

## Precision CMOS Analog Switches

### Features

- $\pm 15\text{-V}$  Analog Signal Range
- On-Resistance— $r_{DS(on)}$ :  $20\ \Omega$
- Fast Switching Action— $t_{ON}$ :  $100\text{ ns}$
- Ultra Low Power Requirements— $P_D$ :  $35\text{ nW}$
- TTL and CMOS Compatible
- MiniDIP and SOIC Packaging
- 44-V Supply Max Rating

### Benefits

- Wide Dynamic Range
- Low Signal Errors and Distortion
- Break-Before-Make Switching Action
- Simple Interfacing
- Reduced Board Space
- Improved Reliability

### Applications

- Precision Test Equipment
- Precision Instrumentation
- Battery Powered Systems
- Sample-and-Hold Circuits
- Military Radios
- Guidance and Control Systems
- Hard Disk Drives

### Description

The DG417/418/419 monolithic CMOS analog switches were designed to provide high performance switching of analog signals. Combining low power, low leakages, high speed, low on-resistance and small physical size, the DG417 series is ideally suited for portable and battery powered industrial and military applications requiring high performance and efficient use of board space.

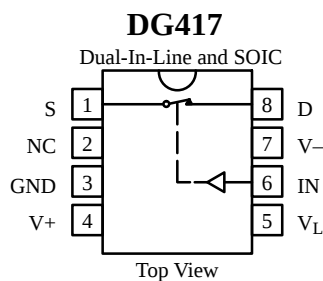
To achieve high-voltage ratings and superior switching performance, the DG417 series is built on Siliconix's high

voltage silicon gate (HVSG) process. Break-before-make is guaranteed for the DG419, which is an SPDT configuration. An epitaxial layer prevents latchup.

Each switch conducts equally well in both directions when on, and blocks up to the power supply level when off.

The DG417 and DG418 respond to opposite control logic levels as shown in the Truth Table.

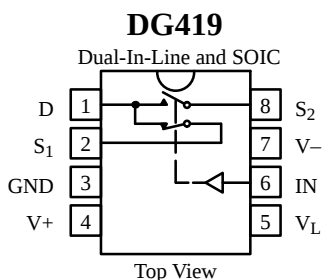
### Functional Block Diagram and Pin Configuration



Truth Table

| Logic | DG417 | DG418 |
|-------|-------|-------|
| 0     | ON    | OFF   |
| 1     | OFF   | ON    |

Logic "0" =  $\leq 0.8\text{ V}$ , Logic "1" =  $\geq 2.4\text{ V}$



Truth Table—DG419

| Logic | SW <sub>1</sub> | SW <sub>2</sub> |
|-------|-----------------|-----------------|
| 0     | ON              | OFF             |
| 1     | OFF             | ON              |

Logic "0" =  $\leq 0.8\text{ V}$ , Logic "1" =  $\geq 2.4\text{ V}$

Updates to this data sheet may be obtained via facsimile by calling Siliconix FaxBack, 1-408-970-5600. Please request FaxBack document #70051.

## Ordering Information

| Temp Range   | Package               | Part Number          |
|--------------|-----------------------|----------------------|
| DG417/418    |                       |                      |
| -40 to 85°C  | 8-Pin Plastic MiniDIP | DG417DJ              |
|              |                       | DG418DJ              |
|              | 8-Pin Narrow SOIC     | DG417DY              |
|              |                       | DG418DY              |
| -55 to 125°C | 8-Pin CerDIP          | DG417AK, DG417AK/883 |
|              |                       | DG418AK, DG418AK/883 |
| DG419        |                       |                      |
| -40 to 85°C  | 8-Pin Plastic MiniDIP | DG419DJ              |
|              | 8-Pin Narrow SOIC     | DG419DY              |
| -55 to 125°C | 8-Pin CerDIP          | DG419AK, DG419AK/883 |

## Absolute Maximum Ratings

Voltages Referenced to V-

V+ ..... 44 V

GND ..... 25 V

V<sub>L</sub> ..... (GND -0.3 V) to (V+) + 0.3 V

Digital Inputs<sup>a</sup> V<sub>S</sub>, V<sub>D</sub> ..... (V-) -2 V to (V+) + 2 V  
or 30 mA, whichever occurs first

Current, (Any Terminal) Continuous ..... 30 mA

Current (S or D) Pulsed 1 ms, 10% duty cycle ..... 100 mA

Storage Temperature (AK Suffix) ..... -65 to 150°C  
(DJ, DY Suffix) ..... -65 to 125°C

Power Dissipation (Package)<sup>b</sup>

8-Pin Plastic MiniDIP<sup>c</sup> ..... 400 mW

8-Pin Narrow SOIC<sup>d</sup> ..... 400 mW

8-Pin CerDIP<sup>e</sup> ..... 600 mW

Notes:

- Signals on S<sub>X</sub>, D<sub>X</sub>, or IN<sub>X</sub> exceeding V+ or V- 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 75°C
- Derate 6.5 mW/°C above 25°C
- Derate 12 mW/°C above 75°C

## Schematic Diagram (Typical Channel)

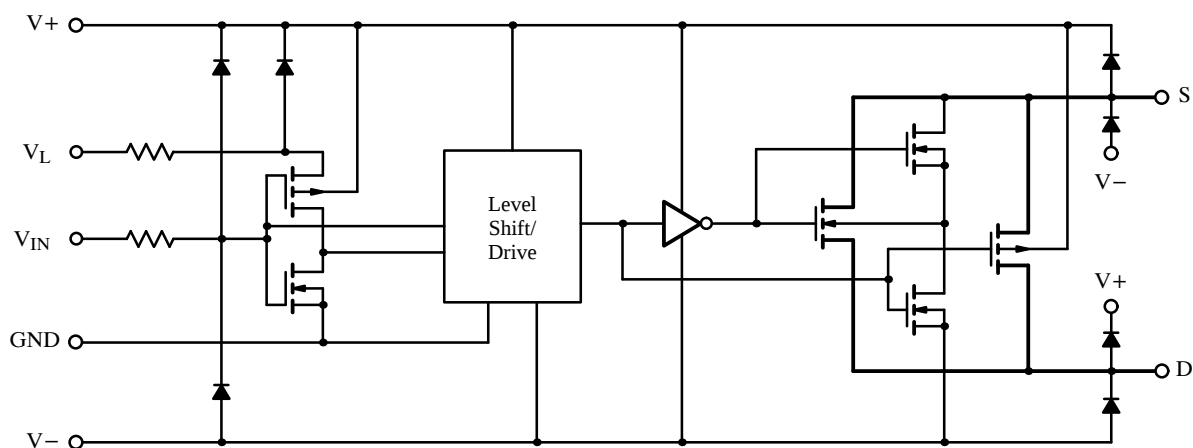


Figure 1.

## Specifications<sup>a</sup>

| Parameter                        | Symbol  | Test Conditions<br>Unless Otherwise Specified<br>V+ = 15 V, V– = –15 V<br>VL = 5 V, VIN = 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> | VANALOG |                                                                                                                     |  | Full              |                  | –15                      | 15               | –15                     | 15               | V          |            |
| Drain-Source On-Resistance       | rDS(on) | IS = –10 mA, VD = ±12.5 V<br>V+ = 13.5 V, V– = –13.5 V                                                              |  | Room Full         | 20               |                          | 35<br>45         |                         | 35<br>45         | Ω          |            |
| Switch Off Leakage Current       | IS(off) | V+ = 16.5 V, V– = –16.5 V<br>VD = ±15.5 V<br>VS = ±15.5 V                                                           |  | Room Full         | –0.1             | –0.25<br>–20             | 0.25<br>20       | –0.25<br>–5             | 0.25<br>5        | nA         |            |
|                                  | ID(off) |                                                                                                                     |  | DG417<br>DG418    | Room Full        | –0.1                     | –0.25<br>–20     | 0.25<br>20              | –0.25<br>–5      |            | 0.25<br>5  |
|                                  |         |                                                                                                                     |  | DG419             | Room Full        | –0.1                     | –0.75<br>–60     | 0.75<br>60              | –0.75<br>–12     |            | 0.75<br>12 |
| Channel On Leakage Current       | ID(on)  | V+ = 16.5 V, V– = –16.5 V<br>VS = VD = ±15.5 V                                                                      |  | DG417<br>DG418    | Room Full        | –0.4                     | –0.4<br>–40      | 0.4<br>40               | –0.4<br>–10      | 0.4<br>10  |            |
|                                  |         |                                                                                                                     |  | DG419             | Room Full        | –0.4                     | –0.75<br>–60     | 0.75<br>60              | –0.75<br>–12     | 0.75<br>12 |            |
| Digital Control                  |         |                                                                                                                     |  |                   |                  |                          |                  |                         |                  |            |            |
| Input Current VIN Low            | IIL     |                                                                                                                     |  | Full              | 0.005            | –0.5                     | 0.5              | –0.5                    | 0.5              | μA         |            |
| Input Current VIN High           | IIH     |                                                                                                                     |  | Full              | 0.005            | –0.5                     | 0.5              | –0.5                    | 0.5              |            |            |
| Dynamic Characteristics          |         |                                                                                                                     |  |                   |                  |                          |                  |                         |                  |            |            |
| Turn-On Time                     | tON     | RL = 300 Ω, CL = 35 pF<br>VS = ±10 V                                                                                |  | DG417<br>DG418    | Room Full        | 100                      |                  | 175<br>250              |                  | ns         |            |
| Turn-Off Time                    | tOFF    | See Switching Time Test Circuit                                                                                     |  | DG417<br>DG418    | Room Full        | 60                       |                  | 145<br>210              |                  |            |            |
| Transition Time                  | tTRANS  | RL = 300 Ω, CL = 35 pF<br>VS1 = ±10 V<br>VS2 = ∓10 V                                                                |  | DG419             | Room Full        |                          |                  | 175<br>250              |                  |            |            |
| Break-Before-Make Time Delay     | tD      | RL = 300 Ω, CL = 35 pF<br>VS1 = VS2 = ±10 V                                                                         |  | DG419             | Room             | 13                       | 5                |                         | 5                |            |            |
| Charge Injection                 | Q       | CL = 10 nF, Vgen = 0 V, Rgen = 0 Ω                                                                                  |  | Room              | 60               |                          |                  |                         |                  | pC         |            |
| Source Off Capacitance           | CS(off) | f = 1 MHz, VS = 0 V                                                                                                 |  | Room              | 8                |                          |                  |                         |                  | pF         |            |
| Drain Off Capacitance            | CD(off) |                                                                                                                     |  | DG417<br>DG418    | Room             | 8                        |                  |                         |                  |            |            |
| Channel On Capacitance           | CD(on)  | f = 1 MHz, VS = 0 V                                                                                                 |  | DG417<br>DG418    | Room             | 30                       |                  |                         |                  |            |            |
|                                  |         |                                                                                                                     |  | DG419             | Room             | 35                       |                  |                         |                  |            |            |
| Power Supplies                   |         |                                                                                                                     |  |                   |                  |                          |                  |                         |                  |            |            |
| Positive Supply Current          | I+      | V+ = 16.5 V, V– = –16.5 V<br>VIN = 0 or 5 V                                                                         |  | Room Full         | 0.001            |                          | 1<br>5           |                         | 1<br>5           | μA         |            |
| Negative Supply Current          | I–      |                                                                                                                     |  | Room Full         | –0.001           | –1<br>–5                 |                  | –1<br>–5                |                  |            |            |
| Logic Supply Current             | IL      |                                                                                                                     |  | Room Full         | 0.001            |                          | 1<br>5           |                         | 1<br>5           |            |            |
| Ground Current                   | IGND    |                                                                                                                     |  | Room Full         | –0.000<br>1      | –1<br>–5                 |                  | –1<br>–5                |                  |            |            |

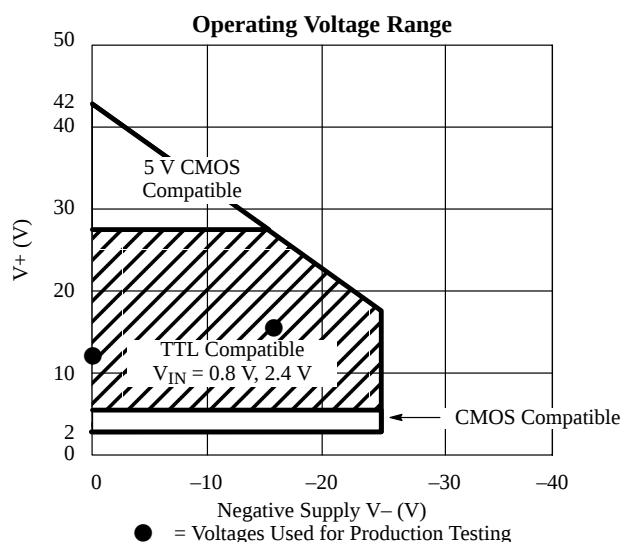
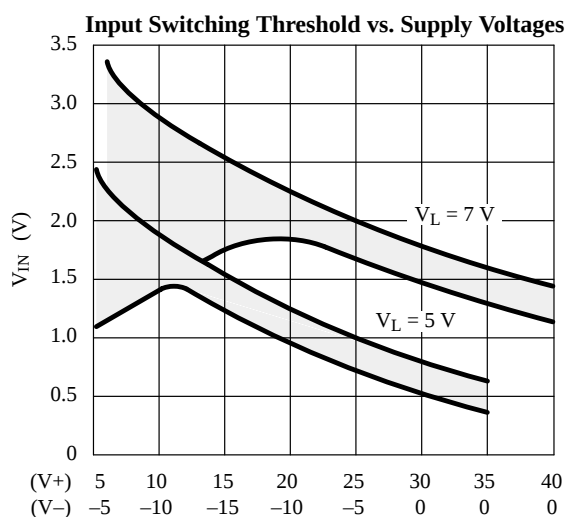
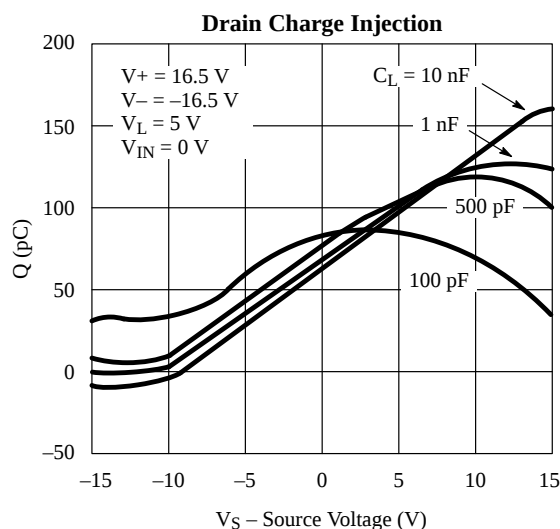
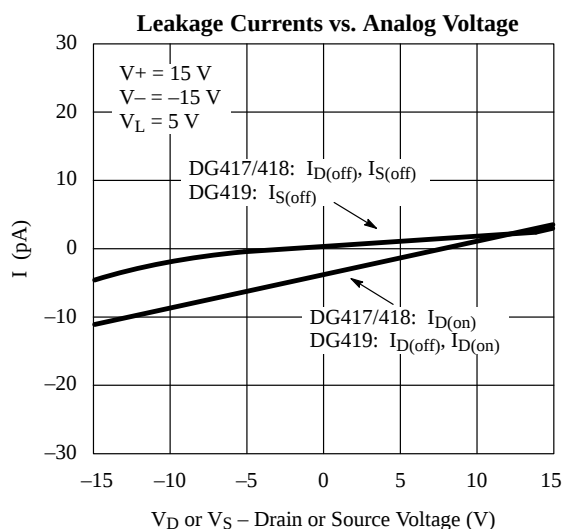
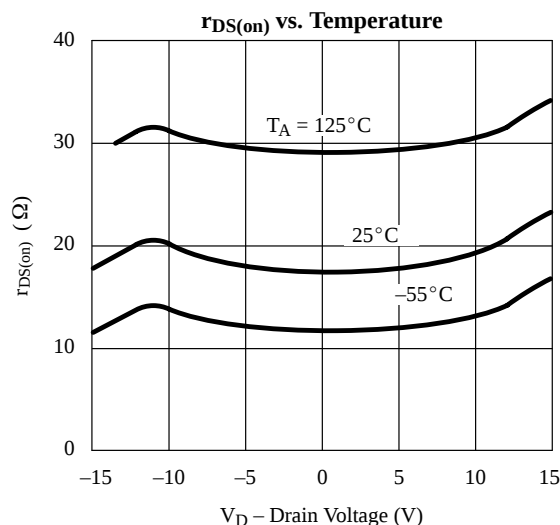
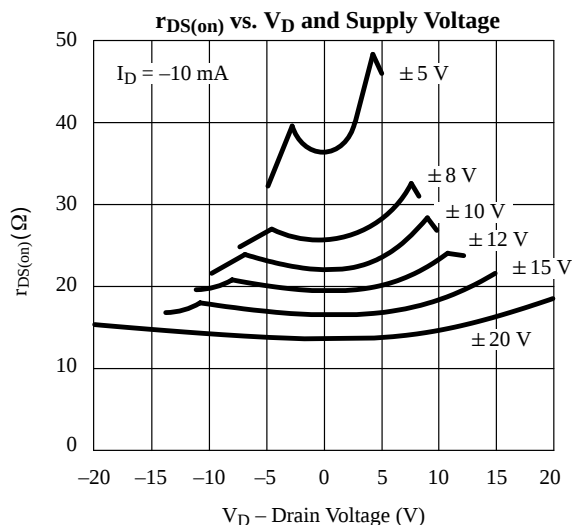
## Specifications<sup>a</sup> for Unipolar Supplies

| Parameter                        | Symbol              | Test Conditions<br>Unless Otherwise Specified                                                           |       | Temp <sup>b</sup> | Typ <sup>c</sup> | A Suffix<br>–55 to 125°C |                  | D Suffix<br>–40 to 85°C |                  | Unit |
|----------------------------------|---------------------|---------------------------------------------------------------------------------------------------------|-------|-------------------|------------------|--------------------------|------------------|-------------------------|------------------|------|
|                                  |                     | 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>                |       |                   |                  | 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              |                  | 0                        | 12               | 0                       | 12               | V    |
| Drain-Source On-Resistance       | r <sub>DS(on)</sub> | I <sub>S</sub> = –10 mA, V <sub>D</sub> = 3.8 V<br>V+ = 10.8 V                                          |       | Room              | 40               |                          |                  |                         |                  | Ω    |
| Dynamic Characteristics          |                     |                                                                                                         |       |                   |                  |                          |                  |                         |                  |      |
| Turn-On Time                     | t <sub>ON</sub>     | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF, V <sub>S</sub> = 8 V<br>See Switching Time Test Circuit |       | Room              | 110              |                          |                  |                         |                  | ns   |
| Turn-Off Time                    | t <sub>OFF</sub>    |                                                                                                         |       | Room              | 40               |                          |                  |                         |                  |      |
| Break-Before-Make Time Delay     | t <sub>D</sub>      | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF                                                          | DG419 | Room              | 60               |                          |                  |                         |                  |      |
| Charge Injection                 | Q                   | C <sub>L</sub> = 10 nF, V <sub>gen</sub> = 0 V, R <sub>gen</sub> = 0 Ω                                  |       | Room              | 5                |                          |                  |                         |                  | pC   |
| Power Supplies                   |                     |                                                                                                         |       |                   |                  |                          |                  |                         |                  |      |
| Positive Supply Current          | I+                  | V+ = 13.2 V, V <sub>L</sub> = 5.25 V<br>V <sub>IN</sub> = 0 or 5 V                                      |       | Room              | 0.001            |                          |                  |                         |                  | μA   |
| Negative Supply Current          | I–                  |                                                                                                         |       | Room              | –0.001           |                          |                  |                         |                  |      |
| Logic Supply Current             | I <sub>L</sub>      |                                                                                                         |       | Room              | 0.001            |                          |                  |                         |                  |      |
| Ground Current                   | I <sub>GND</sub>    |                                                                                                         |       | Room              | –0.001           |                          |                  |                         |                  |      |

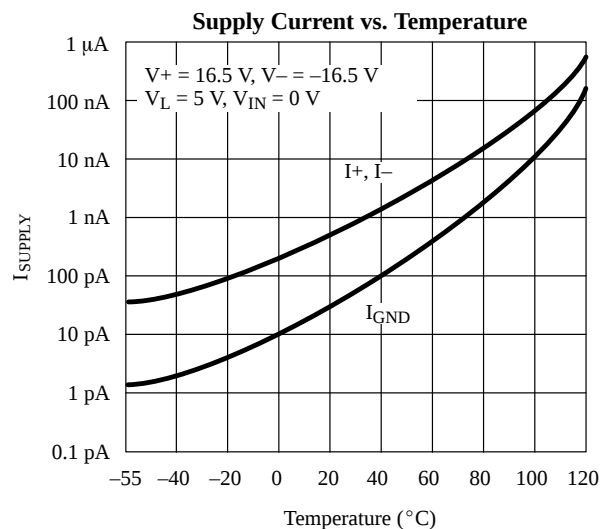
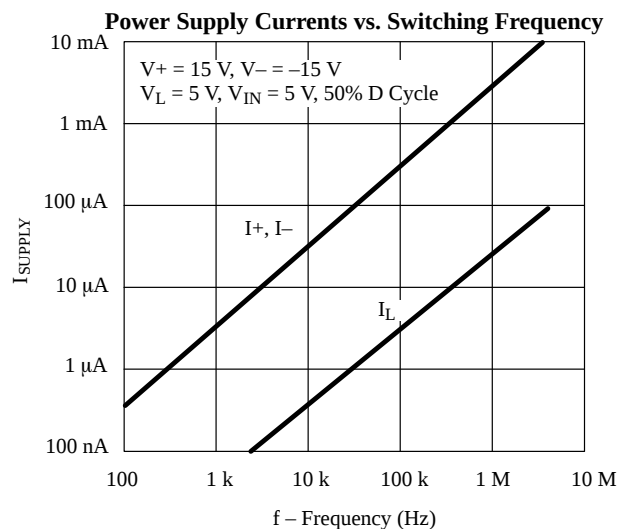
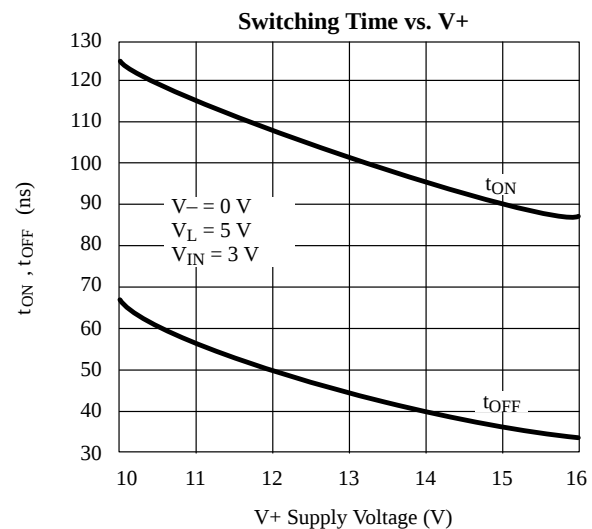
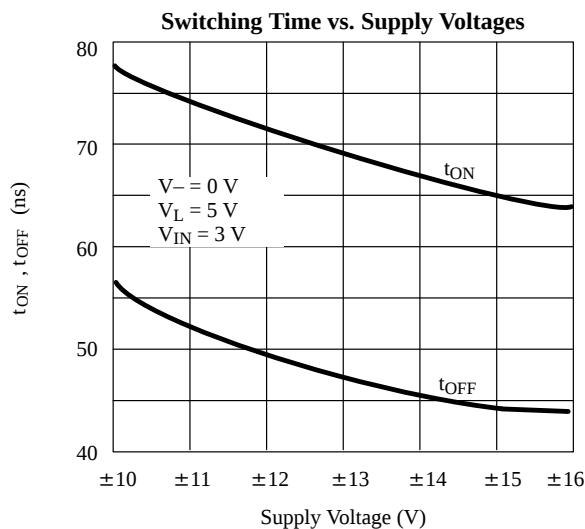
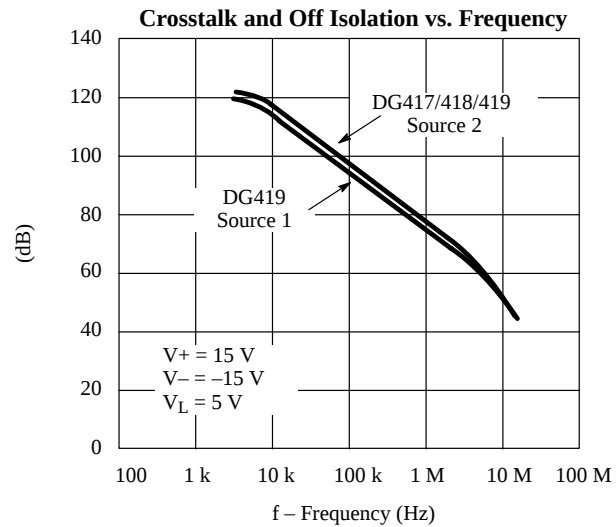
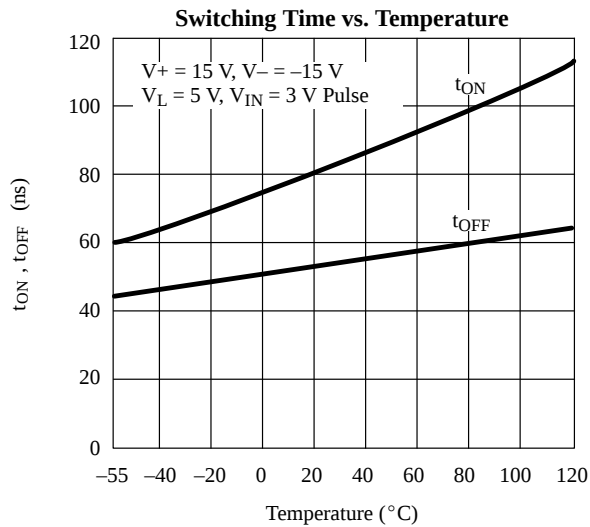
**Notes:**

- 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

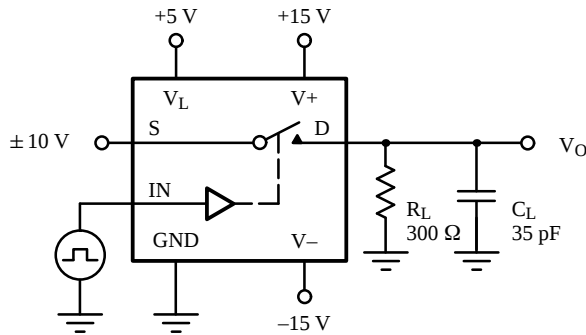


## Typical Characteristics (Cont'd)



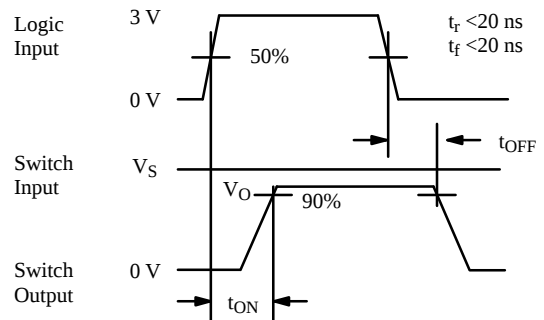
## Test Circuits

$V_O$  is the steady state output with the switch on.



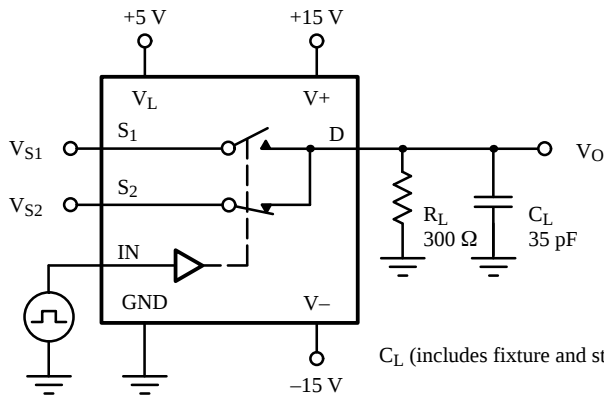
$C_L$  (includes fixture and stray capacitance)

$$V_O = V_S \frac{R_L}{R_L + r_{DS(on)}}$$

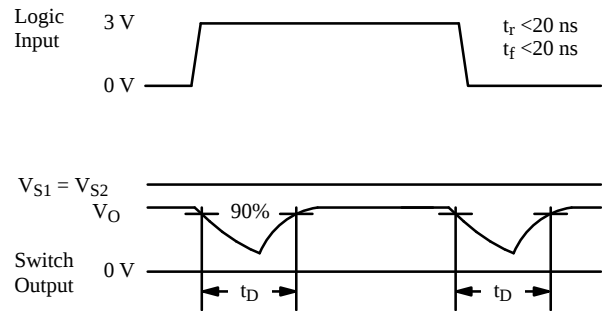


Note: Logic input waveform is inverted for switches that have the opposite logic sense.

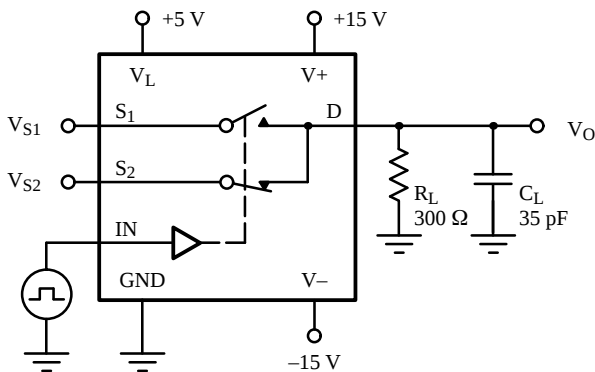
**Figure 2.** Switching Time (DG417/418)



$C_L$  (includes fixture and stray capacitance)

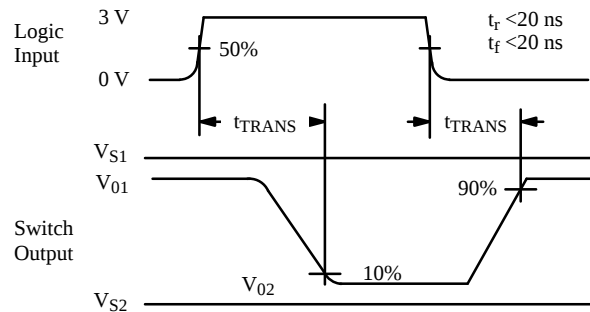


**Figure 3.** Break-Before-Make (DG419)



$C_L$  (includes fixture and stray capacitance)

$$V_O = V_S \frac{R_L}{R_L + r_{DS(on)}}$$



**Figure 4.** Transition Time (DG419)

## Test Circuits (Cont'd)

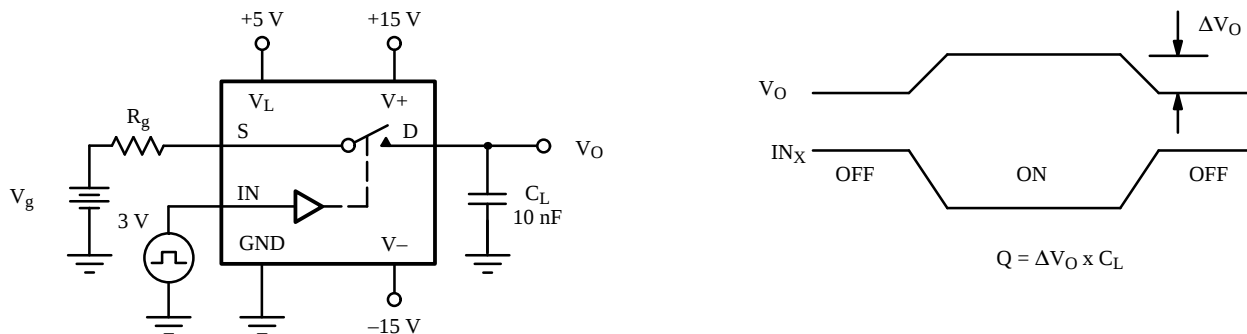


Figure 5. Charge Injection

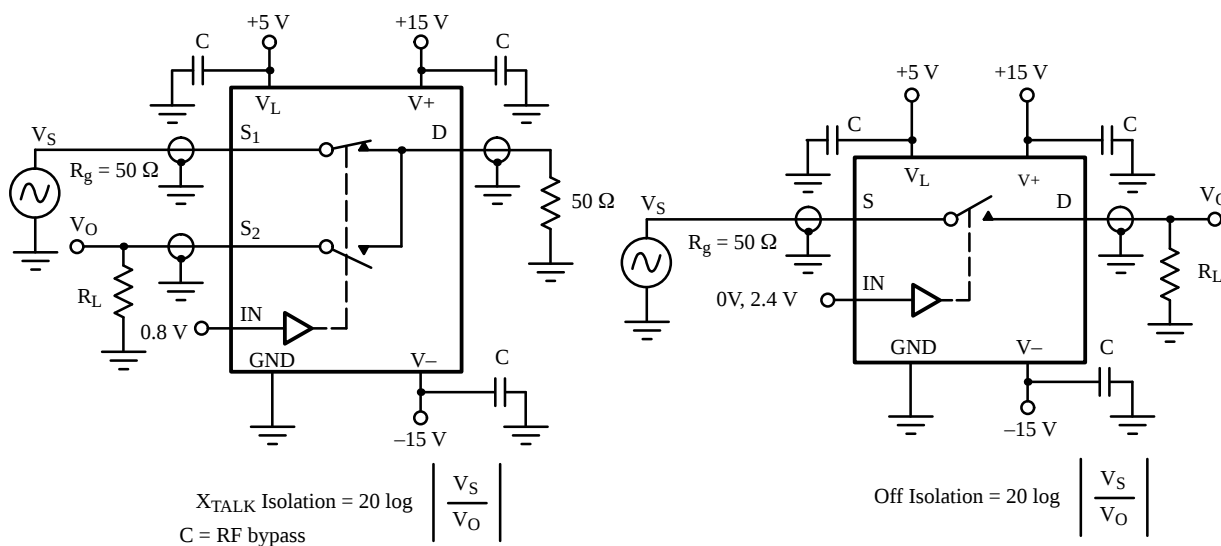


Figure 6. Crosstalk (DG419)

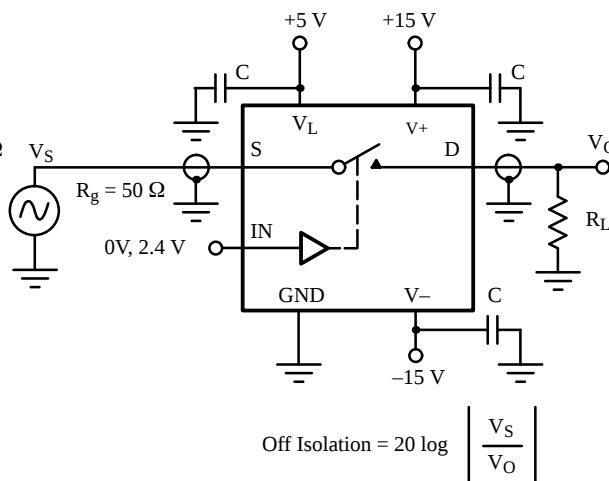


Figure 7. Off Isolation

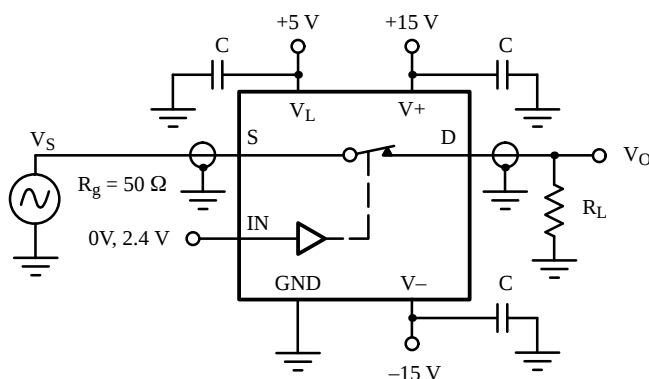


Figure 8. Insertion Loss

## Test Circuits (Cont'd)

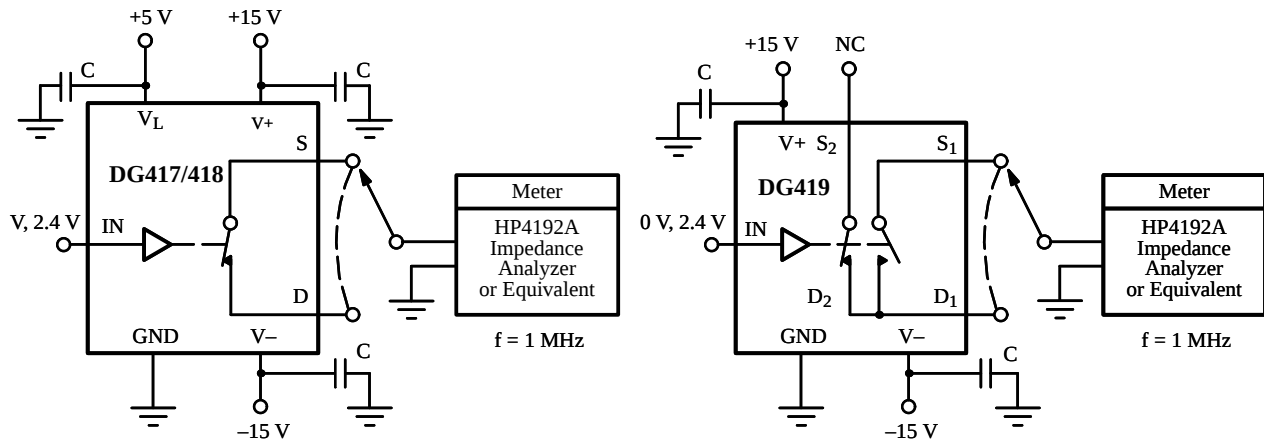


Figure 9. Source/Drain Capacitances

## Applications

### Switched Signal Powers Analog Switch

The analog switch in Figure 10 derives power from its input signal, provided the input signal amplitude exceeds 4 V and its frequency exceeds 1 kHz.

This circuit is useful when signals have to be routed to either of two remote loads. Only three conductors are required: one for the signal to be switched, one for the control signal and a common return.

A positive input pulse turns on the clamping diode  $D_1$  and charges  $C_1$ . The charge stored on  $C_1$  is used to power the chip; operation is satisfactory because the switch requires less than 1  $\mu\text{A}$  of stand-by supply current. Loading of the signal source is imperceptible. The DG419's on-resistance is a low 100  $\Omega$  for a 5-V input signal.

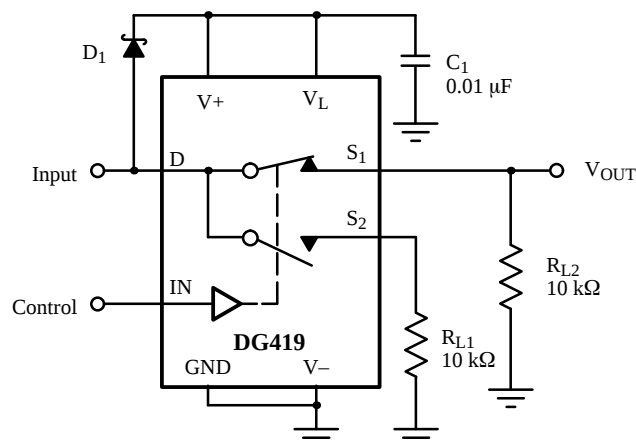


Figure 10. Switched Signal Powers Remote SPDT Analog Switch

## Applications (Cont'd)

### Micropower UPS Transfer Switch

When  $V_{CC}$  drops to 3.3 V, the DG417 changes states, closing  $SW_1$  and connecting the backup cell, as shown in Figure 11.  $D_1$  prevents current from leaking back towards the rest of the circuit. Current consumption by the CMOS analog switch is around 100 pA; this ensures that most of the power available is applied to the memory, where it is really needed. In the stand-by mode, hundreds of  $\mu A$  are sufficient to retain memory data.

When the 5-V supply comes back up, the resistor divider senses the presence of at least 3.5 V, and causes a new

change of state in the analog switch, restoring normal operation.

### Programmable Gain Amplifier

The DG419, as shown in Figure 12, allows accurate gain selection in a small package. Switching into virtual ground reduces distortion caused by  $r_{DS(on)}$  variation as a function of analog signal amplitude.

### GaAs FET Driver

The DG419, as shown in Figure 13 may be used as a GaAs FET driver. It translates a TTL control signal into  $-8$ -V, 0-V level outputs to drive the gate.

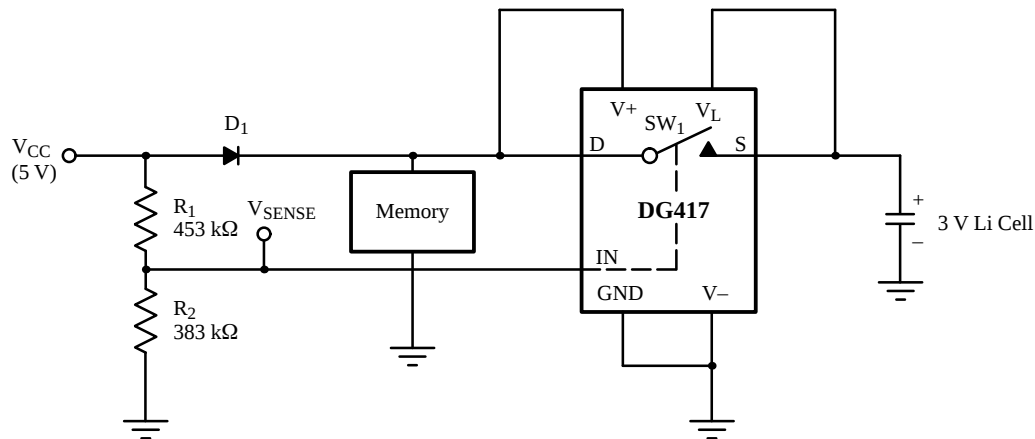


Figure 11. Micropower UPS Circuit

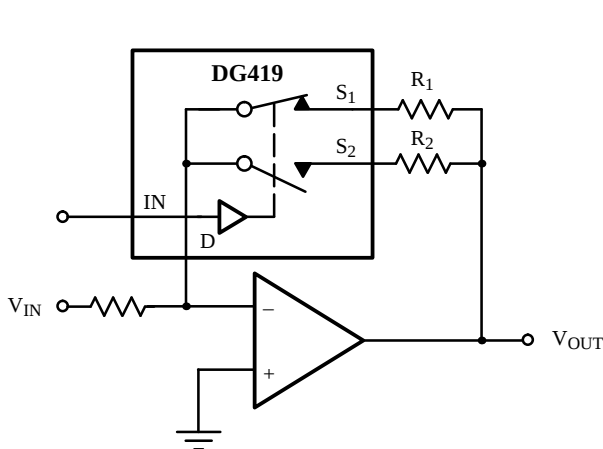


Figure 12. Programmable Gain Amplifier

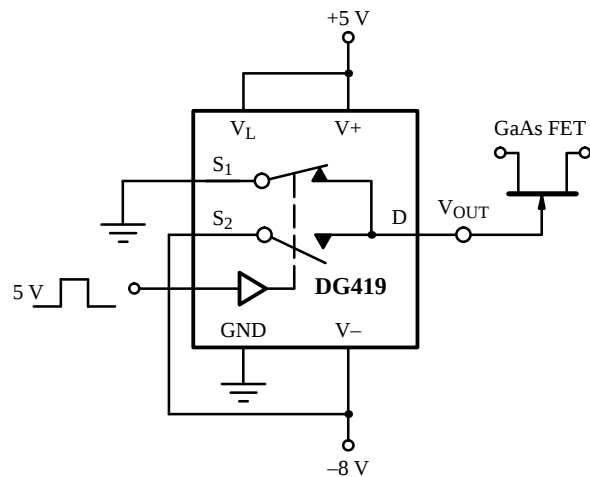


Figure 13. GaAs FET Driver