

## FEATURES

- 1.3 pF off capacitance
- 3.5 pF on capacitance
- 1 pC charge injection
- 33 V supply range
- 120  $\Omega$  on resistance
- Fully specified at +12 V,  $\pm 15$  V
- No  $V_L$  supply required
- 3 V logic-compatible inputs
- Rail-to-rail operation
- 16-lead TSSOP and 12-lead LFCSP packages
- Typical power consumption: <0.03  $\mu$ W

## APPLICATIONS

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

## GENERAL DESCRIPTION

The **ADG1236** is a monolithic CMOS device containing two independently selectable SPDT switches. It is designed on an *i*CMOS<sup>®</sup> process. *i*CMOS (industrial CMOS) is a modular manufacturing process combining high voltage complementary metal-oxide semiconductor (CMOS) and bipolar technologies. It enables the development of a wide range of high performance analog ICs capable of 33 V operation in a footprint that no previous generation of high voltage devices 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.

The ultralow capacitance and charge injection of the device make it an ideal solution for data acquisition and sample-and-hold applications, where low glitch and fast settling are required. Fast switching speed coupled with high signal bandwidth makes the device suitable for video signal switching. *i*CMOS construction ensures ultralow power dissipation, making the device ideally suited for portable and battery-powered instruments.

## FUNCTIONAL BLOCK DIAGRAM

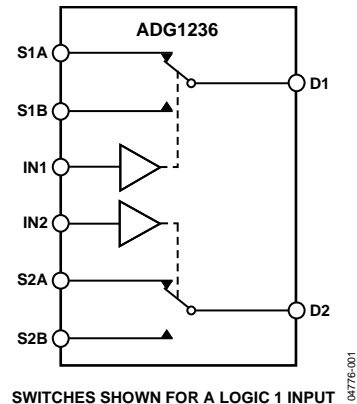


Figure 1.

Each switch conducts equally well in both directions when on and has an input signal range that extends to the supplies. In the off condition, signal levels up to the supplies are blocked. Both switches exhibit break-before-make switching action for use in multiplexer applications.

## PRODUCT HIGHLIGHTS

1. 1.3 pF off capacitance ( $\pm 15$  V supply).
2. 1 pC charge injection.
3. 3 V logic-compatible digital inputs:  $V_{IH} = 2.0$  V,  $V_{IL} = 0.8$  V.
4. No  $V_L$  logic power supply required.
5. Ultralow power dissipation: <0.03  $\mu$ W.
6. 16-lead TSSOP and 12-lead 3 mm  $\times$  3 mm LFCSP packages.

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**REVISION HISTORY**

**3/16—Rev. 0 to Rev. A**

Changes to Figure 2 and Figure 3 .....	7
Updated Outline Dimensions .....	14
Changes to Ordering Guide .....	14

**9/05—Revision 0: Initial Version**

## SPECIFICATIONS

## DUAL SUPPLY

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

Table 1.

Parameters	Y Version <sup>1</sup>			Unit	Test Conditions/Comments <sup>1</sup>
	25°C	-40°C to +85°C	-40°C to +125°C		
<b>ANALOG SWITCH</b>					
Analog Signal Range			$V_{DD}$ to $V_{SS}$	V	
On Resistance ( $R_{ON}$ )	120			$\Omega$ typ	$V_S = \pm 10\text{ V}$ , $I_S = -1\text{ mA}$ ; Figure 20
	190	230	260	$\Omega$ max	$V_{DD} = +13.5\text{ V}$ , $V_{SS} = -13.5\text{ V}$
On Resistance Match Between Channels ( $\Delta R_{ON}$ )	3.5			$\Omega$ typ	$V_S = \pm 10\text{ V}$ , $I_S = -1\text{ mA}$
	6	10	12	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	20			$\Omega$ typ	$V_S = -5\text{ V}, 0\text{ V}, +5\text{ V}$ ; $I_S = -1\text{ mA}$
	57	72	79	$\Omega$ max	
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage, $I_S$ (Off)	$\pm 0.02$			nA typ	$V_{DD} = +16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$
	$\pm 0.1$	$\pm 0.6$	$\pm 1$	nA max	$V_S = \pm 10\text{ V}$ , $V_S = \mp 10\text{ V}$ ; Figure 21
Drain Off Leakage, $I_D$ (Off)	$\pm 0.02$			nA typ	$V_S = \pm 10\text{ V}$ , $V_S = \mp 10\text{ V}$ ; Figure 21
	$\pm 0.1$	$\pm 0.6$	$\pm 1$	nA max	
Channel On Leakage, $I_D$ , $I_S$ (On)	$\pm 0.02$			nA typ	$V_S = V_D = \pm 10\text{ V}$ ; Figure 22
	$\pm 0.2$	$\pm 0.6$	$\pm 1$	nA max	
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{INH}$			2.0	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	
Digital Input Capacitance, $C_{IN}$	2			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
Transition Time, $t_{TRANS AOFF B0N}$	125			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
	150		200	ns max	$V_S = 10\text{ V}$ ; Figure 23
Transition Time, $t_{TRANS BOFF A0N}$	70			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
	90		115	ns max	$V_S = 10\text{ V}$ ; Figure 23
Break-Before-Make Time Delay, $t_D$	25			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
			10	ns min	$V_{S1} = V_{S2} = 10\text{ V}$ ; Figure 24
Charge Injection	-1			pC typ	$V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; Figure 25
Off Isolation	80			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 26
Channel-to-Channel Crosstalk	85			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 27
Total Harmonic Distortion + Noise	0.15			% typ	$R_L = 10\text{ k}\Omega$ , $5\text{ V rms}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$
-3 dB Bandwidth	1000			MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; Figure 28
$C_S$ (Off)	1.3			pF typ	$f = 1\text{ MHz}$ ; $V_S = 0\text{ V}$
	1.6			pF max	$f = 1\text{ MHz}$ ; $V_S = 0\text{ V}$
$C_D$ , $C_S$ (On)	3.5			pF typ	$f = 1\text{ MHz}$ ; $V_S = 0\text{ V}$
	4.3			pF max	$f = 1\text{ MHz}$ ; $V_S = 0\text{ V}$

Parameters	Y Version <sup>1</sup>			Unit	Test Conditions/Comments <sup>1</sup>
	25°C	-40°C to +85°C	-40°C to +125°C		
POWER REQUIREMENTS					$V_{DD} = +16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$
$I_{DD}$	0.001		1.0	$\mu\text{A typ}$ $\mu\text{A max}$	Digital inputs = 0 V or $V_{DD}$
$I_{DD}$	170		230	$\mu\text{A typ}$ $\mu\text{A max}$	Digital inputs = 5 V
$I_{SS}$	0.001		1.0	$\mu\text{A typ}$ $\mu\text{A max}$	Digital inputs = 0 V or $V_{DD}$
$I_{SS}$	0.001		1.0	$\mu\text{A typ}$ $\mu\text{A max}$	Digital inputs = 5 V

<sup>1</sup> Temperature range for Y version is -40°C to +125°C.

<sup>2</sup> Guaranteed by design; not subject to production test.

**SINGLE SUPPLY**

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

**Table 2.**

Parameters	Y Version <sup>1</sup>			Unit	Test Conditions/Comments
	25°C	-40°C to +85°C	-40°C to +125°C		
<b>ANALOG SWITCH</b>					
Analog Signal Range			0 V to $V_{DD}$	V	
On Resistance ( $R_{ON}$ )	300			$\Omega$ typ	$V_S = 0\text{ V to }10\text{ V}$ , $I_S = -1\text{ mA}$ ; Figure 20
	475	567	625	$\Omega$ max	$V_{DD} = 10.8\text{ V}$ , $V_{SS} = 0\text{ V}$
On Resistance Match Between Channels ( $\Delta R_{ON}$ )	4.5			$\Omega$ typ	$V_S = 0\text{ V to }10\text{ V}$ , $I_S = -1\text{ mA}$
	16	26	27	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	60			$\Omega$ typ	$V_S = 3\text{ V, }6\text{ V, }9\text{ V}$ , $I_S = -1\text{ mA}$
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage, $I_S$ (Off)	$\pm 0.02$			nA typ	$V_{DD} = 13.2\text{ V}$
	$\pm 0.1$	$\pm 0.6$	$\pm 1$	nA max	$V_S = 1\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/1\text{ V}$ ; Figure 21
Drain Off Leakage, $I_D$ (Off)	$\pm 0.02$			nA typ	$V_S = 1\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/1\text{ V}$ ; Figure 21
	$\pm 0.1$	$\pm 0.6$	$\pm 1$	nA max	
Channel On Leakage, $I_D$ , $I_S$ (On)	$\pm 0.02$			nA typ	$V_S = V_D = 1\text{ V or }10\text{ V}$ , Figure 22
	$\pm 0.2$	$\pm 0.6$	$\pm 1$	nA max	
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{INH}$			2.0	V min	
Input Low Voltage, $V_{INL}$			0.8	V max	
Input Current, $I_{INL}$ or $I_{INH}$	0.001			$\mu\text{A}$ typ	$V_{IN} = V_{INL}$ or $V_{INH}$
			$\pm 0.1$	$\mu\text{A}$ max	
Digital Input Capacitance, $C_{IN}$	3			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
Transition Time, $t_{TRANS\ OFF\ AON}$	105			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
	140		175	ns max	$V_S = 8\text{ V}$ ; Figure 23
Transition Time, $t_{TRANS\ AOFF\ BON}$	155			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
	190		255	ns max	$V_S = 8\text{ V}$ ; Figure 23
Break-Before-Make Time Delay, $t_D$	50			ns typ	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$
			10	ns min	$V_{S1} = V_{S2} = 8\text{ V}$ ; Figure 24
Charge Injection	-0.8			pC typ	$V_S = 6\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; Figure 25
Off Isolation	75			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 26;
Channel-to-Channel Crosstalk	85			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 27
-3 dB Bandwidth	800			MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; Figure 28
$C_S$ (Off)	1.6			pF typ	$f = 1\text{ MHz}$ ; $V_S = 6\text{ V}$
	1.9			pF max	$f = 1\text{ MHz}$ ; $V_S = 6\text{ V}$
$C_D$ , $C_S$ (On)	4			pF typ	$f = 1\text{ MHz}$ ; $V_S = 6\text{ V}$
	4.9			pF max	$f = 1\text{ MHz}$ ; $V_S = 6\text{ V}$
<b>POWER REQUIREMENTS</b>					
$I_{DD}$	0.001			$\mu\text{A}$ typ	$V_{DD} = 13.2\text{ V}$
			1.0	$\mu\text{A}$ max	Digital inputs = 0 V or $V_{DD}$
$I_{DD}$	170			$\mu\text{A}$ typ	Digital inputs = 5 V
			230	$\mu\text{A}$ max	

<sup>1</sup> Temperature range for Y version is -40°C to +125°C.

<sup>2</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 $V_{SS}$	35 V
$V_{DD}$ to GND	-0.3 V to +25 V
$V_{SS}$ to GND	+0.3 V to -25 V
Analog Inputs <sup>1</sup>	$V_{SS} - 0.3\text{ V}$ to $V_{DD} + 0.3\text{ V}$ or 30 mA, whichever occurs first
Digital Inputs <sup>1</sup>	GND - 0.3 V to $V_{DD} + 0.3\text{ V}$ or 30 mA, whichever occurs first
Peak Current, S or D	100 mA (pulsed at 1 ms, 10% duty cycle max)
Continuous Current per Channel, S or D	25 mA
Operating Temperature Range Automotive (Y Version)	-40°C to +125°C
Storage Temperature Range	-65°C to +150°C
Junction Temperature	150°C
16-Lead TSSOP, $\theta_{JA}$ Thermal Impedance	112°C/W
12-Lead LFCSP, $\theta_{JA}$ Thermal Impedance	80°C/W
Reflow Soldering Peak Temperature, Pb Free	260°C

<sup>1</sup> Over voltages at IN, S, or D are clamped by internal diodes. Current must be limited to the maximum ratings given.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

### ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

### TRUTH TABLE FOR SWITCHES

Table 4.

IN	Switch A	Switch B
0	Off	On
1	On	Off

# PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

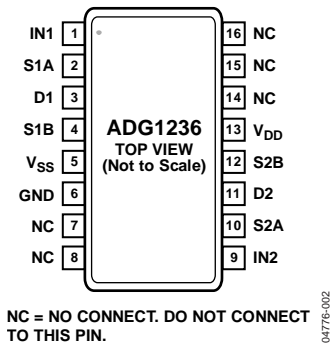


Figure 2. TSSOP Pin Configuration

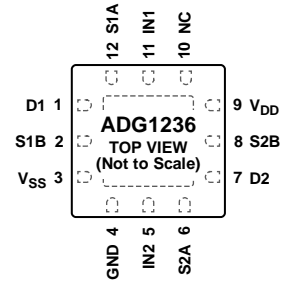


Figure 3. LFCSP Pin Configuration

Table 5. Pin Function Descriptions

Pin No.		Mnemonic	Description
TSSOP	LFCSP		
1	11	IN1	Logic Control Input.
2	12	S1A	Source Terminal. Can be an input or output.
3	1	D1	Drain Terminal. Can be an input or output.
4	2	S1B	Source Terminal. Can be an input or output.
5	3	V <sub>SS</sub>	Most Negative Power Supply Potential.
6	4	GND	Ground (0 V) Reference.
7, 8, 14 to 16	10	NC	No Connect.
9	5	IN2	Logic Control Input.
10	6	S2A	Source Terminal. Can be an input or output.
11	7	D2	Drain Terminal. Can be an input or output.
12	8	S2B	Source Terminal. Can be an input or output.
13	9	V <sub>DD</sub>	Most Positive Power Supply Potential.

## TERMINOLOGY

**I<sub>DD</sub>**

The positive supply current.

**I<sub>SS</sub>**

The negative supply current.

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

The analog voltage on Terminals D and S.

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

The 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</sub> (Off)**

The source leakage current with the switch off.

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

The drain leakage current with the switch off.

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

The channel leakage current with the switch on.

**V<sub>INL</sub>**

The maximum input voltage for Logic 0.

**V<sub>INH</sub>**

The minimum input voltage for Logic 1.

**I<sub>INL</sub> (I<sub>INH</sub>)**

The input current of the digital input.

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

The off switch source capacitance, measured with reference to ground.

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

The off switch drain capacitance, measured with reference to ground.

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

The on switch capacitance, measured with reference to ground.

**C<sub>IN</sub>**

The digital input capacitance.

**t<sub>TRANS</sub>**

The delay time between the 50% and 90% points of the digital input and switch on condition when switching from one address state to another.

**Charge Injection**

A measure of the glitch impulse transferred from the digital input to the analog output during switching.

**Off Isolation**

A measure of unwanted signal coupling through an off switch.

**Crosstalk**

A measure of unwanted signal that is coupled through from one channel to another as a result of parasitic capacitance.

**Bandwidth**

The frequency at which the output is attenuated by 3 dB.

**On Response**

The frequency response of the on switch.

**Insertion Loss**

The loss due to the on resistance of the switch.

**THD + N**

The ratio of the harmonic amplitude plus noise of the signal to the fundamental.



### TYPICAL PERFORMANCE CHARACTERISTICS

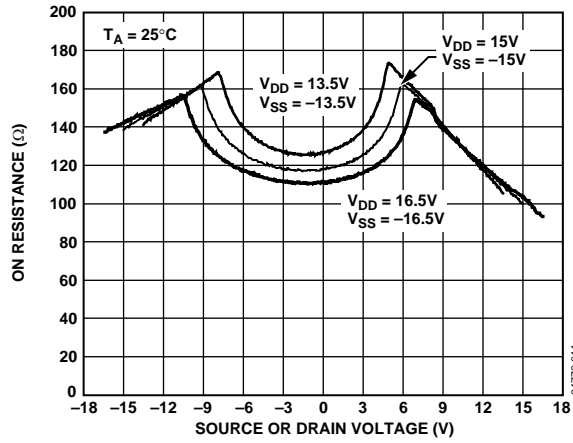


Figure 4. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Dual Supply

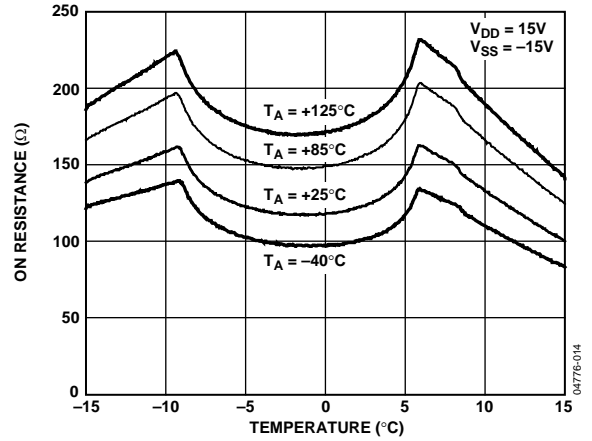


Figure 7. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures, Dual Supply

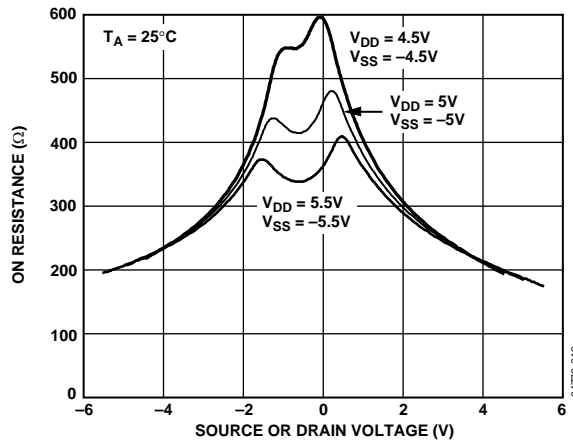


Figure 5. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Dual Supply

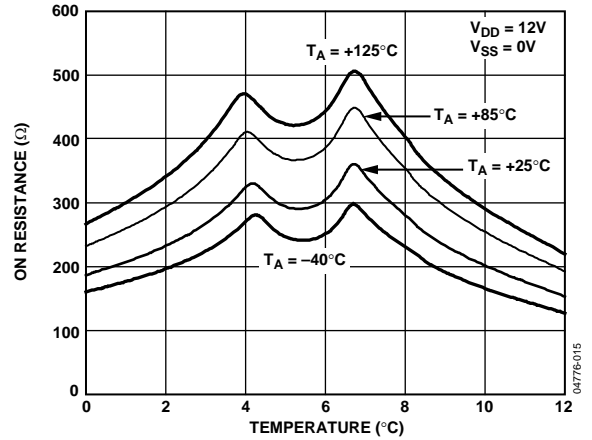


Figure 8. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures, Single Supply

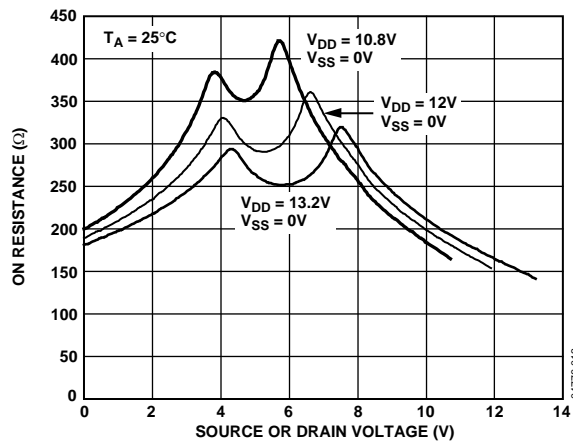


Figure 6. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Single Supply

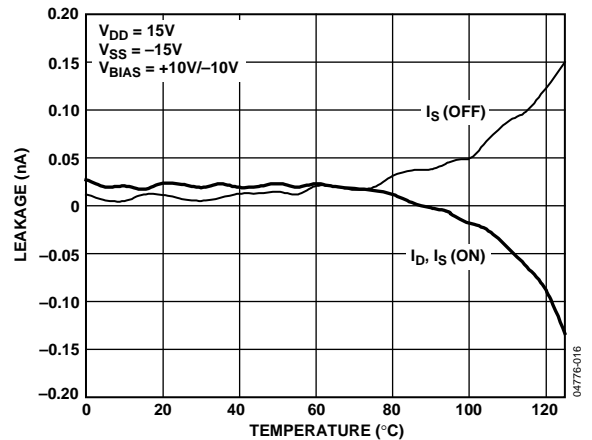


Figure 9. Leakage Currents as a Function of Temperature, Dual Supply

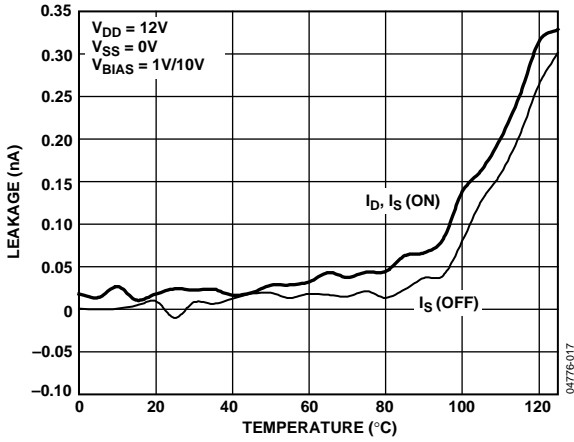


Figure 10. Leakage Currents as a Function of Temperature, Single Supply

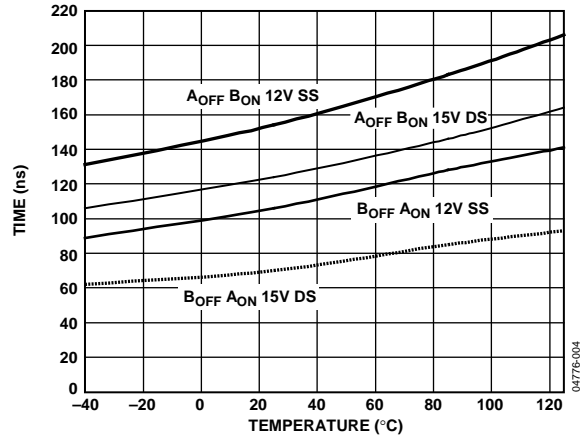


Figure 13.  $t_{TRANSITION}$  Times vs. Temperature

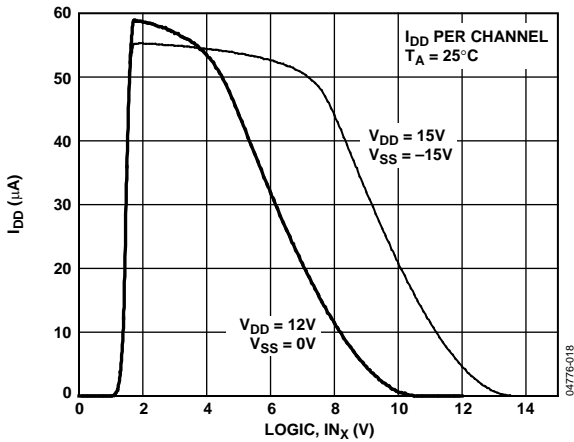


Figure 11.  $I_{DD}$  vs. Logic Level

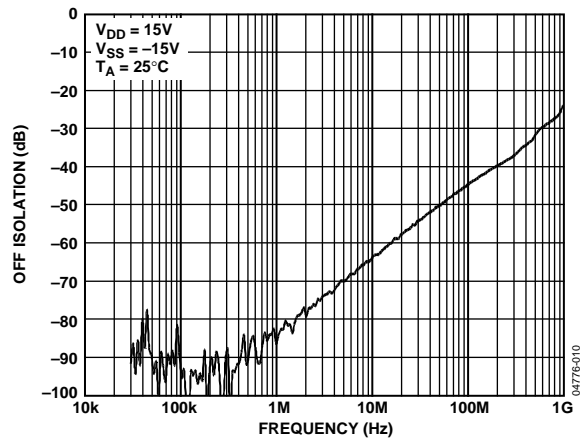


Figure 14. Off Isolation vs. Frequency

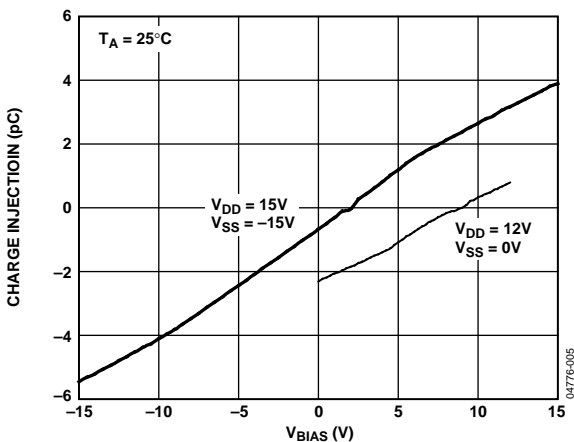


Figure 12. Charge Injection vs. Source Voltage

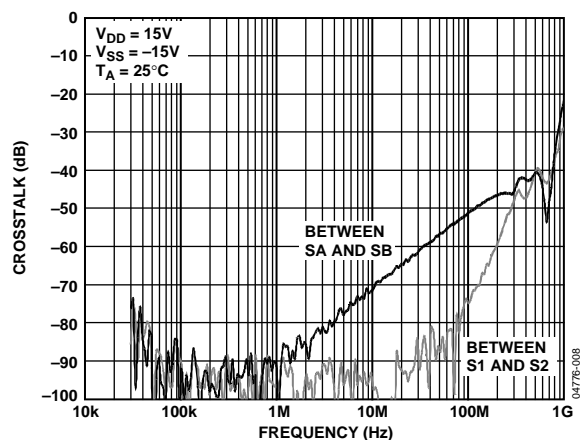


Figure 15. Crosstalk vs. Frequency

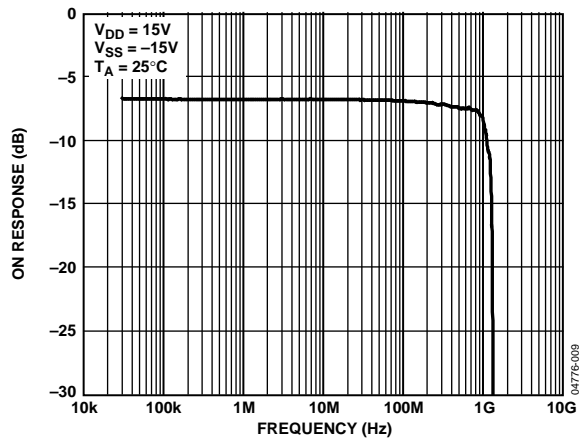


Figure 16. On Response vs. Frequency

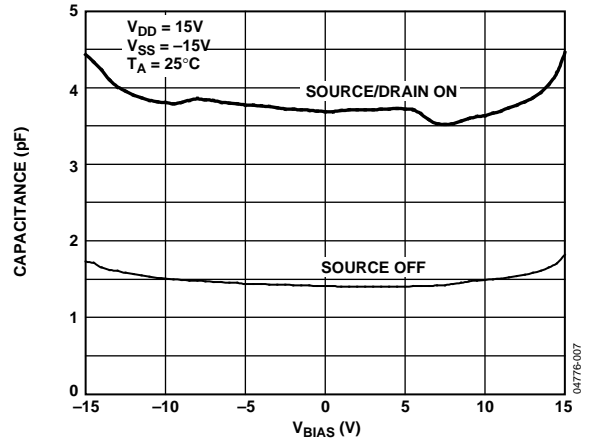


Figure 18. Capacitance vs. Source Voltage for Dual Supply

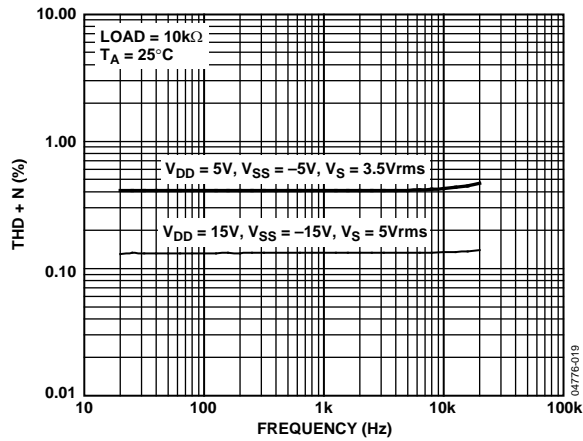


Figure 17. THD + N vs. Frequency

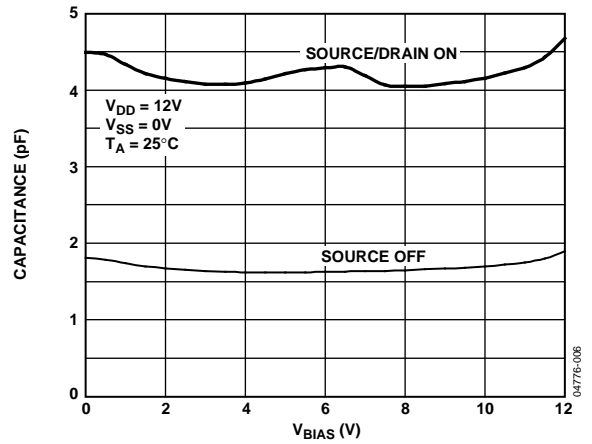


Figure 19. Capacitance vs. Source Voltage for Single Supply

TEST CIRCUITS

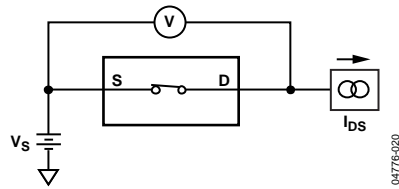


Figure 20. Test Circuit 1—On Resistance

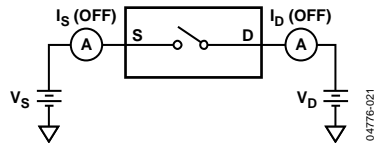


Figure 21. Test Circuit 2—Off Resistance

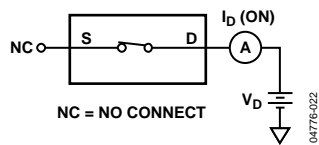


Figure 22. Test Circuit 3—On Leakage

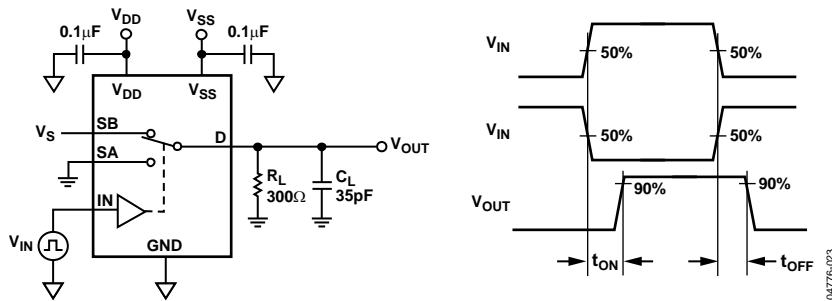


Figure 23. Test Circuit 4—Switching Times

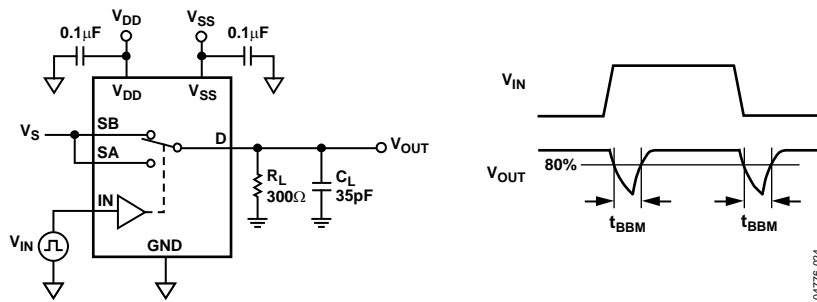


Figure 24. Test Circuit 5—Break-Before-Make Time Delay

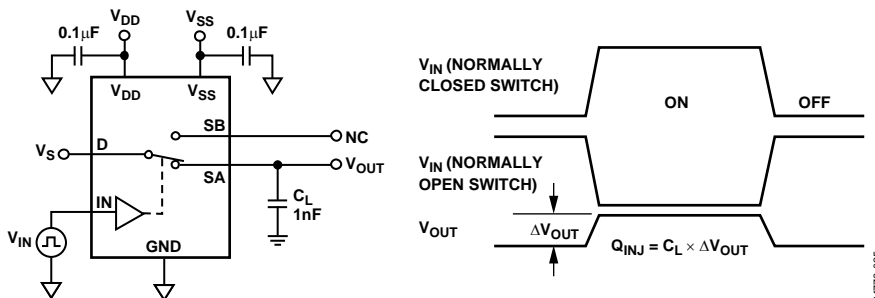


Figure 25. Test Circuit 6—Charge Injection

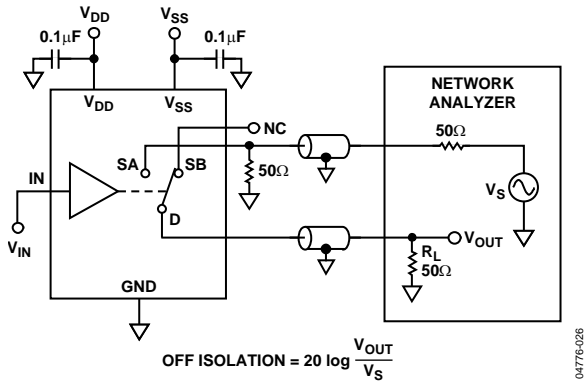


Figure 26. Test Circuit 7—Off Isolation

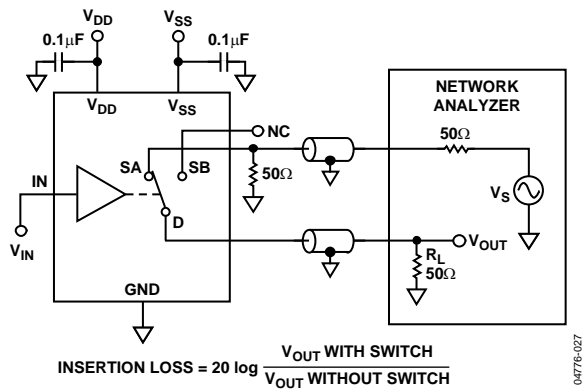


Figure 27. Test Circuit 8—Channel-to-Channel Crosstalk

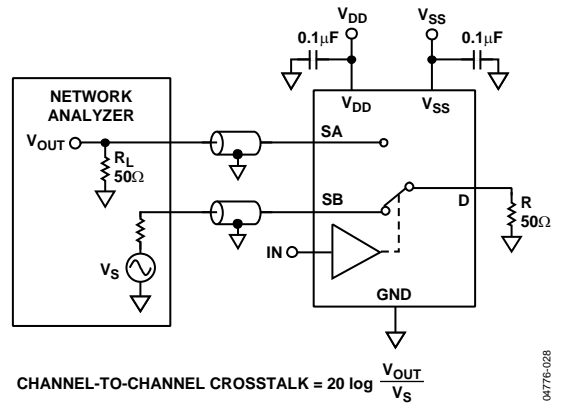


Figure 28. Test Circuit 9—Bandwidth

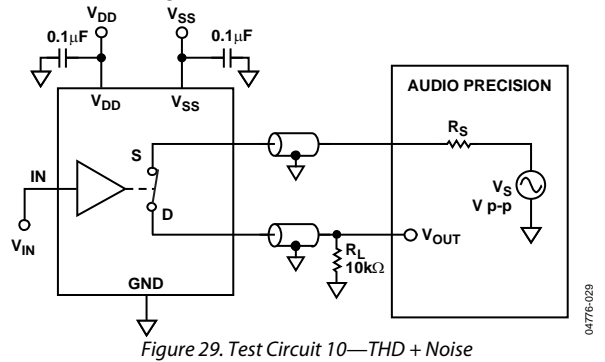


Figure 29. Test Circuit 10—THD + Noise

OUTLINE DIMENSIONS

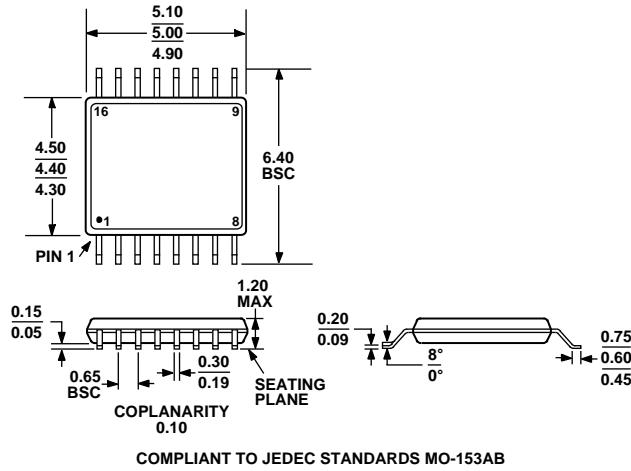


Figure 30. 16-Lead Thin Shrink Small Outline Package [TSSOP] (RU-16)  
Dimensions shown in millimeters

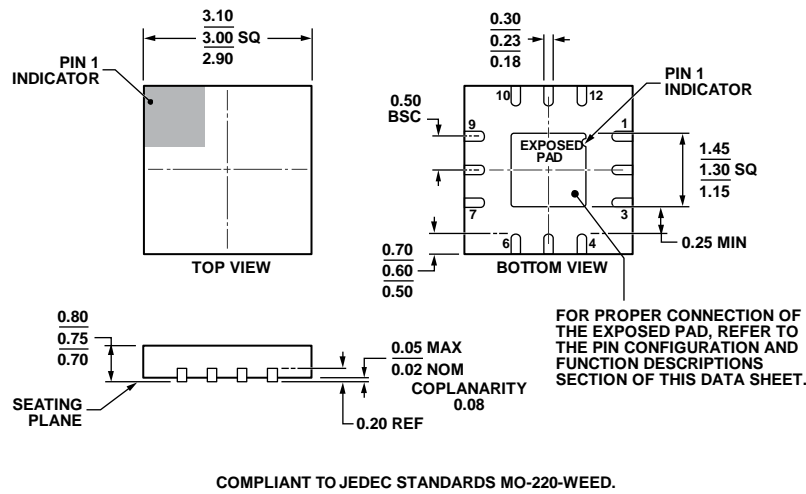


Figure 31. 12-Lead Lead Frame Chip Scale Package [LFCSP] 3 mm x 3 mm Body and 0.75 mm Package Height (CP-12-4)  
Dimensions shown in millimeters

ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	Package Description	Package Option
ADG1236YRUZ	-40°C to +125°C	16-Lead Thin Shrink Small Outline Package [TSSOP]	RU-16
ADG1236YRUZ-REEL	-40°C to +125°C	16-Lead Thin Shrink Small Outline Package [TSSOP]	RU-16
ADG1236YRUZ-REEL7	-40°C to +125°C	16-Lead Thin Shrink Small Outline Package [TSSOP]	RU-16
ADG1236YCPZ-500RL7	-40°C to +125°C	12-Lead Lead Frame Chip Scale Package [LFCSP]	CP-12-4
ADG1236YCPZ-REEL7	-40°C to +125°C	12-Lead Lead Frame Chip Scale Package [LFCSP]	CP-12-4

<sup>1</sup> Z = RoHS Compliant Part.

**NOTES**

**NOTES**



Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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