

## 8-Ch/Dual 4-Ch High-Performance CMOS Analog Multiplexers

### DESCRIPTION

The DG408 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 DG409 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 protects against momentary crosstalk between adjacent channels.

An on channel conducts current equally well in both directions. In the off state each channel blocks voltages up to the power supply rails. An enable (EN) function allows the user to reset the multiplexer/demultiplexer to all switches off for stacking several devices. All control inputs, address ( $A_x$ ) and enable (EN) are TTL compatible over the full specified operating temperature range.

Applications for the DG408, DG409 include high speed data acquisition, audio signal switching and routing, ATE systems, and avionics. High performance and low power dissipation make them ideal for battery operated and remote instrumentation applications.

Designed in the 44 V silicon-gate CMOS process, the absolute maximum voltage rating is extended to 44 V. Additionally, single supply operation is also allowed. An epitaxial layer prevents latchup.

For additional information please see Technical Article TA201.

### FEATURES

- Low on-resistance -  $R_{DS(on)}$ : 100  $\Omega$
- Low charge injection - Q: 20 pC
- Fast transition time -  $t_{TRANS}$ : 160 ns
- Low power -  $I_{SUPPLY}$ : 10  $\mu$ A
- Single supply capability
- 44 V supply max. rating
- TTL compatible logic
- **Compliant to RoHS Directive 2002/95/EC**



### BENEFITS

- Reduced switching errors
- Reduced glitching
- Improved data throughput
- Reduced power consumption
- Increased ruggedness
- Wide supply ranges ( $\pm 5$  V to  $\pm 20$  V)

### APPLICATIONS

- Data acquisition systems
- Audio signal routing
- ATE systems
- Battery powered systems
- Single supply systems
- Medical instrumentation

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



\* Pb containing terminations are not RoHS compliant, exemptions may apply

TRUTH TABLE (DG408)				
A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>	EN	ON SWITCH
X	X	X	0	None
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

TRUTH TABLE (DG409)			
A <sub>1</sub>	A <sub>0</sub>	EN	ON SWITCH
X	X	0	None
0	0	1	1
0	1	1	2
1	0	1	3
1	1	1	4

**Notes**

- Logic "0" =  $V_{AL} \leq 0.8\text{ V}$
- Logic "1" =  $V_{AH} \geq 2.4\text{ V}$
- X = Do not care

ORDERING INFORMATION (Commercial)				
PART	CONFIGURATION	TEMP. RANGE	PACKAGE	ORDERING PART NUMBER
DG408	8:1 x 1	- 40 °C to 85 °C	16-pin plastic DIP	DG408DJ
				DG408DJ-E3
				DG408DY
			16-pin SOIC	DG408DY-E3
				DG408DY-T1
				DG408DY-T1-E3
			16-pin TSSOP	DG408DQ
				DG408DQ-E3
				DG408DQ-T1
DG409	4:1 x 2	- 40 °C to 85 °C	16-pin plastic DIP	DG409DJ
				DG409DJ-E3
				DG409DY
			16-pin SOIC	DG409DY-E3
				DG409DY-T1
				DG409DY-T1-E3
			16-pin TSSOP	DG409DQ
				DG409DQ-E3
				DG409DQ-T1
			DG409DQ-T1-E3	

ABSOLUTE MAXIMUM RATINGS			
PARAMETER		LIMIT	UNIT
Voltages Referenced to V-	V+	44	V
	GND	25	
Digital Inputs <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub>		(V-) - 2 to (V+) + 2 or 20 mA, whichever occurs first	
Current (any terminal)		30	mA
Peak Current, S or D (pulsed at 1 ms, 10 % duty cycle max.)		100	
Storage Temperature	(DJ, DY suffix)	- 65 to 125	°C
Power Dissipation (Package) <sup>b</sup>	16-pin plastic DIP <sup>c</sup>	450	mW
	16-pin narrow SOIC and TSSOP <sup>d</sup>	600	

**Notes**

- Signals on S<sub>X</sub>, D<sub>X</sub> or I<sub>NX</sub> exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current ratings.
- All leads soldered or welded to PC board.
- Derate 6 mW/°C above 75 °C.
- Derate 7.6 mW/°C above 75 °C.



SPECIFICATIONS <sup>a</sup>									
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED			D SUFFIX - 40 °C to 85 °C		UNIT		
		V <sub>+</sub> = 15 V, V <sub>-</sub> = - 15 V			TEMP. <sup>b</sup>	TYP. <sup>c</sup>		MIN. <sup>d</sup>	MAX. <sup>d</sup>
		V <sub>AL</sub> = 0.8 V, V <sub>AH</sub> = 2.4 V <sup>f</sup>							
<b>Analog Switch</b>									
Analog Signal Range <sup>e</sup>	V <sub>ANALOG</sub>			Full	-	- 15	15	V	
Drain-Source On-Resistance	R <sub>DS(on)</sub>	V <sub>D</sub> = ± 10 V, I <sub>S</sub> = - 10 mA	Room	40	-	100	Ω		
			Full	-	-	125			
R <sub>DS(on)</sub> Matching Between Channels <sup>9</sup>	ΔR <sub>DS(on)</sub>	V <sub>D</sub> = ± 10 V	Room	-	-	15			
Source Off Leakage Current	I <sub>S(off)</sub>	V <sub>S</sub> = ± 10 V, V <sub>D</sub> = ± 10 V, V <sub>EN</sub> = 0 V	Room	-	- 0.5	0.5			
			Full	-	- 5	5			
DG408	Drain Off Leakage Current	V <sub>D</sub> = ± 10 V, V <sub>S</sub> = ± 10 V, V <sub>EN</sub> = 0 V	Room	-	- 1	1	nA		
DG408			Full	-	- 20	20			
DG409			Room	-	- 1	1			
DG409			Full	-	- 10	10			
DG408	Drain On Leakage Current	V <sub>S</sub> = V <sub>D</sub> = ± 10 V sequence each switch on	Room	-	- 1	1			
DG408			Full	-	- 20	20			
DG409			Room	-	- 1	1			
DG409			Full	-	- 10	10			
<b>Digital Control</b>									
Logic High Input Voltage	V <sub>INH</sub>			Full	-	2.4	-	V	
Logic Low Input Voltage	V <sub>INL</sub>			Full	-	-	0.8		
Logic High Input Current	I <sub>AH</sub>	V <sub>A</sub> = 2.4 V, 15 V		Full	-	- 10	10	μA	
Logic Low Input Current	I <sub>AL</sub>	V <sub>EN</sub> = 0 V, 2.4 V, V <sub>A</sub> = 0 V		Full	-	- 10	10		
Logic Input Capacitance	C <sub>in</sub>	f = 1 MHz		Room	8	-	-	pF	
<b>Dynamic Characteristics</b>									
Transition Time	t <sub>TRANS</sub>	see figure 2		Full	160	-	250	ns	
Break-Before-Make Interval	t <sub>OPEN</sub>	see figure 4		Room	-	10	-		
Enable Turn-On Time	t <sub>ON(EN)</sub>	see figure 3		Room	115	-	150		
Enable Turn-Off Time	t <sub>OFF(EN)</sub>			Full	-	-	-		
Charge Injection	Q	C <sub>L</sub> = 10 nF, V <sub>S</sub> = 0 V		Room	20	-	-	pC	
Off Isolation <sup>h</sup>	OIRR	V <sub>EN</sub> = 0 V, R <sub>L</sub> = 1 kΩ, f = 1 MHz		Room	- 75	-	-		
Source Off Capacitance	C <sub>S(off)</sub>	V <sub>EN</sub> = 0 V, V <sub>S</sub> = 0 V, f = 1 MHz		Room	3	-	-	pF	
DG408	Drain Off Capacitance	V <sub>EN</sub> = 0 V, V <sub>D</sub> = 0 V, f = 1 MHz		Room	26	-	-		
DG409				Room	14	-	-		
DG408	Drain On Capacitance			Room	37	-	-		
DG409				Room	25	-	-		
<b>Power Supplies</b>									
Positive Supply Current	I <sub>+</sub>	V <sub>EN</sub> = V <sub>A</sub> = 0 V or 5 V		Full	10	-	75	μA	
Negative Supply Current	I <sub>-</sub>			Full	1	- 75	-		
Positive Supply Current	I <sub>+</sub>	V <sub>EN</sub> = V <sub>A</sub> = 0 V or 5 V		Room	0.2	-	0.5	mA	
Negative Supply Current	I <sub>-</sub>			Full	-	-	2		
				Full	-	- 500	-	μA	

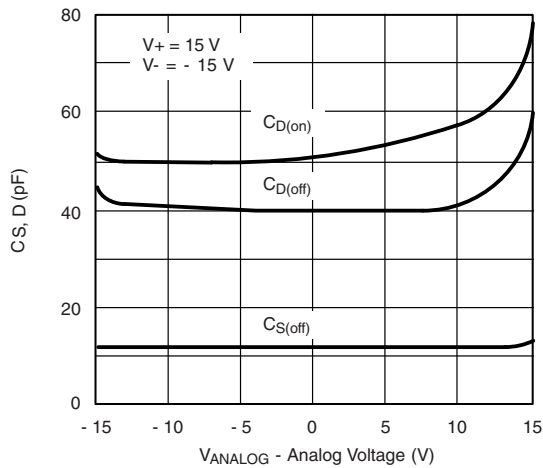


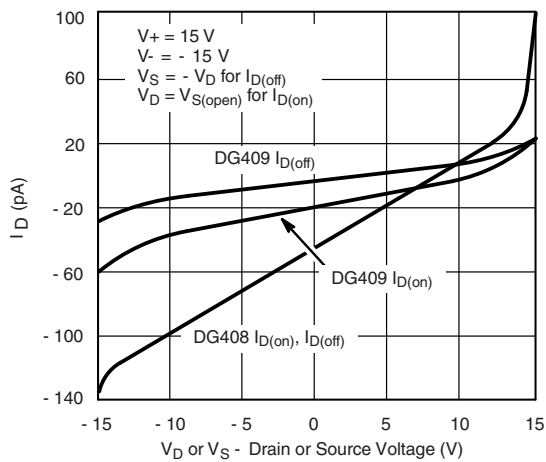
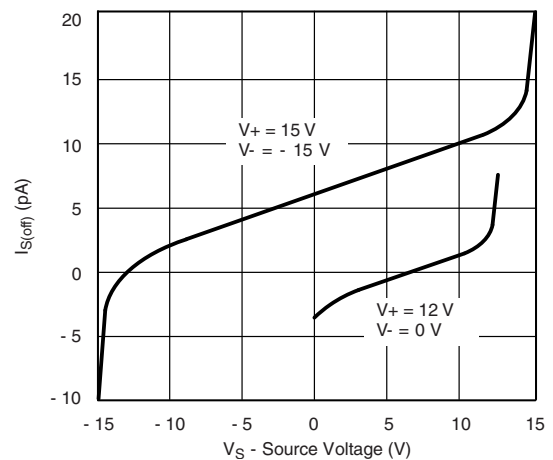
SPECIFICATIONS <sup>a</sup> (Single Supply)							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED	TEMP. <sup>b</sup>	TYP. <sup>c</sup>	D SUFFIX - 40 °C to 85 °C		UNIT
		V <sub>+</sub> = 12 V, V <sub>-</sub> = 0 V			MIN. <sup>d</sup>	MAX. <sup>d</sup>	
		V <sub>AL</sub> = 0.8 V, V <sub>AH</sub> = 2.4 V <sup>f</sup>					
<b>Analog Switch</b>							
Drain-Source On-Resistance <sup>e, f</sup>	R <sub>DS(on)</sub>	V <sub>D</sub> = 3 V, 10 V, I <sub>S</sub> = -1 mA	Room	90	-	-	Ω
<b>Dynamic Characteristics</b>							
Switching Time of Multiplexer <sup>e</sup>	t <sub>TRANS</sub>	V <sub>S1</sub> = 8 V, V <sub>S8</sub> = 0 V, V <sub>IN</sub> = 2.4 V	Room	180	-	-	ns
Enable Turn-On Time <sup>e</sup>	t <sub>ON(EN)</sub>	V <sub>INH</sub> = 2.4 V, V <sub>INL</sub> = 0 V, V <sub>S1</sub> = 5 V	Room	180	-	-	
Enable Turn-Off Time <sup>e</sup>	t <sub>OFF(EN)</sub>		Room	120	-	-	
Charge Injection <sup>e</sup>	Q	C <sub>L</sub> = 1 nF, V <sub>S</sub> = 0 V, R <sub>S</sub> = 0	Room	5	-	-	pC

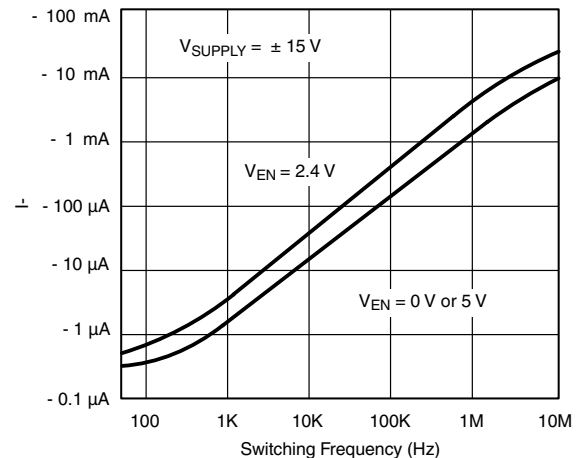
### Notes

- Refer to PROCESS OPTION FLOWCHART.
- Room = 25 °C, Full = as determined by the operating temperature suffix.
- Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet.
- Guaranteed by design, not subject to production test.
- V<sub>IN</sub> = input voltage to perform proper function.
- ΔR<sub>DS(on)</sub> = R<sub>DS(on) max.</sub> - R<sub>DS(on) min.</sub>
- Worst case isolation occurs on channel 4 due to proximity to the drain pin.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Source/Drain Capacitance vs. Analog Voltage**

**Drain Leakage Current vs. Source/Drain Voltage (Single 12 V Supply)**

**Drain Leakage Current vs. Source/Drain Voltage**

**Source Leakage Current vs. Source Voltage**

**Input Switching Threshold vs. Supply Voltage**

**Negative Supply Current vs. Switching Frequency**

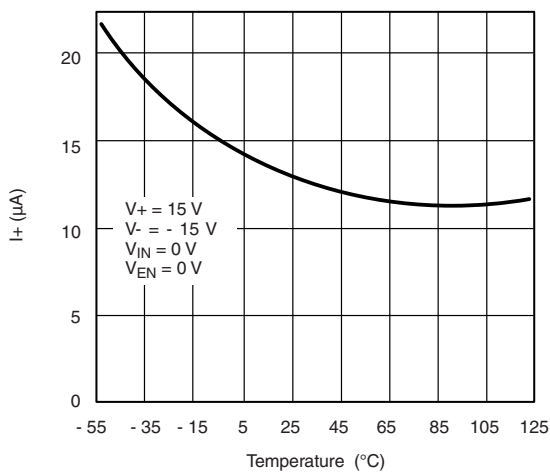
## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



Positive Supply Current vs. Switching Frequency



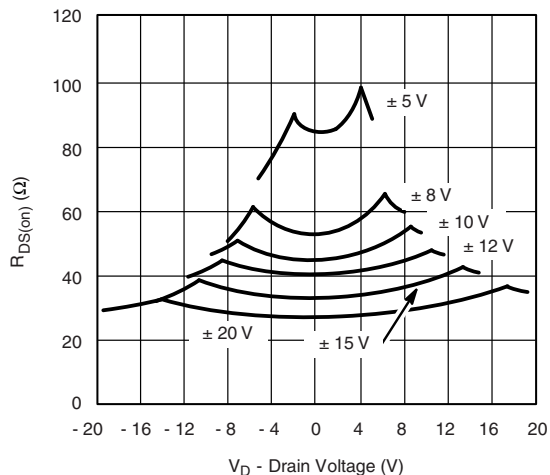
$I_{SUPPLY}$  vs. Temperature



Positive Supply Current vs. Temperature (DG408)



Charge Injection vs. Analog Voltage



$R_{DS(on)}$  vs.  $V_D$  and Supply

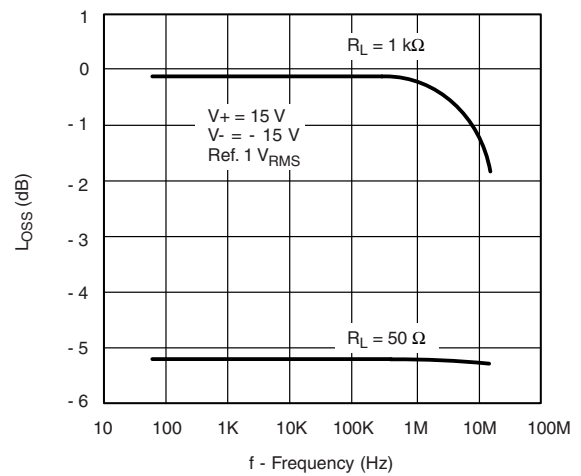


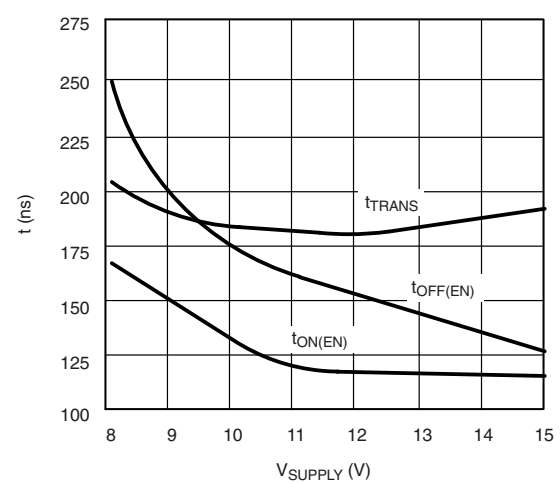
$R_{DS(on)}$  vs.  $V_D$  and Supply (Single Supply)

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

 **$R_{DS(on)}$  vs.  $V_D$  and Temperature**

 **$R_{DS(on)}$  vs.  $V_D$  and Temperature (Single Supply)**

**Off Isolation and Crosstalk vs. Frequency**

**Insertion Loss vs. Frequency**

**Switching Time vs. Bipolar Supply**

**Switching Time vs. Single Supply**

## SCHEMATIC DIAGRAM (Typical Channel)



Fig. 1

## TEST CIRCUITS

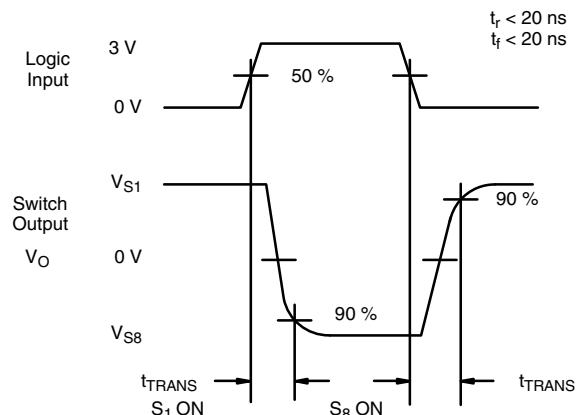
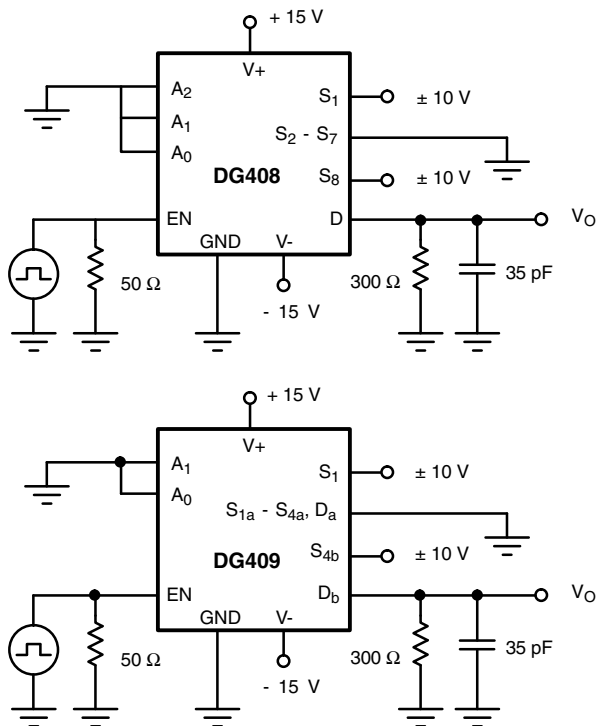
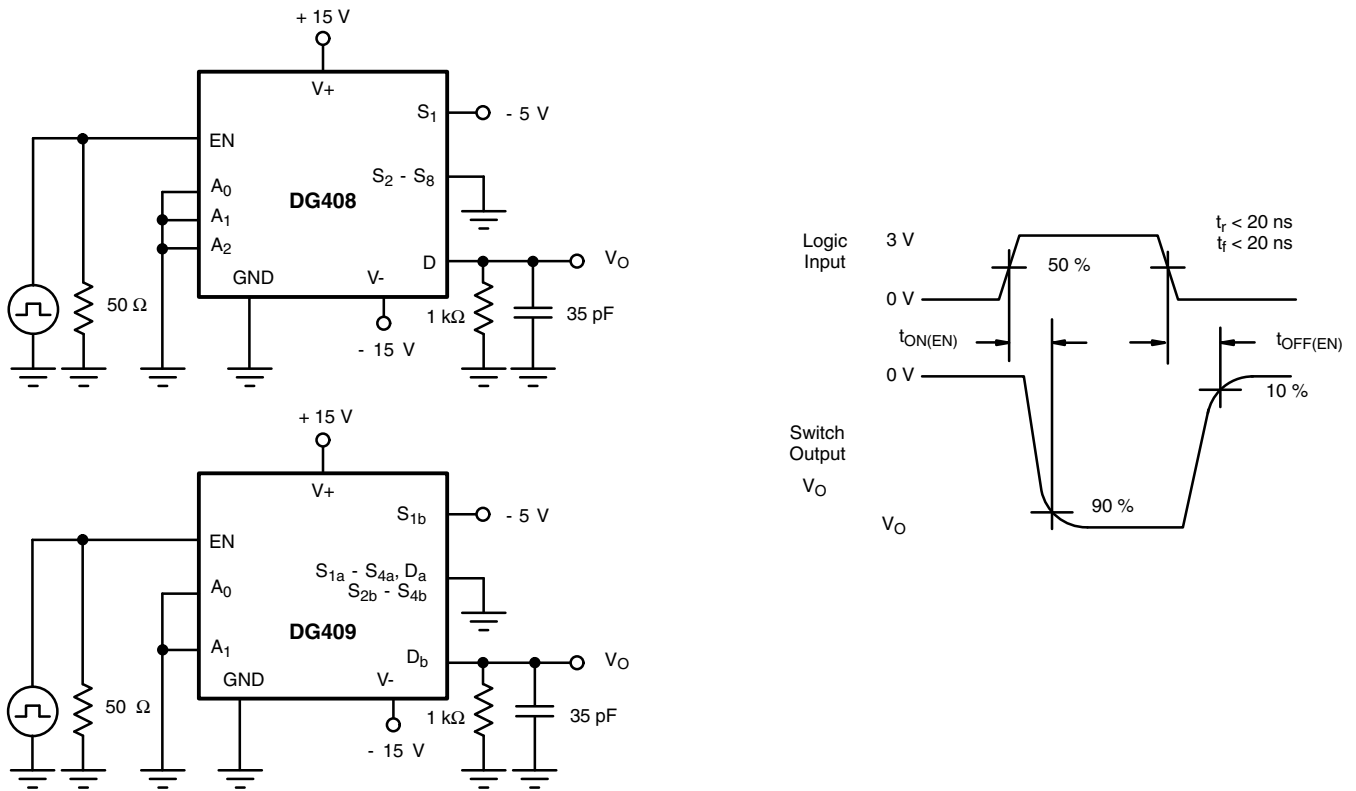
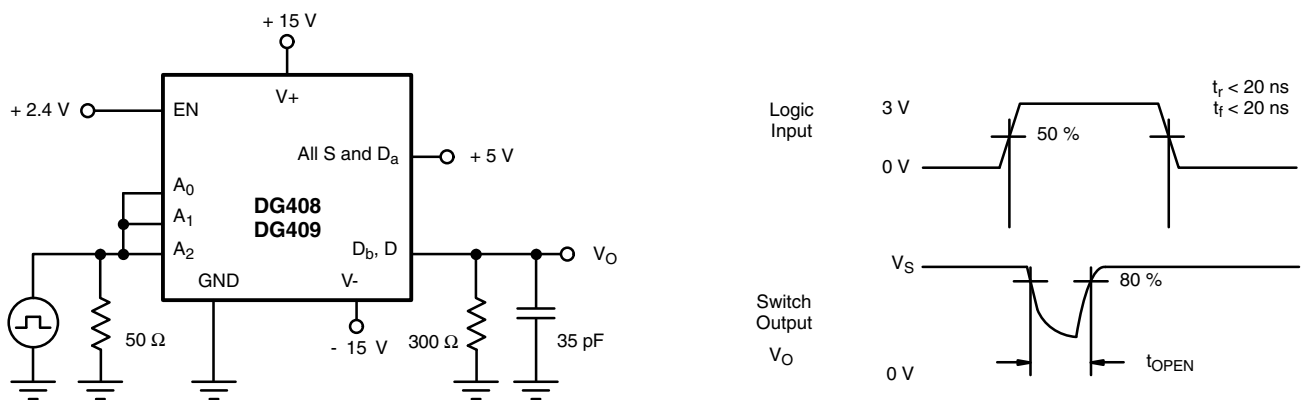


Fig. 2 - Transition Time



**TEST CIRCUITS**

**Fig. 3 - Enable Switching Time**

**Fig. 4 - Break-Before-Make Interval**

## TEST CIRCUITS

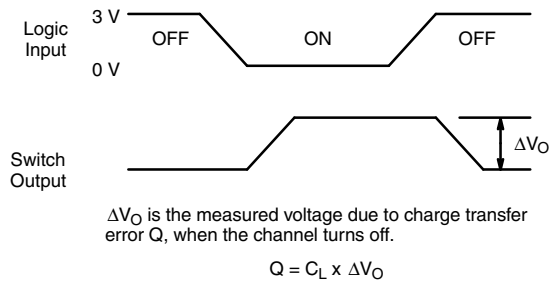
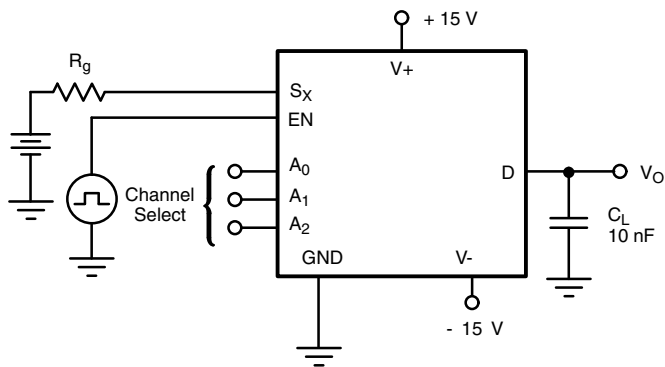


Fig. 5 - Charge Injection



Fig. 6 - Off Isolation

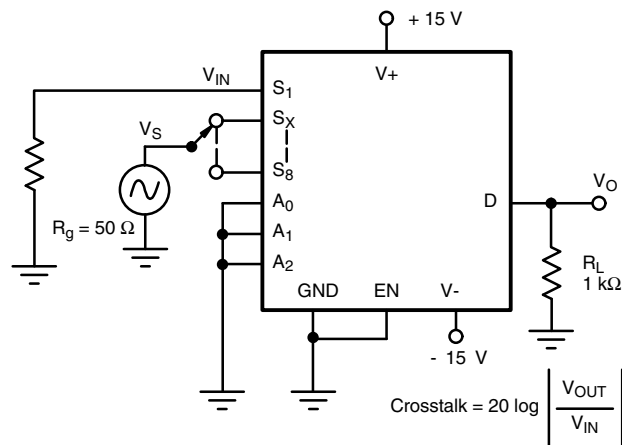


Fig. 7 - Crosstalk

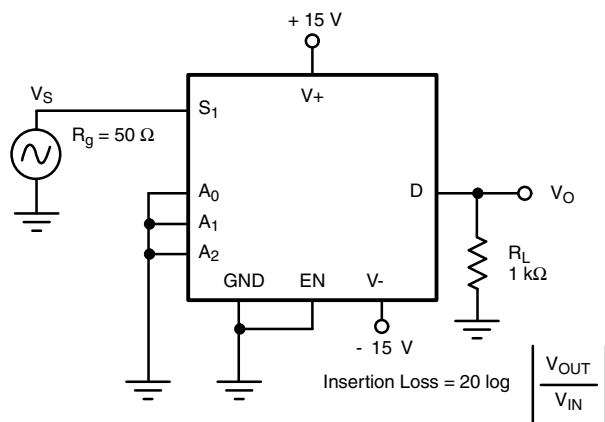


Fig. 8 - Insertion Loss

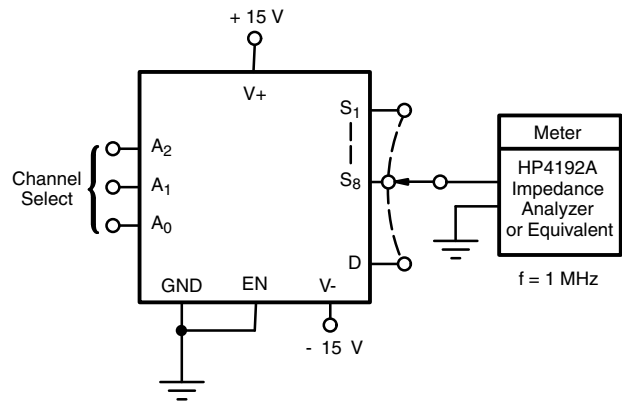


Fig. 9 - Source Drain Capacitance

## APPLICATION HINTS

### Overvoltage Protection

A very convenient form of overvoltage protection consists of adding two small signal diodes (1N4148, 1N914 type) in series with the supply pins (see figure 10). This arrangement effectively blocks the flow of reverse currents. It also floats the supply pin above or below the normal  $V+$  or  $V-$  value. In this case the overvoltage signal actually becomes the power

supply of the IC. From the point of view of the chip, nothing has changed, as long as the difference  $V_S - (V-)$  does not exceed + 44 V. The addition of these diodes will reduce the analog signal range to 1 V below  $V+$  and 1 V above  $V-$ , but it preserves the low channel resistance and low leakage characteristics.

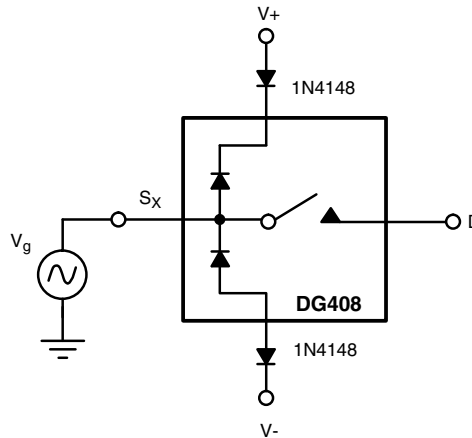


Fig. 10 - Overvoltage Protection Using Blocking Diodes

### 8-Channel Sequential Multiplexer/Demultiplexer

### Differential 4-Channel Sequential Multiplexer/Demultiplexer

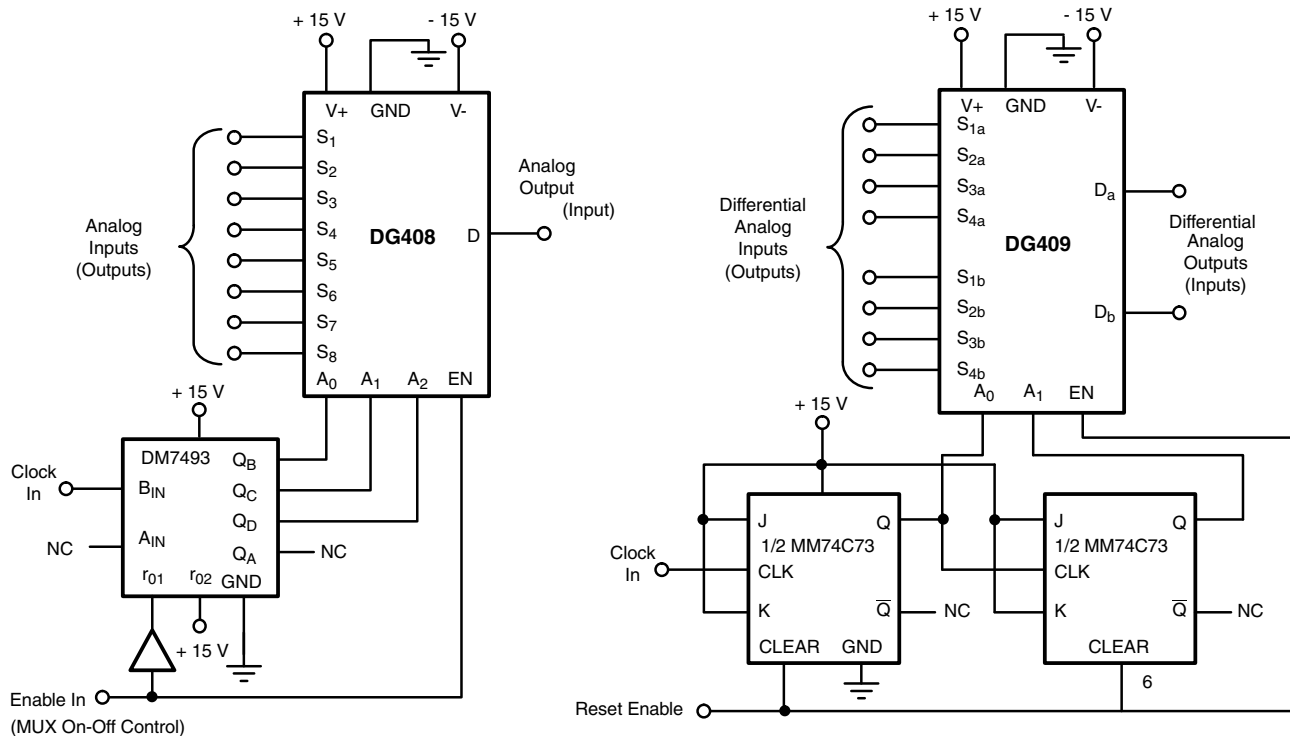


Fig. 11

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**SOIC (NARROW): 16-LEAD**  
JEDEC Part Number: MS-012



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.20	0.004	0.008
B	0.38	0.51	0.015	0.020
C	0.18	0.23	0.007	0.009
D	9.80	10.00	0.385	0.393
E	3.80	4.00	0.149	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
L	0.50	0.93	0.020	0.037
∅	0°	8°	0°	8°

ECN: S-03946—Rev. F, 09-Jul-01  
DWG: 5300



### PDIP: 16-LEAD



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.150	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>B</b>	0.38	0.51	0.015	0.020
<b>B<sub>1</sub></b>	0.89	1.65	0.035	0.065
<b>C</b>	0.20	0.30	0.008	0.012
<b>D</b>	18.93	21.33	0.745	0.840
<b>E</b>	7.62	8.26	0.300	0.325
<b>E<sub>1</sub></b>	5.59	7.11	0.220	0.280
<b>e<sub>1</sub></b>	2.29	2.79	0.090	0.110
<b>e<sub>A</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>Q<sub>1</sub></b>	1.27	2.03	0.050	0.080
<b>S</b>	0.38	1.52	.015	0.060

ECN: S-03946—Rev. D, 09-Jul-01  
DWG: 5482



**CERDIP: 16-LEAD**



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	4.06	5.08	0.160	0.200
A <sub>1</sub>	0.51	1.14	0.020	0.045
B	0.38	0.51	0.015	0.020
B <sub>1</sub>	1.14	1.65	0.045	0.065
C	0.20	0.30	0.008	0.012
D	19.05	19.56	0.750	0.770
E	7.62	8.26	0.300	0.325
E <sub>1</sub>	6.60	7.62	0.260	0.300
e <sub>1</sub>	2.54 BSC		0.100 BSC	
e <sub>A</sub>	7.62 BSC		0.300 BSC	
L	3.18	3.81	0.125	0.150
L <sub>1</sub>	3.81	5.08	0.150	0.200
Q <sub>1</sub>	1.27	2.16	0.050	0.085
S	0.38	1.14	0.015	0.045
∞	0°	15°	0°	15°

ECN: S-03946—Rev. G, 09-Jul-01  
DWG: 5403



**20-LEAD LCC**



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	1.37	2.24	0.054	0.088
<b>A<sub>1</sub></b>	1.63	2.54	0.064	0.100
<b>B</b>	0.56	0.71	0.022	0.028
<b>D</b>	8.69	9.09	0.342	0.358
<b>E</b>	8.69	9.09	0.442	0.358
<b>e</b>	1.27 BSC		0.050 BSC	
<b>L</b>	1.14	1.40	0.045	0.055
<b>L<sub>1</sub></b>	1.96	2.36	0.077	0.093
ECN: S-03946—Rev. B, 09-Jul-01 DWG: 5321				

## TSSOP: 16-LEAD



Symbols	DIMENSIONS IN MILLIMETERS		
	Min	Nom	Max
A	-	1.10	1.20
A1	0.05	0.10	0.15
A2	-	1.00	1.05
B	0.22	0.28	0.38
C	-	0.127	-
D	4.90	5.00	5.10
E	6.10	6.40	6.70
E1	4.30	4.40	4.50
e	-	0.65	-
L	0.50	0.60	0.70
L1	0.90	1.00	1.10
y	-	-	0.10
θ1	0°	3°	6°

ECN: S-61920-Rev. D, 23-Oct-06  
DWG: 5624





## RECOMMENDED MINIMUM PAD FOR TSSOP-16



Recommended Minimum Pads  
Dimensions in inches (mm)

## RECOMMENDED MINIMUM PADS FOR SO-16



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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