

## Precision Monolithic Quad SPST CMOS Analog Switches

### Features

- 44-V Supply Max Rating
- $\pm 15$ -V Analog Signal Range
- On-Resistance— $r_{DS(on)}$ : 25  $\Omega$
- Fast Switching— $t_{ON}$ : 110 ns
- Ultra Low Power— $P_D$ : 0.35  $\mu$ W
- TTL, CMOS Compatible
- Single Supply Capability

### Benefits

- Widest Dynamic Range
- Low Signal Errors and Distortion
- Break-Before-Make Switching Action
- Simple Interfacing

### Applications

- Precision Automatic Test Equipment
- Precision Data Acquisition
- Communication Systems
- Battery Powered Systems
- Computer Peripherals

### Description

The DG411 series of monolithic quad analog switches was designed to provide high speed, low error switching of precision analog signals. Combining low power (0.35  $\mu$ W) with high speed ( $t_{ON}$ : 110 ns), the DG411 family is ideally suited for portable and battery powered industrial and military applications.

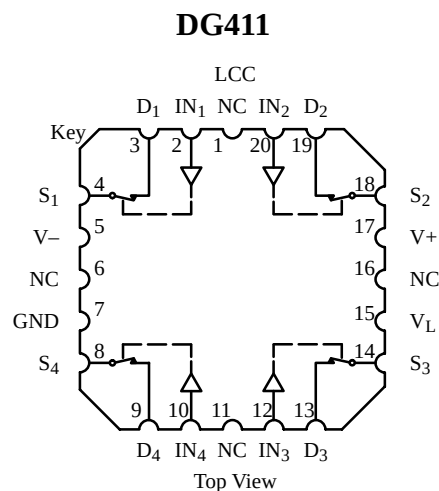
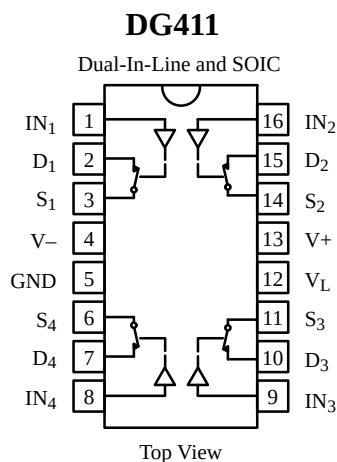
To achieve high-voltage ratings and superior switching performance, the DG411 series was built on Siliconix's

high voltage silicon gate process. An epitaxial layer prevents latchup.

Each switch conducts equally well in both directions when on, and blocks input voltages up to the supply levels when off.

The DG411 and DG412 respond to opposite control logic as shown in the Truth Table. The DG413 has two normally open and two normally closed switches.

### Functional Block Diagram and Pin Configuration



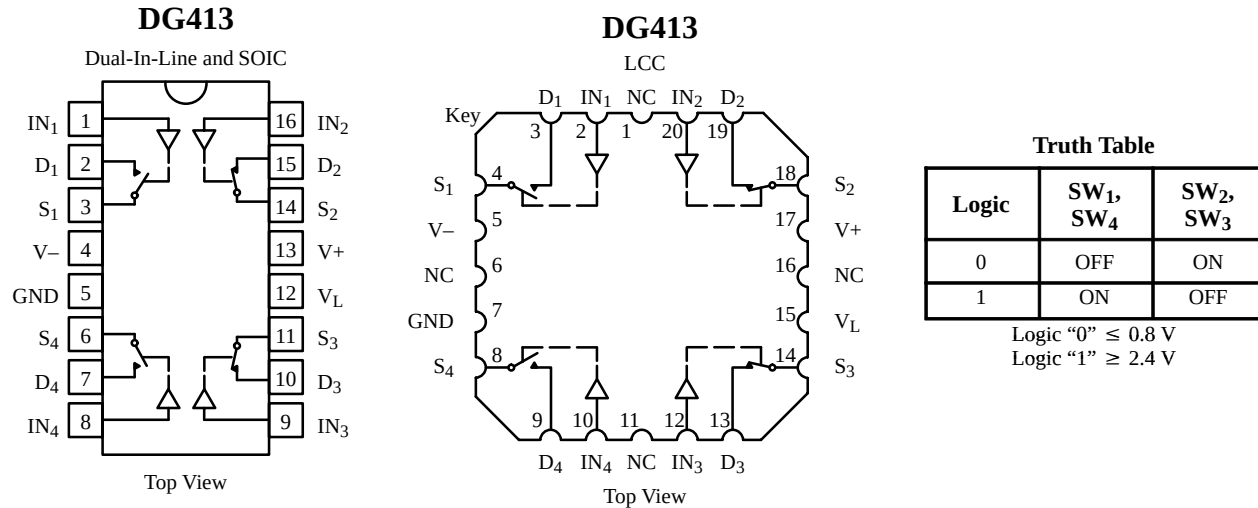
| Truth Table |       |       |
|-------------|-------|-------|
| Logic       | DG411 | DG412 |
| 0           | ON    | OFF   |
| 1           | OFF   | ON    |

Logic "0"  $\leq 0.8$  V  
Logic "1"  $\geq 2.4$  V

Updates to this data sheet may be obtained via facsimile by calling Siliconix FaxBack, 1-408-970-5600. Please request FaxBack document #70050.

# DG411/412/413

## Functional Block Diagram and Pin Configuration



## Ordering Information

| Temp Range       | Package            | Part Number                                     |
|------------------|--------------------|-------------------------------------------------|
| <b>DG411/412</b> |                    |                                                 |
| –40 to 85°C      | 16-Pin Plastic DIP | DG411DJ                                         |
|                  |                    | DG412DJ                                         |
| –40 to 85°C      | 16-Pin Narrow SOIC | DG411DY                                         |
|                  |                    | DG412DY                                         |
| –55 to 125°C     | 16-Pin CerDIP      | DG411AK, DG411AK/883, 5962-9073101MEA           |
|                  |                    | DG412AK, DG412AK/883, 5962-9073102MEA           |
|                  | LCC-20             | DG411AZ/883, 5962-9073101M2A<br>5962-9073102M2A |
| <b>DG413</b>     |                    |                                                 |
| Temp Range       | Package            | Part Number                                     |
| –40 to 85°C      | 16-Pin Plastic DIP | DG413DJ                                         |
|                  | 16-Pin Narrow SOIC | DG413DY                                         |
| –55 to 125°C     | 16-Pin CerDIP      | DG413AK, DG413AK/883, 5962-9073103MEA           |
|                  | LCC-20             | 5962-9073103M2A                                 |

## Absolute Maximum Ratings

V<sub>+</sub> to V<sub>–</sub> ..... 44 V  
 GND to V<sub>–</sub> ..... 25 V  
 V<sub>L</sub> ..... (GND –0.3 V) to (V<sub>+</sub>) +0.3 V  
 Digital Inputs<sup>a</sup>, V<sub>S</sub>, V<sub>D</sub> ..... (V<sub>–</sub>) –2 V to (V<sub>+</sub>) +2 V  
 or 30 mA, whichever occurs first  
 Continuous Current (Any Terminal) ..... 30 mA  
 Peak Current, S or D (Pulsed 1 ms, 10% Duty Cycle) ..... 100 mA  
 Storage Temperature (AK, AZ Suffix) ..... –65 to 150°C  
 (DJ, DY Suffix) ..... –65 to 125°C  
 Power Dissipation (Package)<sup>b</sup>  
 16-Pin Plastic DIP<sup>c</sup> ..... 470 mW

16-Pin Narrow SOIC<sup>d</sup> ..... 600 mW  
 16-Pin CerDIP<sup>e</sup> ..... 900 mW  
 LCC-20<sup>e</sup> ..... 900 mW

### Notes:

- Signals on S<sub>x</sub>, D<sub>x</sub>, or IN<sub>x</sub> exceeding V<sub>+</sub> or V<sub>–</sub> will be clamped by internal diodes. Limit forward diode current to maximum current ratings.
- All leads welded or soldered to PC Board.
- Derate 6 mW/°C above 25°C
- Derate 7.6 mW/°C above 75°C
- Derate 12 mW/°C above 75°C

## Specifications<sup>a</sup>

| Parameter                                 | Symbol              | Test Conditions<br>Unless Otherwise Specified<br><br>V+ = 15 V, V– = –15 V<br>V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup> | Temp <sup>b</sup> | Typ <sup>c</sup> | A Suffix<br>–55 to 125°C |                  | D Suffix<br>–40 to 85°C |                  | Unit |
|-------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|--------------------------|------------------|-------------------------|------------------|------|
|                                           |                     |                                                                                                                                                 |                   |                  | Min <sup>d</sup>         | Max <sup>d</sup> | Min <sup>d</sup>        | Max <sup>d</sup> |      |
| Analog Switch                             |                     |                                                                                                                                                 |                   |                  |                          |                  |                         |                  |      |
| Analog Signal Range <sup>e</sup>          | V <sub>ANALOG</sub> |                                                                                                                                                 | Full              |                  | –15                      | 15               | –15                     | 15               | V    |
| Drain-Source On-Resistance                | r <sub>DS(on)</sub> | V+ = 13.5 V, V– = –13.5 V<br>I <sub>S</sub> = –10 mA, V <sub>D</sub> = ± 8.5 V                                                                  | Room Full         | 25               |                          | 35<br>45         |                         | 35<br>45         | Ω    |
| Switch Off Leakage Current                | I <sub>S(off)</sub> | V+ = 16.5, V– = –16.5 V<br>V <sub>D</sub> = ± 15.5 V, V <sub>S</sub> = ∓ 15.5 V                                                                 | Room Full         | ± 0.1            | –0.25<br>–20             | 0.25<br>20       | –0.25<br>–5             | 0.25<br>5        | nA   |
|                                           | I <sub>D(off)</sub> |                                                                                                                                                 | Room Full         | ± 0.1            | –0.25<br>–20             | 0.25<br>20       | –0.25<br>–5             | 0.25<br>5        |      |
| Channel On Leakage Current                | I <sub>D(on)</sub>  | V+ = 16.5 V, V– = –16.5 V<br>V <sub>S</sub> = V <sub>D</sub> = ± 15.5 V                                                                         | Room Full         | ± 0.1            | –0.4<br>–40              | 0.4<br>40        | –0.4<br>–10             | 0.4<br>10        |      |
| Digital Control                           |                     |                                                                                                                                                 |                   |                  |                          |                  |                         |                  |      |
| Input Current, V <sub>IN</sub> Low        | I <sub>IL</sub>     | V <sub>IN</sub> Under Test = 0.8 V                                                                                                              | Full              | 0.005            | –0.5                     | 0.5              | –0.5                    | 0.5              | μA   |
| Input Current, V <sub>IN</sub> High       | I <sub>IH</sub>     | V <sub>IN</sub> Under Test = 2.4 V                                                                                                              | Full              | 0.005            | –0.5                     | 0.5              | –0.5                    | 0.5              |      |
| Dynamic Characteristics                   |                     |                                                                                                                                                 |                   |                  |                          |                  |                         |                  |      |
| Turn-On Time                              | t <sub>ON</sub>     | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF<br>V <sub>S</sub> = ± 10 V See Figure 2                                                          | Room Full         | 110              |                          | 175<br>240       |                         | 175<br>220       | ns   |
| Turn-Off Time                             | t <sub>OFF</sub>    |                                                                                                                                                 | Room Full         | 100              |                          | 145<br>160       |                         | 145<br>160       |      |
| Break-Before-Make Time Delay              | t <sub>D</sub>      | DG413 Only, V <sub>S</sub> = 10 V<br>R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF                                                             | Room              | 25               |                          |                  |                         |                  |      |
| Charge Injection                          | Q                   | V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 10 nF                                                                              | Room              | 5                |                          |                  |                         |                  | pC   |
| Off Isolation <sup>e</sup>                | OIRR                | R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF,<br>f = 1 MHz                                                                                      | Room              | 68               |                          |                  |                         |                  | dB   |
| Channel-to-Channel Crosstalk <sup>e</sup> | X <sub>TALK</sub>   |                                                                                                                                                 | Room              | 85               |                          |                  |                         |                  |      |
| Source Off Capacitance <sup>e</sup>       | C <sub>S(off)</sub> | f = 1 MHz                                                                                                                                       | Room              | 9                |                          |                  |                         |                  | pF   |
| Drain Off Capacitance <sup>e</sup>        | C <sub>D(off)</sub> |                                                                                                                                                 | Room              | 9                |                          |                  |                         |                  |      |
| Channel On Capacitance <sup>e</sup>       | C <sub>D(on)</sub>  |                                                                                                                                                 | Room              | 35               |                          |                  |                         |                  |      |
| Power Supplies                            |                     |                                                                                                                                                 |                   |                  |                          |                  |                         |                  |      |
| Positive Supply Current                   | I+                  | V+ = 16.5, V– = –16.5 V<br>V <sub>IN</sub> = 0 or 5 V                                                                                           | Room Full         | 0.0001           |                          | 1<br>5           |                         | 1<br>5           | μA   |
| Negative Supply Current                   | I–                  |                                                                                                                                                 | Room Full         | –0.0001          | –1<br>–5                 |                  | –1<br>–5                |                  |      |
| Logic Supply Current                      | I <sub>L</sub>      |                                                                                                                                                 | Room Full         | 0.0001           |                          | 1<br>5           |                         | 1<br>5           |      |
| Ground Current                            | I <sub>GND</sub>    |                                                                                                                                                 | Room Full         | –0.0001          | –1<br>–5                 |                  | –1<br>–5                |                  |      |

# DG411/412/413

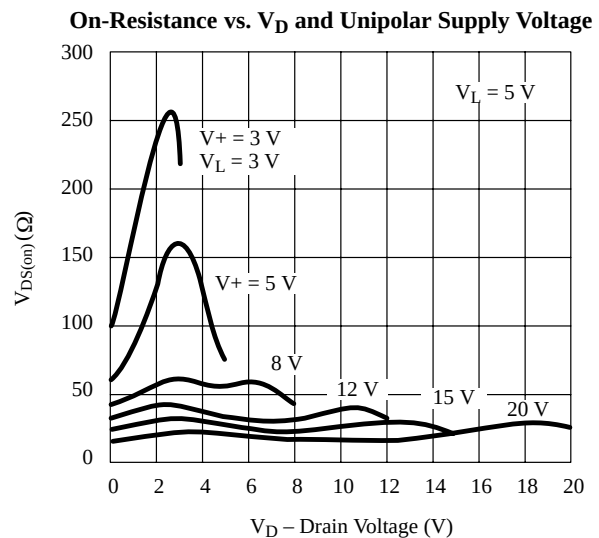
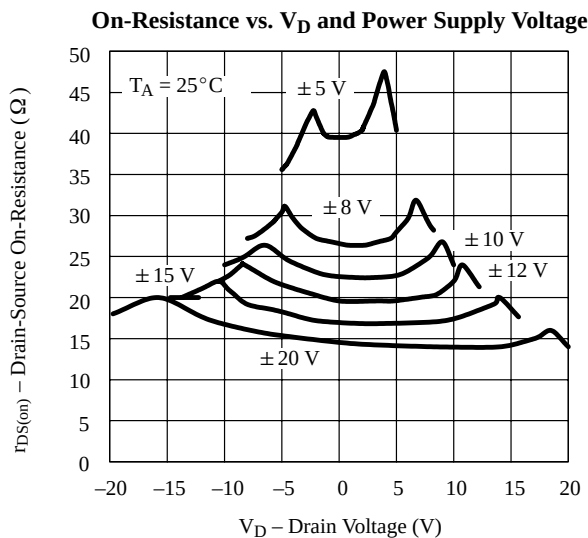
## Specifications<sup>a</sup> for Unipolar Supplies

| Parameter                        | Symbol              | Test Conditions<br>Unless Otherwise Specified<br><br>V+ = 12 V, V− = 0 V<br>V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup> | Temp <sup>b</sup> | Typ <sup>c</sup> | A Suffix<br>−55 to 125°C |                  | D Suffix<br>−40 to 85°C |                  | Unit |
|----------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|--------------------------|------------------|-------------------------|------------------|------|
|                                  |                     |                                                                                                                                               |                   |                  | Min <sup>d</sup>         | Max <sup>d</sup> | Min <sup>d</sup>        | Max <sup>d</sup> |      |
| Analog Switch                    |                     |                                                                                                                                               |                   |                  |                          |                  |                         |                  |      |
| Analog Signal Range <sup>e</sup> | V <sub>ANALOG</sub> |                                                                                                                                               | Full              |                  |                          | 12               |                         | 12               | V    |
| Drain-Source On-Resistance       | r <sub>DS(on)</sub> | V+ = 10.8 V, I <sub>S</sub> = −10 mA<br>V <sub>D</sub> = 3 V, 8 V                                                                             | Room Full         | 40               |                          | 80<br>100        |                         | 80<br>100        | Ω    |
| Dynamic Characteristics          |                     |                                                                                                                                               |                   |                  |                          |                  |                         |                  |      |
| Turn-On Time                     | t <sub>ON</sub>     | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF<br>V <sub>S</sub> = 8 V, See Figure 2                                                          | Room Hot          | 175              |                          | 250<br>400       |                         | 250<br>315       | ns   |
| Turn-Off Time                    | t <sub>OFF</sub>    |                                                                                                                                               | Room Hot          | 95               |                          | 125<br>140       |                         | 125<br>140       |      |
| Break-Before-Make Time Delay     | t <sub>D</sub>      | DG413 Only, V <sub>S</sub> = 8 V,<br>R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF                                                           | Room              | 25               |                          |                  |                         |                  |      |
| Charge Injection                 | Q                   | V <sub>g</sub> = 6 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 10 nF                                                                            | Room              | 25               |                          |                  |                         |                  | pC   |
| Power Supplies                   |                     |                                                                                                                                               |                   |                  |                          |                  |                         |                  |      |
| Positive Supply Current          | I+                  | V+ = 13.5, V <sub>IN</sub> = 0 or 5 V                                                                                                         | Room Hot          | 0.0001           |                          | 1<br>5           |                         | 1<br>5           | μA   |
| Negative Supply Current          | I−                  |                                                                                                                                               | Room Hot          | −0.0001          | −1<br>−5                 |                  | −1<br>−5                |                  |      |
| Logic Supply Current             | I <sub>L</sub>      |                                                                                                                                               | Room Hot          | 0.0001           |                          | 1<br>5           |                         | 1<br>5           |      |
| Ground Current                   | I <sub>GND</sub>    |                                                                                                                                               | Room Hot          | −0.0001          | −1<br>−5                 |                  | −1<br>−5                |                  |      |

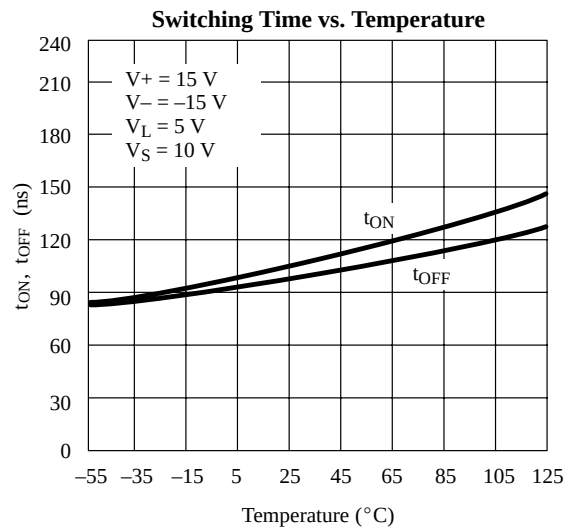
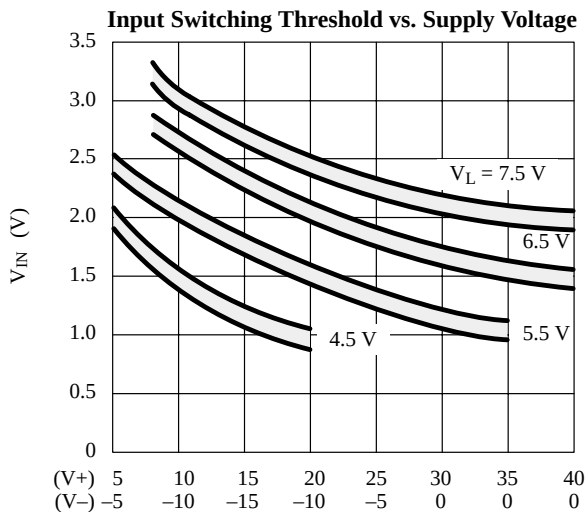
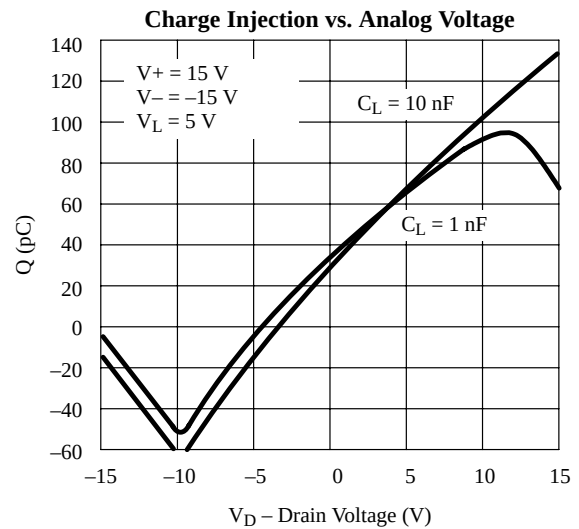
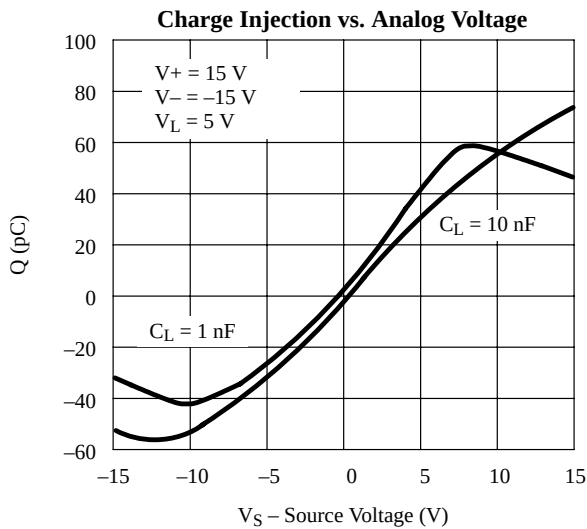
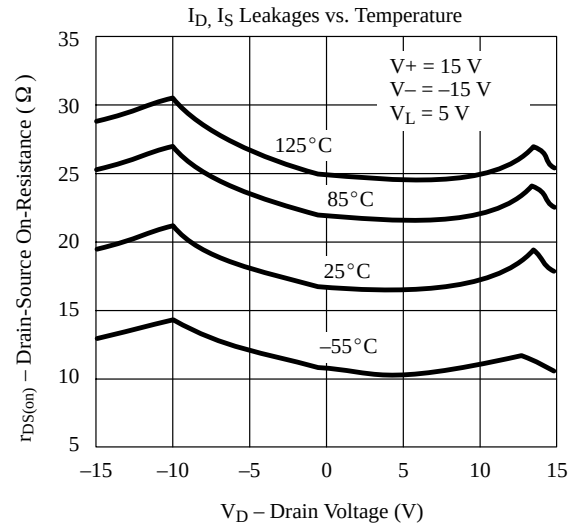
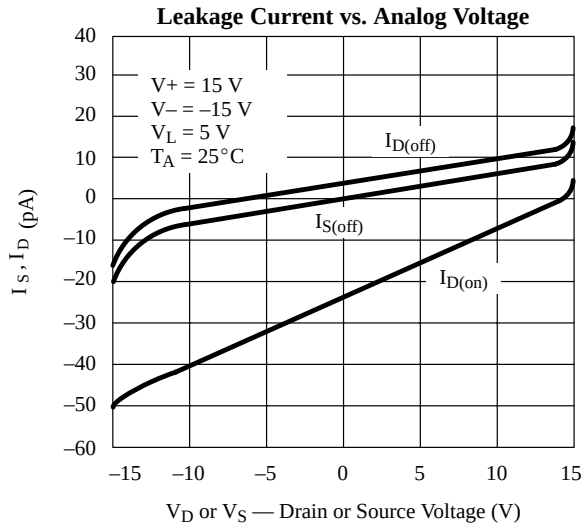
Notes:

- 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 data sheet.
- Guaranteed by design, not subject to production test.
- $V_{IN}$  = input voltage to perform proper function.

## Typical Characteristics

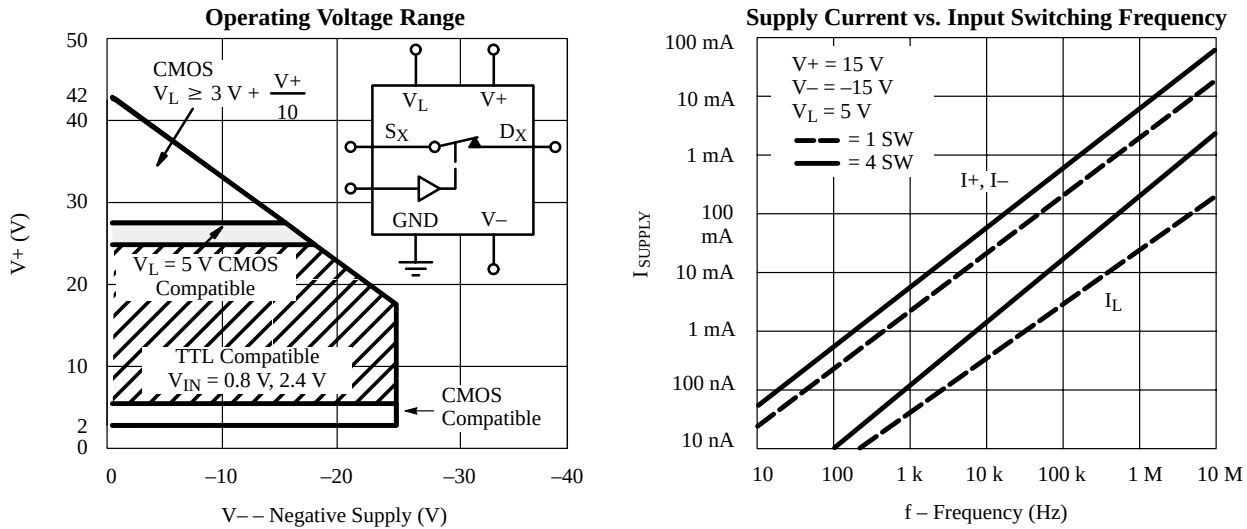


## Typical Characteristics (Cont'd)



# DG411/412/413

## Typical Characteristics (Cont'd)



## Schematic Diagram (Typical Channel)

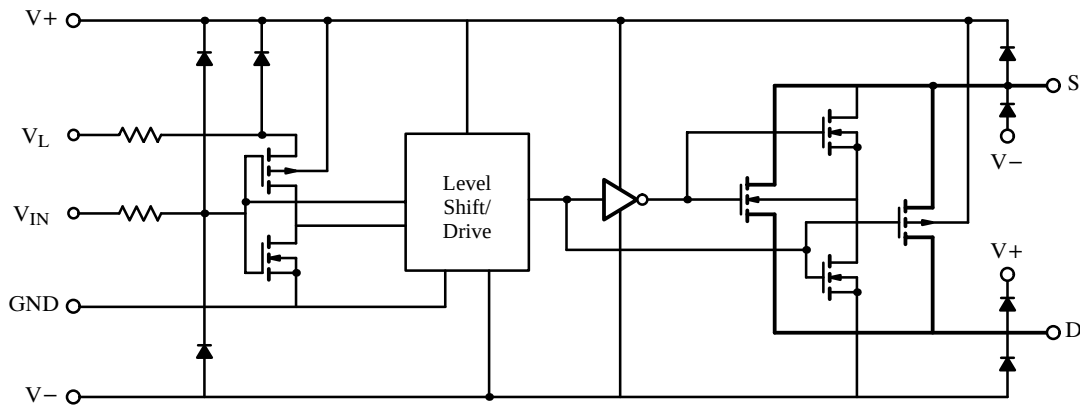
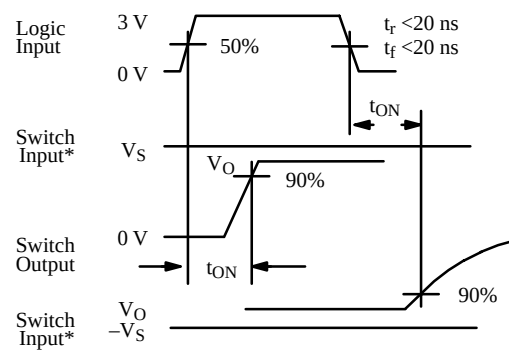
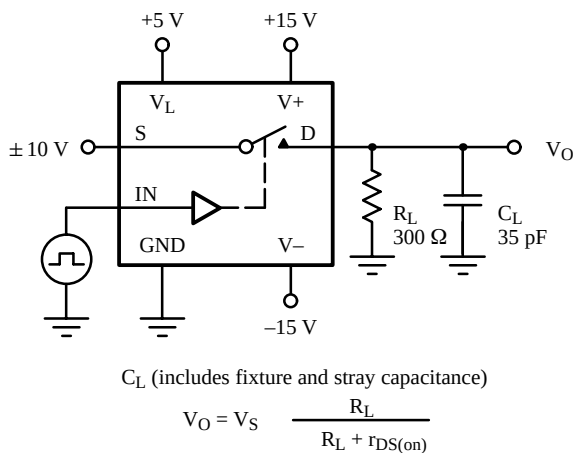


Figure 1.

## Test Circuits

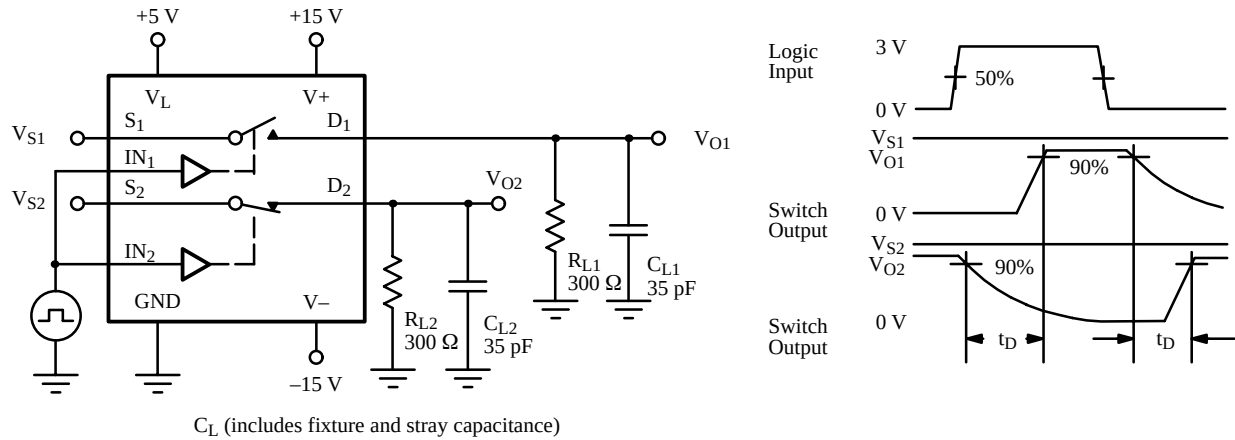


\* $V_S = 10 \text{ V}$  for  $t_{ON}$ ,  $V_S = -10 \text{ V}$  for  $t_{OFF}$

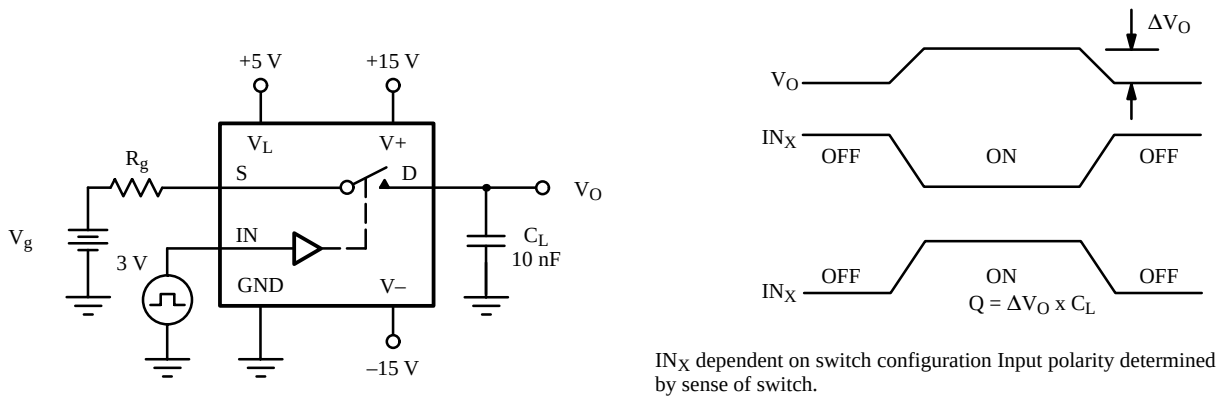
Note: Logic input waveform is inverted for switches that have the opposite logic sense control

Figure 2. Switching Time

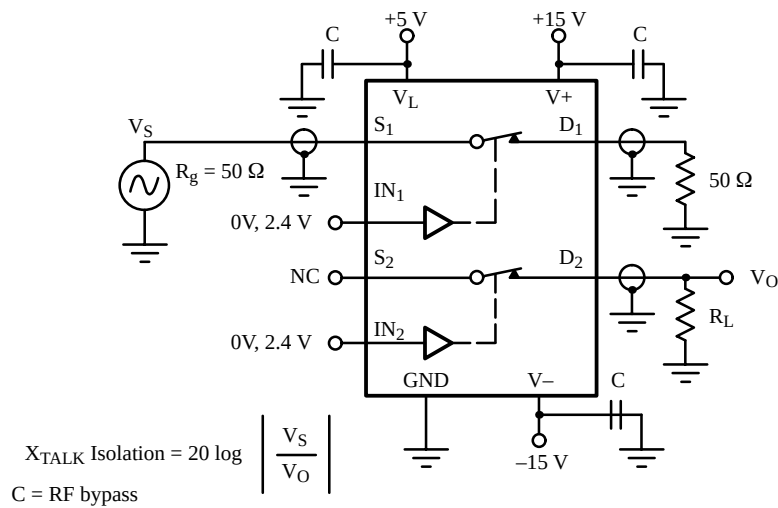
## Test Circuits (Cont'd)



**Figure 3.** Break-Before-Make (DG413)



**Figure 4.** Charge Injection



**Figure 5.** Crosstalk

# DG411/412/413

## Test Circuits (Cont'd)

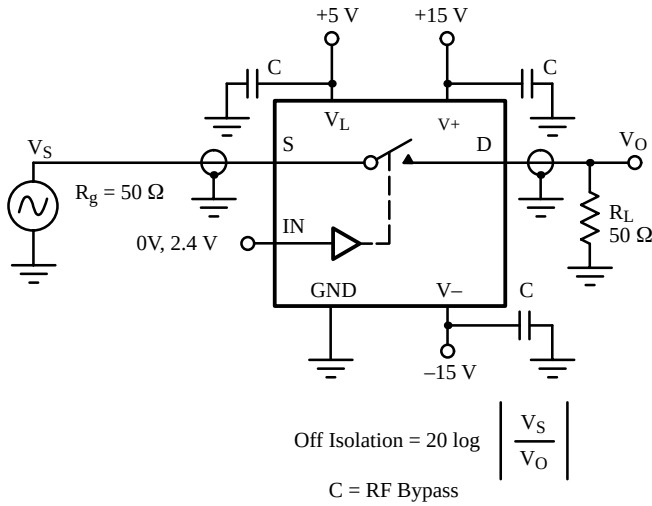


Figure 6. Off Isolation

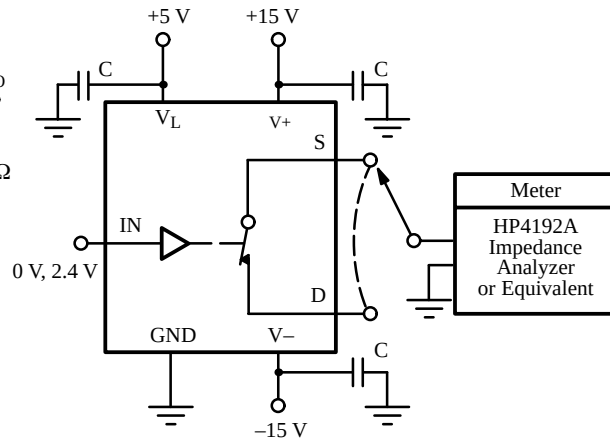


Figure 7. Source/Drain Capacitances

## Applications

### Single Supply Operation:

The DG411/412/413 can be operated with unipolar supplies from 5 V to 44 V. These devices are characterized and tested for unipolar supply operation at 12 V to facilitate the majority of applications. In single supply operation, V+ is tied to V<sub>L</sub> and V- is tied to 0 V. See Input Switching Threshold vs. Supply Voltage curve for V<sub>L</sub> versus input threshold requirements.

### Summing Amplifier

When driving a high impedance, high capacitance load such as shown in Figure 8, where the inputs to the summing amplifier have some noise filtering, it is necessary to have shunt switches for rapid discharge of the filter capacitor, thus preventing offsets from occurring at the output.

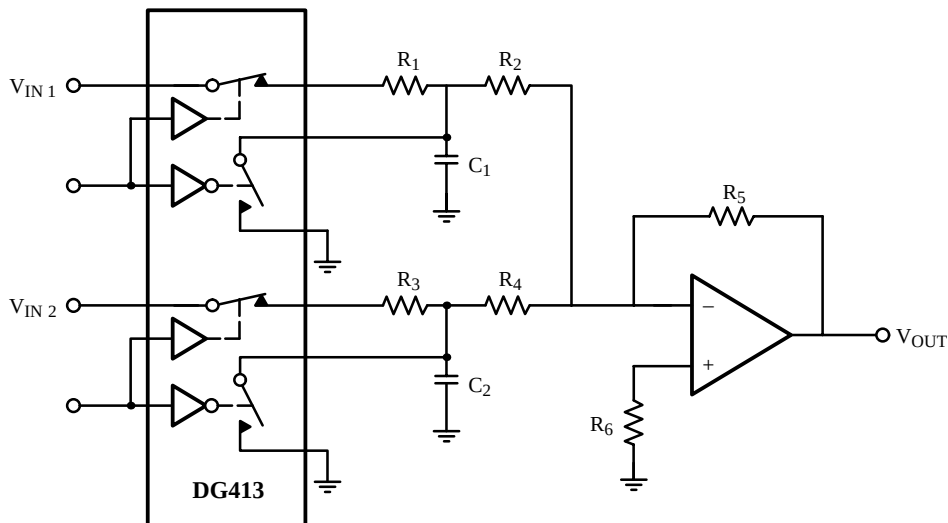


Figure 8. Summing Amplifier