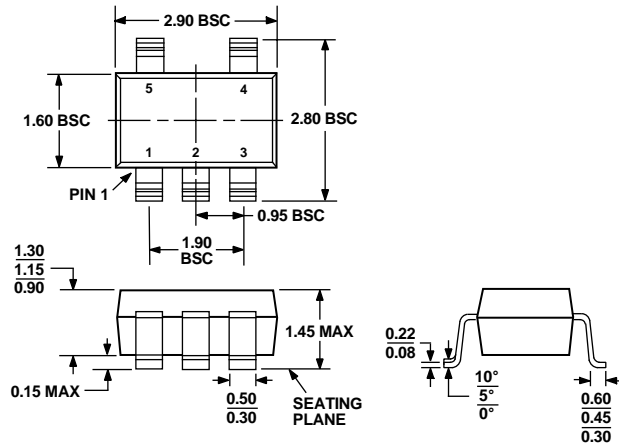
# OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-187-AA  
 Figure 21. 8-Lead Mini Small Outline Package [MSOP] (RM-8)  
 Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-178-AB  
 Figure 22. 6-Lead Small Outline Transistor Package [SOT-23] (RT-6)  
 Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-178-AA  
 Figure 23. 5-Lead Small Outline Transistor Package [SOT-23] (RJ-5)  
 Dimensions shown in millimeters

# ADG701L/ADG702L

## ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding <sup>1</sup>
ADG701LBRJ-500RL7	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S15
ADG701LBRJ-REEL	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S15
ADG701LBRJ-REEL7	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S15
ADG701LBRJZ-500RL7 <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S10
ADG701LBRJZ-REEL <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S10
ADG701LBRJZ-REEL7 <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S10
ADG701LBRM	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S15
ADG701LBRM-REEL	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S15
ADG701LBRM-REEL7	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S15
ADG701LBRMZ <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S10
ADG701LBRMZ-REEL <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S10
ADG701LBRMZ-REEL7 <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S10
ADG701LBRT-REEL	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S15
ADG701LBRT-REEL7	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S15
ADG701LBRTZ-REEL <sup>2</sup>	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S10
ADG701LBRTZ-REEL7 <sup>2</sup>	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S10
ADG702LBRJ-REEL	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S16
ADG702LBRJ-REEL7	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S16
ADG702LBRJZ-500RL7 <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S11
ADG702LBRJZ-REEL <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S11
ADG702LBRJZ-REEL7 <sup>2</sup>	-40°C to +85°C	5-Lead Small Outline Transistor Package [SOT-23]	RJ-5	S11
ADG702LBRM	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S16
ADG702LBRM-REEL	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S16
ADG702LBRM-REEL7	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S16
ADG702LBRMZ <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S11
ADG702LBRMZ-REEL <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S11
ADG702LBRMZ-REEL7 <sup>2</sup>	-40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	S11
ADG702LBRT-REEL	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S16
ADG702LBRT-REEL7	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S16
ADG702LBRTZ-REEL <sup>2</sup>	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S11
ADG702LBRTZ-REEL7 <sup>2</sup>	-40°C to +85°C	6-Lead Small Outline Transistor Package [SOT-23]	RT-6	S11

<sup>1</sup> Due to package size limitations, these three characters represent the part number.

<sup>2</sup> Z = Pb-free part.