2Ω Max On Resistance, ±15 V/12 V/±5 V 4:1 *i*CMOS™ Multiplexer

Preliminary Technical Data

ADG1404

FEATURES

2Ω Max On Resistance
0.5Ω Max On Resistance Flatness
200mA Continuous current
33 V supply range
Fully specified at +12 V, ±15 V, ±5 V
No V_L supply required
3 V logic-compatible inputs
Rail-to-rail operation
14-lead TSSOP and 16-lead LFCSP

APPLICATIONS

Automatic test equipment
Data aquisition systems
Battery-powered systems
Sample-and-hold systems
Audio signal routing
Communication systems
Relay Replacement

FUNCTIONAL BLOCK DIAGRAM

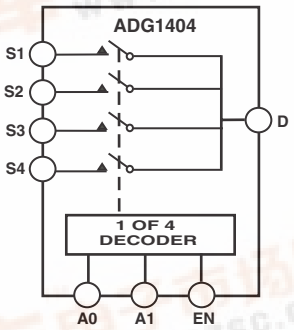

Figure 1.

GENERAL DESCRIPTION

The ADG1404 is a complementary metal-oxide semiconductor (CMOS) analog multiplexer, comprising four single channels designed on an *i*CMOS process. *i*CMOS (industrial CMOS) is a modular manufacturing process that combines high voltage 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 parts 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 on resistance profile is very flat over the full analog input range ensuring excellent linearity and low distortion when switching audio signals.

*i*CMOS construction ensures ultralow power dissipation, making the parts ideally suited for portable and battery-powered instruments.

The ADG1404 switches one of four inputs to a common output, D, as determined by the 3-bit binary address lines, A0, A1, and EN. Logic 0 on the EN pin disables the device. 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. All switches exhibit break-before-make switching action. Inherent in the design is low charge injection for minimum transients when switching the digital inputs.

PRODUCT HIGHLIGHTS

1. 2Ω Max On Resistance over temperature.
2. Minimum distortion
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 µW.
6. 14-lead TSSOP and 16-lead 4 mm × 4 mm LFCSP package.

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SPECIFICATIONS

DUAL SUPPLY

V_{DD} = 15 V ± 10%, V_{SS} = −15 V± 10%, GND = 0 V, unless otherwise noted.

Table 1.

	25°C	−40°C to + 85°C	−40°C to + 125°C		
ANALOG SWITCH					
Analog Signal Range			V_{DD} to V_{SS}	V	
On Resistance (R_{ON})	1.5			Ω typ	V_S = ±10 V, I_S = −10 mA; Figure 21
		2		Ω max	V_{DD} = +13.5 V, V_{SS} = −13.5 V
On Resistance Match Between Channels (ΔR_{ON})	0.1			Ω typ	V_S = ±10 V, I_S = −10 mA
		0.5		Ω max	
On Resistance Flatness ($R_{FLAT(ON)}$)	0.1			Ω typ	V_S = −5 V, 0 V, +5 V; I_S = −10 mA
		0.5		Ω max	
LEAKAGE CURRENTS					V_{DD} = +16.5 V, V_{SS} = −16.5 V
Source Off Leakage, I_S (Off)	±0.01			nA typ	V_S = ±10 V, V_s = ∓10 V; Figure 22
	±0.5	±2.5	±5	nA max	
Drain Off Leakage, I_D (Off)	±0.01			nA typ	V_S = ±10 V, V_s = ∓10 V ; Figure 22
	±0.5	±2.5	±5	nA max	
Channel On Leakage, I_D, I_S (On)	±0.04			nA typ	V_S = V_D = ±10 V; Figure 23
	±1	±2.5	±5	nA max	
DIGITAL INPUTS					
Input High Voltage, V_{INH}			2.0	V min	
Input Low Voltage, V_{INL}			0.8	V max	
Input Current, I_{INL}or I_{NH}	0.005			μA typ	V_{IN} = V_{INL} or V_{INH}
			±0.5	μA max	
Digital Input Capacitance, C_{IN}	2.5			pF typ	
DYNAMIC CHARACTERISTICS[1]					
Transition Time, t_{TRANS}	120			ns typ	R_L = 300 Ω, C_L = 35 pF
	150	200	200	ns max	V_S = +10 V; Figure 24
t_{ON} (EN)	70			ns typ	R_L = 300 Ω, C_L = 35 pF
	85	110	110	ns max	V_S = +10 V; Figure 24
t_{OFF} (EN)	90			ns typ	R_L = 300 Ω, C_L = 35 pF
	110	155	155	ns max	V_S = +10 V; Figure 24
Break-Before-Make Time Delay, t_D	25			ns typ	R_L = 300 Ω, C_L = 35 pF
		10	10	ns min	V_{S1} = V_{S2} = 10 V; Figure 25
Charge Injection	50			pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF; Figure 26
Off Isolation	50			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Figure 27
Channel-to-Channel Crosstalk	60			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Figure 28
Total Harmonic Distortion + Noise	0.01			% typ	R_L = 110 Ω, 5 V rms, f = 20 Hz to 20 kHz
−3 dB Bandwidth	50			MHz typ	R_L = 50 Ω, C_L = 5 pF; Figure 29
Insertion Loss	0.17			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Figure 29
C_S (Off)	35			pF typ	f = 1 MHz; V_S = 0 V
				pF max	f = 1 MHz; V_S = 0 V
C_D (Off)	100			pF typ	f = 1 MHz; V_S = 0 V
				pF max	f = 1 MHz; V_S = 0 V
C_D, C_S (On)	150			pF typ	f = 1 MHz; V_S = 0 V
				pF max	f = 1 MHz; V_S = 0 V
POWER REQUIREMENTS					V_{DD} = +16.5 V, V_{SS} = −16.5 V
I_{DD}	0.001			μA typ	Digital inputs = 0 V or V_{DD}

	25°C	−40°C to + 85°C	−40°C to + 125°C		
			1	µA max	
I_{DD}	150			µA typ	Digital inputs = 5 V
			300	µA max	
I_{SS}	0.001			µA typ	Digital inputs = 0 V, 5V or V_{DD}
			1	µA max	
V_{DD}/V_{SS}			±4.5/±16.5	V min/max	Gnd = 0V

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

SINGLE SUPPLY

V_{DD} = 12 V ± 10%, V_{SS} = 0 V, GND = 0 V, unless otherwise noted.

Table 2.

	25°C	−40°C to +85°C	−40°C to +125°C		
ANALOG SWITCH					
Analog Signal Range			0 V to V_{DD}	V	
On Resistance (R_{ON})	2.5			Ω typ	V_S = 10 V, I_S = −10 mA; Figure 21
	3	4		Ω max	V_{DD} = +10.8 V, V_{SS} = 0 V
On Resistance Match Between	0.1			Ω typ	V_S = 10 V, I_S = −10 mA
Channels (ΔR_{ON})				Ω max	
On Resistance Flatness ($R_{FLAT(ON)}$)	0.1			Ω typ	V_S = 3 V, 6 V, 9 V; I_S = −10 mA
LEAKAGE CURRENTS					V_{DD} = 13.2 V
Source Off Leakage, I_S (Off)	±0.01			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V; Figure 22
	±0.5	±2.5	±5	nA max	
Drain Off Leakage, I_D (Off)	±0.01			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V; Figure 22
	±0.5	±2.5	±5	nA max	
Channel On Leakage, I_D, I_S (On)	±0.04			nA typ	V_S = V_D = 1 V or 10 V; Figure 23
	±1	±2.5	±5	nA max	
DIGITAL INPUTS					
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			μA typ	V_{IN} = V_{INL} or V_{INH}
			±0.5	μA max	
Digital Input Capacitance, C_{IN}	2.5			pF typ	
DYNAMIC CHARACTERISTICS[1]					
Transition Time, t_{TRANS}	150			ns typ	R_L = 300 Ω, C_L = 35 pF
	190		265	ns max	V_S = 8 V; Figure 24
t_{ON} (EN)	95			ns typ	R_L = 300 Ω, C_L = 35 pF
	120		170	ns max	V_S = 8 V; Figure 24
t_{OFF} (EN)	100			ns typ	R_L = 300 Ω, C_L = 35 pF
	125		170	ns max	V_S = 8 V; Figure 24
Break-Before-Make Time Delay, t_D	50			ns typ	R_L = 300 Ω, C_L = 35 pF
			10	ns min	V_{S1} = V_{S2} = 8 V; Figure 25
Charge Injection	50			pC typ	V_S = 6 V, R_S = 0 Ω, C_L = 1 nF; Figure 26
Off Isolation	50			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Figure 27
Channel-to-Channel Crosstalk	60			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; Figure 28
−3 dB Bandwidth	50			MHz typ	R_L = 50 Ω, C_L = 5 pF; Figure 29
C_S (Off)	35			pF typ	f = 1 MHz; V_S = 6V
				pF max	f = 1 MHz; V_S = 6V
C_D (Off)	100			pF typ	f = 1 MHz; V_S = 6 V
				pF max	f = 1 MHz; V_S = 6 V
C_D, C_S (On)	150			pF typ	f = 1 MHz; V_S = 6 V
				pF max	f = 1 MHz; V_S = 6 V
POWER REQUIREMENTS					V_{DD} = 13.2 V
I_{DD}	0.001			μA typ	Digital inputs = 0 V or V_{DD}
			1	μA max	
I_{DD}	150			μA typ	Digital inputs = 5 V
			300	μA max	
V_{DD}			5/16.5	V min/max	Gnd = 0V, Vss = 0V

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

DUAL SUPPLY

V_{DD} = 5 V ± 10%, V_{SS} = -5 V ± 10%, GND = 0 V, unless otherwise noted.

Table 3.

	25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			0 V to V_{DD}	V	
On Resistance (R_{ON})	4			Ω typ	V_S = ±3.3V, I_S = −10 mA; See figure x
	5			Ω max	V_{DD} = +4.5 V, V_{SS} = −4.5 V
On Resistance Match Between Channels (ΔR_{ON})	0.1			Ω typ	V_S = ±3.3 V , I_S = −10 mA
				Ω max	
On Resistance Flatness ($R_{FLAT(ON)}$)	0.1			Ω typ	V_S = −3 V/0 V/+3 V; I_S = −10 mA
LEAKAGE CURRENTS					V_{DD} = +5.5 V, V_{SS} = −5.5 V
Source Off Leakage, I_S (Off)	±0.01			nA typ	V_S = ±4.5 V, V_D = ∓4.5 V; See figure x
	±0.5	±2.5	±5	nA max	
Drain Off Leakage, I_D (Off)	±0.01			nA typ	V_S = ±4.5V, V_D = ∓4.5 V; See figure x
	±0.5	±2.5	±5	nA max	
Channel On Leakage, I_D, I_S (On)	±0.04			nA typ	V_S = V_D = ±4.5V; See figure x
	±1	±5	±5	nA max	
DIGITAL INPUTS					
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			μA typ	V_{IN} = V_{INL} or V_{INH}
			±0.5	μA max	
Digital Input Capacitance, C_{IN}	3			pF typ	
DYNAMIC CHARACTERISTICS[1]					
Transition Time, t_{TRANS}	150			ns typ	R_L = 300 Ω, C_L = 35 pF
	190		265	ns max	V_S = 3 V; Figure 24
t_{ON} (EN)	95			ns typ	R_L = 300 Ω, C_L = 35 pF
	120		170	ns max	V_S = 3 V; Figure 24
t_{OFF} (EN)	100			ns typ	R_L = 300 Ω, C_L = 35 pF
	125		170	ns max	V_S = 3 V; Figure 24
Break-Before-Make Time Delay, t_D	50			ns typ	R_L = 300 Ω, C_L = 35 pF
			10	ns min	V_{S1} = V_{S2} = 8 V; See figure x
Charge Injection	50			pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF; See figure x
Off Isolation	50			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; See figure x
Channel-to-Channel Crosstalk	60			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; See figure x
−3 dB Bandwidth	50			MHz typ	R_L = 50 Ω, C_L = 5 pF; See figure x
C_S (Off)	35			pF typ	Vs = 0V, f = 1 MHz
				pF max	Vs = 0V, f = 1 MHz
C_D (Off)	35			pF typ	Vs = 0V, f = 1 MHz
				pF max	Vs = 0V, f = 1 MHz
C_D, C_S (On)	150			pF typ	Vs = 0V, f = 1 MHz
				pF max	Vs = 0V, f = 1 MHz
POWER REQUIREMENTS					V_{DD} = 5.5 V , Vss = -5.5V
I_{DD}	0.001			μA typ	Digital inputs = 0 V, 5V or V_{DD}
			1	μA max	
V_{DD}/V_{SS}			±4.5/±16.5	V min/max	Gnd = 0V

ABSOLUTE MAXIMUM RATINGS

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

T_A = 25°C, unless otherwise noted.

Table 4.

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[1]	V_{SS} − 0.3 V to V_{DD} + 0.3 V
Digital Inputs	GND − 0.3 V to V_{DD} + 0.3 V or 30 mA, whichever occurs first
Peak Current, S or D	300 mA (pulsed at 1 ms, 10% duty cycle max)
Continuous Current, S or D	200 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, θ_{JA} Thermal Impedance	150.4°C/W
16-Lead LFCSP, θ_{JA} Thermal Impedance	72.7°C/W
Reflow Soldering Peak Temperature, Pb free	260°C

[1] 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 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.

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.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

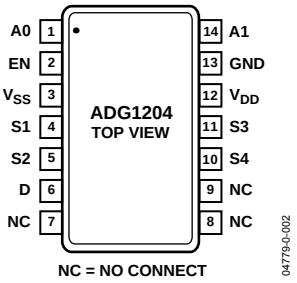


Figure 2. TSSOP Pin Configuration

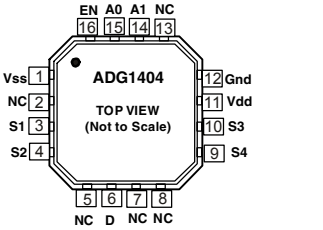


Figure 3. LFCSP Pin Configuration

Table 5. Pin Function Descriptions

Pin No.			
TSSOP	**LFCSP**	**Mnemonic**	**Description**
1	15	A0	Logic Control Input.
2	16	EN	Active High Digital Input. When low, the device is disabled and all switches are off. When high, Ax logic inputs determine on switches.
3	1	V_{SS}	Most Negative Power Supply Potential.
4	3	S1	Source Terminal. Can be an input or an output.
5	4	S2	Source Terminal. Can be an input or an output.
6	6	D	Drain Terminal. Can be an input or an output.
7 to 9	2,5,7,8, 13	NC	No Connection.
10	9	S4	Source Terminal. Can be an input or an output.
11	10	S3	Source Terminal. Can be an input or an output.
12	11	V_{DD}	Most Positive Power Supply Potential.
13	12	GND	Ground (0 V) Reference.
14	14	A1	Logic Control Input.

TRUTH TABLE

Table 6.

EN	A1	A0	S1	S2	S3	S4
0	X	X	Off	Off	Off	Off
1	0	0	On	Off	Off	Off
1	0	1	Off	On	Off	Off
1	1	0	Off	Off	On	Off
1	1	1	Off	Off	Off	On

TERMINOLOGY

I_{DD}
The positive supply current.

I_{SS}
The negative supply current.

V_D (V_S)
The analog voltage on Terminals D and S.

R_{ON}
The 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)
The source leakage current with the switch off.

I_D (Off)
The drain leakage current with the switch off.

I_D, I_S (On)
The channel leakage current with the switch on.

V_{INL}
The maximum input voltage for Logic 0.

V_{INH}
The minimum input voltage for Logic 1.

I_{INL} (I_{INH})
The input current of the digital input.

C_S (Off)
The off switch source capacitance, which is measured with reference to ground.

C_D (Off)
The off switch drain capacitance, which is measured with reference to ground.

C_D, C_S (On)
The on switch capacitance, which is measured with reference to ground.

C_{IN}
The digital input capacitance.

t_{ON} (EN)
The delay between applying the digital control input and the output switching on. See Figure 24, Test Circuit 4.

t_{OFF} (EN)
The delay between applying the digital control input and the output switching off.

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.

t_{TRANS}
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.

TYPICAL PERFORMANCE CHARACTERISTICS

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

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

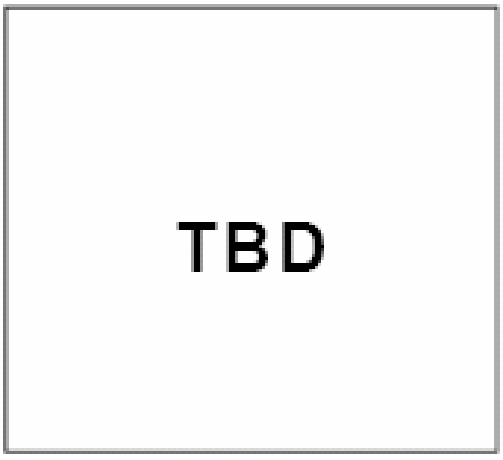


Figure 5. On Resistance as a Function of V_D (V_S) for Dual Supply

Figure 8. Leakage Currents as a Function of Temperature for Dual Supply

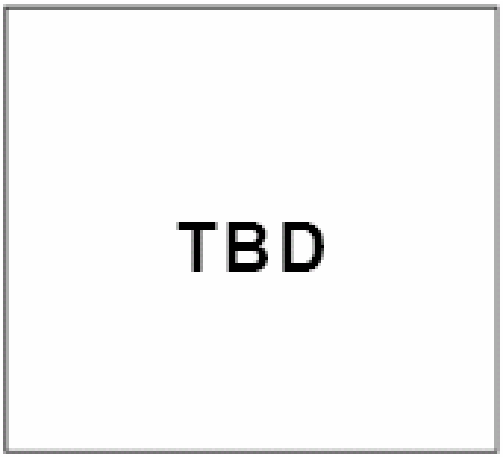


Figure 6. On Resistance as a Function of V_D (V_S) for Different Temperatures, Dual Supply

Figure 9. Leakage Currents as a Function of Temperature for Single Supply

Figure 10. Logic Threshold Voltage vs Supply Voltage

Figure 13. 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 17. THD + N vs. Frequency

Figure 18. Off Capacitance vs. Source Voltage

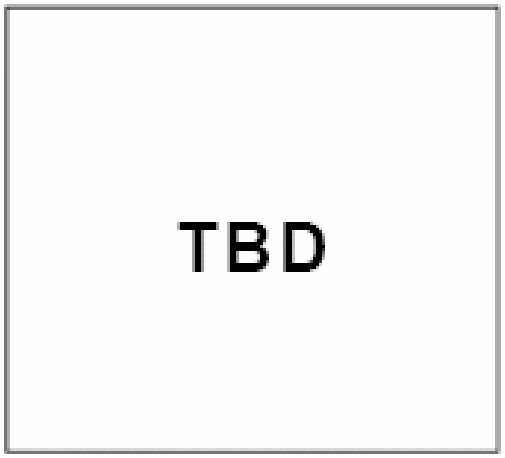


Figure 19. On Capacitance vs. Source Voltage

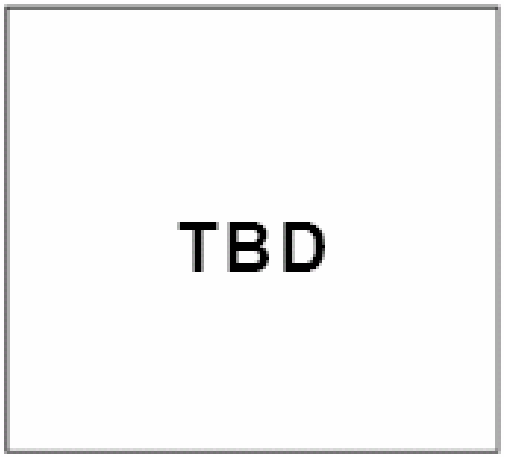


Figure 20. Capacitance vs. Source Voltage for Single Supply

TEST CIRCUITS

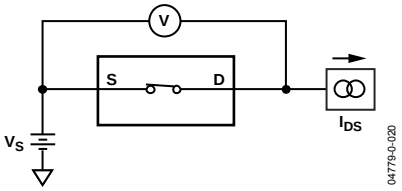


Figure 21. Test Circuit 1—On Resistance

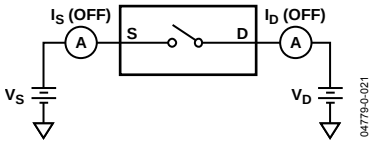


Figure 22. Test Circuit 2—Off Leakage

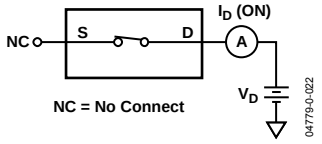
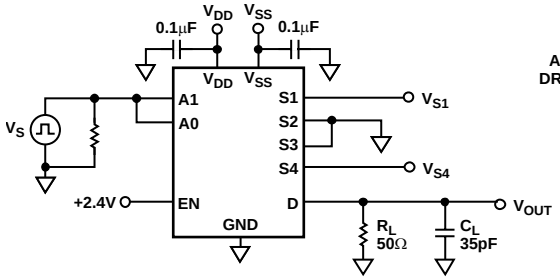


Figure 23. Test Circuit 3—On Leakage



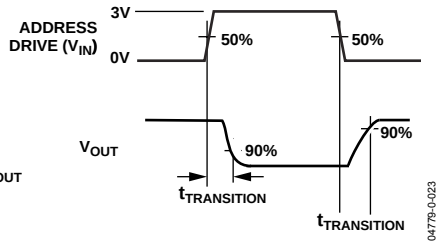
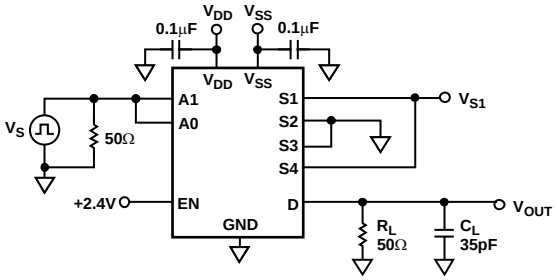


Figure 24. Test Circuit 4—Address to Output Switching Times



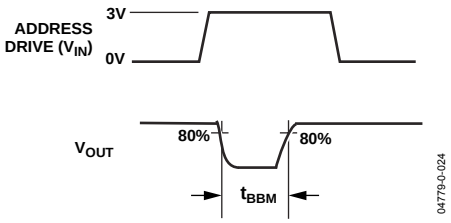
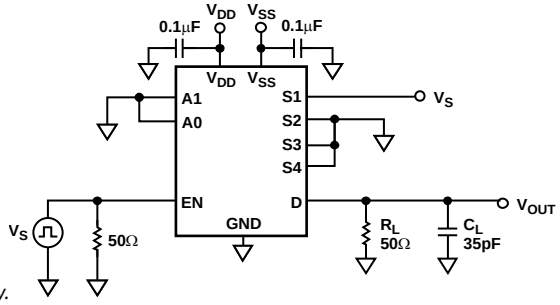
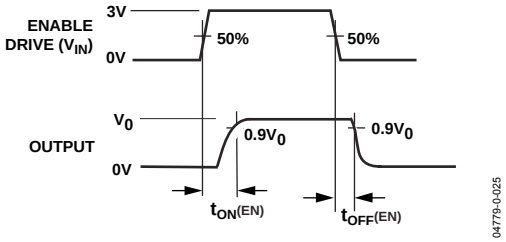


Figure 25. Test Circuit 5—Break-Before-Make Time





Delay.

Figure 26. Test Circuit 6—Enable-to-Output Switching Delay

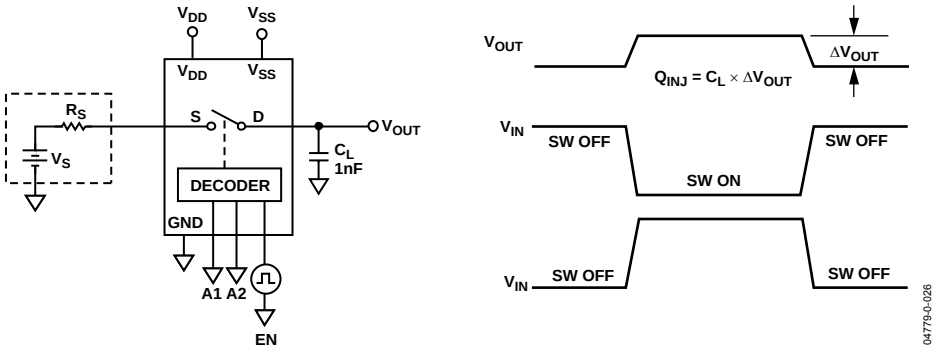


Figure 27. Test Circuit 7— Charge Injection

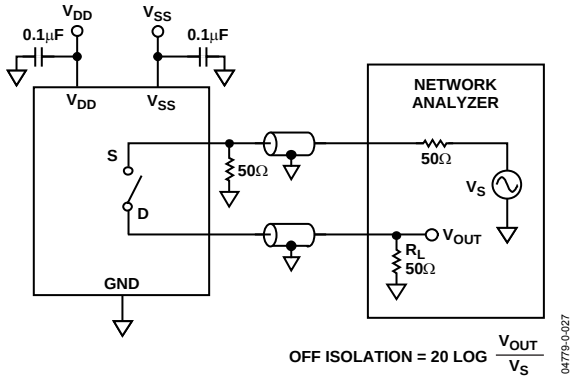


Figure 28. Test Circuit 8—Off Isolation

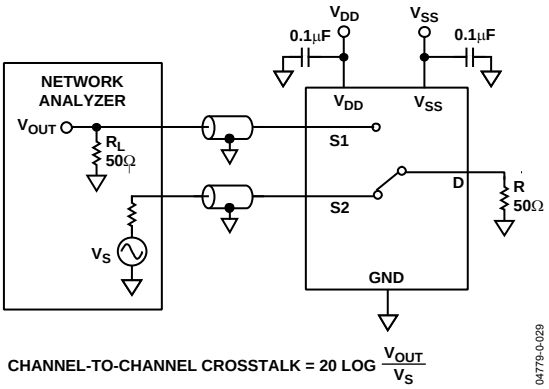


Figure 30. Test Circuit 10—Channel-to-Channel Crosstalk

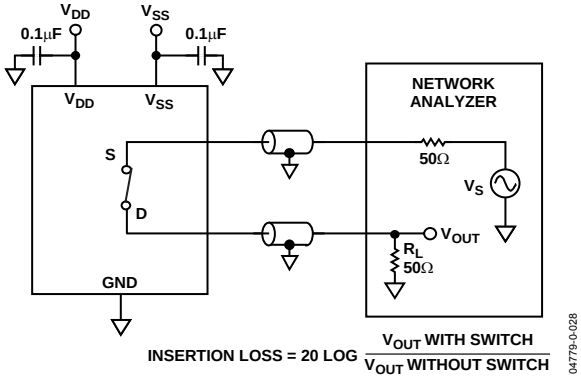


Figure 29. Test Circuit 9—Bandwidth

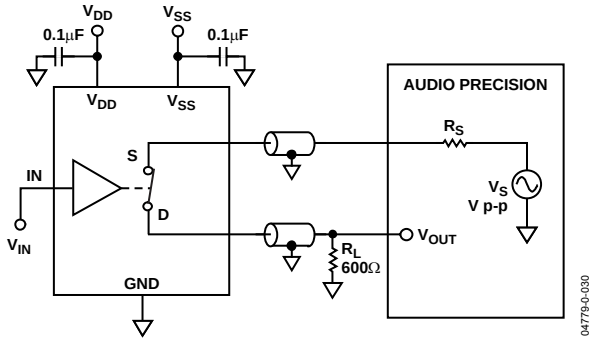


Figure 31. Test Circuit 11—THD + Noise

OUTLINE DIMENSIONS

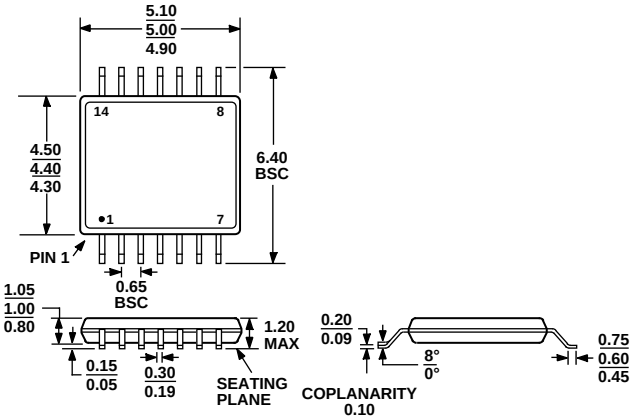


Figure 32. 14-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-14)
Dimension shown in millimeters

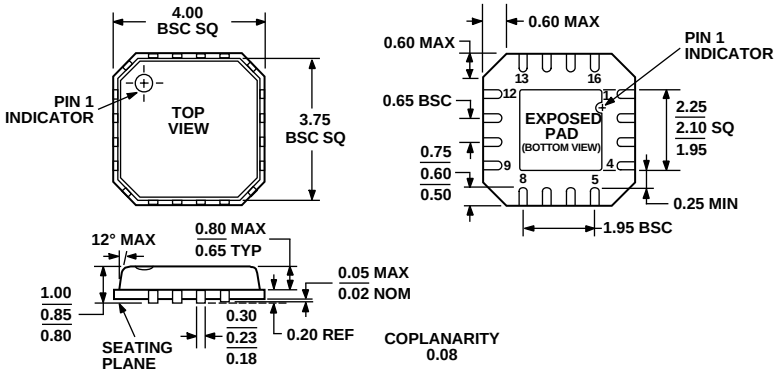


Figure 33. 16-Lead Lead Frame Chip Scale Package [VQ_LFCSP]
4 mm × 4 mm Body, Very Thin Quad
(CP-16-4)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADG1404YRUZ[1]	–40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1404YRUZ-REEL[1]	–40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1404YRUZ-REEL7[1]	–40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1404YCPZ-500RL7[1]	–40°C to +125°C	Lead Frame Chip Scale Package (VQ_LFCSP)	CP-16-4
ADG1404YCPZ-REEL7[1]	–40°C to +125°C	Lead Frame Chip Scale Package (VQ_LFCSP)	CP-16-4

[1] Z = Pb-free part.

NOTES

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PR06841-0-5/07(PrB)