# Single 4 x 1 and Dual 2 x 1 Multiplexers

## DESCRIPTION

The DG9414, a single 4 to 1 multiplexer, and the DG9415, a dual 2 x 1 multiplexer, are monolithic CMOS analog devices designed for high performance low voltage operation. Combining low power, high speed, low on-resistance and small physical size, the DG9414 and DG9415 are ideal for portable and battery powered applications requiring high performance and efficient use of board space.

Both the DG9414 and DG9415 are built on Vishay Siliconix's low voltage BCD-15 process. Minimum ESD protection, per Method 3015.7, is 2000 volts. An epitaxial layer prevents latchup. Break-before-make is guaranteed for DG9415.

## FEATURES

- Low Voltage Operation (+ 2.7 to + 12 V)
- Low On-Resistance - $r_{DS(on)}$: 14 Ω
- Low Power Consumption
- TTL Compatible
- ESD Protection > 2000 V (Method 3015.7)
- Available in TSSOP-10 (aka MSOP-10)

Pb-free
RoHS COMPLIANT

## BENEFITS

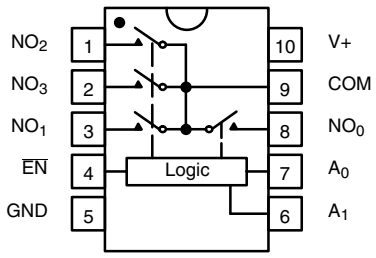
- High Accuracy
- Simple Logic Interface
- Reduce Board Space

## APPLICATIONS

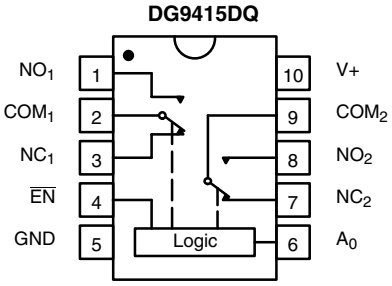
- Battery Operated Systems
- Portable Test Equipment
- Sample and Hold Circuits
- Cellular Phones
- Communication Systems
- Networking Equipment

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION

**DG9414DQ**




**DG9415DQ**




| $\overline{EN}$ | $A_1$ | $A_0$ | On Switch |
|---|---|---|---|
| 1 | X | X | None |
| 0 | 0 | 0 | $NO_0$ |
| 0 | 0 | 1 | $NO_1$ |
| 0 | 1 | 0 | $NO_2$ |
| 0 | 1 | 1 | $NO_3$ |

X = Do not Care

| $\overline{EN}$ | $A_0$ | On Switch |
|---|---|---|
| 1 | X | None |
| 0 | 0 | $NC_1$<br>$NC_2$ |
| 0 | 1 | $NO_1$<br>$NO_2$ |

X = Do not Care

## ORDERING INFORMATION

| Temp Range | Package | Part Number |
|---|---|---|
| - 40 to 85 °C | MSOP-10 | DG9414DQ-T1-E3 |
| | | DG9415DQ-T1-E3 |

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Limit | Unit |
|---|---|---|
| Reference V+ to GND | - 0.3 to + 13 | V |
| IN, COM, NC, NO[a] | - 0.3 to (V+ + 0.3) | |
| Continuous Current (Any terminal) | ± 20 | mA |
| Peak Current (Pulsed at 1 ms, 10 % duty cycle) | ± 40 | |
| ESD (Method 3015.7) | > 2000 | V |
| Storage Temperature (D Suffix) | - 65 to 150 | °C |

Notes:
a. Signals on $S_X$, $D_X$ or $IN_X$ 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.

## SPECIFICATIONS (V+ = 3 V)

| Parameter | Symbol | Test Conditions Otherwise Unless Specified V+ = 3 V, ± 10 %, $V_{IN}$ = 0.4 V or 2.4 V[e] | | Temp[a] | Limits - 40 to 85 °C Min[c] | Typ[b] | Max[c] | Unit |
|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | |
| Analog Signal Range[d] | $V_{ANALOG}$ | | | Full | 0 | | V+ | V |
| On-Resistance | $r_{ON}$ | V+ = 2.7 V, $V_{COM}$ = 1.0 V/1.5 V/2.0 V $I_{NO}$ or $I_{NC}$ = 5 mA | | Room<br>Full | | 63 | 97<br>101 | Ω |
| $r_{ON}$ Match[d] | $\Delta r_{ON}$ | | | Room | | 3 | 11 | |
| $r_{ON}$ Flatness[d,f] | $r_{ON}$ Flatness | | | Room | | 14 | 33 | |
| NO or NC Off Leakage Current[g] | $I_{NO/NC(off)}$ | V+ = 3.3 , $V_{NO}$ or $V_{NC}$ = 0.3 V/3 V $V_{COM}$ = 3 V/0.3 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | nA |
| COM Off Leakage Current[g] | $I_{COM(off)}$ | | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | |
| Channel-On Leakage Current[g] | $I_{COM(on)}$ | V+ = 3.3 V $V_{COM}$ = $V_{NO}$ or $V_{NC}$ = 0.3 V/3 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | |
| **Digital Control** | | | | | | | | |
| Input Current[g] | $I_{INL}$ or $I_{INH}$ | $V_{IN}$ = 0 or V+ | | Full | - 1.0 | | 1.0 | µA |
| Input High Voltage[d] | $V_{INH}$ | | | Full | 1.6 | | | V |
| Input Low Voltage[d] | $V_{INL}$ | | | Full | | | 0.4 | |
| **Dynamic Characteristics** | | | | | | | | |
| Turn-On Time | $t_{ON}$ | $V_{NO}$ or $V_{NC}$ = 1.5 V | | Room<br>Full | | 102 | 125<br>142 | ns |
| Turn-Off Time | $t_{OFF}$ | | | Room<br>Full | | 45 | 68<br>75 | |
| Break-Before-Make Time | $t_D$ | | | Room | 7 | 78 | | |
| Transition Time | $t_{trans}$ | $V_{NO}$ = 1.5 V/0 V, $V_{NC}$ = 0 V/1.5 V | | Room<br>Full | | 81 | 128<br>144 | |
| Charge Injection[d] | $Q_{INJ}$ | $C_L$ = 1 nF, $V_{gen}$ = 0 V, $R_{gen}$ = 0 Ω | | Room | | 3 | | pC |
| Off-Isolation | OIRR | $R_L$ = 50 Ω, $C_L$ = 5 pF, f = 1 MHz | | Room | | - 58 | | dB |
| Channel-to-Channel Crosstalk (DG9415) | $X_{TALK}$ | $R_L$ = 50 Ω, f = 1 MHz | | Room | | - 64 | | |
| NO, NC Off Capacitance | $C_{NO(off)}$, $C_{NC(off)}$ | f = 1 MHz | DG9414 | Room | | 11 | | pF |
| | | | DG9415 | Room | | 10 | | |
| COM Off Capacitance | $C_{COM(off)}$ | | DG9414 | Room | | 26 | | |
| | | | DG9415 | Room | | 13 | | |
| COM On Capacitance | $C_{COM(on)}$ | | DG9414 | Room | | 43 | | |
| | | | DG9415 | Room | | 25 | | |
| **Power Supply** | | | | | | | | |
| Power Supply Range | V+ | | | | 2.7 | | 3.3 | V |
| Power Supply Current[h] | I+ | V+ = 3.3 V, $V_{IN}$ = 0 or 3.3 V | | Full | | | 1.0 | µA |

## SPECIFICATIONS (V+ = 5 V)

| Parameter | Symbol | Test Conditions Otherwise Unless Specified V+ = 5 V, ± 10 %, $V_{IN}$ = 0.8 V or 2.4 V[e] | | Temp[a] | Limits - 40 to 85 °C Min[c] | Typ[b] | Max[c] | Unit |
|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | |
| Analog Signal Range[d] | $V_{ANALOG}$ | | | Full | 0 | | V+ | V |
| On-Resistance | $r_{ON}$ | V+ = 4.5 V, $V_{COM}$ = 1.5 V/2.5 V/3.5 V $I_{NO}$ or $I_{NC}$ = 10 mA | | Room<br>Full | | 33 | 56<br>60 | Ω |
| $r_{ON}$ Match | $\Delta r_{ON}$ | | | Room | | 2 | 10 | |
| $r_{ON}$ Flatness[f] | $r_{ON}$ Flatness | | | Room | | 10 | 20 | |
| NO or NC Off Leakage Current[g] | $I_{NO/NC(off)}$ | V+ = 5.5 V, $V_{NO}$ or $V_{NC}$ = 1 V/4.5 V $V_{COM}$ = 4.5 V/1 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | nA |
| COM Off Leakage Current[g] | $I_{COM(off)}$ | | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | |
| Channel-On Leakage Current[g] | $I_{COM(on)}$ | V+ = 5.5 V $V_{COM}$ = $V_{NO}$ or $V_{NC}$ = 1 V/4.5 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | |
| **Digital Control** | | | | | | | | |
| Input Current[h] | $I_{INL}$ or $I_{INH}$ | $V_{IN}$ = 0 or V+ | | Full | - 1.0 | | 1.0 | µA |
| Input High Voltage[d] | $V_{INH}$ | | | Full | 1.8 | | | V |
| Input Low Voltage[d] | $V_{INL}$ | | | Full | | | 0.6 | |
| **Dynamic Characteristics** | | | | | | | | |
| Turn-On Time[h] | $t_{ON}$ | $V_{NO}$ or $V_{NC}$ = 3.0 V | | Room<br>Full | | 56 | 77<br>86 | ns |
| Turn-Off Time[h] | $t_{OFF}$ | | | Room<br>Full | | 25 | 46<br>50 | |
| Break-Before-Make Time[h] | $t_D$ | | | Room | 7 | 34 | | |
| Transition Time | $t_{trans}$ | $V_{NO}$ = 3 V/ 0 V, $V_{NC}$ = 0 V/3 V | | Room<br>Full | | 47 | 77<br>84 | |
| Off-Isolation | OIRR | $R_L$ = 50 Ω, $C_L$ = 5 pF, f = 1 MHz | | Room | | - 58 | | dB |
| Channel-to-Channel Crosstalk (DG9415) | $X_{TALK}$ | $R_L$ = 50 Ω, f = 1 MHz | | Room | | - 64 | | |
| Charge Injection[d] | $Q_{INJ}$ | $C_L$ = 1 nF, $V_{gen}$ = 0 V, $R_{gen}$ = 0 Ω | | Room | | 6 | | pC |
| NO, NC Off Capacitance | $C_{NO(off)}$, $C_{NC(off)}$ | f = 1 MHz | DG9414 | Room | | 11 | | pF |
| | | | DG9415 | Room | | 10 | | |
| COM Off Capacitance | $C_{COM(off)}$ | | DG9414 | Room | | 25 | | |
| | | | DG9415 | Room | | 13 | | |
| COM On Capacitance | $C_{COM(on)}$ | | DG9414 | Room | | 42 | | |
| | | | DG9415 | Room | | 24 | | |
| **Power Supply** | | | | | | | | |
| Power Supply Range | V+ | | | | 4.5 | | 5.5 | V |
| Power Supply Current[h] | I+ | V+ = 5.5 V, $V_{IN}$ = 0 or 5.5 V | | Full | | | 1.0 | µA |

Notes:
a. Room = 25 °C, Full = as determined by the operating suffix.
b. Typical values are for design aid only, not guaranteed nor subject to production testing.
c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
d. Guarantee by design, nor subjected to production test.
e. $V_{IN}$ = input voltage to perform proper function.
f. Difference of min and max values.
g. Guaranteed by 12 V leakage testing, not production tested.
h. Guaranteed by worst case test conditions and not subject to test.

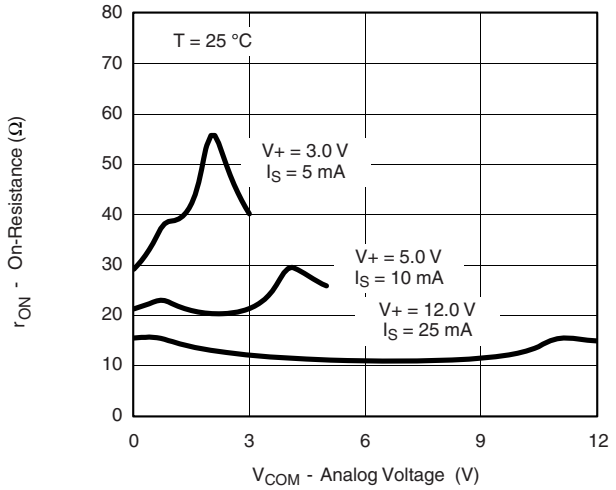
## SPECIFICATIONS (V+ = 12 V)

| Parameter | Symbol | Test Conditions Unless Specified V+ = 12 V, $V_{IN}$ = 0.8 V or 2.4 V[e] | | Temp[a] | Limits - 40 to 85 °C Min[c] | Typ[b] | Max[c] | Unit |
|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | |
| Analog Signal Range[d] | $V_{ANALOG}$ | | | Full | 0 | | 12 | V |
| $r_{ON}$ Match | $\Delta r_{ON}$ | | | Room | | 1 | 9 | Ω |
| $r_{ON}$ Flatness[d,f] | $r_{ON}$ Flatness | | | Room | | 1 | 10 | Ω |
| On-Resistance | $r_{ON}$ | V+ = 10.8 V, $I_{NO}$, $I_{NC}$ = 25 mA $V_{COM}$ = 2/9 V | | Room<br>Full | | 14 | 17<br>19 | Ω |
| Switch Off Leakage Current | $I_{NO(off)}$ $I_{NC(off)}$ | $V_{COM}$ = 1/11 V $V_{NO}$, $V_{NC}$ = 11/1 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | nA |
| | $I_{COM(off)}$ | | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | nA |
| Channel On Leakage Current | $I_{COM(on)}$ | $V_{NO}$, $V_{NC}$ = $V_{COM}$ = 11/1 V | | Room<br>Full | - 1<br>- 10 | | 1<br>10 | nA |
| **Digital Control** | | | | | | | | |
| Input Current | $I_{INL}$ or $I_{INH}$ | $V_{IN}$ = 0 or V+ | | Full | - 1 | | 1 | µA |
| Input High Voltage[d] | $V_{INH}$ | | | Full | 2.4 | | | V |
| Input Low Voltage[d] | $V_{INL}$ | | | Full | | | 0.8 | V |
| **Dynamic Characteristics** | | | | | | | | |
| Turn-On Time[h] | $t_{ON}$ | $R_L$ = 300 Ω, $C_L$ = 35 pF $V_{NO}$, $V_{NC}$ = 5 V See Figure 2 | | Room<br>Full | | 33 | 55<br>59 | ns |
| Turn-Off Time[h] | $t_{OFF}$ | | | Room<br>Full | | 17 | 40<br>41 | ns |
| Break-Before-Make Time Delay[h] | $t_D$ | DG419L Only, $V_{NC}$, $V_{NO}$ = 5 V $R_L$ = 300 Ω, $C_L$ = 35 pF | | Room | 2 | 24 | | ns |
| Transition Time | $t_{trans}$ | $V_{NO}$ = 5 V/ 0 V, $V_{NC}$ = 0 V/ 5 V | | Room<br>Full | | 29 | 56<br>59 | ns |
| Charge Injection[d] | $Q_{INJ}$ | $V_g$ = 0 V, $R_g$ = 0 Ω, $C_L$ = 1 nF | | Room | | 13 | | pC |
| Off Isolation[d] | OIRR | $R_L$ = 50 Ω, $C_L$ = 5 pF f = 1 MHz | | Room | | - 58 | | dB |
| Channel-to-Channel Crosstalk[d] | $X_{TALK}$ | | | Room | | - 64 | | dB |
| NO, NC Off Capacitance[d] | $C_{NO(off)}$, $C_{NC(off)}$ | $V_{IN}$ = 0 or V+, f = 1 MHz | DG9414 | Room | | 10 | | pF |
| | | | DG9415 | Room | | 10 | | pF |
| COM Off Capacitance | $C_{COM(off)}$ | | DG9414 | Room | | 24 | | pF |
| | | | DG9415 | Room | | 13 | | pF |
| COM On Capacitance[d] | $C_{COM(on)}$ | | DG9414 | Room | | 40 | | pF |
| | | | DG9415 | Room | | 23 | | pF |
| **Power Supplies** | | | | | | | | |
| Positive Supply Current | I+ | $V_{IN}$ = 0 or 12 V | | Full | | | 1 | µA |

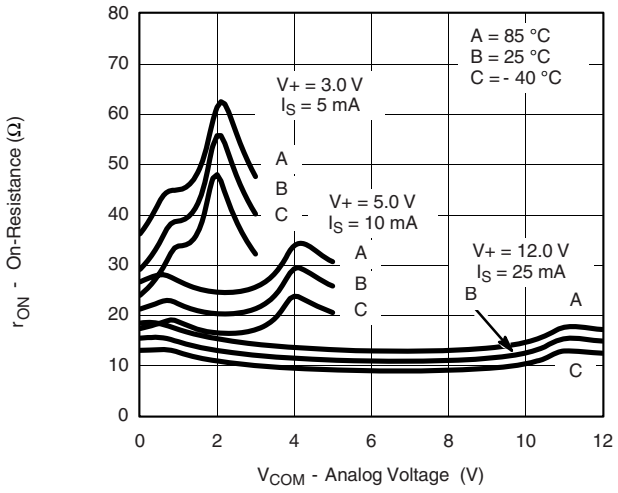
Notes:
a. Room = 25 °C, Full = as determined by the operating suffix.
b. Typical values are for design aid only, not guaranteed nor subject to production testing.
c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
d. Guarantee by design, nor subjected to production test.
e. $V_{IN}$ = input voltage to perform proper function.
f. Difference of min and max values.
g. Guaranteed by 12 V leakage testing, not production tested.
h. Guaranteed by worst case test conditions and not subject to test.

*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.*

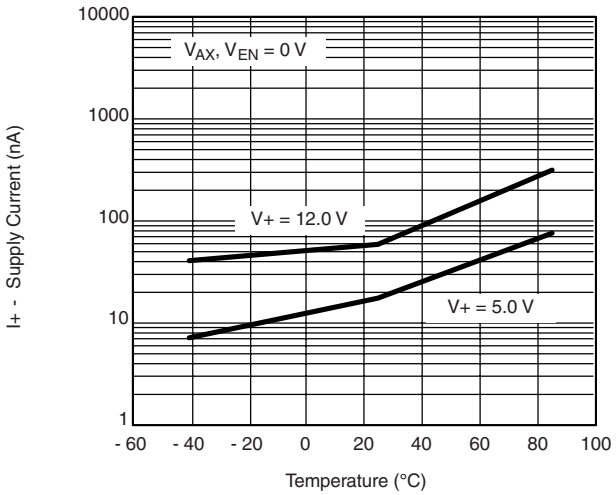
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



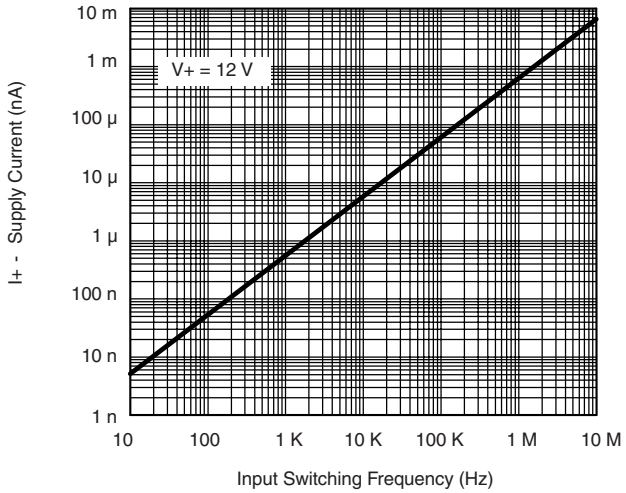

**$r_{ON}$ vs. $V_{COM}$ and Supply Voltage**



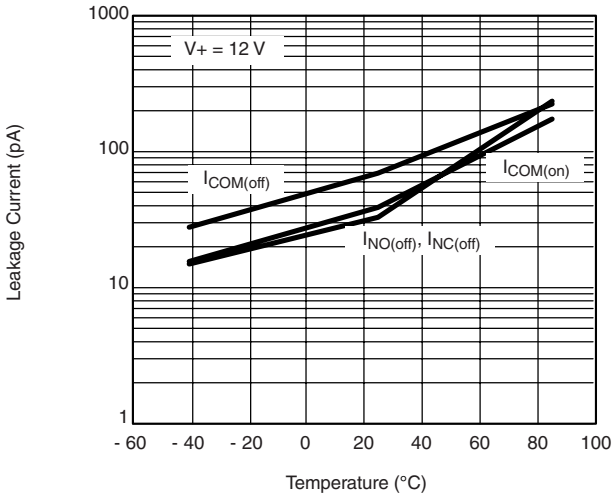

**$r_{ON}$ vs. Analog Voltage and Temperature**



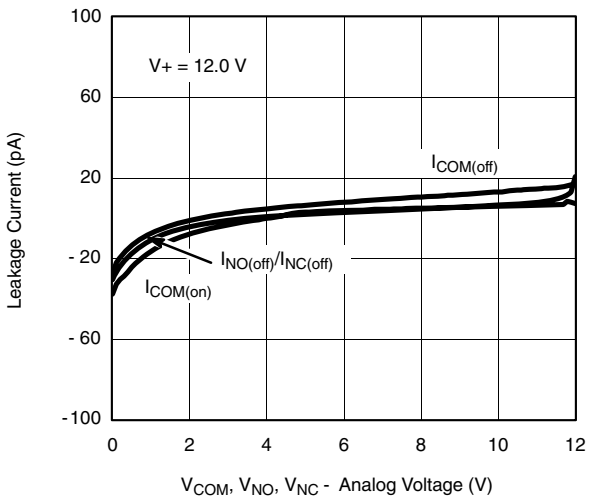

**Supply Current vs. Temperature**




**Supply Current vs. Input Switching Frequency**

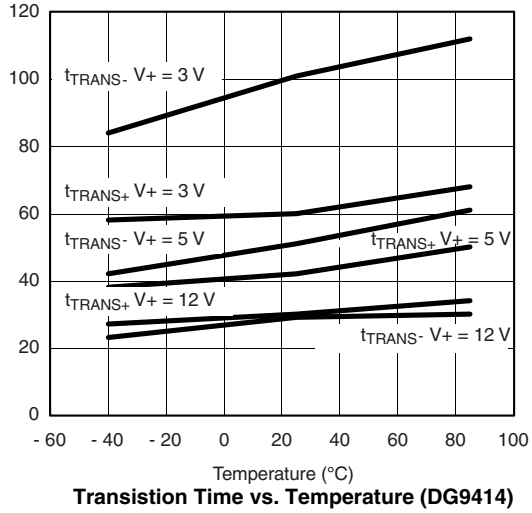



**Leakage Current vs. Temperature**

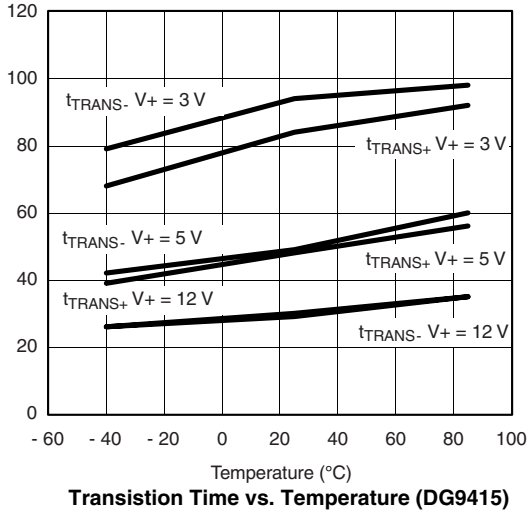



**Leakage vs. Analog Voltage**

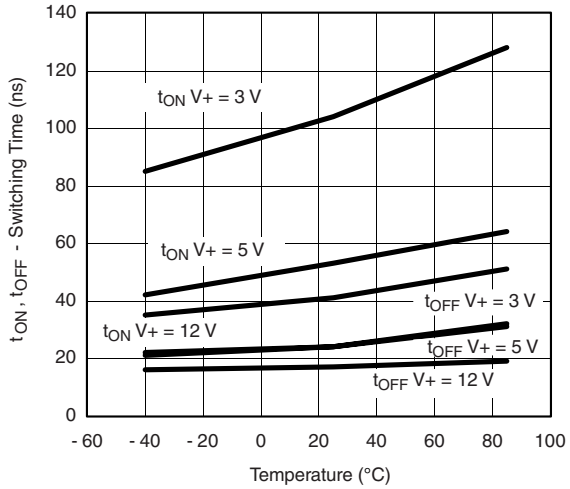
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



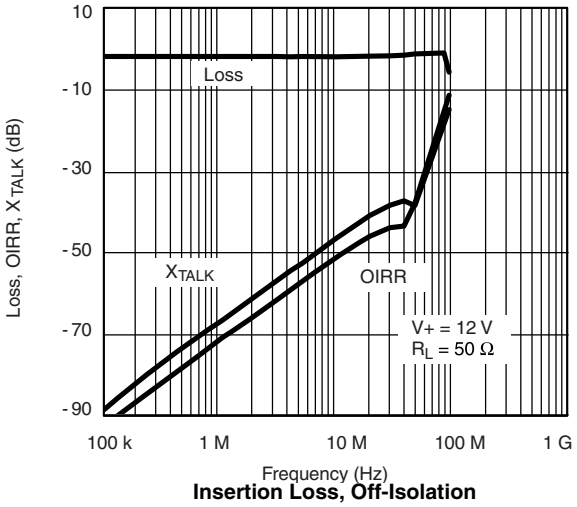

**Transistion Time vs. Temperature (DG9414)**



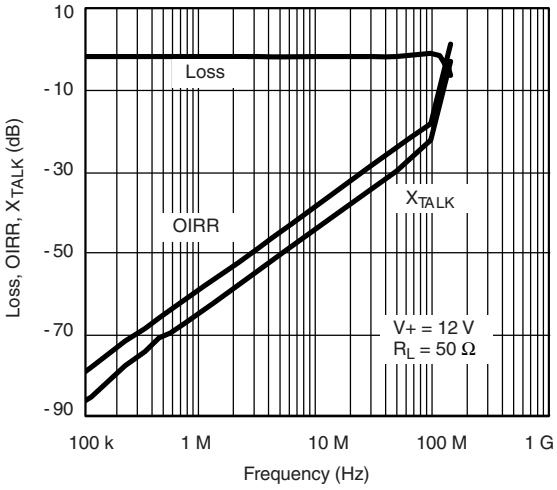

**Transistion Time vs. Temperature (DG9415)**



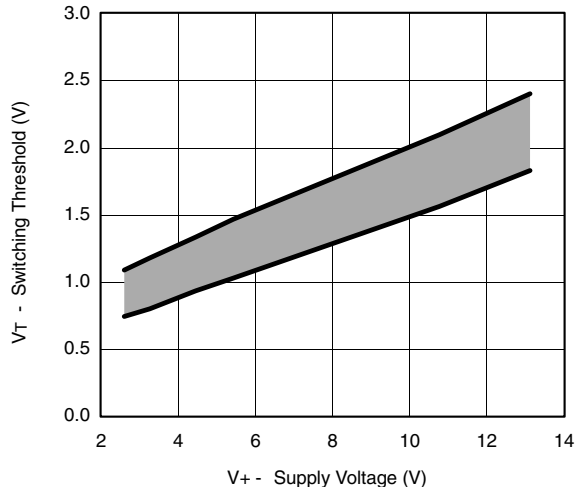

**Switching Time vs. Temperature**




**Insertion Loss, Off-Isolation Crosstalk vs. Frequency (DG9414)**

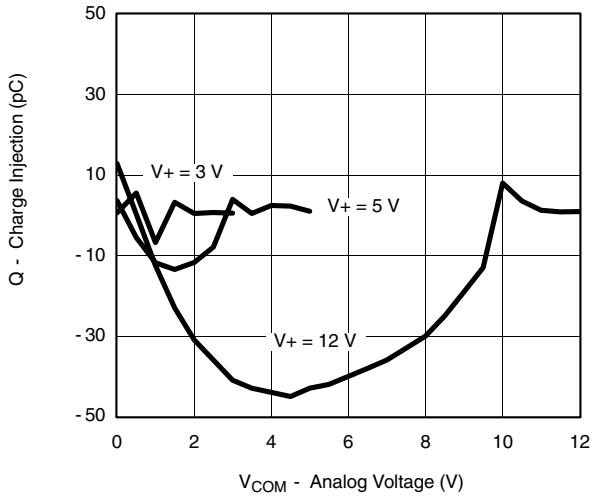



**Insertion Loss, Off-Isolation Crosstalk vs. Frequency (DG9415)**

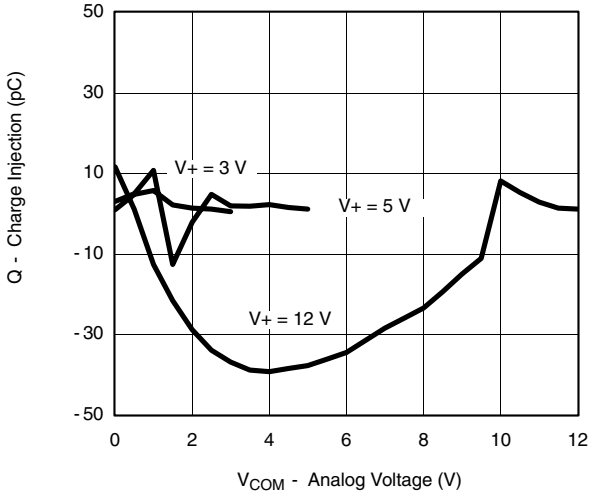



**Switching Threshold vs. Supply Voltage**

## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted




**Charge Injection vs. Analog Voltage (DG9414)**




**Charge Injection vs. Analog Voltage (DG9415)**

## SCHEMATIC DIAGRAM (TYPICAL CHANNEL)

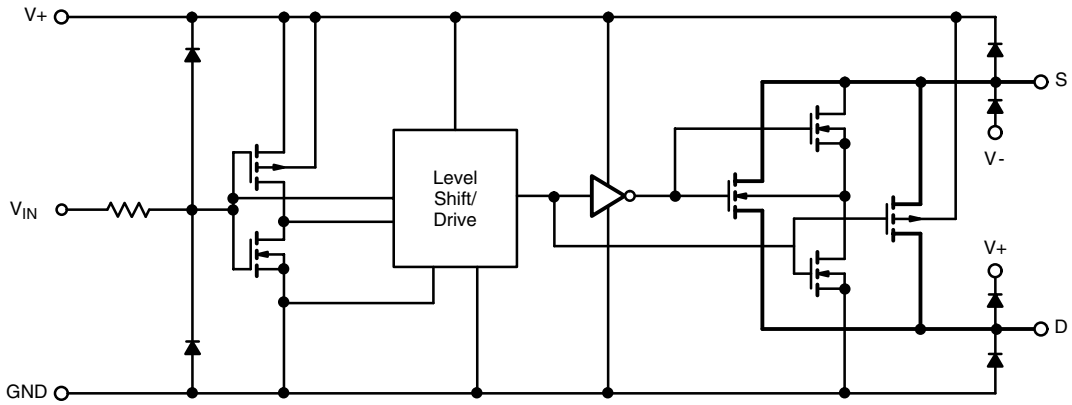
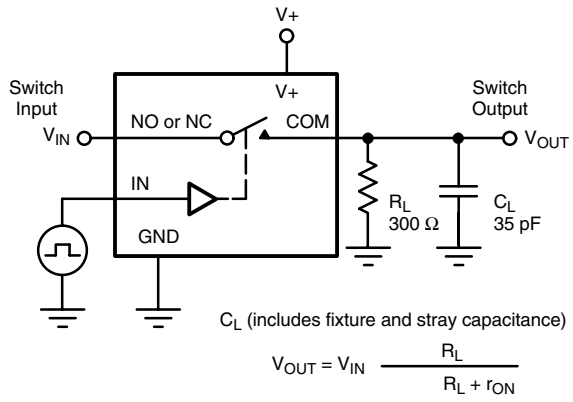
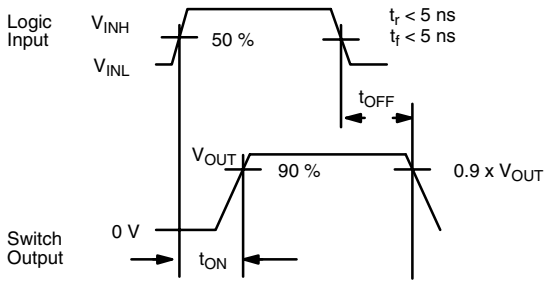



**Figure 1.**

## TEST CIRCUITS

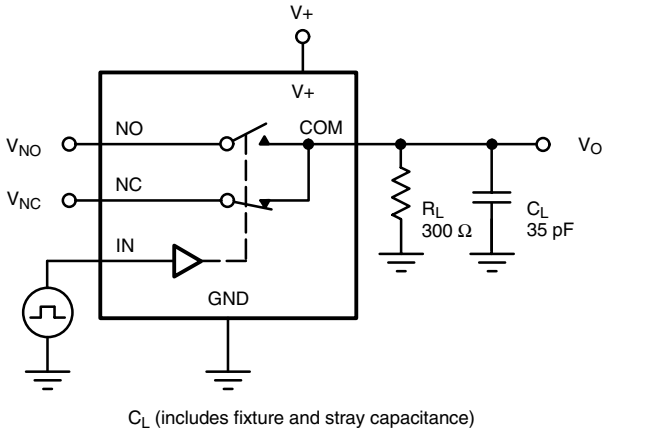



Note: Logic input waveform is inverted for switches that have the opposite logic sense control

**Figure 2. Switching Time**

## TEST CIRCUITS



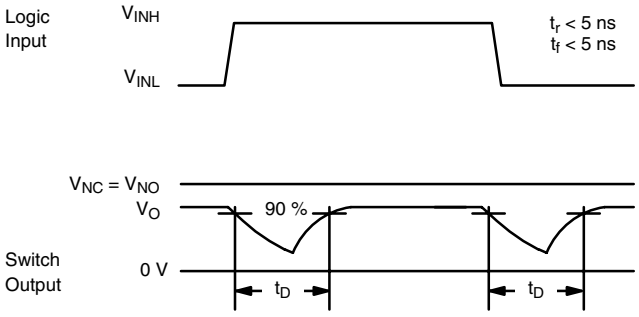
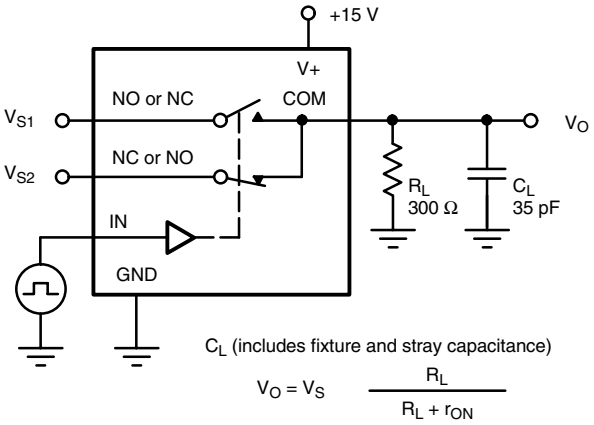




**Figure 3. Break-Before-Make**



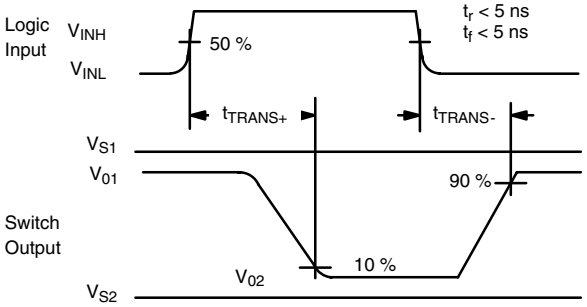
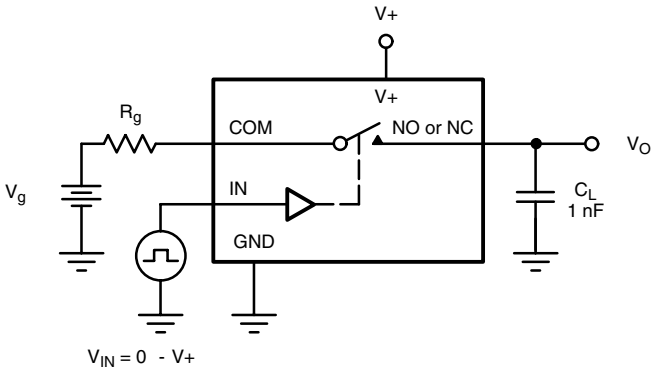
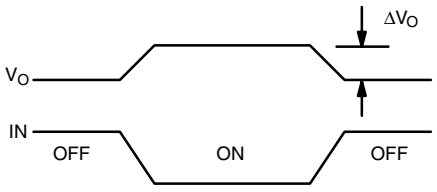




**Figure 4. Transition Time**




$Q = \Delta V_O \times C_L$

IN dependent on switch configuration Input polarity determined by sense of switch.

**Figure 5. Charge Injection**

## TEST CIRCUITS

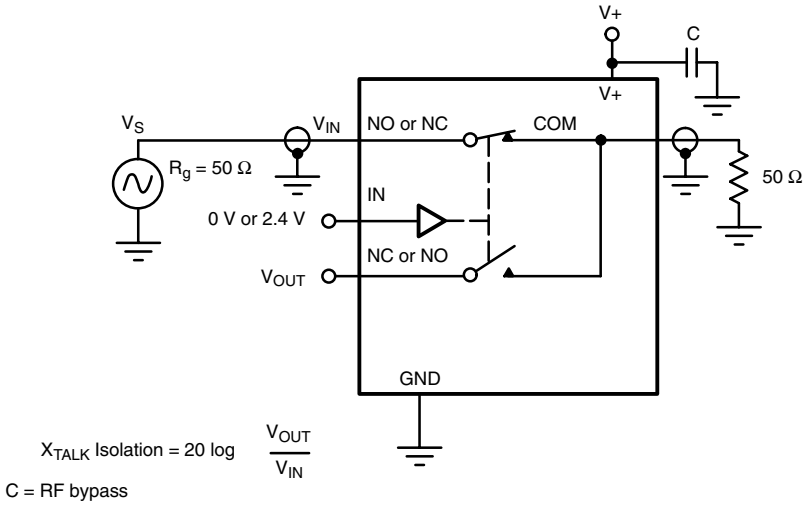



**Figure 6. Crosstalk**

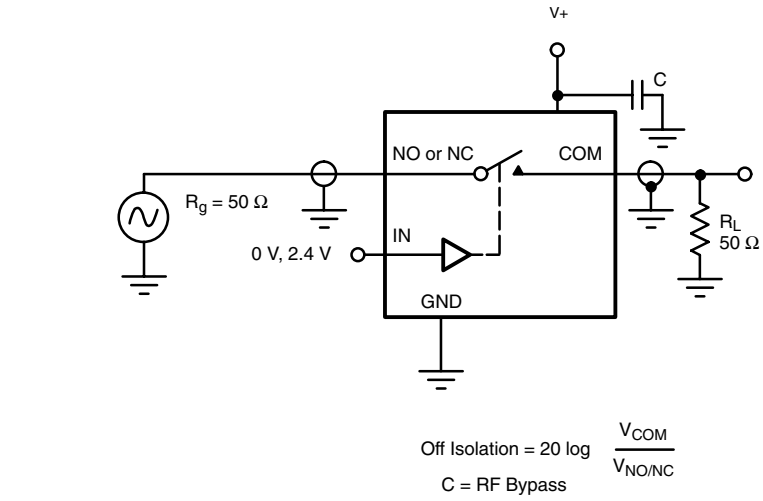



**Figure 7. Off Isolation**

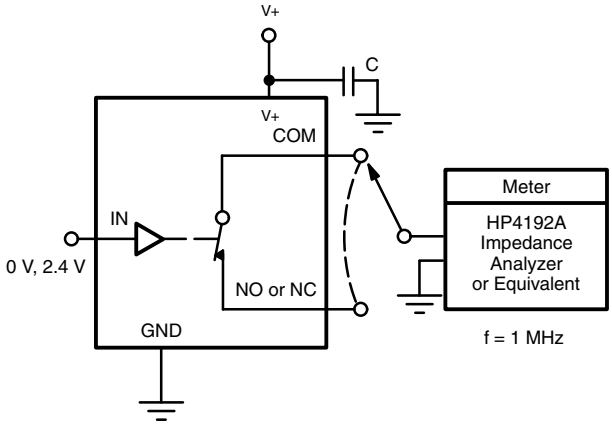



**Figure 8. Source/Drain Capacitances**

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