Precision 8-Ch/Dual 4-Ch Low Voltage Analog Multiplexers

FEATURES

- 2.7-to 12-V Single Supply or ±3- to ±6-V Dual Supply Operation
- Low On-Resistance—r_{ON}: 3.9 Ω Typ.
- Fast Switching: t_{ON} — 42 ns, t_{OFF} — 24 ns
- Break-Before-Make Guaranteed
- Low Leakage
- TTL, CMOS, LV Logic (3 V) Compatible
- 2000-V ESD Protection (HBM)

BENEFITS

- High Accuracy
- Single and Dual Power Rail Capacity
- Wide Operating Voltage Range
- Simple Logic Interface

APPLICATIONS

- Data Acquisition Systems
- Battery Operated Equipment
- Portable Test Equipment
- Sample and Hold Circuits
- Communication Systems
- SDSL, DSLAM
- Audio and Video Signal Routing

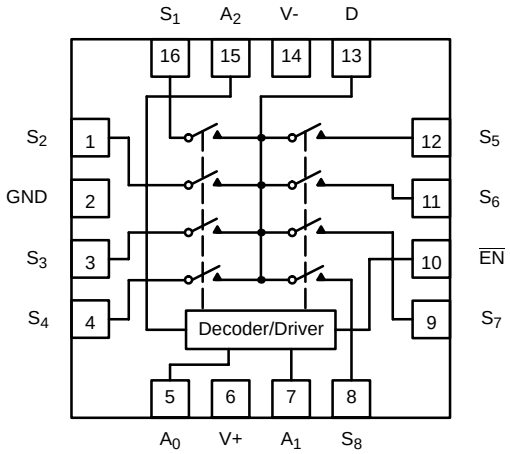
DESCRIPTION

The DG9408/9409 uses BiCMOS wafer fabrication technology that allows the DG9408/9409 to operate on single and dual supplies. Single supply voltage ranges from 3- to 12-V while dual supply operation is recommended with ±3 to ±6 V.

The DG9408 is an 8-channel single-ended analog multiplexer designed to connect one of eight inputs to a common output as determined by a 3-bit binary address (A_0, A_1, A_2). The DG9409 is a dual 4-channel differential analog multiplexer designed to connect one of four differential inputs to a common dual output as determined by its 2-bit binary address (A_0, A_1). Break-before-make switching action to protect against momentary crosstalk between adjacent channels.

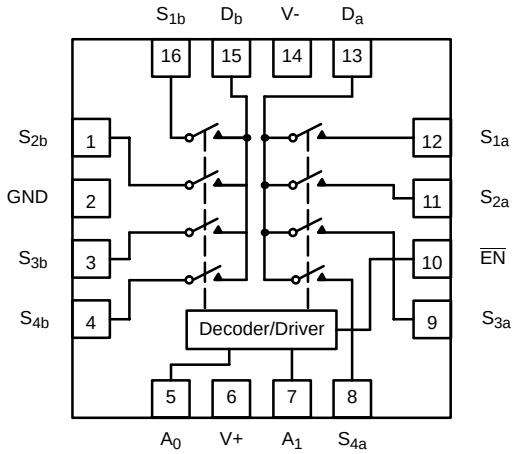
FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION

DG9408
QFN16



Top View

DG9409
QFN16



Top View

TRUTH TABLES AND ORDERING INFORMATION

TRUTH TABLE — DG9408				
A_2	A_1	A_0	$\overline{EN}$	On Switch
X	X	X	1	None
0	0	0	0	1
0	0	1	0	2
0	1	0	0	3
0	1	1	0	4
1	0	0	0	5
1	0	1	0	6
1	1	0	0	7
1	1	1	0	8

TRUTH TABLE — DG9409			
A_1	A_0	$\overline{EN}$	On Switch
X	X	1	None
0	0	0	1
0	1	0	2
1	0	0	3
1	1	0	4

X = Don't Care

For low and high voltage levels for V_{AX} and V_{EN} consult "Digital Control" Parameters for Specific V+ operation. See Specifications Tables for:

Single Supply 12 V
Dual Supply V+ = 5 V, V- = -5 V
Single Supply 5 V
Single Supply 3 V

ORDERING INFORMATION — DG9408		
Temp Range	Package	Part Number
-40 to 85°C	16-Pin QFN (4x4 mm)	DG9408DN

ORDERING INFORMATION — DG9409		
Temp Range	Package	Part Number
-40 to 85°C	16- Pin QFN (4x4 mm)	DG9409DN

ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-
V+ . . . . . 14 V
GND . . . . . 7 V
Digital Inputs[a], V_S, V_D . . . . . (V-) -0.3 V to (V+) +0.3 V
Current (Any Terminal Except S or D) . . . . . 30 mA
Continuous Current, S or D) . . . . . 100 mA
Peak Current, S or D
(Pulsed at 1 ms, 10% Duty Cycle Max) . . . . . 200 mA
Package Solder Reflow Conditions[d]
16-Pin (4x4 mm) QFN . . . . . 240°C
Storage Temperature . . . . . -65 to 150°C

Power Dissipation (Package)[b], (T_A = 70°C)
16-Pin (4x4 mm) QFN[c] . . . . . 1880 mW

Notes
a. Signals on S_X, D_X or IN_X exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current ratings.
b. All leads soldered or welded to PC board.
c. Derate 23.5 mW/°C above 70°C.
d. Manual soldering with soldering iron is not recommended for leadless components. The QFN is a leadless package. The end of the lead terminal is exposed copper (not plated) as a result of the singulation process in manufacturing. A solder fillet at the exposed copper lip cannot be guaranteed and is not required to ensure adequate bottom side solder interconnection.

SPECIFICATIONS (SINGLE SUPPLY 12 V)

Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 12 V, ±10%, V- = 0 V V_A, $V_{\overline{EN}}$ = 0.8 V or 2.4 V[f]		Temp[b]	Limits -40 to 85°C Min[c]	Typ[d]	Max[c]	Unit
Analog Switch								
Analog Signal Range[e]	V_{ANALOG}			Full	0		12	V
On-Resistance	r_{ON}	V+ = 10.8 V, V_D = 2 V or 9 V, I_S = 50 mA Sequence Each Switch On		Room Full		4	7 7.5	Ω
r_{ON} Match Between Channels[g]	Δr_{ON}	V+ = 10.8 V, V_D = 2 V or 9 V, I_S = 50 mA		Room			3.6	Ω
On-Resistance Flatness[i]	r_{ON} Flatness			Room			8	Ω
Switch Off Leakage Current	$I_{S(off)}$	$V_{\overline{EN}}$ = 2.4 V, V_D = 11 V or 1 V, V_S = 1 V or 11 V		Room Full	-2 -15		2 15	nA
	$I_{D(off)}$			Room Full	-2 -15		2 15	nA
Channel On Leakage Current	$I_{D(on)}$	$V_{\overline{EN}}$ = 0 V, V_S = V_D = 1 V or 11 V		Room Full	-2 -15		2 15	nA
Digital Control								
Logic High Input Voltage	V_{INH}			Full	2.4			V
Logic Low Input Voltage	V_{INL}			Full			0.8	V
Input Current	I_{IN}	V_{AX} = $V_{\overline{EN}}$ = 2.4 V or 0.8 V		Full	-1		1	µA
Dynamic Characteristics								
Transition Time	t_{TRANS}	V_{S1} = 8 V, V_{S8} = 0 V, (DG9408) V_{S1b} = 8 V, V_{S4b} = 0 V, (DG9409) See Figure 2		Room Full		42	71 75	ns
Break-Before-Make Time	t_{BBM}	$V_{S(all)}$ = V_{DA} = 5 V See Figure 4		Room Full	2	24		ns
Enable Turn-On Time	$t_{ON(\overline{EN})}$	V_{AX} = 0 V, V_{S1} = 5 V (DG9408) V_{AX} = 0 V, V_{S1b} = 5 V (DG9409) See Figure 3		Room Full		42	70 75	ns
Enable Turn-Off Time	$t_{OFF(\overline{EN})}$			Room Full		24	44 46	ns
Charge Injection[e]	Q	C_L = 1 nF, V_{GEN} = 0 V, R_{GEN} = 0 Ω		Room		29		pC
Off Isolation[e, h]	OIRR	f = 100 kHz, R_L = 1 kΩ		Room		-80		dB
Crosstalk[e]	X_{TALK}			Room		-85		dB
Source Off Capacitance[e]	$C_{S(off)}$	f = 1 MHz, V_S = 0 V, $V_{\overline{EN}}$ = 2.4 V	DG9408	Room		21		pF
			DG9409	Room		23		pF
Drain Off Capacitance[e]	$C_{D(off)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 2.4 V	DG9408	Room		211		pF
			DG9409	Room		112		pF
Drain On Capacitance[e]	$C_{D(on)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 0 V	DG9408	Room		238		pF
			DG9409	Room		137		pF
Power Supplies								
Power Supply Current	I+	$V_{\overline{EN}}$ = V_A = 0 V or V+		Room			1.0	µA

SPECIFICATIONS (DUAL SUPPLY V+ = 5 V, V- = -5 V)

Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 5 V, V- = -5 V ±10% V_A, $V_{\overline{EN}}$ = 0.8 V or 2.0 V[f]		Temp[b]	Limits -40 to 85°C Min[c]	Typ[d]	Max[c]	Unit
Analog Switch								
Analog Signal Range[e]	V_{ANALOG}			Full	-5		5	V
On-Resistance	r_{ON}	V+ = 4.5 V, V- = -4.5 V, V_D = ±3.5 V, I_S = 50 mA Sequence Each Switch On		Room Full		5	8 8.5	Ω
r_{ON} Match Between Channels[g]	Δr_{ON}	V+ = 4.5 V, V- = -4.5 V, V_D = ±3.5 V, I_S = 50 mA		Room			3.6	Ω
On-Resistance Flatness[i]	r_{ON} Flatness			Room			8.2	Ω
Switch Off Leakage Current [a]	$I_{S(off)}$	V+ = 5.5 V, V- = -5.5 V $V_{\overline{EN}}$ = 2.4 V, V_D = ±4.5 V, V_S = ∓4.5 V		Room Full	-2 -15		2 15	nA
	$I_{D(off)}$			Room Full	-2 -15		2 15	nA
Channel On Leakage Current [a]	$I_{D(on)}$	V+ = 5.5 V, V- = -5.5 V $V_{\overline{EN}}$ = 0 V, V_D = ±4.5 V, V_S = ∓4.5 V		Room Full	-2 -15		2 15	nA
Digital Control								
Logic High Input Voltage	V_{INH}			Full	2.0			V
Logic Low Input Voltage	V_{INL}			Full			0.8	V
Input Current[a]	I_{IN}	V_{AX} = V_{EN} = 2.0 V or 0.8 V		Full	-1		1	µA
Dynamic Characteristics								
Transition Time[e]	t_{TRANS}	V_{S1} = 3.5 V, V_{S8} = -3.5 V, (DG9408) V_{S1b} = 3.5 V, V_{S4b} = -3.5 V, (DG9409) See Figure 2		Room Full		68	89 94	ns
Break-Before-Make Time[e]	t_{BBM}	$V_{S(all)}$ = V_{DA} = 3.5 V See Figure 4		Room Full	1	16		ns
Enable Turn-On Time[e]	$t_{ON(\overline{EN})}$	V_{AX} = 0 V, V_{S1} = 3.5 V (DG9408) V_{AX} = 0 V, V_{S1b} = 3.5 V (DG9409) See Figure 3		Room Full		68	88 94	ns
Enable Turn-Off Time[e]	$t_{OFF(\overline{EN})}$			Room Full		58	78 81	ns
Source Off Capacitance[e]	$C_{S(off)}$	f = 1 MHz, V_S = 0 V, $V_{\overline{EN}}$ = 2.0 V	DG9408	Room		23		pF
			DG9409	Room		23		pF
Drain Off Capacitance[e]	$C_{D(off)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ =2. 0 V	DG9408	Room		223		pF
			DG9409	Room		113		pF
Drain On Capacitance[e]	$C_{D(on)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 0 V	DG9408	Room		246		pF
			DG9409	Room		137		pF
Power Supplies								
Power Supply Current	I+	$V_{\overline{EN}}$ = V_A = 0 V or V+		Room			1.0	µA
	I-			Room	-1.0			µA

SPECIFICATIONS (SINGLE SUPPLY 5 V)

Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 5 V, ±10%, V- = 0 V V_A, $V_{\overline{EN}}$ = 0.8 V or 2.0 V[f]		Temp[b]	Limits -40 to 85°C Min[c]	Typ[d]	Max[c]	Unit
Analog Switch								
Analog Signal Range[e]	V_{ANALOG}			Full	0		5	V
On-Resistance	r_{ON}	V+ = 4.5 V, V_D or V_S = 1 V or 3.5 V, I_S = 50 mA		Room Full		7	10.5 11	Ω
r_{ON} Match Between Channels[g]	Δr_{ON}	V+ = 4.5 V, V_D = 1 V or 3.5 V, I_S = 50 mA		Room			3.6	Ω
On-Resistance Flatness[i]	r_{ON} Flatness			Room			9	Ω
Switch Off Leakage Current [a]	$I_{S(off)}$	V+ = 5.5 V V_S = 1 V or 4 V, V_D = 4 V or 1 V		Room Full	-2 -15		2 15	nA
	$I_{D(off)}$			Room Full	-2 -15		2 15	nA
Channel On Leakage Current[a]	$I_{D(on)}$	V+ = 5.5 V V_D = V_S = 1 V or 4 V, Sequence Each Switch On		Room Full	-2 -15		2 15	nA
Digital Control								
Logic High Input Voltage	V_{INH}	V+ = 5 V		Full	2.0			V
Logic Low Input Voltage	V_{INL}			Full			0.8	V
Input Current[a]	I_{IN}	V_{AX} = $V_{\overline{EN}}$ = 2.0 V or 0.8 V		Full	-1		1	µA
Dynamic Characteristics								
Transition Time[e]	t_{TRANS}	V_{S1} = 3.5 V, V_{S8} = 0 V, (DG9408) V_{S1b} = 3.5 V, V_{S4b} = 0 V, (DG9409) See Figure 2		Room Full		73	94 104	ns
Break-Before-Make Time[e]	t_{OPEN}	$V_{S(all)}$ = V_{DA} = 3.5 V See Figure 4		Room Full	2	29		ns
Enable Turn-On Time[e]	$t_{ON(\overline{EN})}$	V_{AX} = 0 V, V_{S1} = 3.5 V (DG9408) V_{AX} = 0 V, V_{S1b} = 3.5 V (DG9409) See Figure 3		Room Full		74	94 104	ns
Enable Turn-Off Time[e]	$t_{OFF(\overline{EN})}$			Room Full		38	57 61	ns
Charge Injection[e]	Q	C_L = 1 nF, R_{GEN} = 0 Ω, V_{GEN} = 0 V		Room		20		pC
Off Isolation[e, h]	OIRR	R_L = 1 kΩ, f = 100 kHz		Room		-81		dB
Crosstalk[e]	X_{TALK}			Room		-85		dB
Source Off Capacitance[e]	$C_{S(off)}$	f = 1 MHz, V_S = 0 V, $V_{\overline{EN}}$ = 0 V	DG9408	Room		22		pF
			DG9409	Room		24		pF
Drain Off Capacitance[e]	$C_{D(off)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 2.0 V	DG9408	Room		223		pF
			DG9409	Room		113		pF
Drain On Capacitance[e]	$C_{D(on)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 0 V	DG9408	Room		244		pF
			DG9409	Room		143		pF
Power Supplies								
Power Supply Current	I+	$V_{\overline{EN}}$ = V_A = 0 V or V+		Room			1.0	µA

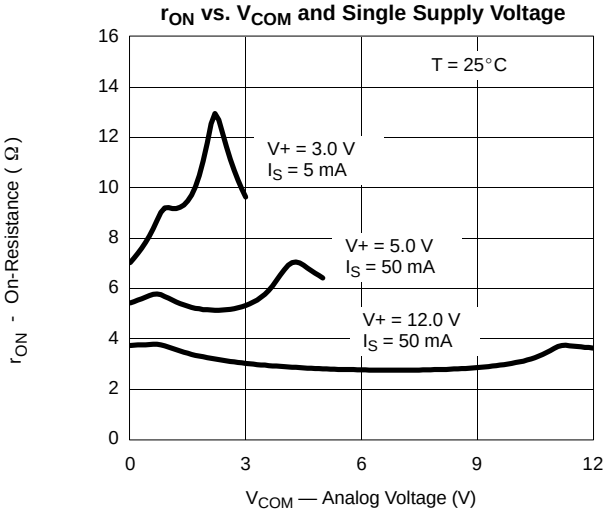
SPECIFICATIONS (SINGLE SUPPLY 3 V)

Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 3 V, ±10%, V- = 0 V $V_{\overline{EN}}$ = 0.4 V or 1.8 V[f]		Temp[b]	Limits -40 to 85°C Min[c]	Typ[d]	Max[c]	Unit
Analog Switch								
Analog Signal Range[e]	V_{ANALOG}			Full	0		3	V
On-Resistance	r_{ON}	V+ = 2.7 V, V_D = 0.5 or 2.2 V, I_S = 5 mA		Room Full		12	25.5 26.5	Ω
r_{ON} Match Between Channels[g]	Δr_{ON}	V+ = ±2.7 V, V_D = 0.5 V or 2.2 V, I_S = 5 mA		Room			3.6	Ω
On-Resistance Flatness[i]	r_{ON} Flatness			Room			13	Ω
Switch Off Leakage Current [a]	$I_{S(off)}$	V+ = 3.3 V V_S = 2 or 1 V, V_D = 1 or 2 V		Room Full	-2 -15		2 15	nA
	$I_{D(off)}$			Room Full	-2 -15		2 15	nA
Channel On Leakage Current[a]	$I_{D(on)}$	V+ = 3.3 V V_D = V_S = 1 or 2 V, Sequence Each Switch On		Room Full	-2 -15		2 15	nA
Digital Control								
Logic High Input Voltage	V_{INH}			Full	1.8			V
Logic Low Input Voltage	V_{INL}			Full			0.4	V
Input Current [a]	I_{IN}	V_{AX} = $V_{\overline{EN}}$ = 1.8 V or 0.4 V		Full	-1		1	µA
Dynamic Characteristics								
Transition Time	t_{TRANS}	V_{S1} = 1.5 V, V_{S8} = 0 V, (DG9408) V_{S1b} = 1.5 V, V_{S4b} = 0 V, (DG9409) See Figure 2		Room Full		140	165 182	ns
Break-Before-Make Time	t_{BBM}	$V_{S(all)}$ = V_{DA} = 1.5 V See Figure 4		Room Full	2	63		ns
Enable Turn-On Time	$t_{ON(\overline{EN})}$	V_{AX} = 0 V, V_{S1} = 1.5 V (DG9408) V_{AX} = 0 V, V_{S1b} = 1.5 V (DG9409) See Figure 3		Room Full		140	162 178	ns
Enable Turn-Off Time	$t_{OFF(\overline{EN})}$			Room Full		76	97 104	ns
Charge Injection[e]	Q	C_L = 1 nF, R_{GEN} = 0 Ω, V_{GEN} = 0 V		Room		7		pC
Off Isolation[e, h]	OIRR	f = 100 kHz, R_L = 1 kΩ		Room		-81		dB
Crosstalk[e]	X_{TALK}			Room		-85		dB
Source Off Capacitance[e]	$C_{S(off)}$	f = 1 MHz, V_S = 0 V, $V_{\overline{EN}}$ = 1.8 V	DG9408	Room		23		pF
			DG9409	Room		25		pF
Drain Off Capacitance[e]	$C_{D(off)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 1.8 V	DG9408	Room		230		pF
			DG9409	Room		120		pF
Drain On Capacitance[e]	$C_{D(on)}$	f = 1 MHz, V_D = 0 V, $V_{\overline{EN}}$ = 0 V	DG9408	Room		256		pF
			DG9409	Room		147		pF
Power Supplies								
Power Supply Current	I+	$V_{\overline{EN}}$ = V_A = 0 V or V+		Room			1.0	µA

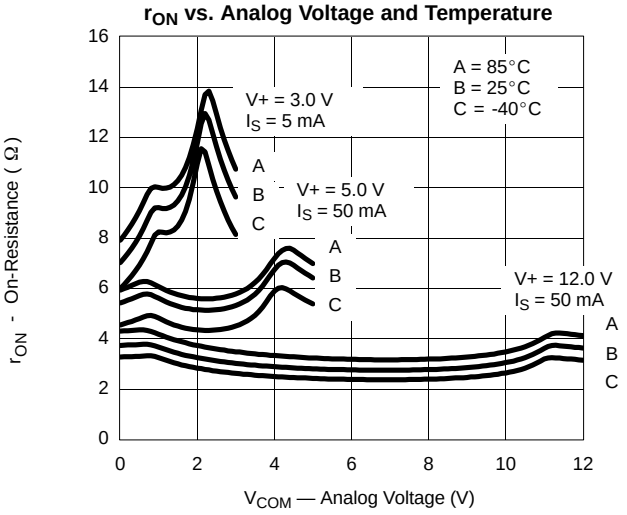
Notes
a. Leakage parameters are guaranteed by worst case test condition and not subject to production test.
b. Room = 25°C, Full = as determined by the operating temperature suffix.
c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
d. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
e. Guaranteed by design, not subject to production test.
f. V_{IN} = input voltage to perform proper function.
g. Δr_{DON} = r_{DON} Max - r_{DON} Min.
h. Worst case isolation occurs on Channel 4 do to proximity to the drain pin.
i. r_{DON} flatness is measured as the difference between the minimum and maximum measured values across a defined Analog signal.

TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)

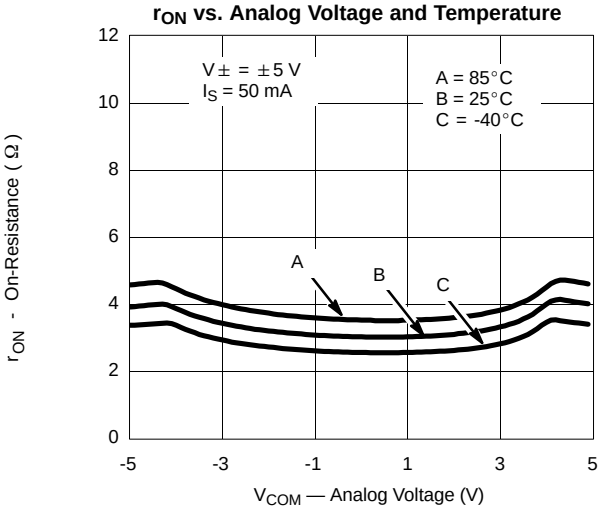
r_{ON} vs. V_{COM} and Single Supply Voltage



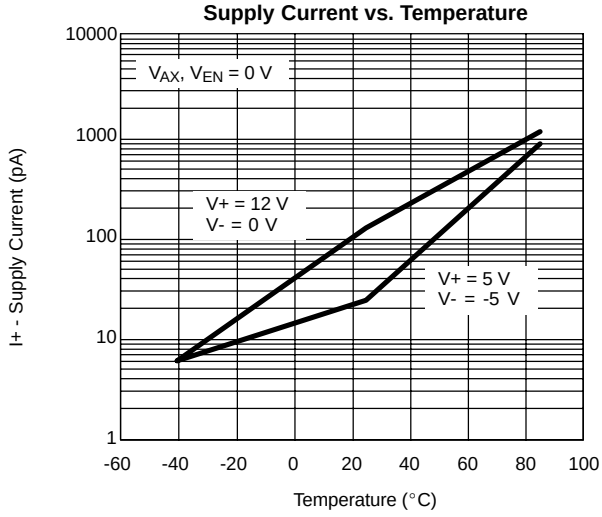
r_{ON} vs. Analog Voltage and Temperature



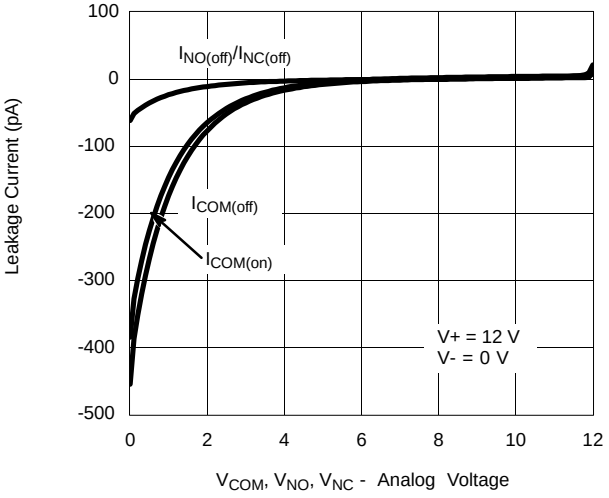
r_{ON} vs. Analog Voltage and Temperature



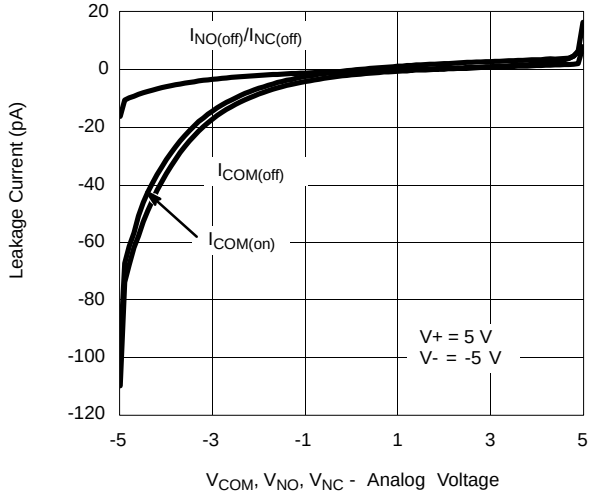
Supply Current vs. Temperature



Leakage Current vs. Analog Voltage

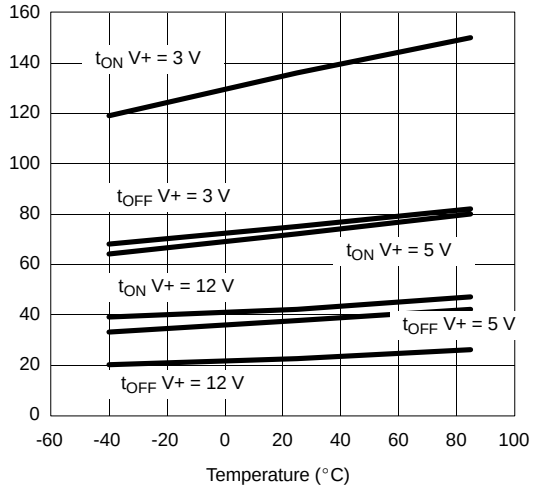


Leakage Current vs. Analog Voltage

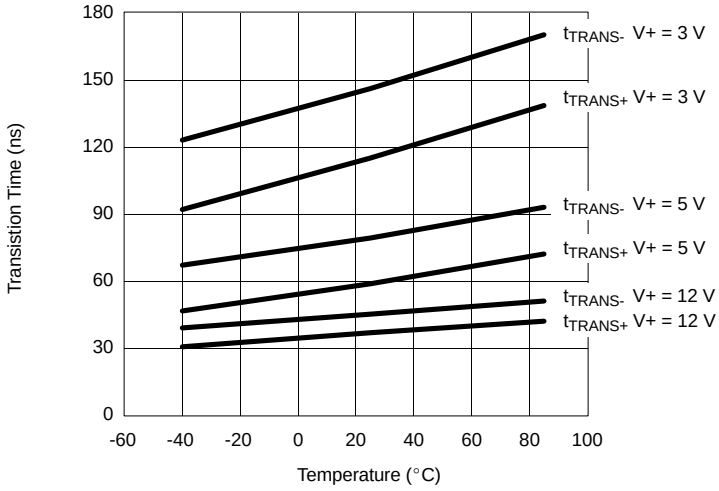


TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)

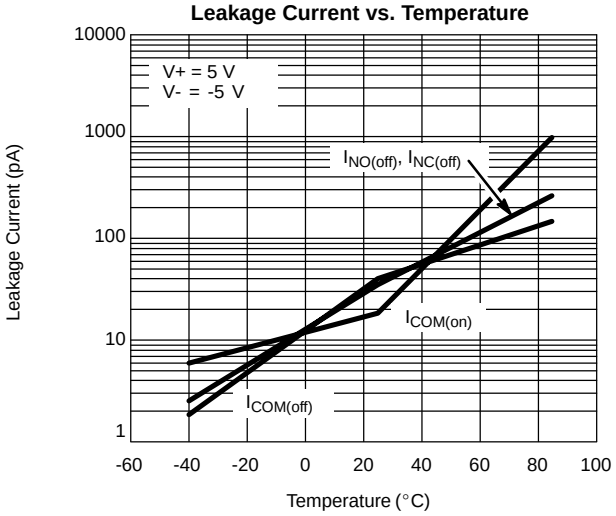
Switching Time vs. Temperature and Single Supply Voltage



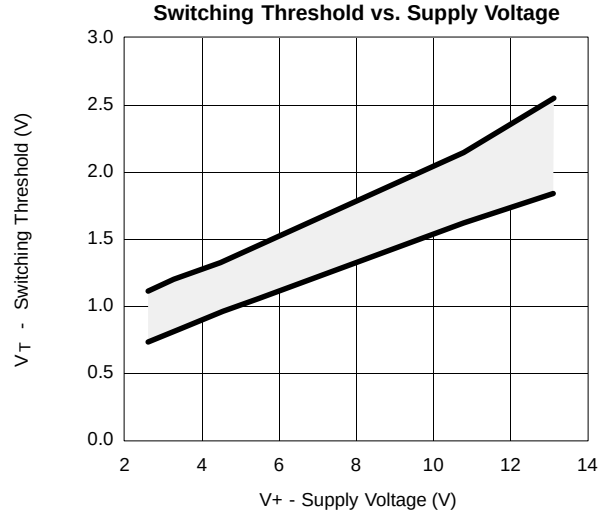
Transition Time vs. Temperature and Single Supply Voltage



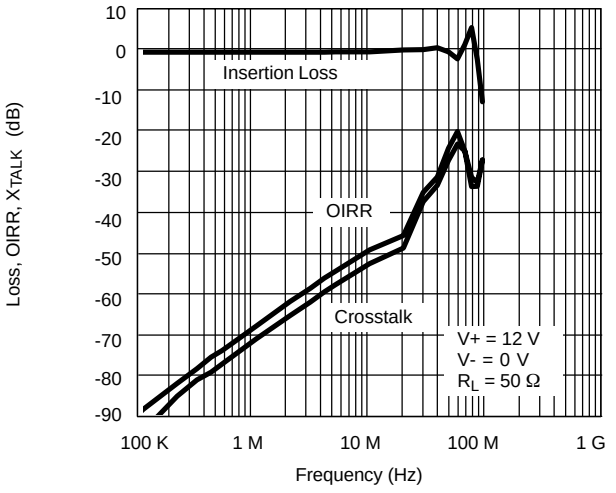
Leakage Current vs. Temperature



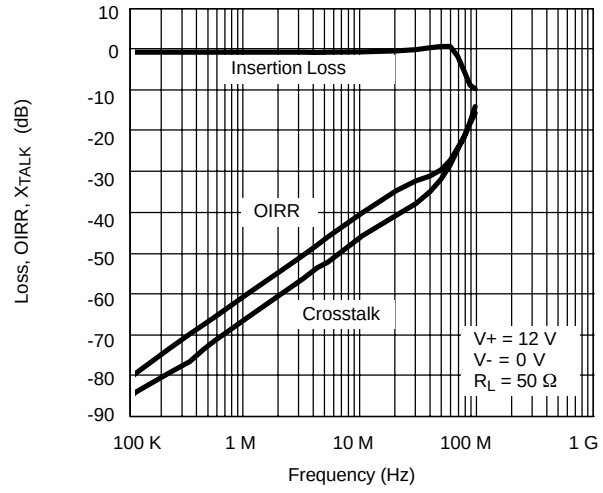
Switching Threshold vs. Supply Voltage



Insertion Loss, Off Isolation and Crosstalk vs. Frequency (DG9408)



Insertion Loss, Off Isolation and Crosstalk vs. Frequency (DG9404)



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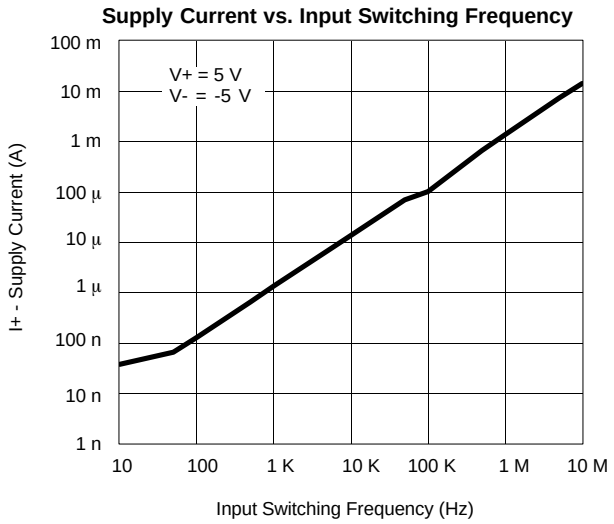
TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)



SCHEMATIC DIAGRAM (TYPICAL CHANNEL)

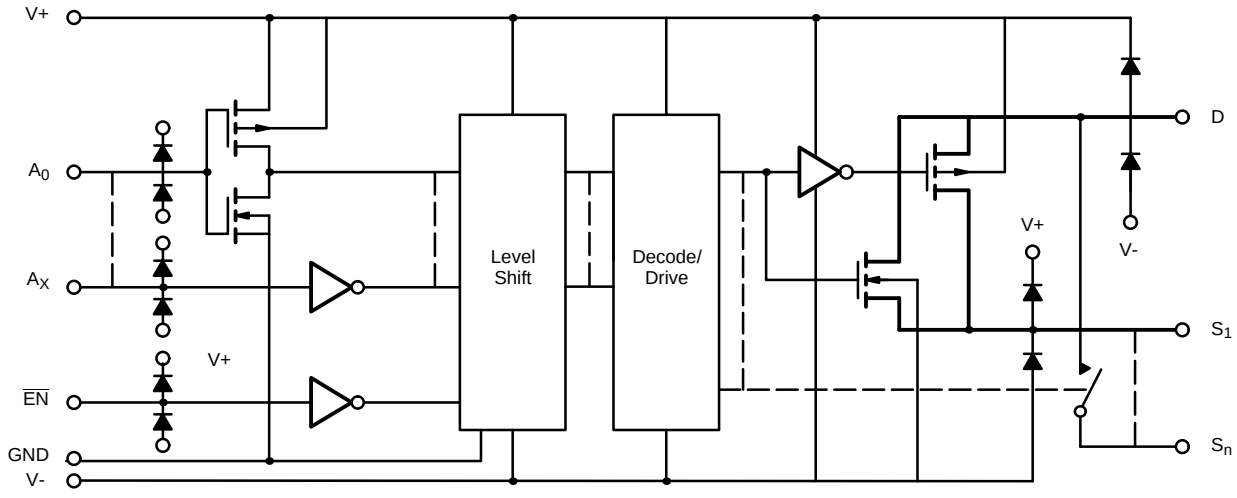
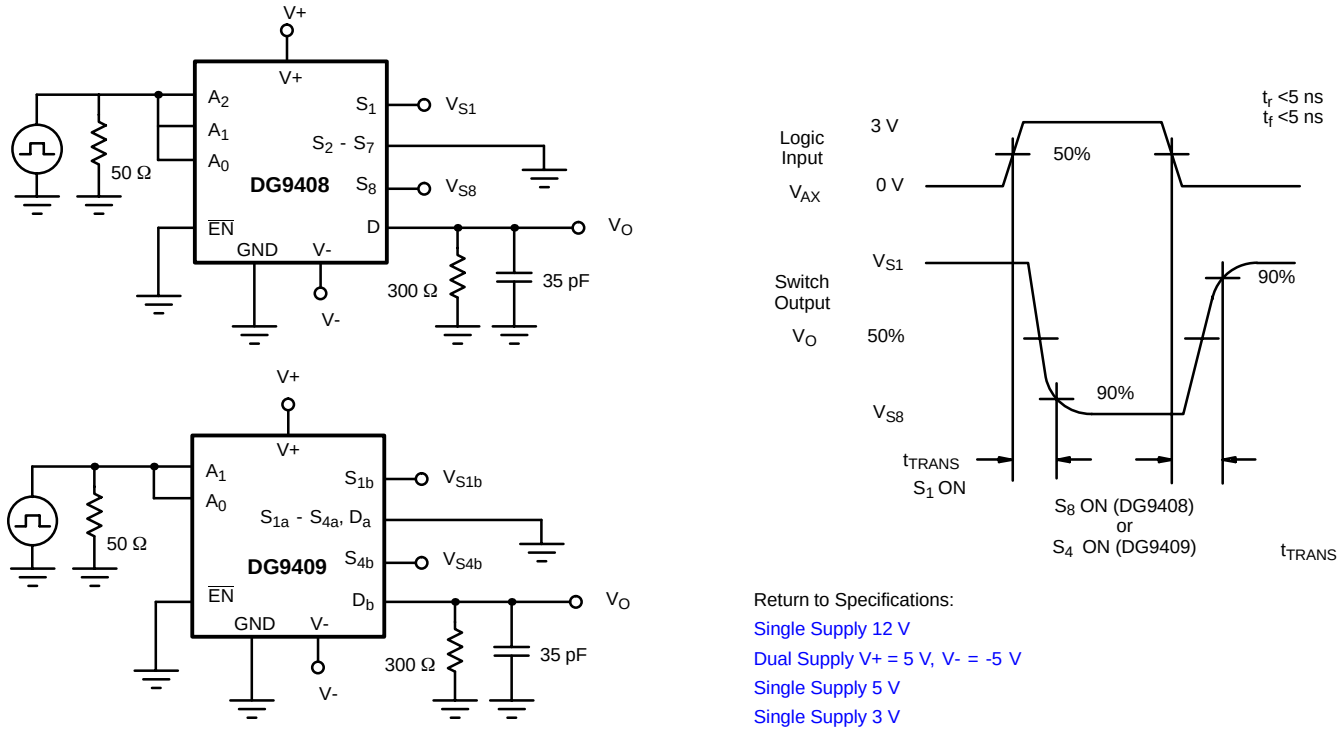


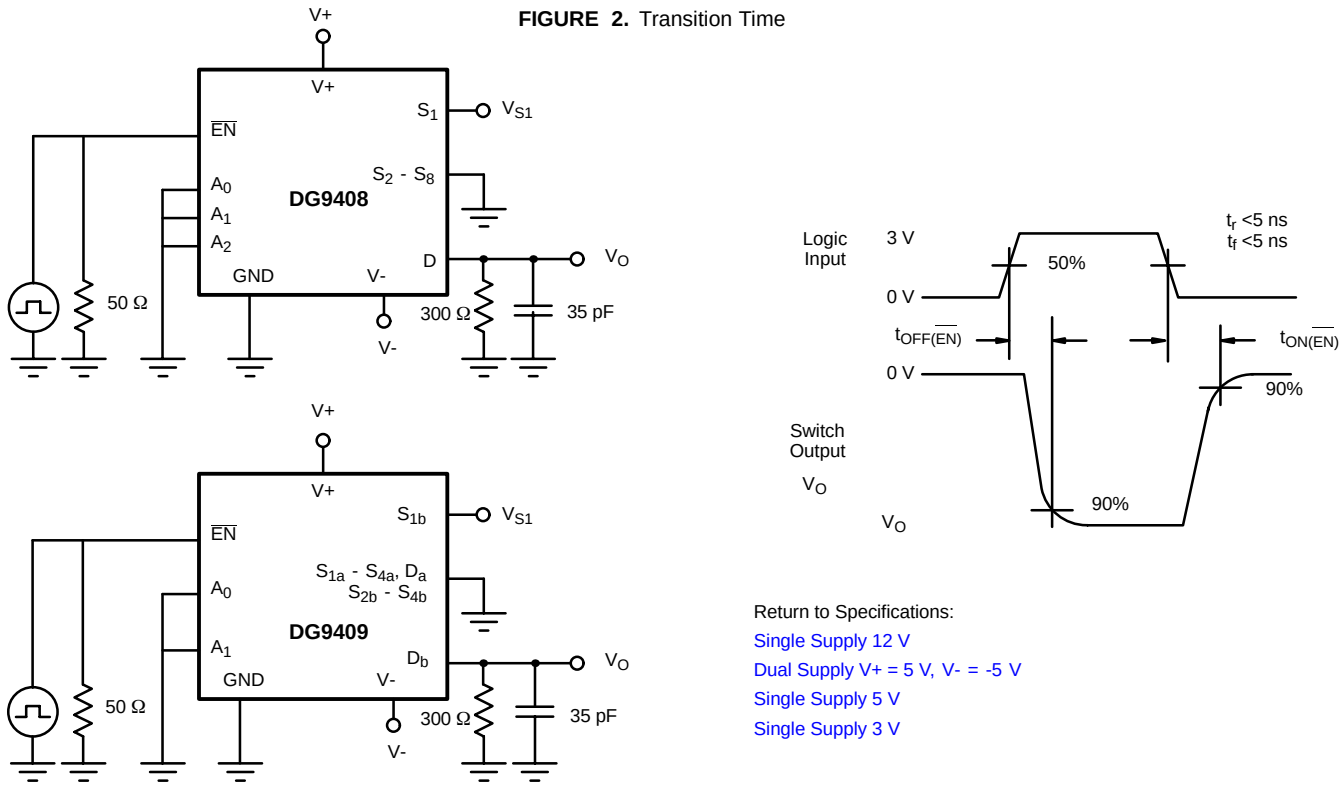
FIGURE 1.

TEST CIRCUITS



Return to Specifications:
Single Supply 12 V
Dual Supply V+ = 5 V, V- = -5 V
Single Supply 5 V
Single Supply 3 V

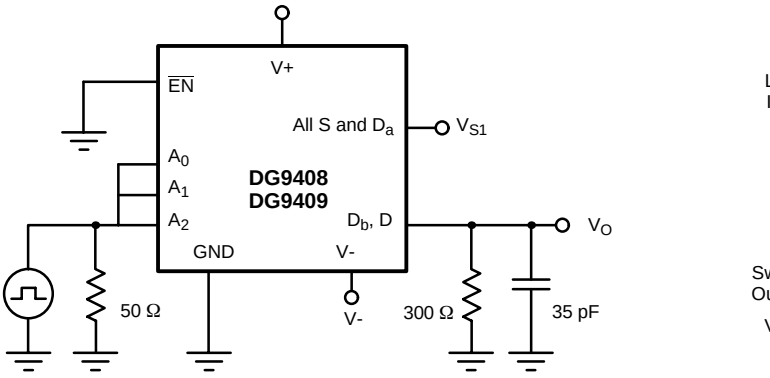
FIGURE 2. Transition Time



Return to Specifications:
Single Supply 12 V
Dual Supply V+ = 5 V, V- = -5 V
Single Supply 5 V
Single Supply 3 V

FIGURE 3. Enable Switching Time

TEST CIRCUITS



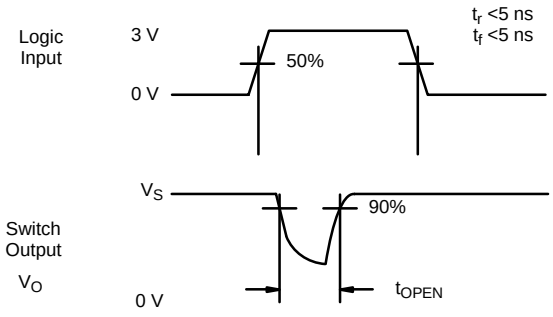
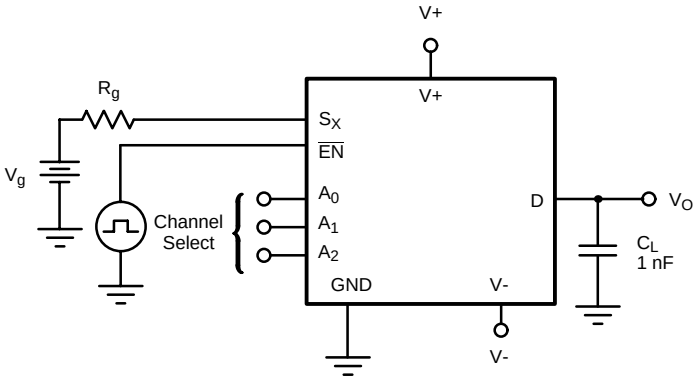
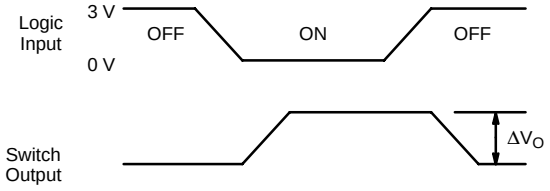


FIGURE 4. Break-Before-Make Interval

Return to Specifications:
Single Supply 12 V
Dual Supply V+ = 5 V, V- = -5 V
Single Supply 5 V
Single Supply 3 V





ΔVO is the measured voltage due to charge transfer error Q, when the channel turns off.

$Q = C_L \times \Delta V_O$

FIGURE 5. Charge Injection

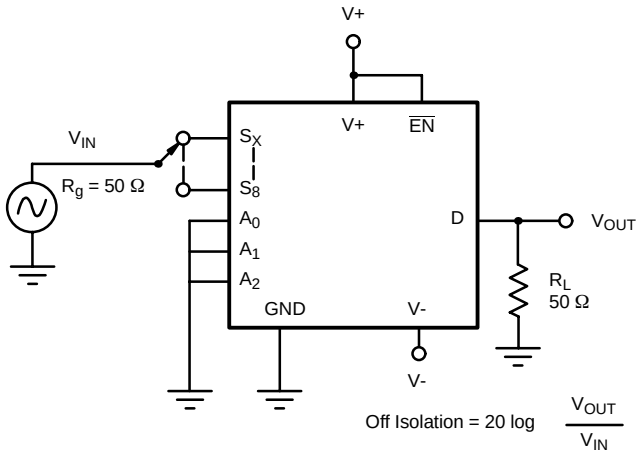


FIGURE 6. Off Isolation

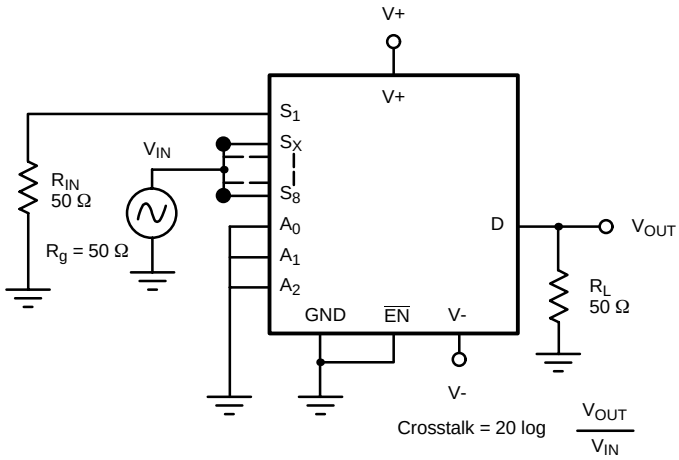


FIGURE 7. Crosstalk

TEST CIRCUITS

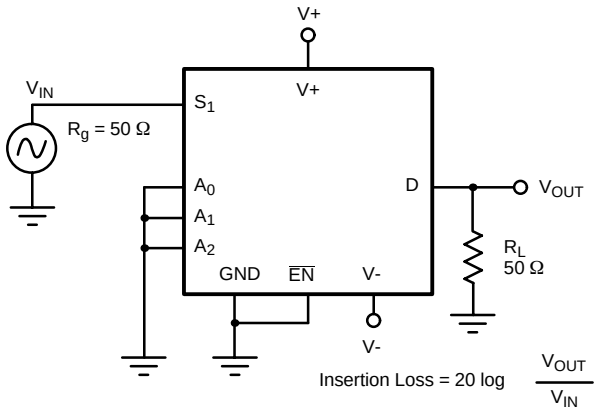


FIGURE 8. Insertion Loss

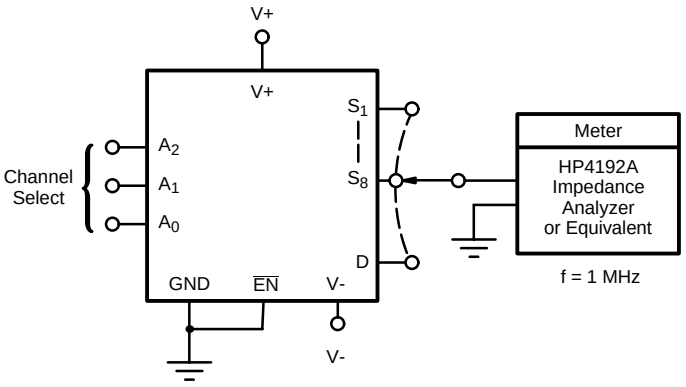


FIGURE 9. Source Drain Capacitance