

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 Ω
- Low Charge Injection - Q: 20 pC
- Fast Transition Time - t_{TRANS} : 160 ns
- Low Power - I_{SUPPLY} : 10 μA
- Single Supply Capability
- 44 V Supply Max Rating
- TTL Compatible Logic



RoHS*
COMPLIANT

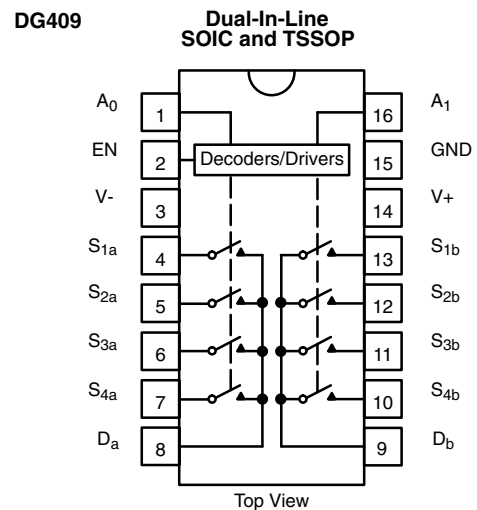
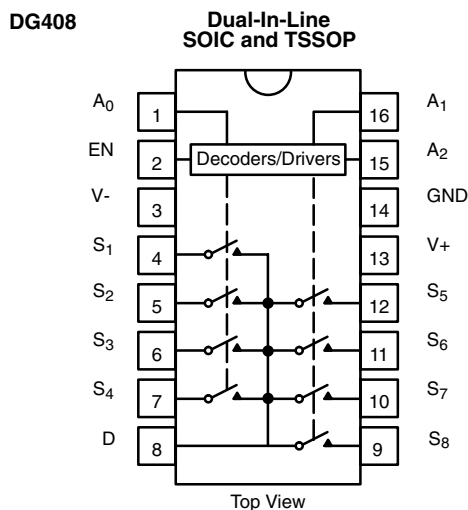
BENEFITS

- 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 ₂ | A ₁ | A ₀ | 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 ₁ | A ₀ | 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" = $V_{AL} \leq 0.8 V$
 Logic "1" = $V_{AH} \geq 2.4 V$
 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 ^a , V _S , V _D | | (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) ^b | 16-Pin Plastic DIP ^c | 450 | mW |
| | 16-Pin Narrow SOIC and TSSOP ^d | 600 | |
| | 16-Pin CerDIP ^e | 900 | |
| | LCC-20 ^f | 750 | |

Notes:

- a. Signals on S_X, D_X or I_{NX} 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.



| SPECIFICATIONS ^a | | | | | | | | | | |
|---|---------------------|--|-------|-------------------|------------------|----------------------------|------------------|---------------------------|------------------|---------------|
| 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 ^b | Typ ^c | A Suffix - 55 to 125 °C | | D Suffix - 40 to 85 °C | | Unit |
| | | | | | | Min ^d | Max ^d | Min ^d | Max ^d | |
| Analog Switch | | | | | | | | | | |
| Analog Signal Range ^e | 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 | Ω |
| $r_{DS(on)}$ Matching Between Channels ^g | $\Delta r_{DS(on)}$ | $V_D = \pm 10\text{ V}$ | | 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 | |
| Digital Control | | | | | | | | | | |
| 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 | μA |
| 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 |
| Dynamic Characteristics | | | | | | | | | | |
| 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 ^h | 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 | $C_{D(on)}$ | $V_{EN} = 0\text{ V}$ $V_D = 0\text{ V}$ $f = 1\text{ MHz}$ | DG408 | Room | 37 | | | | | |
| | | | DG409 | Room | 25 | | | | | |
| Power Supplies | | | | | | | | | | |
| Positive Supply Current | I+ | $V_{EN} = V_A = 0\text{ V}$ or 5 V | | Full | 10 | | 75 | | 75 | μA |
| 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 | | |



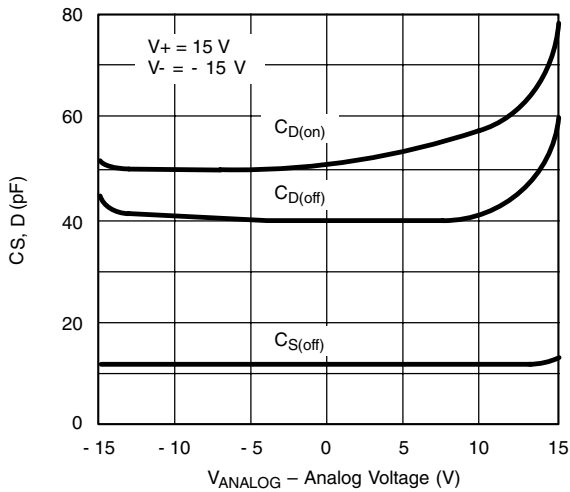
| SPECIFICATIONS ^a FOR SINGLE SUPPLY | | | | | | | | | |
|---|----------------------|---|-------------------|------------------|----------------------------|------------------|---------------------------|------------------|------|
| Parameter | Symbol | Test Conditions Unless Otherwise Specified V ₊ = 12 V, V ₋ = 0 V V _{AL} = 0.8 V, V _{AH} = 2.4 V ^f | Temp ^b | Typ ^c | A Suffix - 55 to 125 °C | | D Suffix - 40 to 85 °C | | Unit |
| | | | | | Min ^d | Max ^d | Min ^d | Max ^d | |
| Analog Switch | | | | | | | | | |
| Drain-Source On-Resistance ^{e,f} | r _{DS(on)} | V _D = 3 V, 10 V, I _S = - 1 mA | Room | 90 | | | | | Ω |
| Dynamic Characteristics | | | | | | | | | |
| Switching Time of Multiplexer ^e | t _{TRANS} | V _{S1} = 8 V, V _{S8} = 0 V, V _{IN} = 2.4 V | Room | 180 | | | | | ns |
| Enable Turn-On Time ^e | t _{ON(EN)} | V _{INH} = 2.4 V, V _{INL} = 0 V | Room | 180 | | | | | |
| Enable Turn-Off Time ^e | t _{OFF(EN)} | V _{S1} = 5 V | Room | 120 | | | | | |
| Charge Injection ^e | Q | C _L = 1 nF, V _S = 6 V, R _S = 0 | Room | 5 | | | | | pC |

Notes:

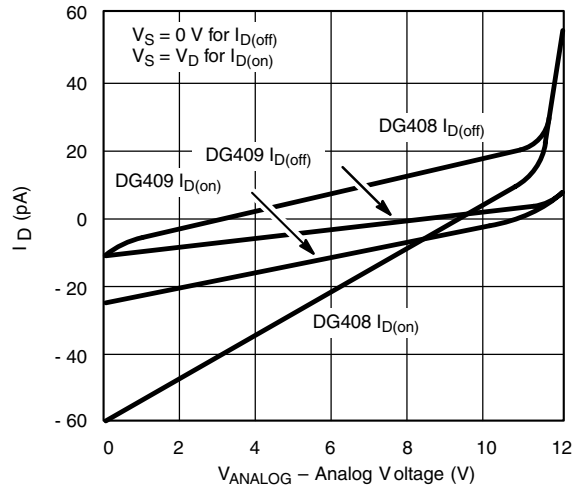
- a. Refer to PROCESS OPTION FLOWCHART.
- b. Room = 25 °C, Full = as determined by the operating temperature suffix.
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- d. The algebraic convention whereby the most negative value is a minimum and the most positive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

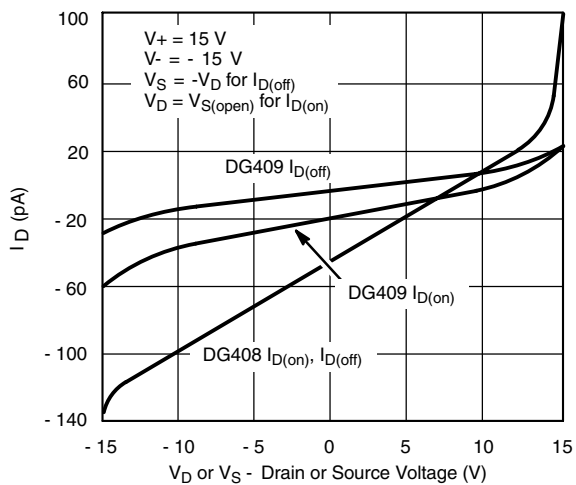
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



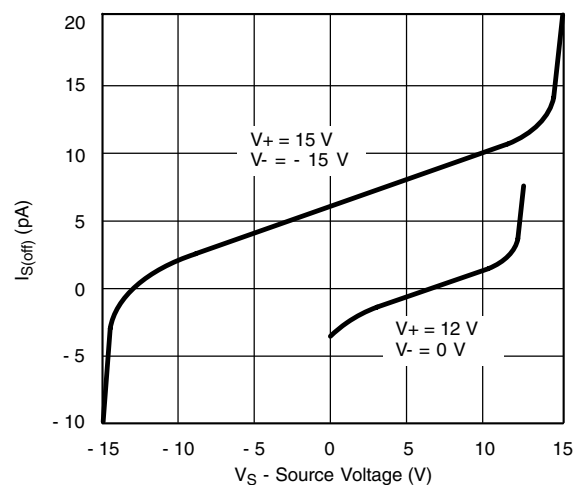
Source/Drain Capacitance vs. Analog Voltage



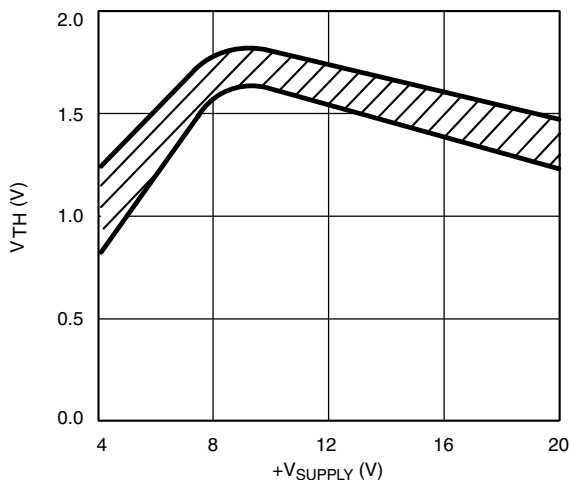
Drain Leakage Current vs. Source/Drain Voltage (Single 12-V Supply)



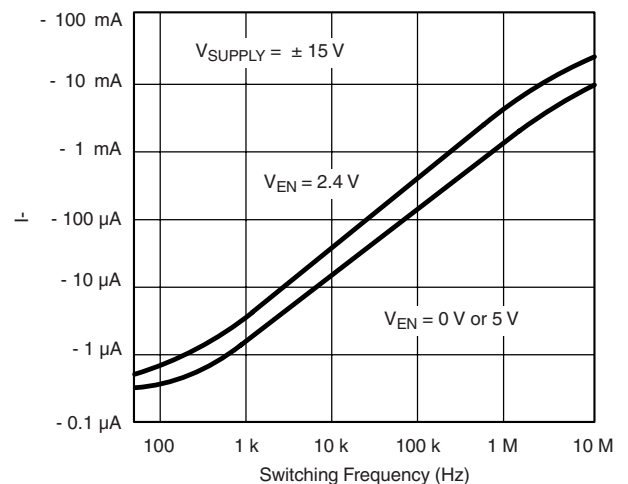
Drain Leakage Current vs. Source/Drain Voltage



Source Leakage Current vs. Source Voltage

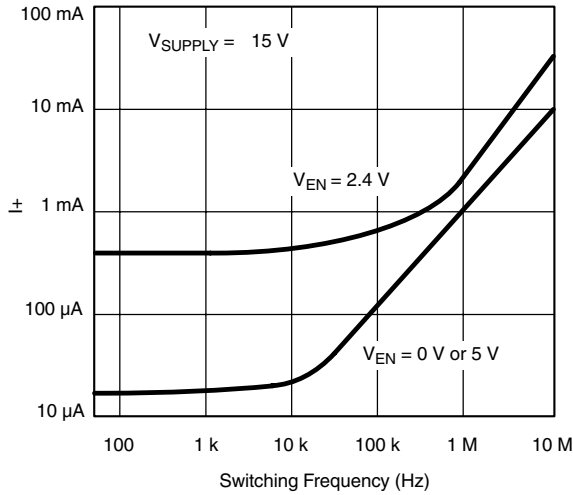


Input Switching Threshold vs. Supply Voltage

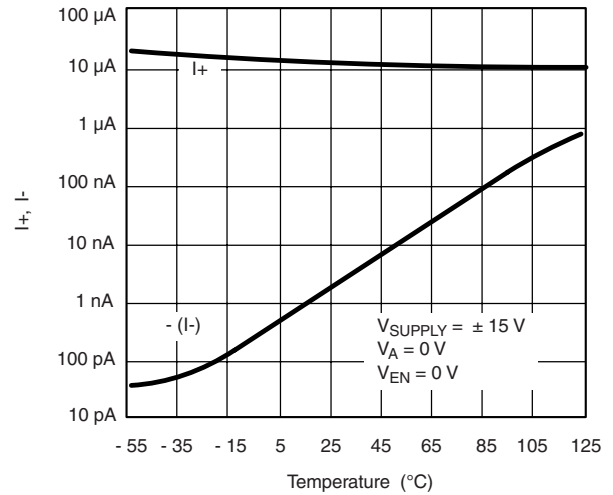


Negative Supply Current vs. Switching Frequency

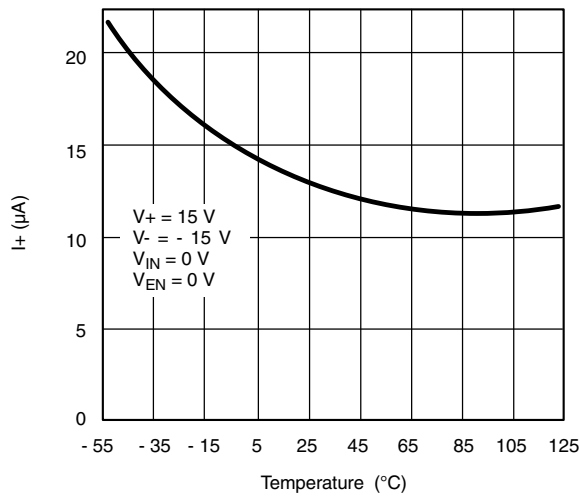
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



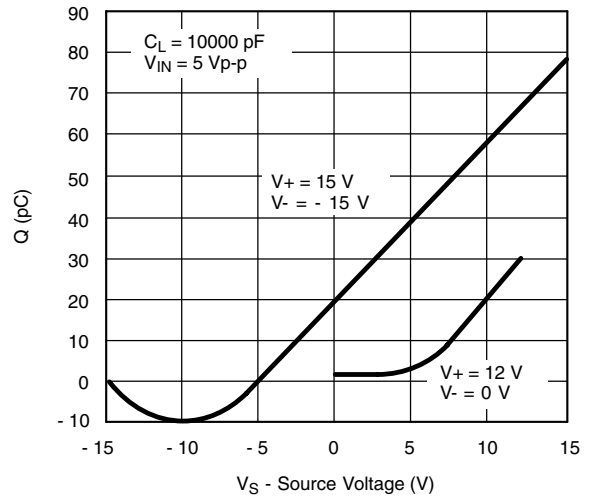
Positive Supply Current vs. Switching Frequency



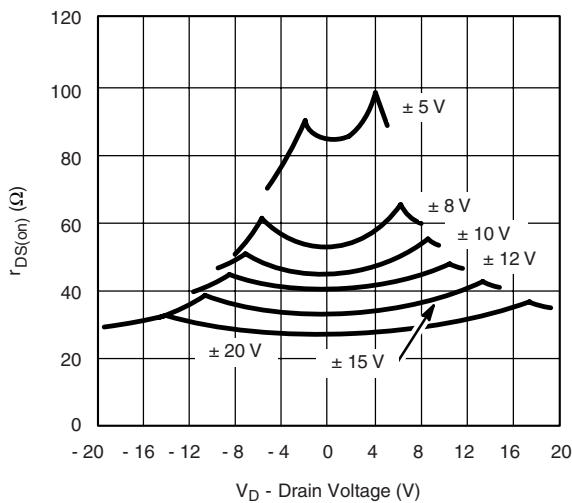
I_{SUPPLY} vs. Temperature



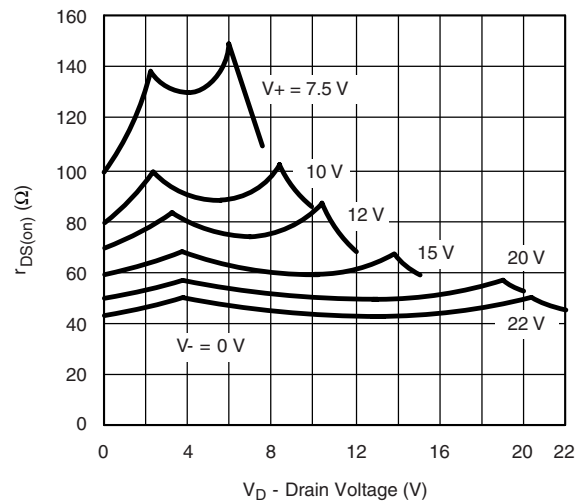
Positive Supply Current vs. Temperature (DG408)



Charge Injection vs. Analog Voltage

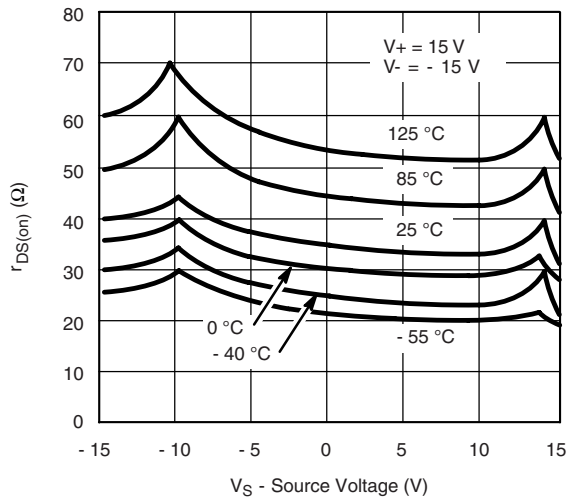


$r_{DS(on)}$ vs. V_D and Supply

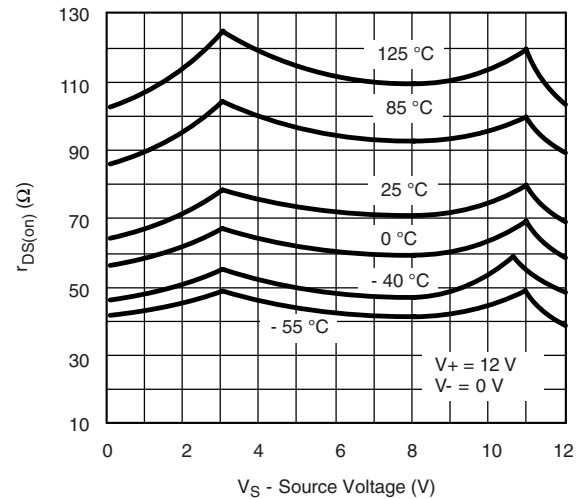


$r_{DS(on)}$ vs. V_D and Supply (Single Supply)

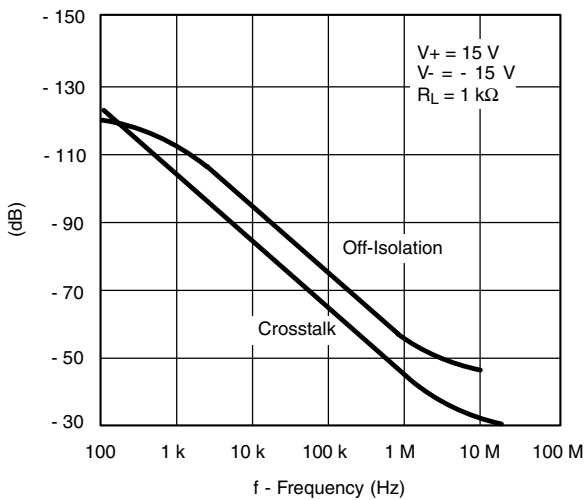
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



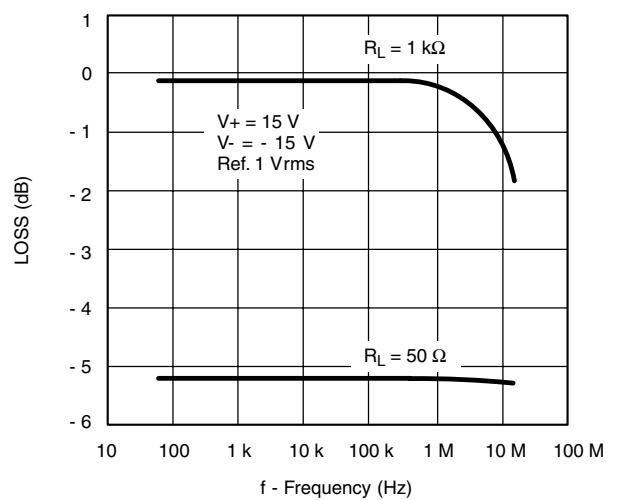
$r_{DS(on)}$ vs. V_S and Temperature



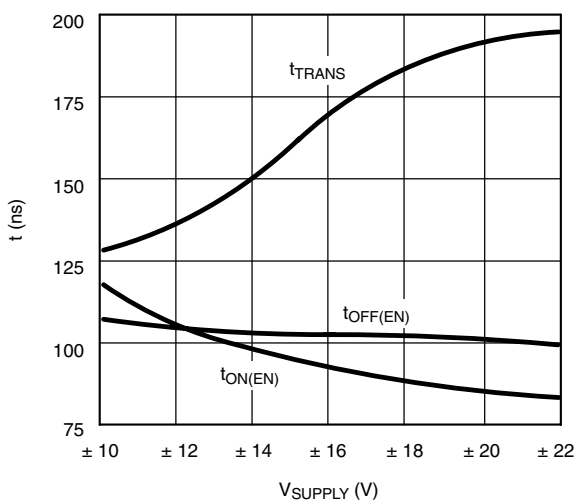
$r_{DS(on)}$ vs. V_S and Temperature (Single Supply)



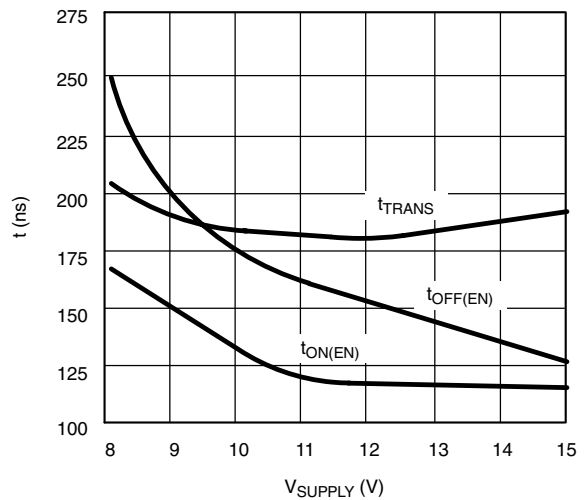
Off Isolation and Crosstalk vs. Frequency



Insertion Loss vs. Frequency



Switching Time vs. Bipolar Supply



Switching Time vs. Single Supply

SCHEMATIC DIAGRAM (TYPICAL CHANNEL)

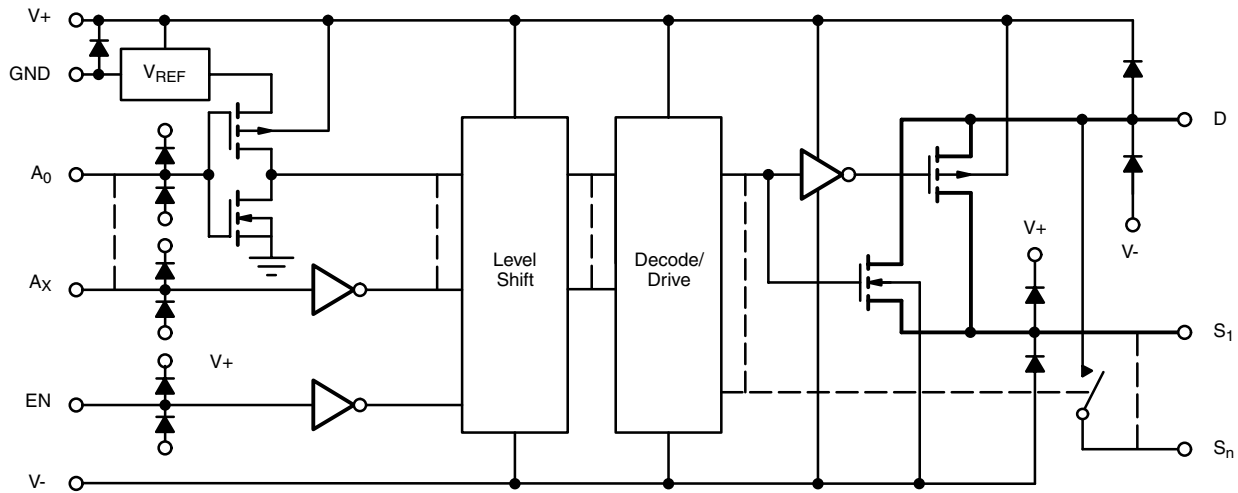


Figure 1.

TEST CIRCUITS

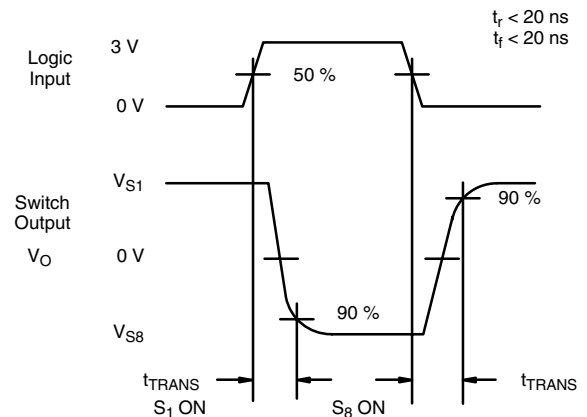
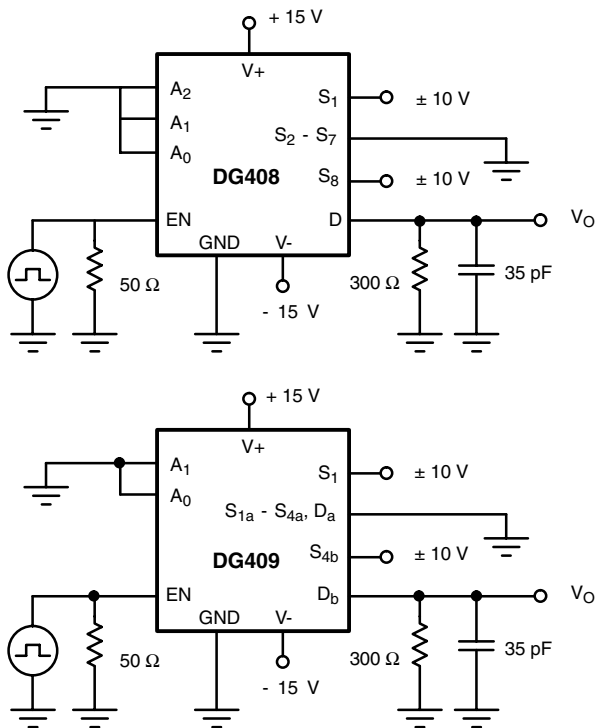


Figure 2. Transition Time

TEST CIRCUITS

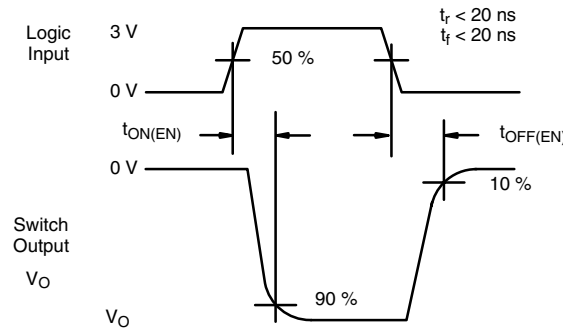
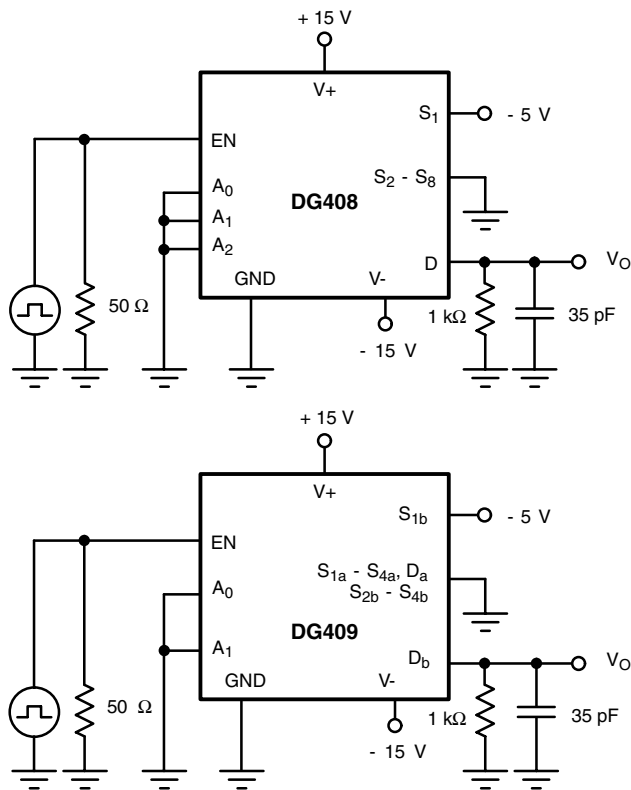


Figure 3. Enable Switching Time

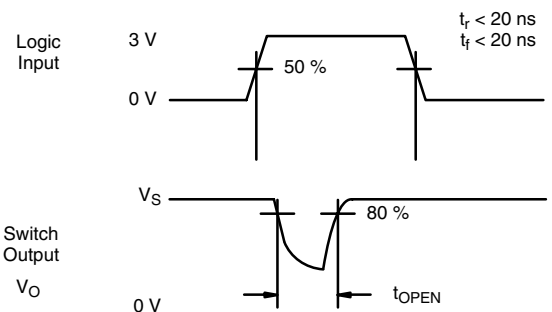
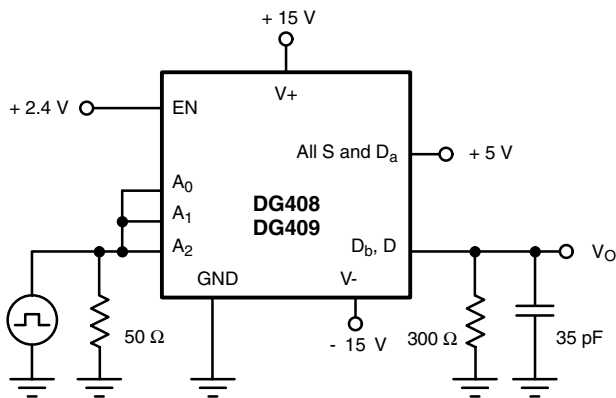


Figure 4. Break-Before-Make Interval

TEST CIRCUITS

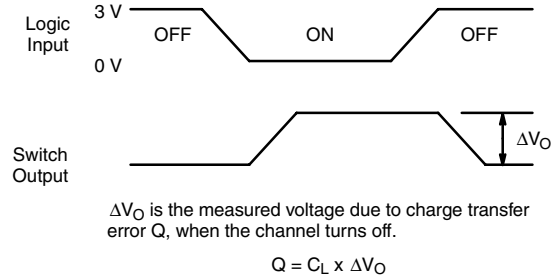
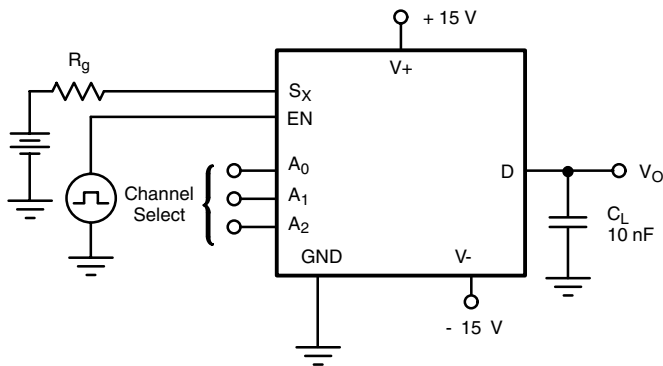


Figure 5. Charge Injection

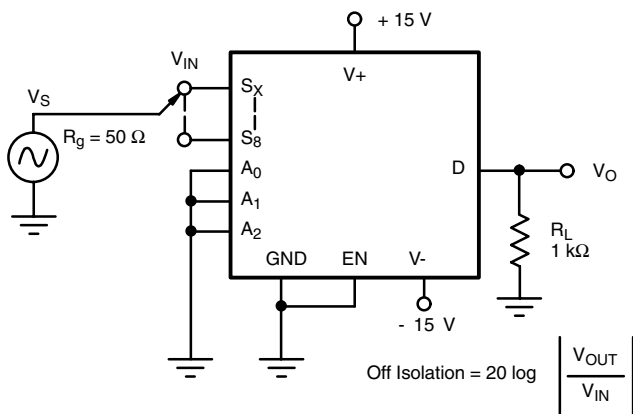


Figure 6. Off Isolation

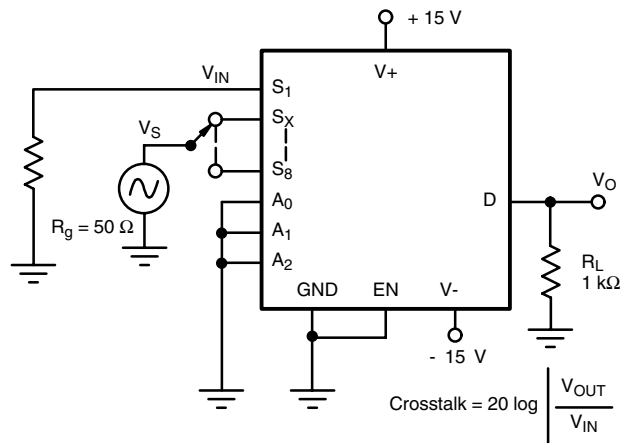


Figure 7. Crosstalk

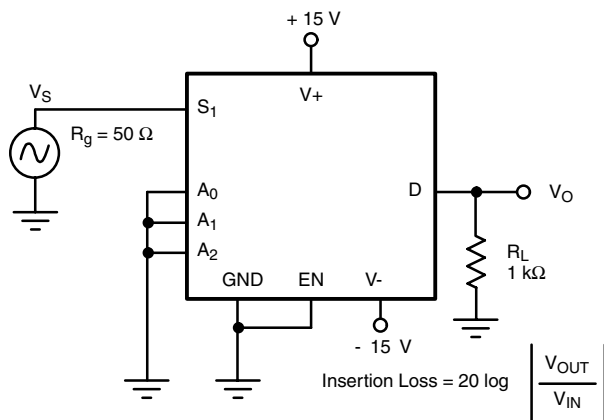


Figure 8. Insertion Loss

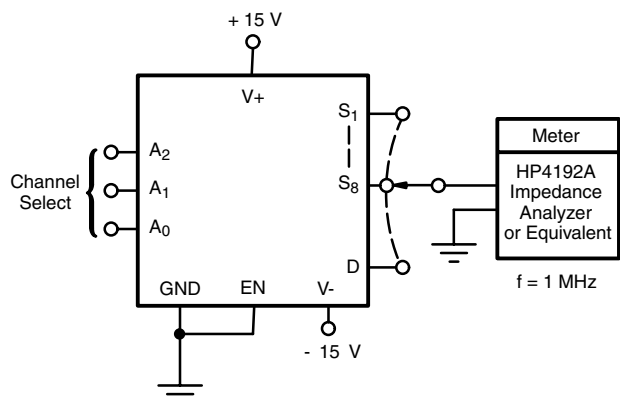


Figure 9. Source Drain Capacitance

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.

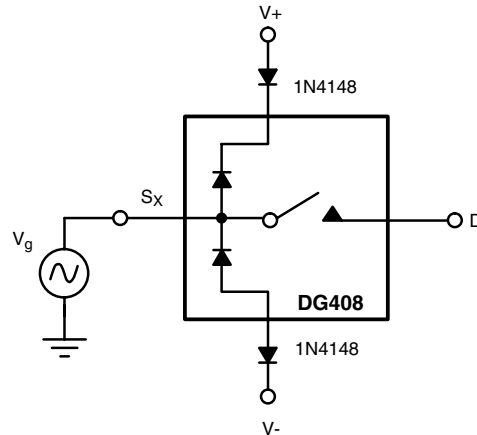


Figure 10. Overvoltage Protection Using Blocking Diodes

8-Channel Sequential Multiplexer/Demultiplexer

Differential 4-Channel Sequential Multiplexer/Demultiplexer

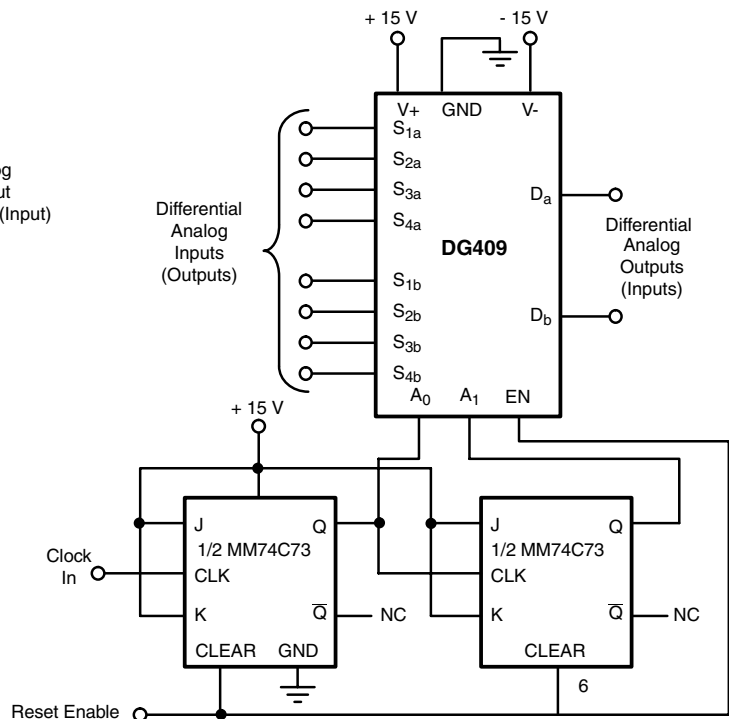
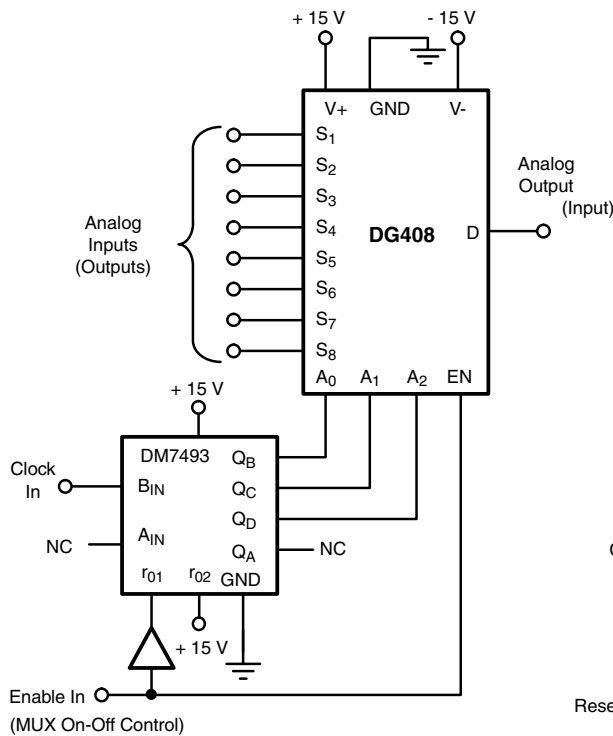


Figure 11.

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