Low Capacitance, Low Charge Injection, ±15 V/+12 V, 4:1 *i*CMOS™ Multiplexer

ADG1204

FEATURES

- 1.5 pF off source capacitance
- <1 pC charge injection
- 33 V supply range
- 120 Ω on resistance
- Fully specified at ±15 V, +12 V
- No V_L supply required
- 3 V logic-compatible inputs
- Rail-to-rail operation
- 14-lead TSSOP and 12-lead LFCSP_VQ
- Typical power consumption < 0.03 µW

APPLICATIONS

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

FUNCTIONAL BLOCK DIAGRAM

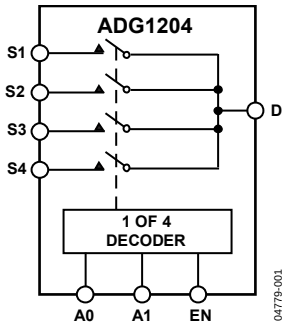

Figure 1.

GENERAL DESCRIPTION

The ADG1204 is a complementary metal-oxide semiconductor (CMOS) analog multiplexer, comprising four single channels designed on an *i*CMOS (industrial CMOS) process. *i*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 ultralow capacitance and charge injection of this multiplexer makes 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 part suitable for video signal switching. *i*CMOS construction ensures ultralow power dissipation, making the part ideally suited for portable and battery-powered instruments.

The ADG1204 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.

PRODUCT HIGHLIGHTS

1. 1.5 pF off capacitance (±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 µW.
6. 14-lead TSSOP and 12-lead, 3 mm × 3 mm LFCSP_VQ packages.

Rev. A

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REVISION HISTORY

7/06—Rev. 0 to Rev. A

Updated Format ..... Universal
Changes to Table 1 3
Changes to Table 2 5
Changes to the Terminology Section 14

7/05—Revision 0: Initial Version

SPECIFICATIONS

DUAL SUPPLY

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

Table 1.

Parameter	25°C	Y Version[1] −40°C to +85°C	Y Version[1] −40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			V_{DD} to V_{SS}	V	
On Resistance (R_{ON})	120			Ω typ	V_S = ±10 V, I_S = −1 mA; see Figure 21
	190	230	260	Ω max	V_{DD} = +13.5 V, V_{SS} = −13.5 V
On Resistance Match Between	3.5			Ω typ	V_S = ±10 V, I_S = −1 mA
Channels (ΔR_{ON})	6	10	12	Ω max	
On Resistance Flatness ($R_{FLAT(ON)}$)	20			Ω typ	V_S = −5 V, 0 V, +5 V; I_S = −1 mA
	57	72	79	Ω max	
LEAKAGE CURRENTS					V_{DD} = +16.5 V, V_{SS} = −16.5 V
Source Off Leakage, I_S (OFF)	±0.02			nA typ	V_S = ±10 V, V_D = ∓10 V; see Figure 22
	±0.1	±0.6	±1	nA max	
Drain Off Leakage, I_D (OFF)	±0.02			nA typ	V_S = ±10 V, V_D = ∓10 V; see Figure 22
	±0.1	±0.6	±1	nA max	
Channel On Leakage, I_D, I_S (ON)	±0.02			nA typ	V_S = V_D = ±10 V; see Figure 23
	±0.2	±0.6	±1	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}
			±0.1	μA max	
Digital Input Capacitance, C_{IN}	2.5			pF typ	
DYNAMIC CHARACTERISTICS[2]					
Transition Time, t_{TRANS}	120			ns typ	R_L = 300 Ω, C_L = 35 pF
	150	180	200	ns max	V_S = 10 V; see Figure 24
t_{ON} (EN)	70			ns typ	R_L = 300 Ω, C_L = 35 pF
	85	100	110	ns max	V_S = 10 V; see Figure 26
t_{OFF} (EN)	90			ns typ	R_L = 300 Ω, C_L = 35 pF
	110	135	155	ns max	V_S = 10 V; see Figure 26
Break-Before-Make Time Delay, t_D	25			ns typ	R_L = 300 Ω, C_L = 35 pF
			10	ns min	V_{S1} = V_{S2} = 10 V; see Figure 25
Charge Injection	−0.7			pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF; see Figure 27
Off Isolation	85			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; see Figure 28
Channel-to-Channel Crosstalk	80			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; see Figure 30
Total Harmonic Distortion + Noise	0.15			% typ	R_L = 10 kΩ, 5 V rms, f = 20 Hz to 20 kHz; see Figure 31
Bandwidth −3 dB	800			MHz typ	R_L = 50 Ω, C_L = 5 pF; see Figure 29
C_S (OFF)	1.2			pF typ	f = 1 MHz, V_S = 0 V
	1.5			pF max	f = 1 MHz, V_S = 0 V
C_D (OFF)	3.6			pF typ	f = 1 MHz, V_S = 0 V
	4.2			pF max	f = 1 MHz, V_S = 0 V
C_D, C_S (ON)	5.5			pF typ	f = 1 MHz, V_S = 0 V
	6.5			pF max	f = 1 MHz, V_S = 0 V

Parameter	25°C	Y Version[1] −40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
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}
			1.0	µA max	
I_{DD}	170			µA typ	Digital inputs = 5 V
			250	µA max	
I_{SS}	0.001			µA typ	Digital inputs = 0 V or V_{DD}
			1.0	µA max	
I_{SS}	0.001			µA typ	Digital inputs = 5 V
			1.0	µA max	

[1] Y version temperature range is −40°C to +125°C.
[2] 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.

Parameter	Y Version[1] 25°C	Y Version[1] −40°C to +85°C	Y Version[1] −40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			0 V to V_{DD}	V	
On Resistance (R_{ON})	300			Ω typ	V_S = 0 V to 10 V, I_S = −1 mA; see Figure 21
	475	567	625	Ω max	V_{DD} = 10.8 V, V_{SS} = 0 V
On Resistance Match Between Channels	5			Ω typ	V_S = 0 V to 10 V, I_S = −1 mA
(ΔR_{ON})	16	26	27	Ω max	
On Resistance Flatness ($R_{FLAT(ON)}$)	60			Ω typ	V_S = 3 V, 6 V, 9 V; I_S = −1 mA
LEAKAGE CURRENTS					V_{DD} = 13.2 V
Source Off Leakage, I_S (OFF)	±0.02			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V;
	±0.1	±0.6	±1	nA max	see Figure 22
Drain Off Leakage, I_D (OFF)	±0.02			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V;
	±0.1	±0.6	±1	nA max	see Figure 22
Channel On Leakage, I_D, I_S (ON)	±0.02			nA typ	V_S = V_D = 1 V or 10 V; see Figure 23
	±0.2	±0.6	±1	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}
			±0.1	μA max	
Digital Input Capacitance, C_{IN}	2.5			pF typ	
DYNAMIC CHARACTERISTICS[2]					
Transition Time, t_{TRANS}	150			ns typ	R_L = 300 Ω, C_L = 35 pF
	190	240	265	ns max	V_S = 8 V; see Figure 24
t_{ON} (EN)	95			ns typ	R_L = 300 Ω, C_L = 35 pF
	120	150	170	ns max	V_S = 8 V; see Figure 26
t_{OFF} (EN)	100			ns typ	R_L = 300 Ω, C_L = 35 pF
	125	155	170	ns max	V_S = 8 V; see Figure 26
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 25
Charge Injection	−0.4			pC typ	V_S = 6 V, R_S = 0 Ω, C_L = 1 nF; see Figure 27
Off Isolation	85			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; see Figure 28
Channel-to-Channel Crosstalk	80			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz; see Figure 30
Bandwidth −3 dB	550			MHz typ	R_L = 50 Ω, C_L = 5 pF; see Figure 29
C_S (OFF)	1.2			pF typ	f = 1 MHz; V_S = 6 V
	1.5			pF max	f = 1 MHz; V_S = 6 V
C_D (OFF)	3.6			pF typ	f = 1 MHz; V_S = 6 V
	4.2			pF max	f = 1 MHz; V_S = 6 V
C_D, C_S (ON)	5.5			pF typ	f = 1 MHz; V_S = 6 V
	6.5			pF max	f = 1 MHz; V_S = 6 V

Parameter	Y Version[1] 25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
POWER REQUIREMENTS					V_{DD} = 13.2 V
I_{DD}	0.001			µA typ	Digital inputs = 0 V or V_{DD}
			1.0	µA max	
I_{DD}	170			µA typ	Digital inputs = 5 V
			250	µA max	

[1] Y version temperature range is −40°C to +125°C.
[2] Guaranteed by design, not subject to production test.

ABSOLUTE MAXIMUM RATINGS

T_A = 25°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[1]	V_{SS} − 0.3 V to V_{DD} + 0.3 V or 30 mA, whichever occurs first
Digital Inputs[1]	GND − 0.3 V to V_{DD} + 0.3 V or 30 mA, whichever occurs first
Peak Current, S or D	100 mA (pulsed at 1 ms, 10% duty cycle maximum)
Continuous Current	45 mA
Operating Temperature Range	
Automotive (Y Version)	−40°C to +125°C
Storage Temperature Range	−65°C to +150°C
Junction Temperature	150°C
14-Lead TSSOP, θ_{JA} Thermal Impedance (4-Layer Board)	112°C/W
12-Lead LFCSP_VQ, θ_{JA} Thermal Impedance	80°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 indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Only one absolute maximum rating can 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

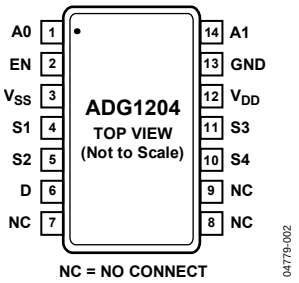


Figure 2. TSSOP Pin Configuration

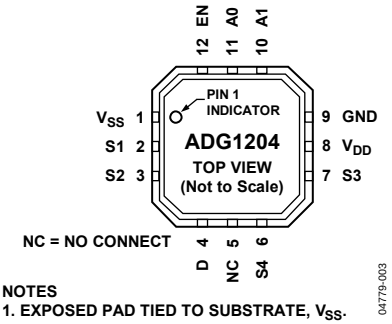


Figure 3. LFCSP_VQ Pin Configuration

Table 4. Pin Function Descriptions

Pin No.			
TSSOP	**LFCSP_VQ**	**Mnemonic**	**Description**
1	11	A0	Logic Control Input.
2	12	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	2	S1	Source Terminal. Can be an input or an output.
5	3	S2	Source Terminal. Can be an input or an output.
6	4	D	Drain Terminal. Can be an input or an output.
7 to 9	5	NC	No Connection.
10	6	S4	Source Terminal. Can be an input or an output.
11	7	S3	Source Terminal. Can be an input or an output.
12	8	V_{DD}	Most Positive Power Supply Potential.
13	9	GND	Ground (0 V) Reference.
14	10	A1	Logic Control Input.

TRUTH TABLE

Table 5.

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

TYPICAL PERFORMANCE CHARACTERISTICS

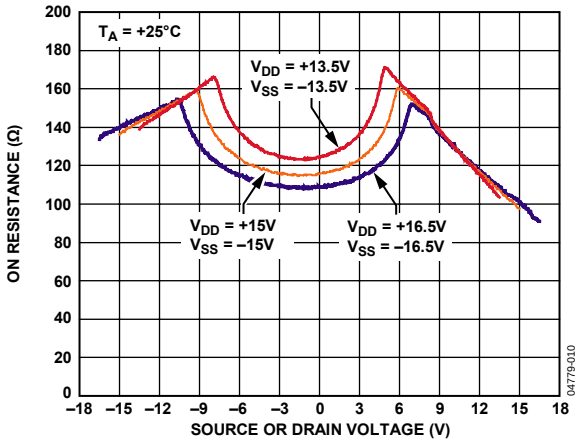


Figure 4. On Resistance as a Function of V_D (V_S), Dual Supply

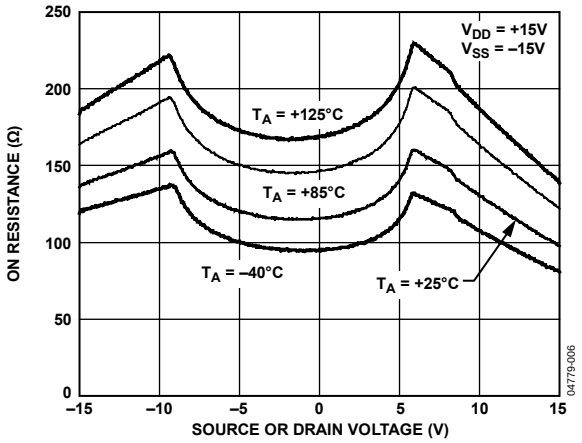


Figure 7. On Resistance as a Function of V_D (V_S) for Different Temperatures, Dual Supply

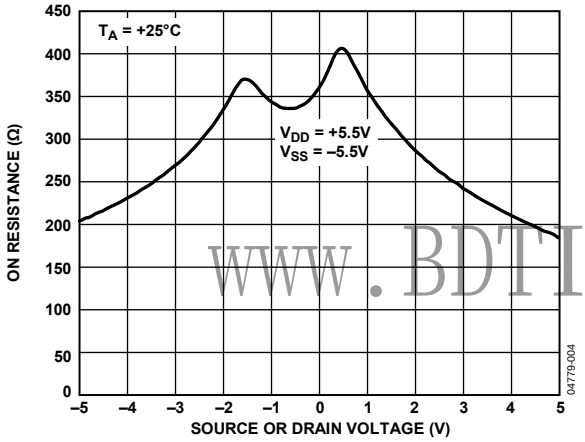


Figure 5. On Resistance as a Function of V_D (V_S), Dual Supply

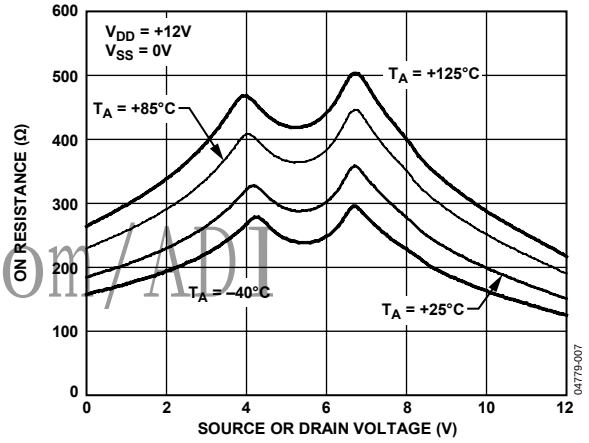


Figure 8. On Resistance as a Function of V_D (V_S) for Different Temperatures, Single Supply

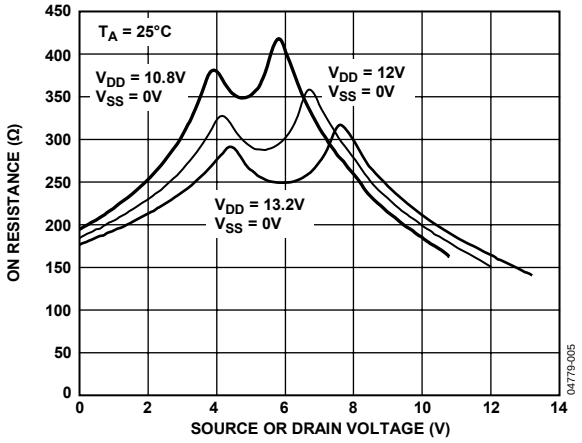


Figure 6. On Resistance as a Function of V_D (V_S), Single Supply

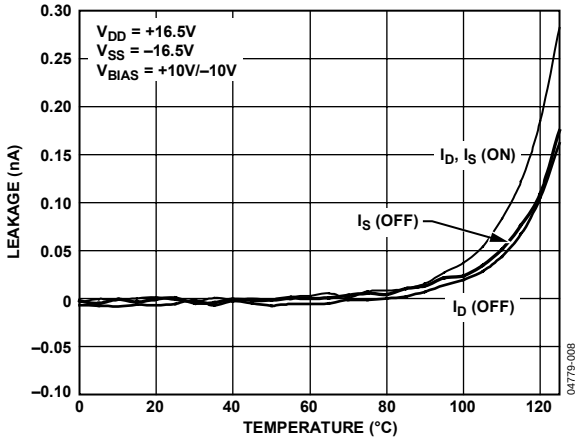


Figure 9. Leakage Currents as a Function of Temperature, Dual Supply

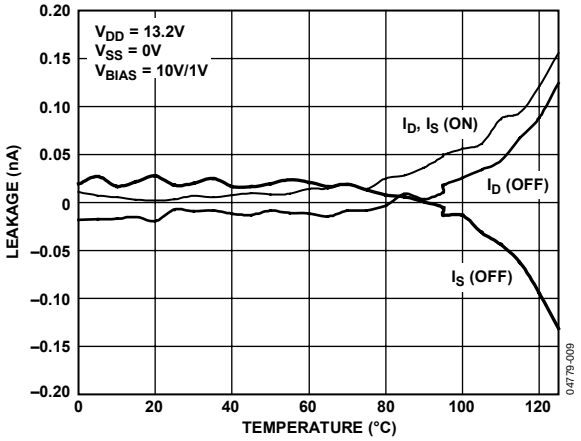


Figure 10. Leakage Currents as a Function of Temperature, Single Supply

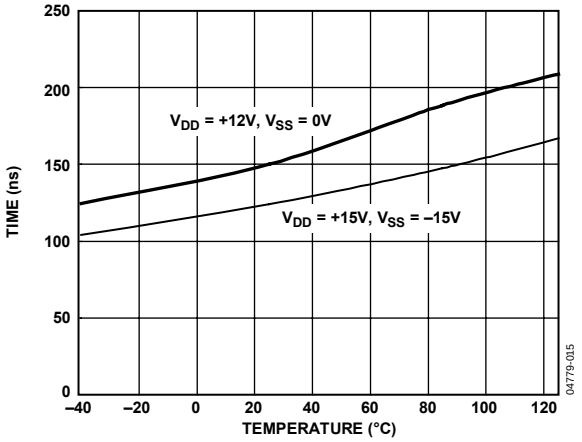


Figure 13. Transition Times vs. Temperature

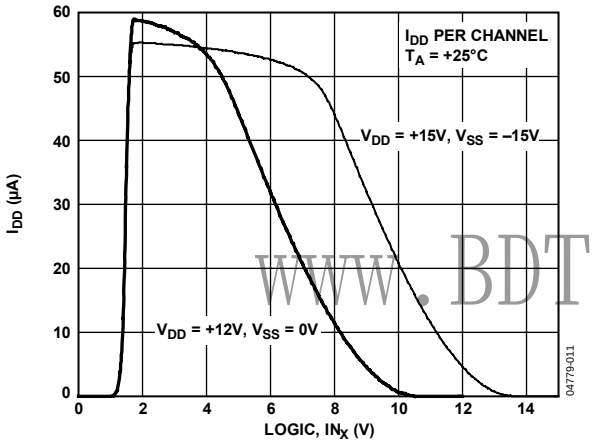


Figure 11. I_{DD} vs. Logic Level

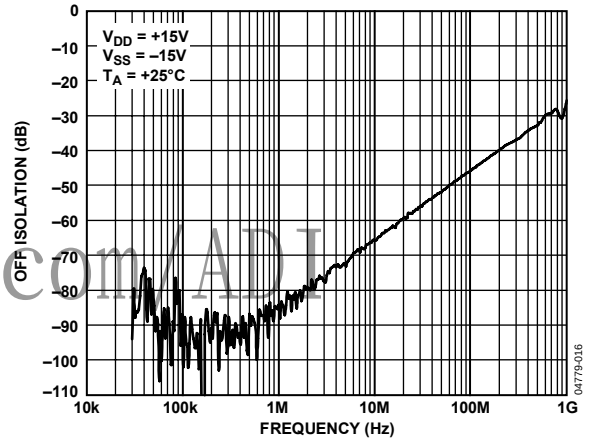


Figure 14. Off Isolation vs. Frequency

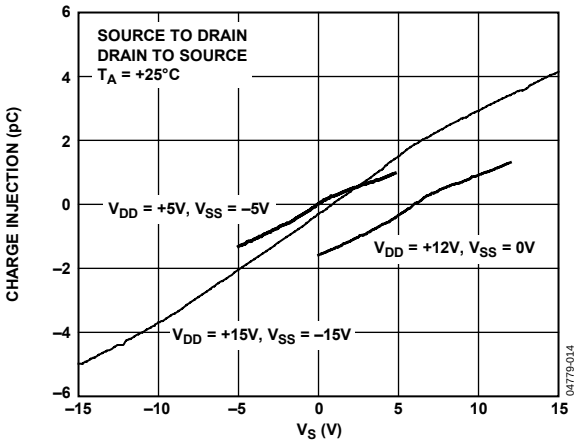


Figure 12. Charge Injection vs. Source Voltage

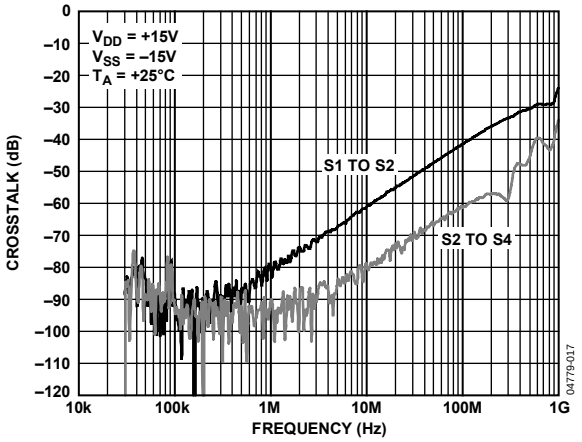


Figure 15. Crosstalk vs. Frequency

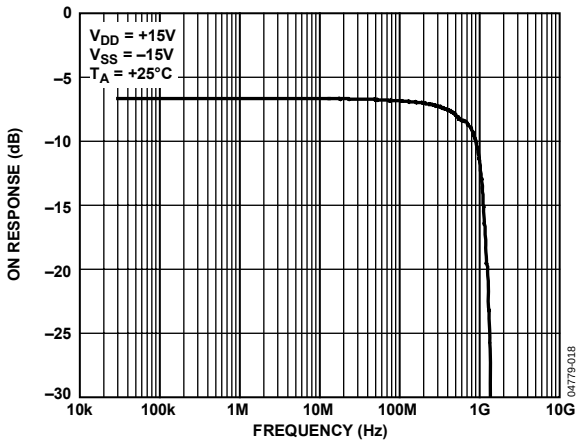


Figure 16. On Response vs. Frequency

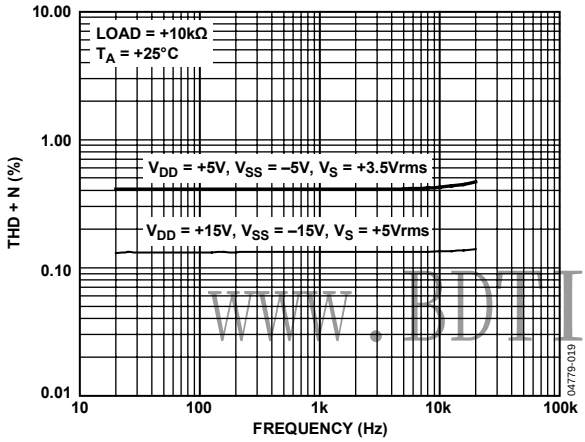


Figure 17. THD + N vs. Frequency

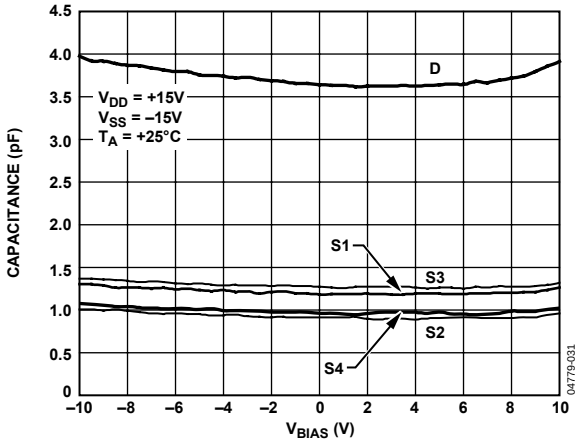


Figure 18. Off Capacitance vs. Source Voltage

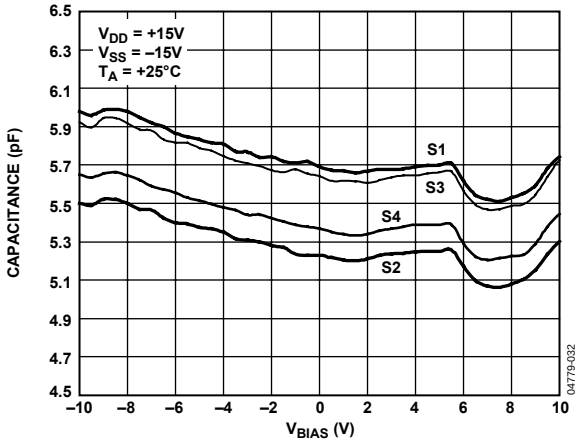


Figure 19. On Capacitance vs. Source Voltage

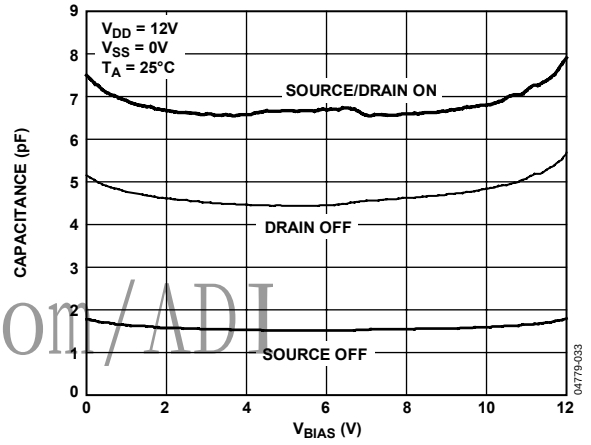


Figure 20. Capacitance vs. Source Voltage, Single Supply

TEST CIRCUITS

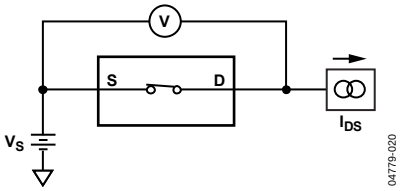


Figure 21. On Resistance

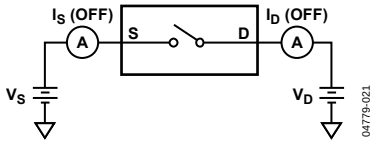


Figure 22. Off Leakage

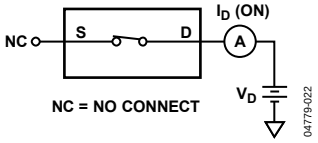
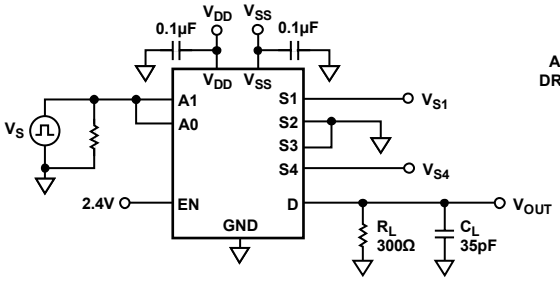


Figure 23. On Leakage



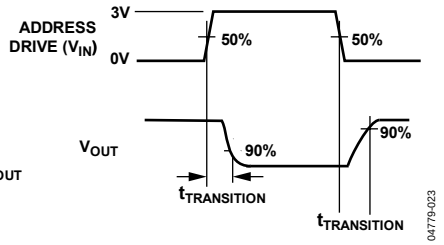
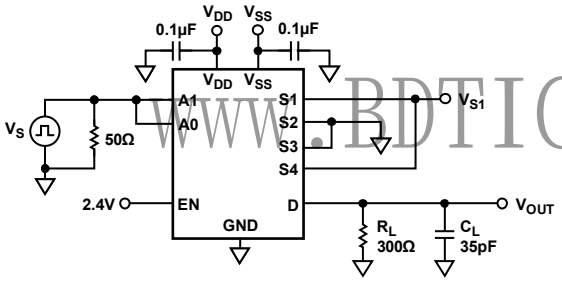


Figure 24. Address to Output Switching Times



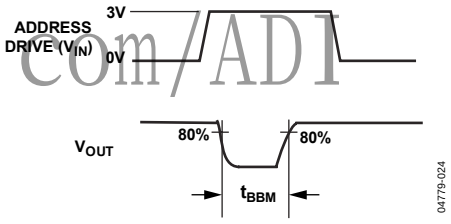
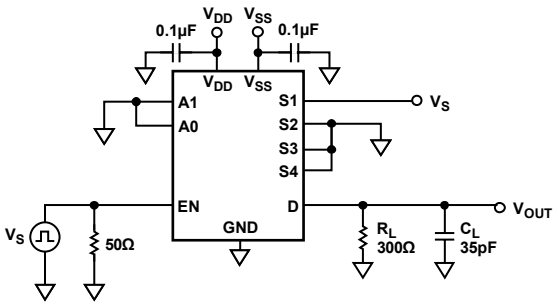


Figure 25. Break-Before-Make Time Delay



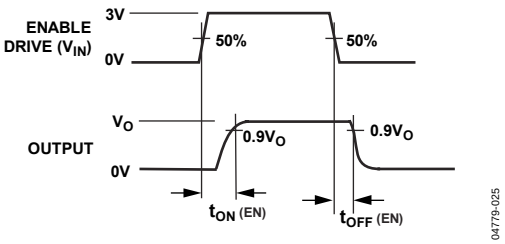


Figure 26. Enable-to-Output Switching Delay

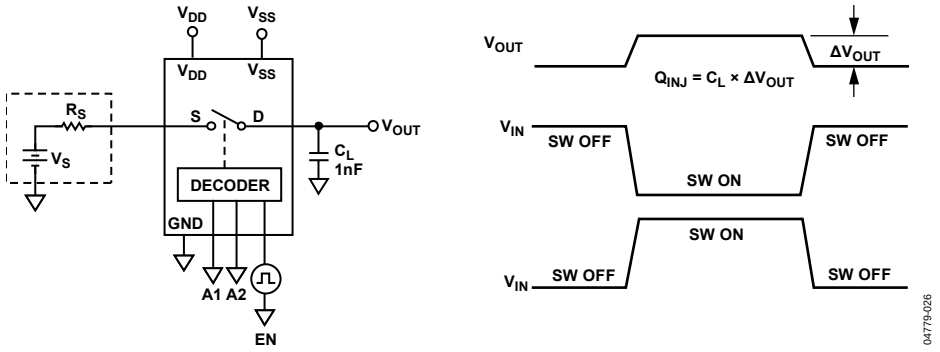


Figure 27. Charge Injection

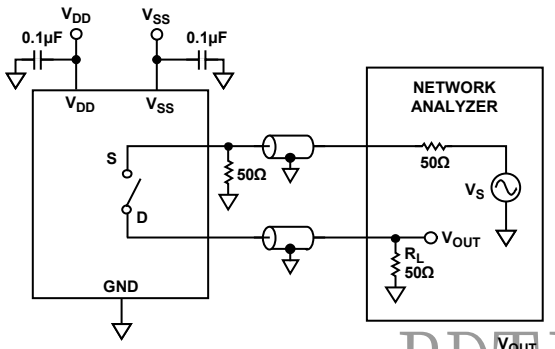


Figure 28. Off Isolation

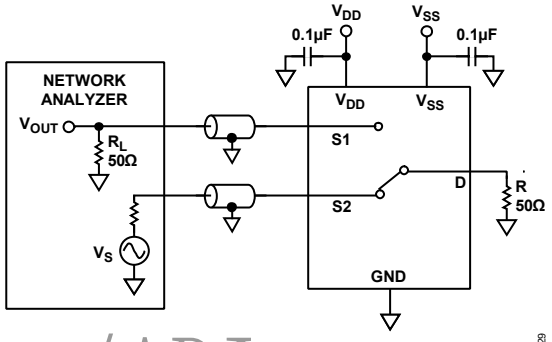


Figure 30. Channel-to-Channel Crosstalk

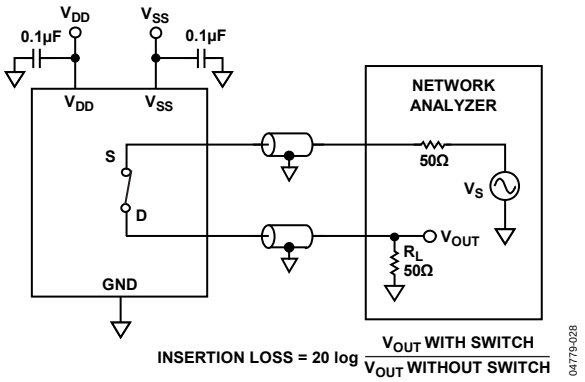


Figure 29. Bandwidth

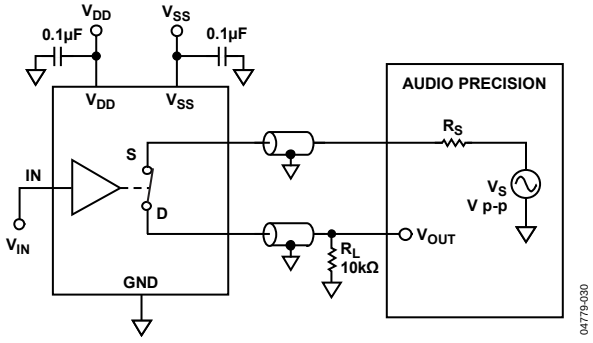


Figure 31. THD + Noise

TERMINOLOGY

I_{DD}
The positive supply current.

I_{SS}
The negative supply current.

V_D (V_S)
The analog voltage on Terminal D and Terminal 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, 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.

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

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.

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.

Total Harmonic Distortion + Noise (THD + N)
The ratio of the harmonic amplitude plus noise of the signal to the fundamental.

OUTLINE DIMENSIONS

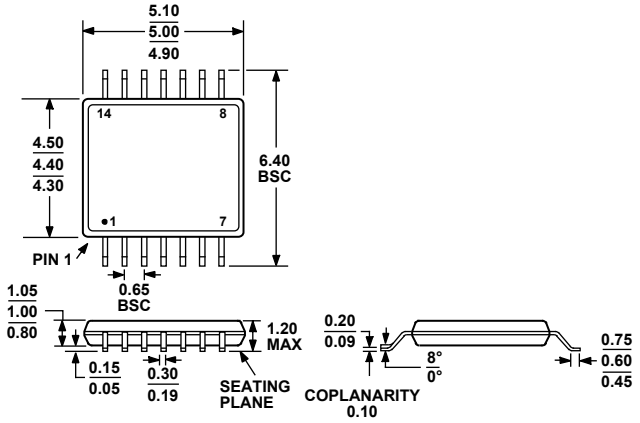


Figure 32. 14-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-14)
Dimensions shown in millimeters

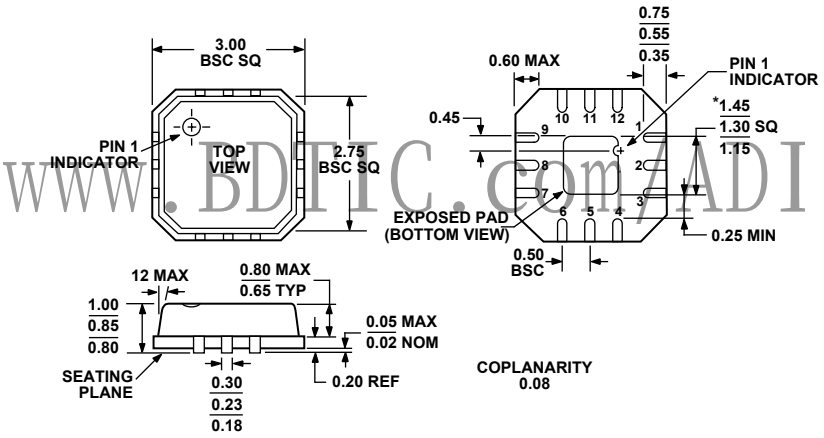


Figure 33. 12-Lead Lead Frame Chip Scale Package [LFCSP_VQ]
3 mm × 3 mm Body, Very Thin Quad
(CP-12-1)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADG1204YRUZ[1]	−40°C to +125°C	14-Lead Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1204YRUZ-REEL[1]	−40°C to +125°C	14-Lead Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1204YRUZ-REEL7[1]	−40°C to +125°C	14-Lead Thin Shrink Small Outline Package (TSSOP)	RU-14
ADG1204YCPZ-500RL7[1]	−40°C to +125°C	12-Lead Lead Frame Chip Scale Package (LFCSP_VQ)	CP-12-1
ADG1204YCPZ-REEL7[1]	−40°C to +125°C	12-Lead Lead Frame Chip Scale Package (LFCSP_VQ)	CP-12-1

[1] Z = Pb-free part.

NOTES

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