

# 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 DG408/409 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 (FaxBack Number 70600).

## 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



RoHS\*  
COMPLIANT

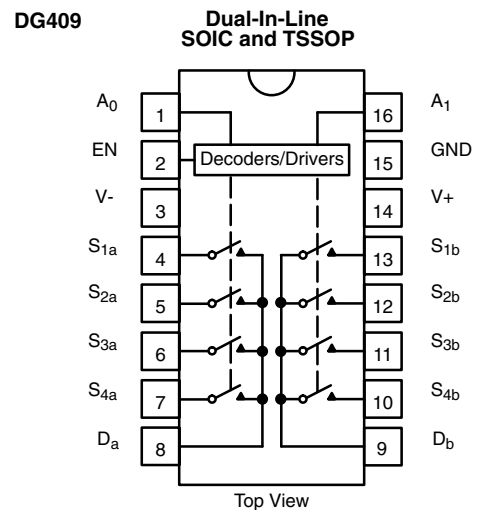
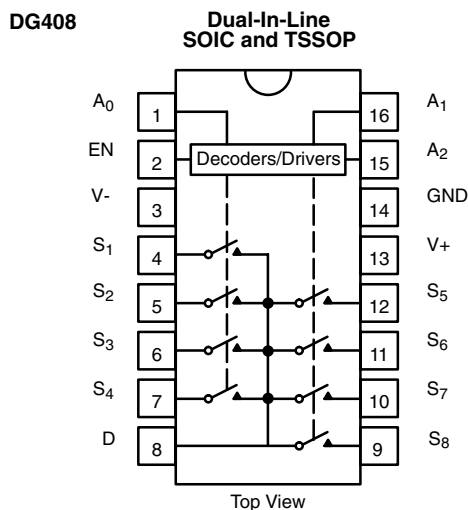
## BENEFITS

- 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
- High Rel Systems
- Single Supply Systems
- Medical Instrumentation

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



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



**TRUTH TABLES AND ORDERING INFORMATION**

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

Logic "0" = V<sub>AL</sub> ≤ 0.8 V  
 Logic "1" = V<sub>AH</sub> ≥ 2.4 V  
 X = Don't Care

ORDERING INFORMATION - DG408		
Temp Range	Package	Part Number
- 40 to 85 °C	16-Pin Plastic DIP	DG408DJ DG408DJ-E3
	16-Pin SOIC	DG408DY DG408DY-E3 DG408DY-T1 DG408DY-T1-E3
	16-Pin TSSOP	DG408DQ DG408DQ-E3 DG408DQ-T1 DG408DQ-T1-E3

ORDERING INFORMATION - DG409		
Temp Range	Package	Part Number
- 40 to 85 °C	16-Pin Plastic DIP	DG409DJ DG409DJ-E3
	16-Pin SOIC	DG409DY 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	(AK Suffix)	- 65 to 150	°C
	(DJ, DY Suffix)	- 65 to 125	
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	
	16-Pin CerDIP <sup>e</sup>	900	
	LCC-20 <sup>f</sup>	750	

Notes:

- a. 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.
- b. All leads soldered or welded to PC board.
- c. Derate 6 mW/°C above 75 °C.
- d. Derate 7.6 mW/°C above 75 °C.
- e. Derate 12 mW/°C above 75 °C.
- f. Derate 10 mW/°C above 75 °C.



<b>SPECIFICATIONS<sup>a</sup></b>										
Parameter	Symbol	Test Conditions Unless Otherwise Specified $V_+ = 15\text{ V}$ , $V_- = -15\text{ V}$ $V_{AL} = 0.8\text{ V}$ , $V_{AH} = 2.4\text{ V}^f$		Temp <sup>b</sup>	Typ <sup>c</sup>	A Suffix - 55 to 125 °C		D Suffix - 40 to 85 °C		Unit
						Min <sup>d</sup>	Max <sup>d</sup>	Min <sup>d</sup>	Max <sup>d</sup>	
<b>Analog Switch</b>										
Analog Signal Range <sup>e</sup>	$V_{ANALOG}$		Full			- 15	15	- 15	15	V
Drain-Source On-Resistance	$r_{DS(on)}$	$V_D = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$	Room Full	40			100 125		100 125	$\Omega$
$r_{DS(on)}$ Matching Between Channels <sup>g</sup>	$\Delta r_{DS(on)}$	$V_D = \pm 10\text{ V}$	Room				15		15	%
Source Off Leakage Current	$I_{S(off)}$	$V_S = \pm 10\text{ V}$ $V_D = \pm 10\text{ V}$ , $V_{EN} = 0\text{ V}$	Room Full			- 0.5 - 50	0.5 50	- 0.5 - 5	0.5 5	nA
Drain Off Leakage Current	$I_{D(off)}$	$V_D = \pm 10\text{ V}$ $V_S = \pm 10\text{ V}$ $V_{EN} = 0\text{ V}$	DG408	Room Full		- 1 - 100	1 100	- 1 - 20	1 20	
			DG409	Room Full		- 1 - 50	1 50	- 1 - 10	1 10	
Drain On Leakage Current	$I_{D(on)}$	$V_S = V_D = \pm 10$ Sequence Each Switch On	DG408	Room Full		- 1 - 100	1 100	- 1 - 20	1 20	
			DG409	Room Full		- 1 - 50	1 50	- 1 - 10	1 10	
<b>Digital Control</b>										
Logic High Input Voltage	$V_{INH}$		Full			2.4		2.4		V
Logic Low Input Voltage	$V_{INL}$		Full				0.8		0.8	
Logic High Input Current	$I_{AH}$	$V_A = 2.4\text{ V}$ , 15 V	Full			- 10	10	- 10	10	$\mu\text{A}$
Logic Low Input Current	$I_{AL}$	$V_{EN} = 0\text{ V}$ , 2.4 V, $V_A = 0\text{ V}$	Full			- 10	10	- 10	10	
Logic Input Capacitance	$C_{in}$	$f = 1\text{ MHz}$	Room	8						pF
<b>Dynamic Characteristics</b>										
Transition Time	$t_{TRANS}$	See Figure 2	Full	160			250		250	ns
Break-Before-Make Interval	$t_{OPEN}$	See Figure 4	Room			10		10		
Enable Turn-On Time	$t_{ON(EN)}$	See Figure 3	Room Full	115			150 225		150	
Enable Turn-Off Time	$t_{OFF(EN)}$		Room	105			150		150	
Charge Injection	Q	$C_L = 10\text{ nF}$ , $V_S = 0\text{ V}$	Room	20						pC
Off Isolation <sup>h</sup>	OIRR	$V_{EN} = 0\text{ V}$ , $R_L = 1\text{ k}\Omega$ $f = 100\text{ kHz}$	Room	- 75						dB
Source Off Capacitance	$C_{S(off)}$	$V_{EN} = 0\text{ V}$ , $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$	Room	3						pF
Drain Off Capacitance	$C_{D(off)}$	$V_{EN} = 0\text{ V}$ $V_D = 0\text{ V}$ $f = 1\text{ MHz}$	DG408	Room	26					
			DG409	Room	14					
Drain On Capacitance	$C_{D(on)}$		DG408	Room	37					
			DG409	Room	25					
<b>Power Supplies</b>										
Positive Supply Current	I+	$V_{EN} = V_A = 0\text{ V}$ or 5 V	Full	10			75		75	$\mu\text{A}$
Negative Supply Current	I-		Full	1	- 75		- 75			
Positive Supply Current	I+	$V_{EN} = 2.4\text{ V}$ , $V_A = 0\text{ V}$	Room Full	0.2			0.5 2		0.5 2	mA
Negative Supply Current	I-		Full		- 500		- 500			



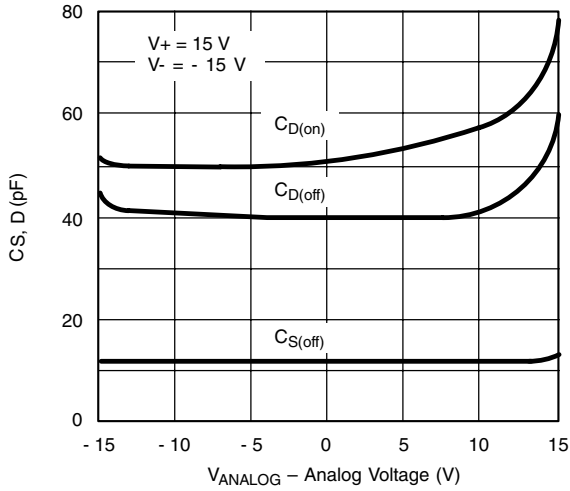
SPECIFICATIONS <sup>a</sup> FOR SINGLE SUPPLY									
Parameter	Symbol	Test Conditions Unless Otherwise Specified V <sub>+</sub> = 12 V, V <sub>-</sub> = 0 V V <sub>AL</sub> = 0.8 V, V <sub>AH</sub> = 2.4 V <sup>f</sup>	Temp <sup>b</sup>	Typ <sup>c</sup>	A Suffix - 55 to 125 °C		D Suffix - 40 to 85 °C		Unit
					Min <sup>d</sup>	Max <sup>d</sup>	Min <sup>d</sup>	Max <sup>d</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	Room	180					
Enable Turn-Off Time <sup>e</sup>	t <sub>OFF(EN)</sub>	V <sub>S1</sub> = 5 V	Room	120					
Charge Injection <sup>e</sup>	Q	C <sub>L</sub> = 1 nF, V <sub>S</sub> = 6 V, R <sub>S</sub> = 0	Room	5					pC

Notes:

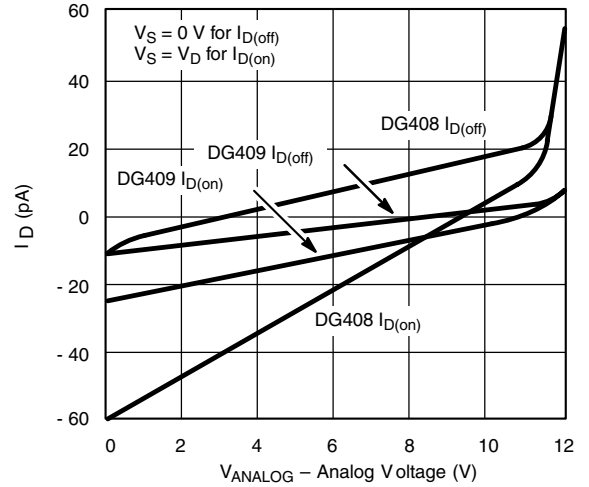
- a. Refer to PROCESS OPTION FLOWCHART.
- b. Room = 25 °C, Full = as determined by the operating temperature suffix.
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- e. Guaranteed by design, not subject to production test.
- f. V<sub>IN</sub> = input voltage to perform proper function.
- g. Δr<sub>DS(on)</sub> = r<sub>DS(on)</sub> MAX - r<sub>DS(on)</sub> MIN.
- h. 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.

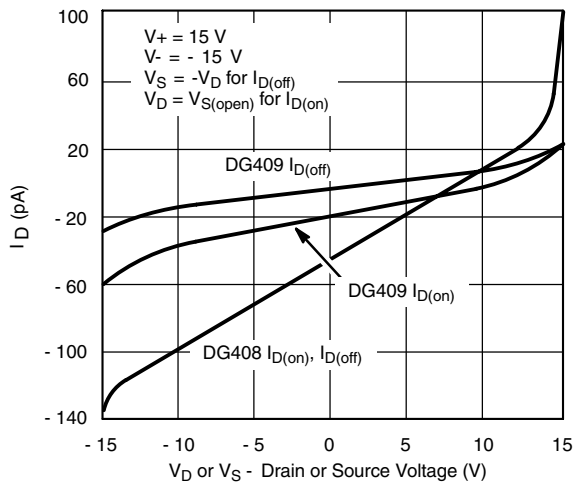
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



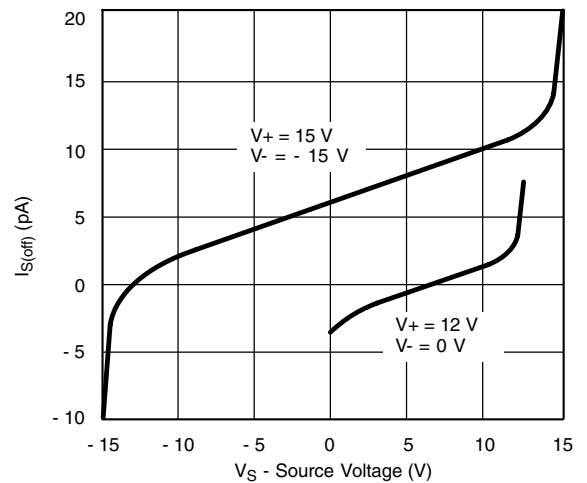
**Source/Drain Capacitance vs. Analog Voltage**



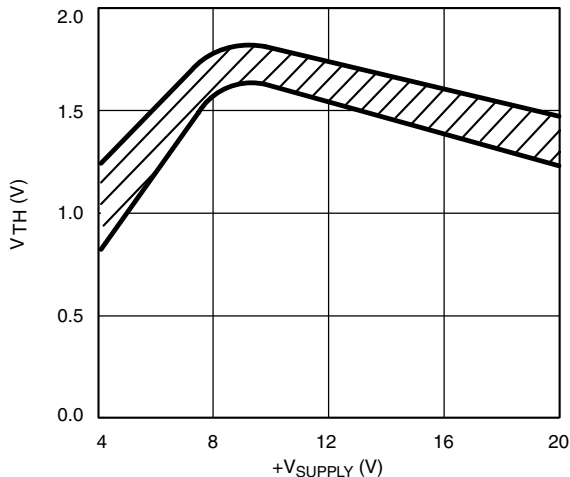
**Drain Leakage Current vs. Source/Drain Voltage (Single 12-V Supply)**



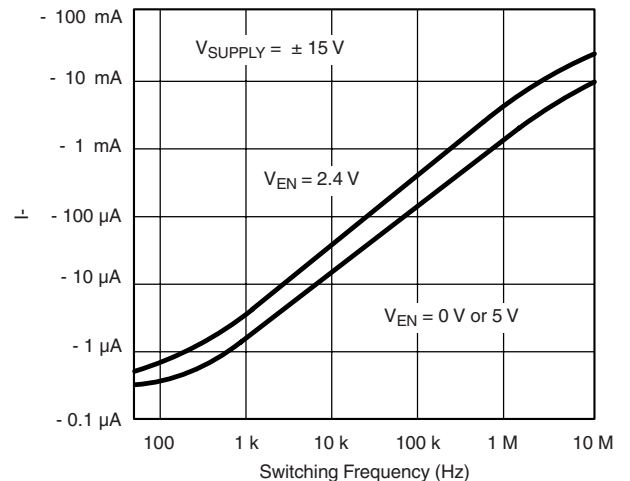
**Drain Leakage Current vs. Source/Drain Voltage**



**Source Leakage Current vs. Source Voltage**



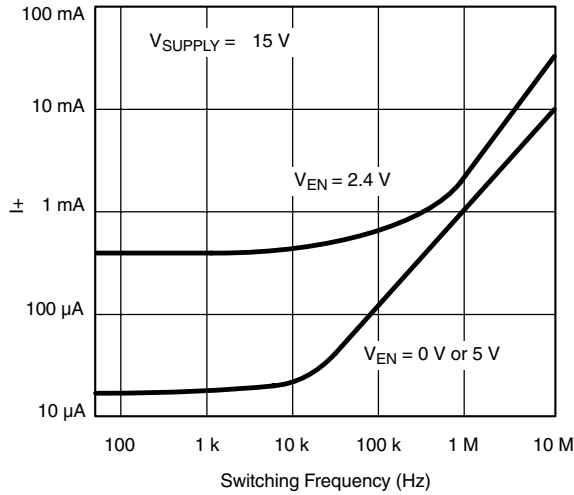
**Input Switching Threshold vs. Supply Voltage**



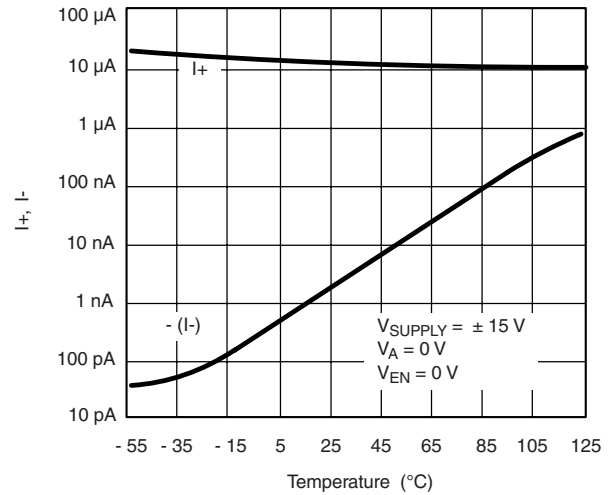
**Negative Supply Current vs. Switching Frequency**



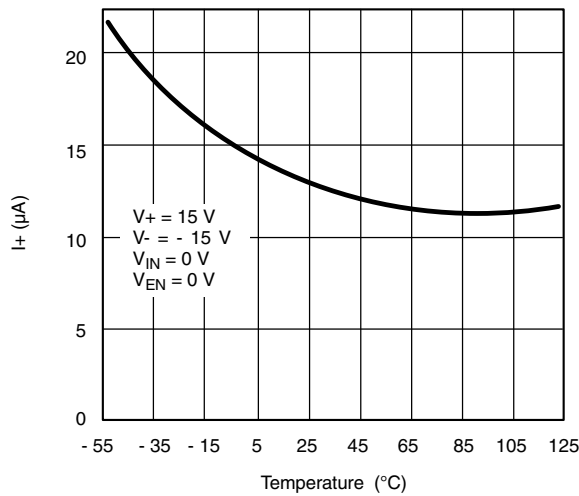
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



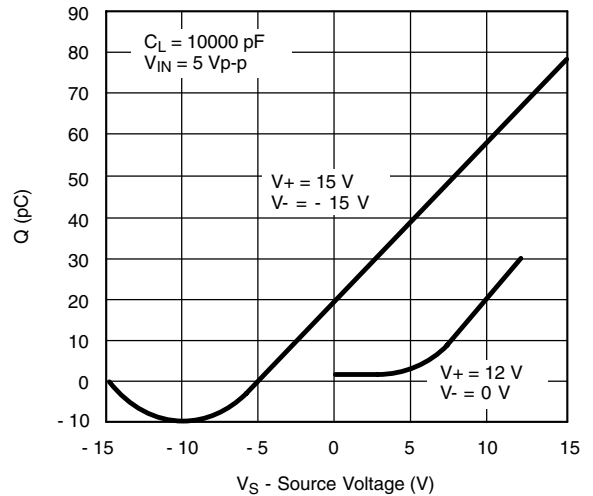
**Positive Supply Current vs. Switching Frequency**



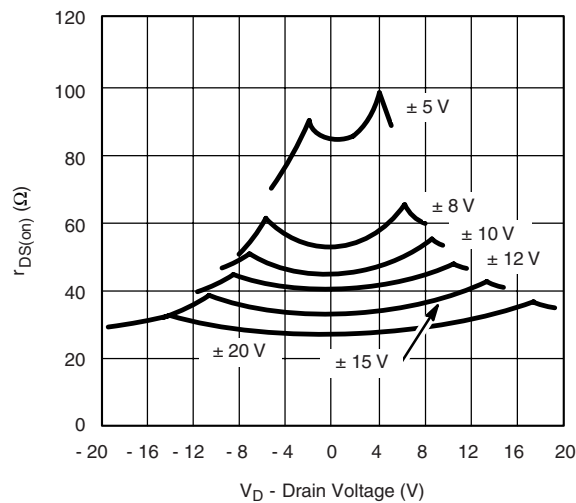
**I<sub>SUPPLY</sub> vs. Temperature**



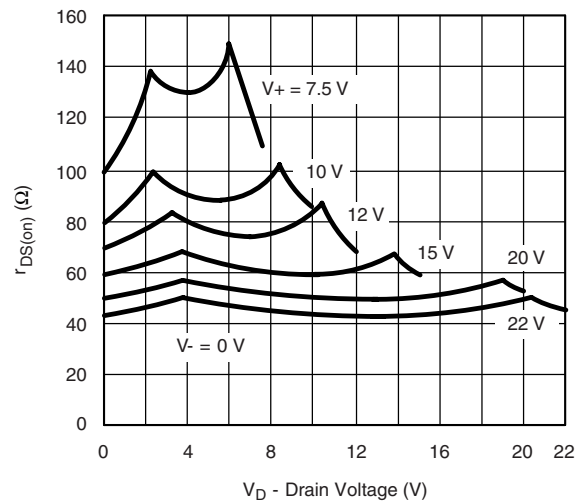
**Positive Supply Current vs. Temperature (DG408)**



**Charge Injection vs. Analog Voltage**

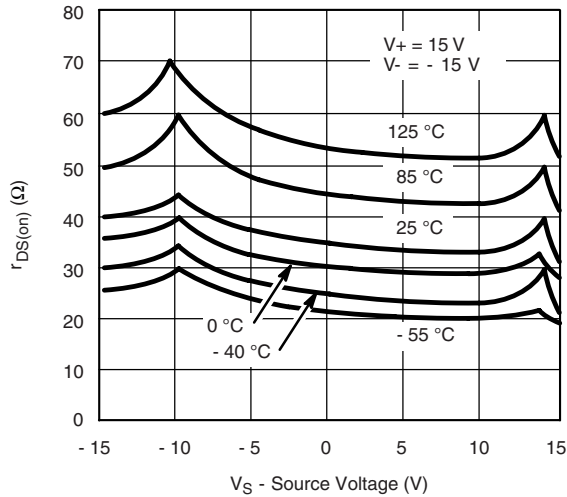


**r<sub>DS(on)</sub> vs. V<sub>D</sub> and Supply**

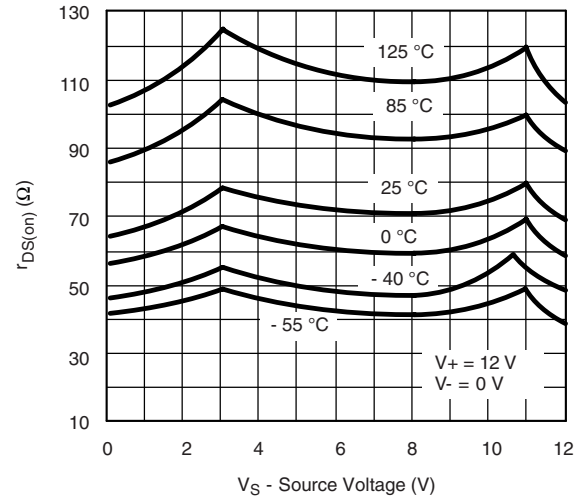


**r<sub>DS(on)</sub> vs. V<sub>D</sub> and Supply (Single Supply)**

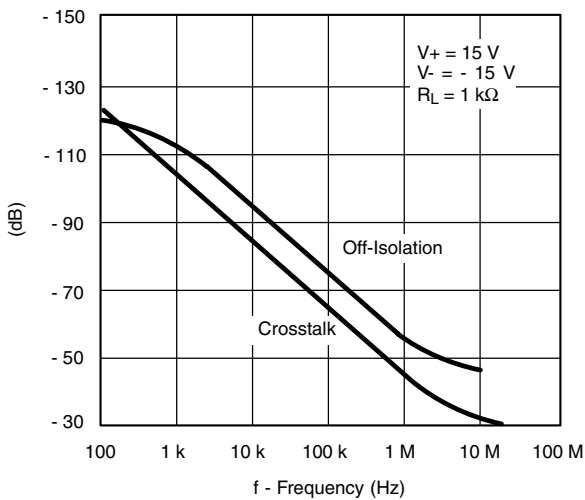
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



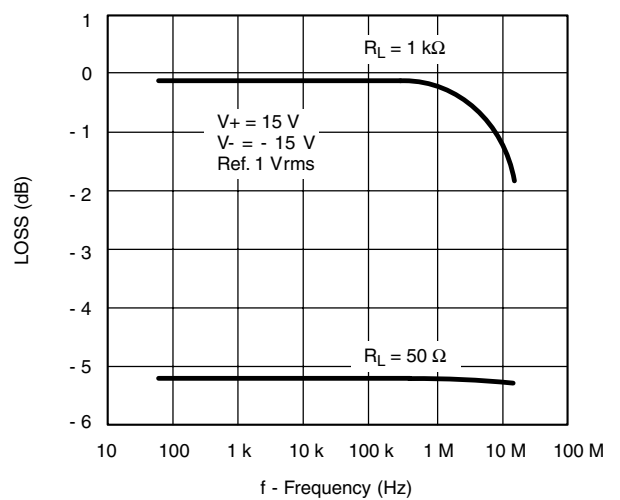
**$r_{DS(on)}$  vs.  $V_S$  and Temperature**



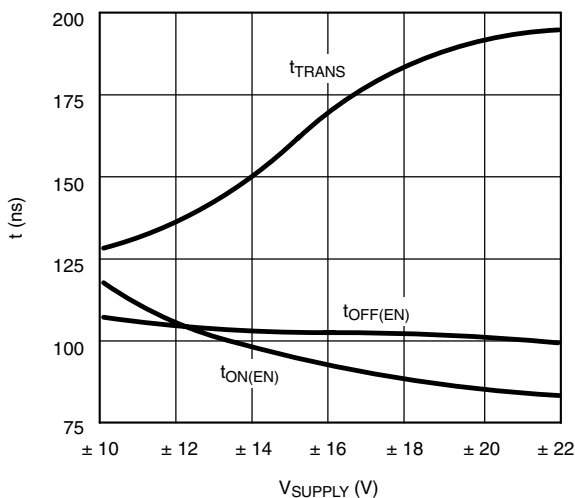
**$r_{DS(on)}$  vs.  $V_S$  and Temperature (Single Supply)**



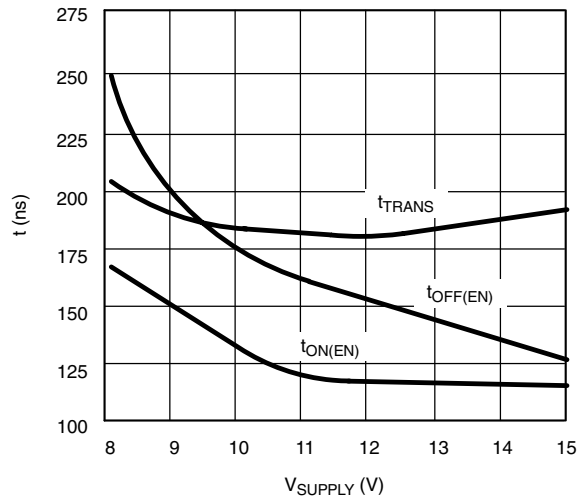
**Off Isolation and Crosstalk vs. Frequency**



**Insertion Loss vs. Frequency**



**Switching Time vs. Bipolar Supply**



**Switching Time vs. Single Supply**

**SCHEMATIC DIAGRAM (TYPICAL CHANNEL)**

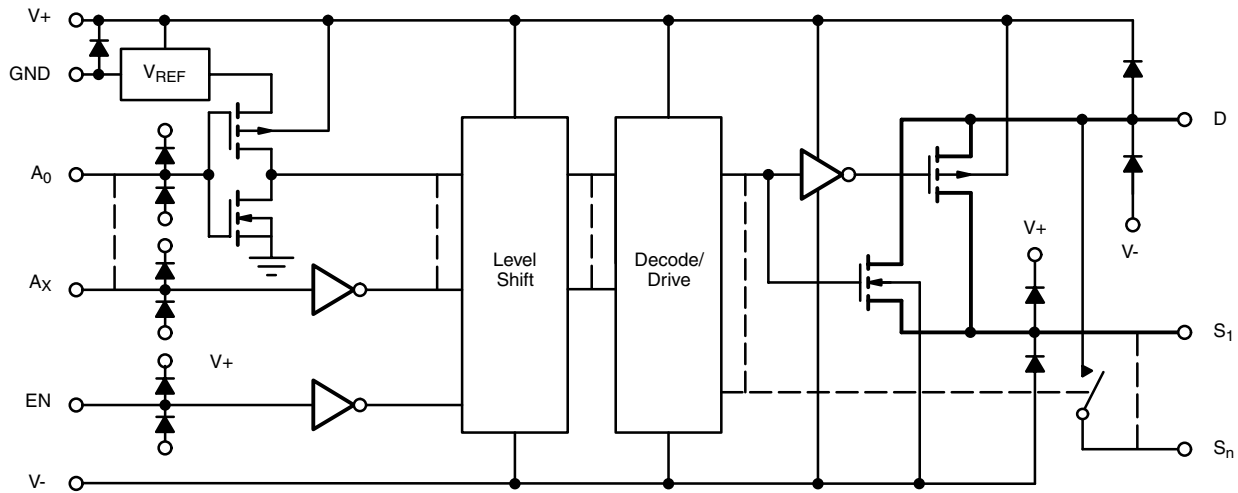


Figure 1.

**TEST CIRCUITS**

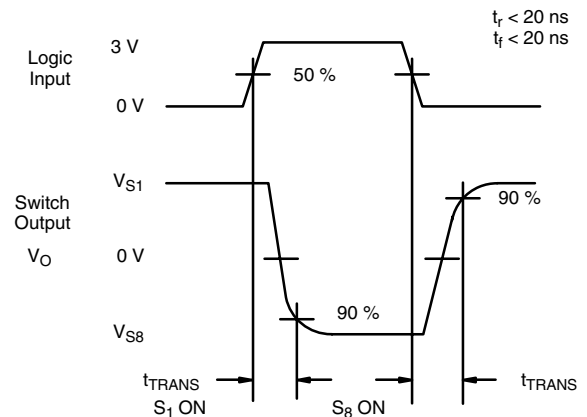
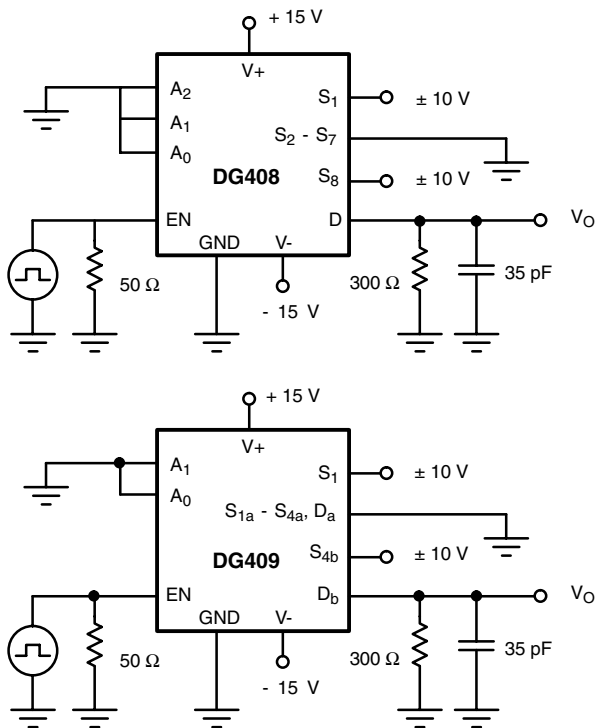


Figure 2. Transition Time



TEST CIRCUITS

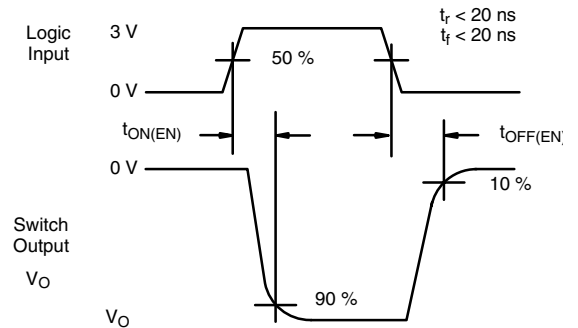
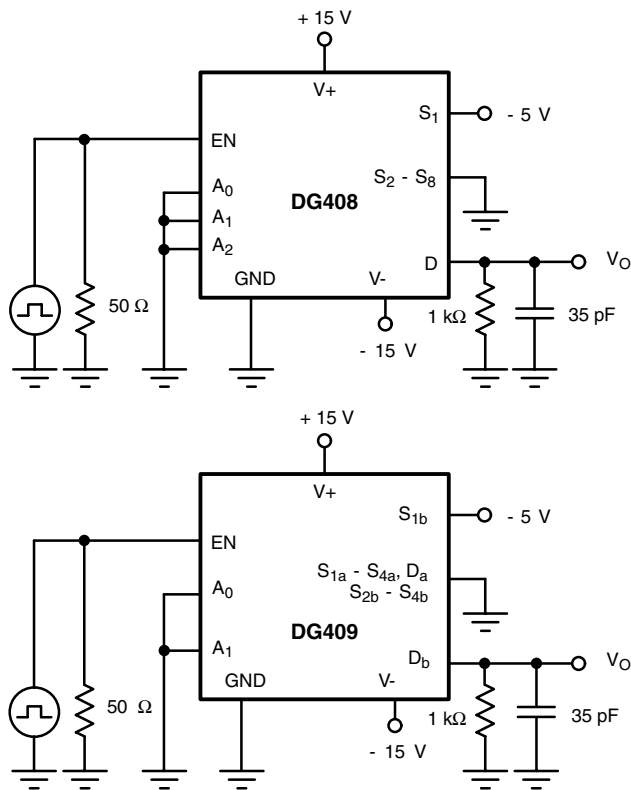


Figure 3. Enable Switching Time

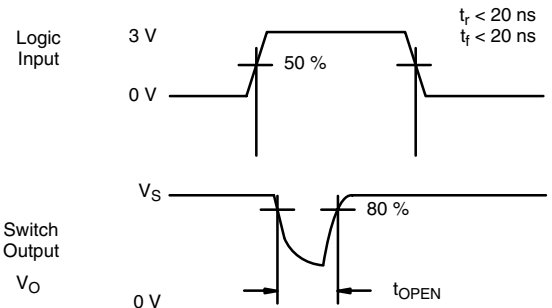
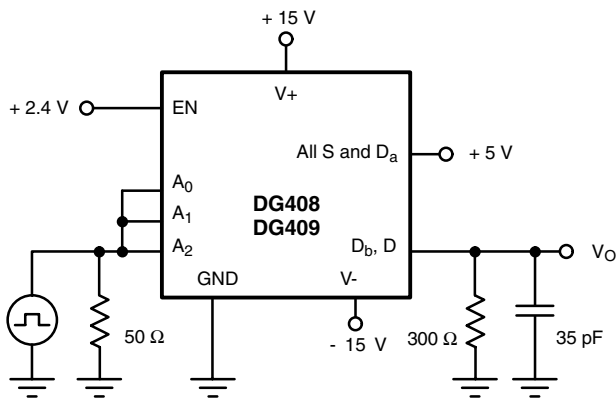


Figure 4. Break-Before-Make Interval

TEST CIRCUITS

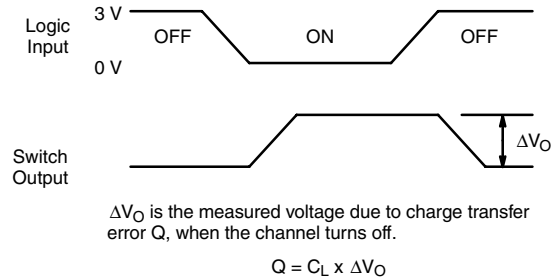
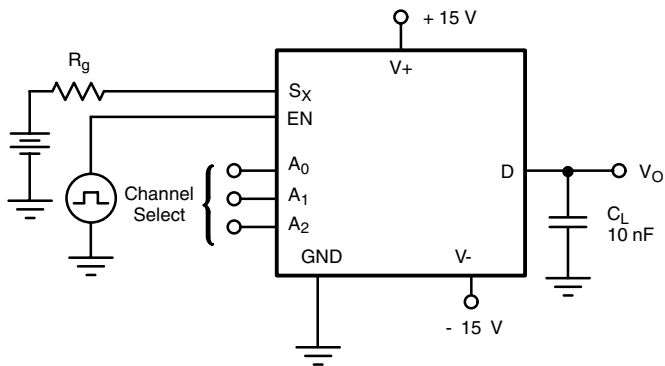


Figure 5. Charge Injection

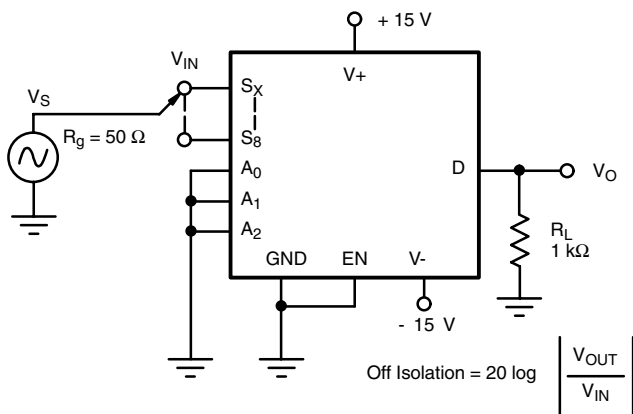


Figure 6. Off Isolation

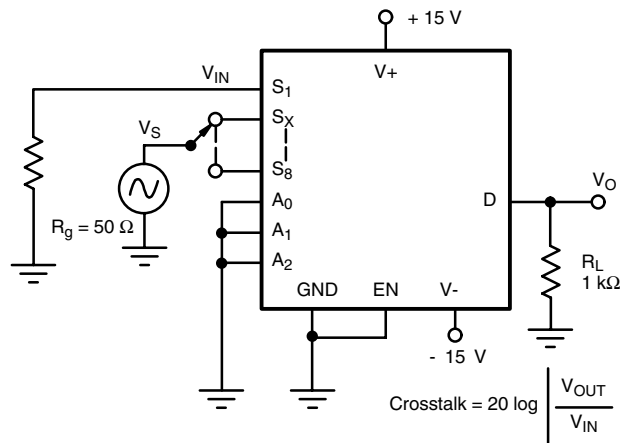


Figure 7. Crosstalk

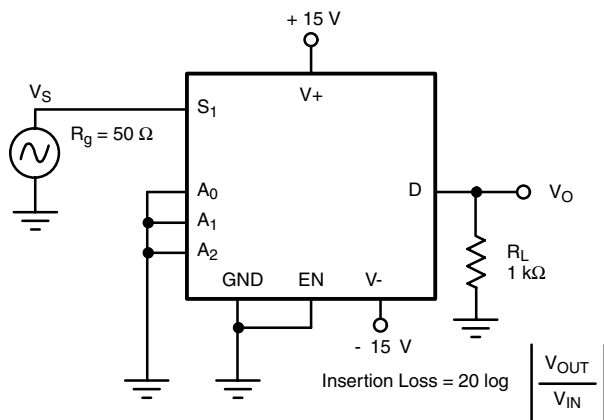


Figure 8. Insertion Loss

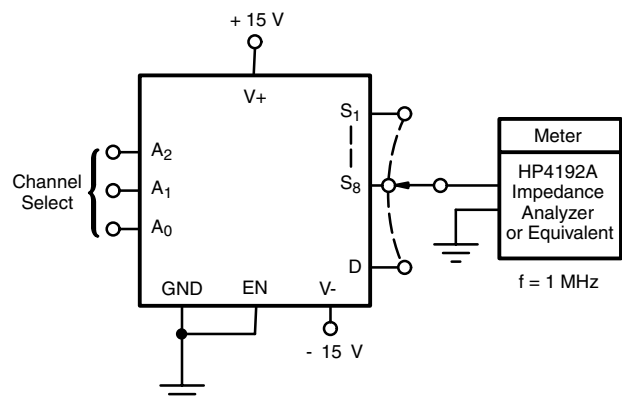


Figure 9. Source Drain Capacitance

**APPLICATIONS 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  $V_S - (V_-)$  doesn't 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.

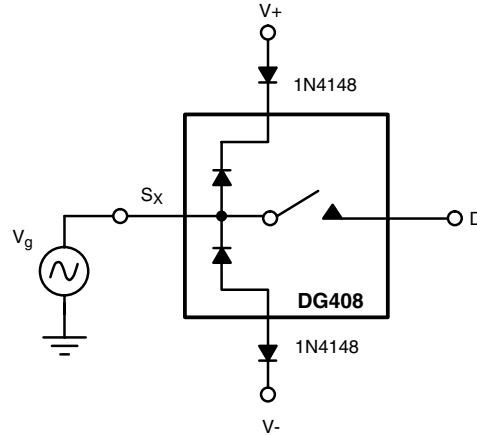


Figure 10. Overvoltage Protection Using Blocking Diodes

**8-Channel Sequential Multiplexer/Demultiplexer**

**Differential 4-Channel Sequential Multiplexer/Demultiplexer**

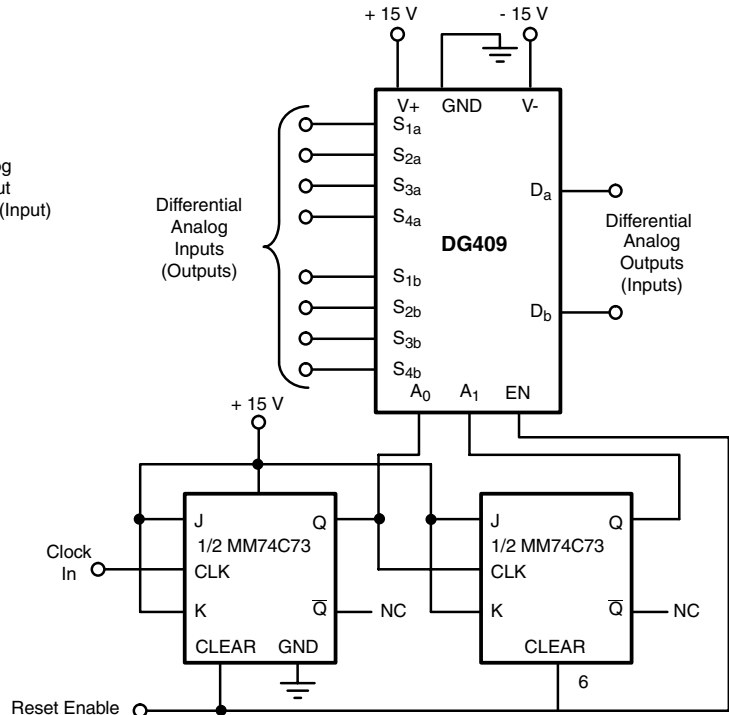
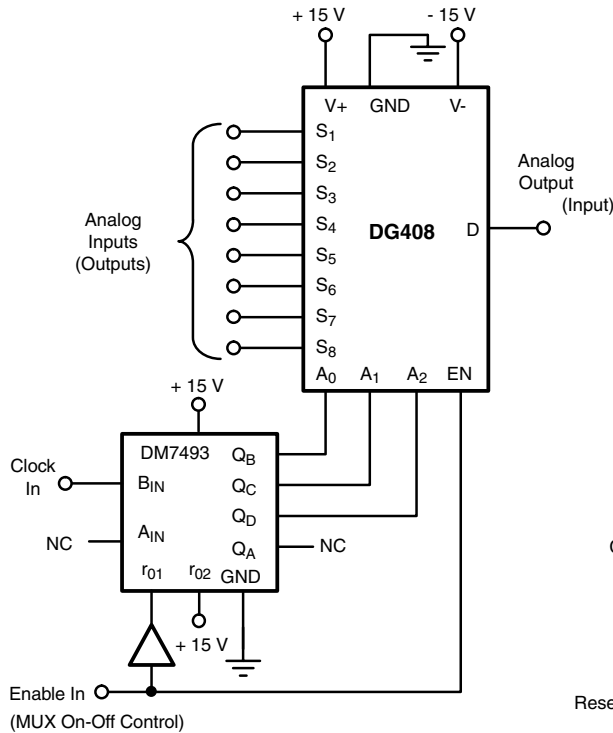


Figure 11.

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see <http://www.vishay.com/ppg?70062>.



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