

Powered-off Protection, 6 Ω, 1.8 V to 5.5 V, SPDT Analog Switch (2:1 Multiplexer)

DESCRIPTION

The DG9411E is a high performance single-pole, double-throw (SPDT) analog switch designed for 1.8 V to 5.5 V operation with a single power rail.

Fabricated with high density CMOS technology, the device achieves low on resistance of 6 Ω and switch off capacitance of 7 pF at a 5 V power supply and low power consumption, and fast switching speeds.

The DG9411E can handle both analog and digital signals and permits signals with amplitudes of up to V+ to be transmitted in either direction. Its control logic inputs can go over V+ up to 5.5 V. It features break before make switching performance.

A powered-off protection circuit is built into the switch to prevent an abnormal current flow from COM pin to V+ during the power-down condition. Each output pin can withstand greater than 7 kV (human body model).

Operation temperature is specified from -40 °C to +85 °C. The DG9411E is available in the compact SC-70-6L package.

FEATURES

- Low switch on-resistance (6 Ω)
- 1.8 V to 5.5 V single supply operation
- Powered-off protection
- Control logic inputs can go over V+ up to 5.5 V
- Low parasitic capacitance, 7 pF at switch off
- Low charge injection, 1 pC
- Break before make switching
- Latch-up performance exceeds 200 mA per JESD 78
- ESD tested
 - 7000 V human body model (JS-001)
 - 1000 V charge device model (JS-002)
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



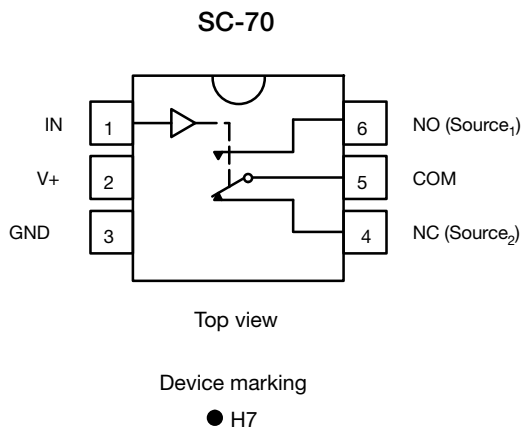
Note

* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

APPLICATIONS

- Battery powered devices
- Smartphones and tablets
- Consumer and computing
- Portable instrumentation
- Medical equipment

FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



TRUTH TABLE

| LOGIC | NC | NO |
|-------|-----|-----|
| 0 | On | Off |
| 1 | Off | On |

Notes

- Logic "0" ≤ 0.8 V
- Logic "1" ≥ 2.4 V

ORDERING INFORMATION

| TEMP. RANGE | PACKAGE | PART NUMBER |
|------------------|---------|------------------|
| -40 °C to +85 °C | SC-70-6 | DG9411EDL-T1-GE3 |



| ABSOLUTE MAXIMUM RATINGS | | | |
|------------------------------------------------|--------------------------------------|-------------|------|
| PARAMETER | | LIMIT | UNIT |
| V+, COM, NC, NO, IN reference to GND | | -0.3 to 6 | V |
| Continuous current (any terminal) | | ± 50 | mA |
| Peak current (pulsed at 1 ms, 10 % duty cycle) | | ± 200 | |
| Storage temperature | | -65 to +150 | °C |
| Power dissipation (packages) ^a | 6-pin SC-70 ^b | 250 | mW |
| ESD / HBM | JS-001 | 7000 | V |
| ESD / CDM | JS-002 | 1000 | |
| Latch up | Per JEDEC78 with 1.5 x voltage clamp | 200 | mA |

Notes

- a. All leads welded or soldered to PC board
- b. Derate 3.1 mW/°C above 70 °C

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 ratings conditions for extended periods may affect device reliability.

| SPECIFICATIONS (V+ = 5 V) | | | | | | | |
|-------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------|----------------------------|-------------------|-------------------|------|
| PARAMETER | SYMBOL | TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 5 V, ± 10 % VIN = 0.8 V or 2.4 V ^e | TEMP. ^a | LIMITS -40 °C to +85 °C | | | UNIT |
| | | | | MIN. ^b | TYP. ^c | MAX. ^b | |
| Analog Switch | | | | | | | |
| Analog signal range ^d | V _{NO} , V _{NC} V _{COM} | | Full | 0 | - | V+ | V |
| Drain-source on-resistance ^d | R _{DS(on)} | V+ = 4.5 V, V _{COM} = 3 V, I _{NO} , I _{NC} = 10 mA | Room | - | 6 | 8 | Ω |
| | | | Full | - | 8 | 10 | |
| R _{DS(on)} flatness ^d | R _{DS(on)} flatness | V+ = 5 V, V _{COM} = 1.5 V, 3.5 V, I _{NO} , I _{NC} = 10 mA | Room | - | 0.4 | - | Ω |
| R _{DS(on)} match ^d | ΔR _{DS(on)} | V+ = 4.5 V, V _{COM} = 3 V, I _{NO} , I _{NC} = 10 mA | Room | - | 0.04 | 0.2 | |
| Switch-off leakage current ^f | I _{NO(off)} , I _{NC(off)} | V+ = 5.5 V, V _{NO} , V _{NC} = 1 V / 4.5 V, V _{COM} = 4.5 V / 1 V | Room | -1.5 | - | 1.5 | nA |
| | | | Full | -4 | - | 4 | |
| | I _{COM(off)} | Room | -1 | - | 1 | | |
| | | Full | -4 | - | 4 | | |
| Channel-on leakage current ^f | I _{COM(on)} | V+ = 5.5 V, V _{NO} , V _{NC} = V _{COM} = 1 V / 4.5 V | Room | -1 | - | 1 | nA |
| | | | Full | -4 | - | 4 | |
| Power-down leakage | I _{PD} | V+ = 0 V, V _{COM} = 5 V, NO/NC open, V _{IN} = GND | Full | - | - | 2 | μA |
| | | V+ = 0 V, V _{NO} , V _{NC} = 5 V, COM open, V _{IN} = GND | Full | - | - | 2 | |
| Digital Control | | | | | | | |
| Input high voltage | V _{INH} | | Full | 2.4 | - | - | V |
| Input low voltage | V _{INL} | | Full | - | - | 0.8 | |
| Input capacitance ^d | C _{IN} | | Full | - | 6 | - | pF |
| Input current | I _{INL} or I _{INH} | V _{IN} = 0 V or V+ | Full | -1 | - | 1 | μA |
| Dynamic Characteristics | | | | | | | |
| Turn-on time ^d | t _{ON} | V _{NO} or V _{NC} = 3 V, R _L = 300 Ω, C _L = 35 pF | Room | - | 10 | 30 | ns |
| | | | Full | - | - | 32 | |
| Turn-off time ^d | t _{OFF} | | Room | - | 8 | 24 | |
| | | | Full | - | - | 26 | |
| Break-before-make time ^d | t _{BBM} | | Room | 1 | - | - | |
| Charge injection ^d | Q _{INJ} | C _L = 1 nF, V _{GEN} = 0 V, V _{NO} , V _{NC} = 0 V, R _{GEN} = 0 Ω | Room | - | 1 | - | pC |
| Off-isolation ^d | OIRR | R _L = 50 Ω, C _L = 5 pF, f = 1 MHz | Room | - | -78 | - | dB |
| Crosstalk ^d | X _{TALK} | | Room | - | -77 | - | |
| NO, NC off capacitance ^d | C _{NO(off)} | V _{IN} = 0 V or V+, f = 1 MHz | Room | - | 7 | - | pF |
| | C _{NC(off)} | | Room | - | 7 | - | |
| Channel-on capacitance ^d | C _{ON} | | Room | - | 13 | - | |
| Power Supply | | | | | | | |
| Power supply current ^d | I+ | V _{IN} = 0 V or V+ | Full | - | 0.004 | 1 | μA |



| SPECIFICATIONS (V+ = 3 V) | | | | | | | |
|-------------------------------------------|-------------------------------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------------|-------------------|-------------------|------|
| PARAMETER | SYMBOL | TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 3 V, ± 10 % VIN = 0.4 V or 2 V ^e | TEMP. ^a | LIMITS -40 °C to +85 °C | | | UNIT |
| | | | | MIN. ^b | TYP. ^c | MAX. ^b | |
| Analog Switch | | | | | | | |
| Analog signal range ^d | V _{NO} , V _{NC} V _{COM} | | Full | 0 | - | V+ | V |
| Drain-source on-resistance ^d | R _{DS(on)} | V+ = 2.7 V, V _{COM} = 1.5 V, I _{NO} , I _{NC} = 10 mA | Room | - | 13 | 22 | Ω |
| | | | Full | - | 15 | 24 | |
| R _{DS(on)} flatness ^d | R _{DS(on)} flatness | V+ = 3 V, V _{COM} = 0 V to V+, I _{NO} , I _{NC} = 10 mA | Room | - | 1.4 | - | |
| R _{DS(on)} match ^d | ΔR _{DS(on)} | V+ = 2.7 V, V _{COM} = 1.5 V, I _{NO} , I _{NC} = 10 mA | Room | - | 0.03 | 0.35 | |
| Switch-off leakage current ^f | I _{NO(off)} , I _{NC(off)} | V+ = 3.3 V, V _{NO} , V _{NC} = 1 V / 3 V, V _{COM} = 3 V / 1 V | Room | -400 | - | 400 | pA |
| | | | Full | -4 | - | 4 | nA |
| | Room | | -800 | - | 800 | pA | |
| | Full | | -8 | - | 8 | nA | |
| Channel-on leakage current ^f | I _{COM(on)} | V+ = 3.3 V, V _{NO} , V _{NC} = V _{COM} = 1 V / 3 V | Room | -800 | - | 800 | pA |
| | | | Full | -8 | - | 8 | nA |
| Digital Control | | | | | | | |
| Input high voltage | V _{INH} | | Full | 2 | - | - | V |
| Input low voltage | V _{INL} | | Full | - | - | 0.4 | |
| Input capacitance ^d | C _{IN} | | Full | - | 6 | - | pF |
| Input current | I _{INL} or I _{INH} | V _{IN} = 0 V or V+ | Full | -1 | - | 1 | μA |
| Dynamic Characteristics | | | | | | | |
| Turn-on time ^d | t _{ON} | V _{NO} or V _{NC} = 2 V, R _L = 300 Ω, C _L = 35 pF | Room | - | 13 | 34 | ns |
| | | | Full | - | - | 37 | |
| Turn-off time ^d | t _{OFF} | | Room | - | 9 | 20 | |
| | | | Full | - | - | 22 | |
| Break-before-make time ^d | t _{BBM} | | Room | 1 | - | - | |
| Charge injection ^d | Q _{INJ} | | C _L = 1 nF, V _{GEN} = 0 V, V _{NO} , V _{NC} = 0 V, R _{GEN} = 0 Ω | Room | - | 0.9 | |
| Off-isolation ^d | OIRR | R _L = 50 Ω, C _L = 5 pF, f = 1 MHz | Room | - | -78 | - | dB |
| Crosstalk ^d | X _{TALK} | | Room | - | -77 | - | |
| NO, NC off capacitance ^d | C _{NO(off)} | V _{IN} = 0 V or V+, f = 1 MHz | Room | - | 7 | - | pF |
| | C _{NC(off)} | | Room | - | 7 | - | |
| Channel-on capacitance ^d | C _{ON} | | Room | - | 14 | - | |
| Power Supply | | | | | | | |
| Power supply current ^d | I+ | V _{IN} = 0 V or V+ | Full | - | 0.002 | 1 | μA |



| SPECIFICATIONS (V+ = 2.5 V) | | | | | | | |
|-------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------------|-------------------|-------------------|------|
| PARAMETER | SYMBOL | TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 2.5 V, ± 10 % VIN = 0.4 V or 2 V ^e | TEMP. ^a | LIMITS -40 °C to +85 °C | | | UNIT |
| | | | | MIN. ^b | TYP. ^c | MAX. ^b | |
| Analog Switch | | | | | | | |
| Analog signal range ^d | V _{NO} , V _{NC} V _{COM} | | Full | 0 | - | V+ | V |
| Drain-source on-resistance ^d | R _{DS(on)} | V+ = 2.2 V, V _{COM} = 1 V, I _{NO} , I _{NC} = 10 mA | Room Full ^d | - - | 23 24 | 27 28 | Ω |
| R _{DS(on)} flatness ^d | R _{DS(on)} flatness | V+ = 2.5 V, V _{COM} = 0 V to V+, I _{NO} , I _{NC} = 10 mA | Room | - | 1.7 | - | |
| R _{DS(on)} match ^d | ΔR _{DS(on)} | V+ = 2.2 V, V _{COM} = 1.2 V, I _{NO} , I _{NC} = 10 mA | Room | - | 0.1 | 0.5 | |
| Switch-off leakage current ^f | I _{NO(off)} , I _{NC(off)} | V+ = 2.7 V, V _{NO} , V _{NC} = 0.5 V / 1.5 V, V _{COM} = 1.5 V / 0.5 V | Room | -200 | - | 200 | |
| | | | Full ^d | -3 | - | 3 | nA |
| | I _{COM(off)} | | Room | -200 | - | 200 | pA |
| | | | Full ^d | -3 | - | 3 | nA |
| Channel-on leakage current ^f | I _{COM(on)} | V+ = 2.7 V, V _{NO} , V _{NC} = V _{COM} = 0.5 V / 1.5 V | Room | -200 | - | 200 | pA |
| | | | Full ^d | -3 | - | 3 | nA |
| Digital Control | | | | | | | |
| Input high voltage | V _{INH} | | Full | 2 | - | - | V |
| Input low voltage | V _{INL} | | Full | - | - | 0.4 | |
| Input capacitance ^d | C _{IN} | | Full | - | 6 | - | pF |
| Input current | I _{INL} or I _{INH} | V _{IN} = 0 V or V+ | Full | -1 | - | 1 | μA |
| Dynamic Characteristics | | | | | | | |
| Turn-on time ^d | t _{ON} | V _{NO} or V _{NC} = 1.5 V, R _L = 300 Ω, C _L = 35 pF | Room | - | 16 | 36 | ns |
| | | | Full ^d | - | - | 38 | |
| Turn-off time ^d | t _{OFF} | | Room | - | 10 | 19 | |
| | | | Full | - | - | 21 | |
| Break-before-make time ^d | t _{BBM} | | Room ^d | 1 | - | - | |
| Charge injection ^d | Q _{INJ} | | C _L = 1 nF, V _{GEN} = 0 V, V _{NO} , V _{NC} = 0 V, R _{GEN} = 0 Ω | Room | - | 0.9 | |
| Off-isolation ^d | OIRR | R _L = 50 Ω, C _L = 5 pF, f = 1 MHz | Room | - | -78 | - | dB |
| Crosstalk ^d | X _{TALK} | | Room | - | -77 | - | |
| NO, NC off capacitance ^d | C _{NO(off)} | V _{IN} = 0 V or V+, f = 1 MHz | Room | - | 7 | - | pF |
| | C _{NC(off)} | | Room | - | 7 | - | |
| Channel-on capacitance ^d | C _{ON} | | Room | - | 14 | - | |
| Power Supply | | | | | | | |
| Power supply current ^d | I+ | V _{IN} = 0 V or V+ | Full | - | - | 1 | μA |

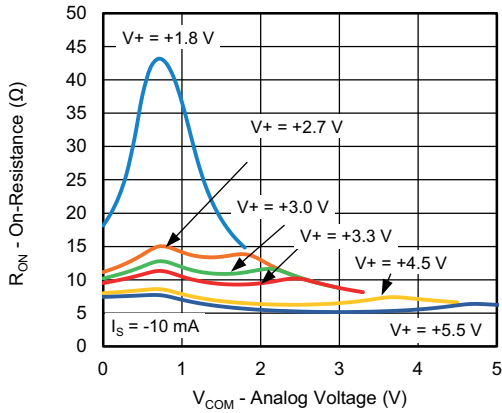


| SPECIFICATIONS (V+ = 2 V) | | | | | | | | |
|-------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------------|-------------------|-------------------|------|---|
| PARAMETER | SYMBOL | TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 2 V, ± 10 % VIN = 0.4 V or 1.6 V ^e | TEMP. ^a | LIMITS -40 °C to +85 °C | | | UNIT | |
| | | | | MIN. ^b | TYP. ^c | MAX. ^b | | |
| Analog Switch | | | | | | | | |
| Analog signal range ^d | V _{NO} , V _{NC} V _{COM} | | Full | 0 | - | V+ | V | |
| Drain-source on-resistance ^d | R _{DS(on)} | V+ = 1.8 V, V _{COM} = 1 V, I _{NO} , I _{NC} = 10 mA | Room | - | 37 | 42 | Ω | |
| | | | Full ^d | - | 36 | 44 | | |
| R _{DS(on)} flatness ^d | R _{DS(on)} flatness | V+ = 2 V, V _{COM} = 0 V to V+, I _{NO} , I _{NC} = 10 mA | Room | - | 3 | - | | |
| R _{DS(on)} match ^d | ΔR _{DS(on)} | V+ = 1.8 V, V _{COM} = 1 V, I _{NO} , I _{NC} = 10 mA | Room | - | 0.04 | 0.5 | | |
| Switch-off leakage current ^f | I _{NO(off)} , I _{NC(off)} | V+ = 2.2 V, V _{NO} , V _{NC} = 0.5 V / 1.5 V, V _{COM} = 1.5 V / 0.5 V | Room | -200 | - | 200 | pA | |
| | | | Full ^d | -3 | - | 3 | nA | |
| | I _{COM(off)} | | Room | -200 | - | 200 | pA | |
| | | | Full ^d | -3 | - | 3 | nA | |
| Channel-on leakage current ^f | I _{COM(on)} | V+ = 2.2 V, V _{NO} , V _{NC} = V _{COM} = 0.5 V / 1.5 V | Room | -200 | - | 200 | pA | |
| | | | Full ^d | -3 | - | 3 | nA | |
| Digital Control | | | | | | | | |
| Input high voltage | V _{INH} | | Full | 1.6 | - | - | V | |
| Input low voltage | V _{INL} | | Full | - | - | 0.4 | | |
| Input capacitance ^d | C _{IN} | | Full | - | 6 | - | pF | |
| Input current | I _{INL} or I _{INH} | V _{IN} = 0 V or V+ | Full | -1 | - | 1 | μA | |
| Dynamic Characteristics | | | | | | | | |
| Turn-on time ^d | t _{ON} | V _{NO} or V _{NC} = 1.5 V, R _L = 300 Ω, C _L = 35 pF | Room | - | 21 | 40 | ns | |
| | | | Full ^d | - | - | 42 | | |
| Turn-off time ^d | t _{OFF} | | Room | - | 13 | 20 | | |
| | | | Full ^d | - | - | 21 | | |
| Break-before-make time ^d | t _{BBM} | | | Room | 1 | - | | - |
| Charge injection ^d | Q _{INJ} | | C _L = 1 nF, V _{GEN} = 0 V, V _{NO} , V _{NC} = 0 V, R _{GEN} = 0 Ω | Room | - | 0.8 | | - |
| Off-isolation ^d | OIRR | R _L = 50 Ω, C _L = 5 pF, f = 1 MHz | Room | - | -78 | - | dB | |
| Crosstalk ^d | X _{TALK} | | Room | - | -77 | - | | |
| NO, NC off capacitance ^d | C _{NO(off)} | V _{IN} = 0 V or V+, f = 1 MHz | Room | - | 7 | - | pF | |
| | C _{NC(off)} | | Room | - | 7 | - | | |
| Channel-on capacitance ^d | C _{ON} | | Room | - | 14 | - | | |
| Power Supply | | | | | | | | |
| Power supply current ^d | I+ | V _{IN} = 0 V or V+ | Full | - | - | 1 | μA | |

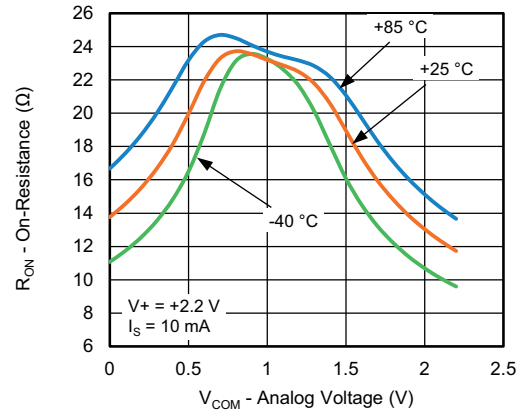
Notes

- a. Room = 25 °C, full = as determined by the operating suffix
- b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet
- c. Typical values are for design aid only, not guaranteed nor subject to production testing
- d. Guarantee by design, nor subjected to production test
- e. V_{IN} = input voltage to perform proper function
- f. Guaranteed by 5 V leakage testing, not production tested

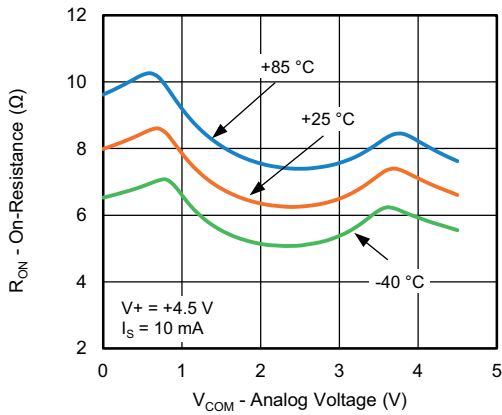
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



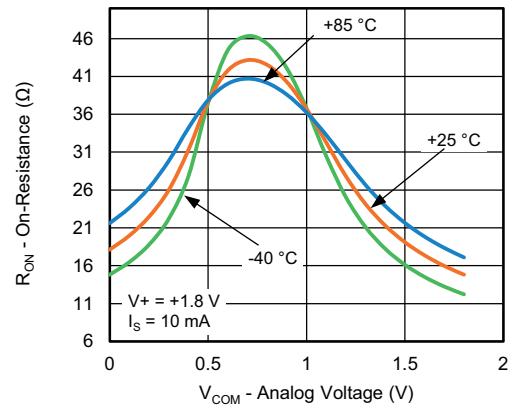
R_{DS(on)} vs. V_{COM} and Supply Voltage



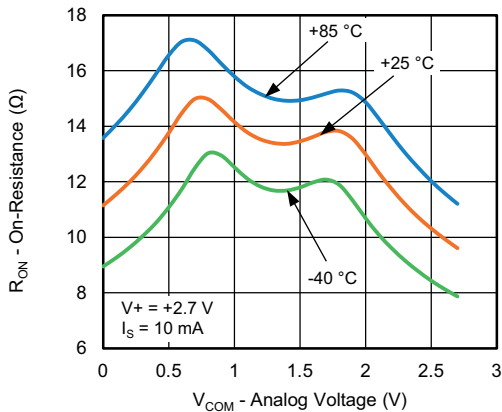
R_{DS(on)} vs. Analog Voltage and Temperature



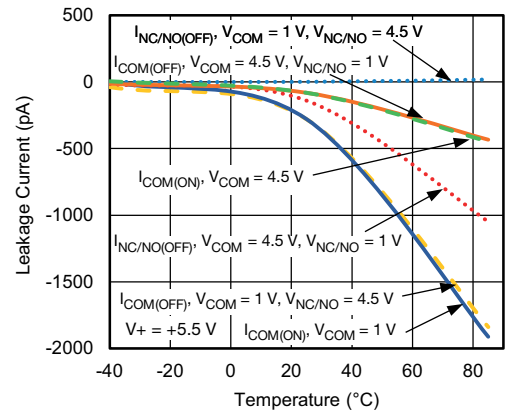
R_{DS(on)} vs. Analog Voltage and Temperature



R_{DS(on)} vs. Analog Voltage and Temperature



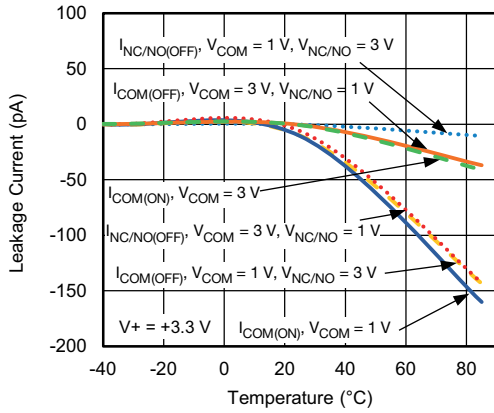
R_{DS(on)} vs. Analog Voltage and Temperature



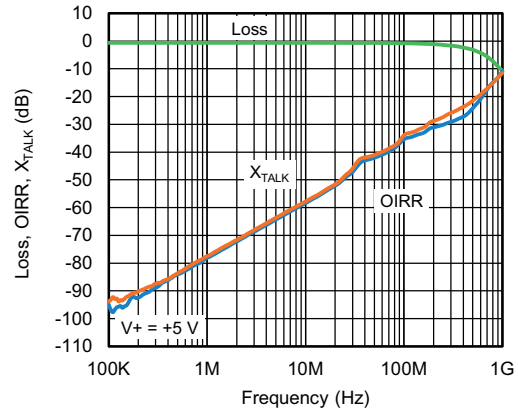
Leakage Current vs. Temperature



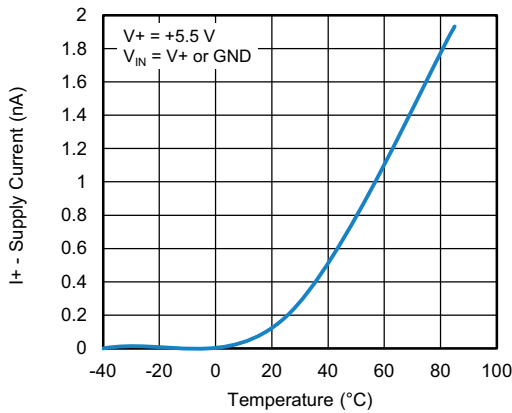
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



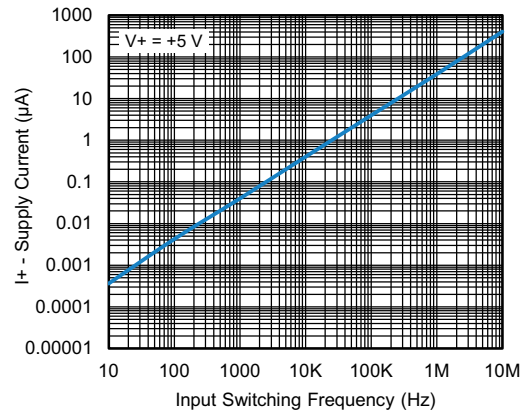
Leakage Current vs. Temperature



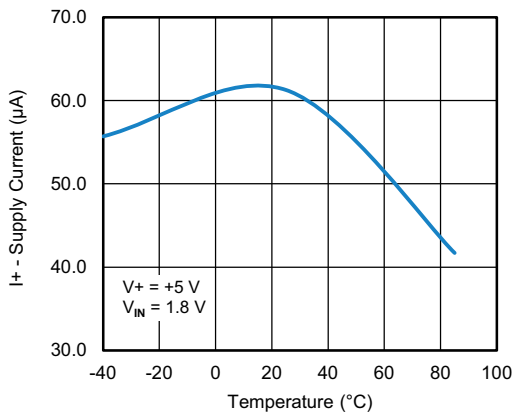
Insertion Loss, Off-Isolation Crosstalk vs. Frequency



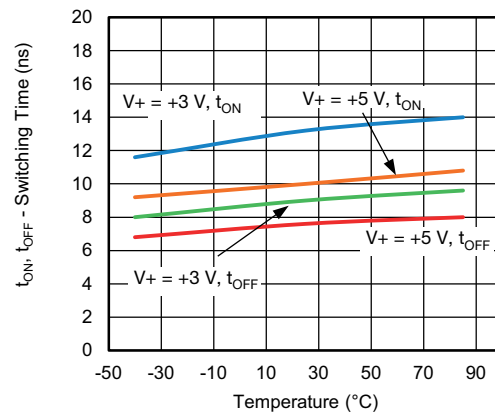
Supply Current vs. Temperature



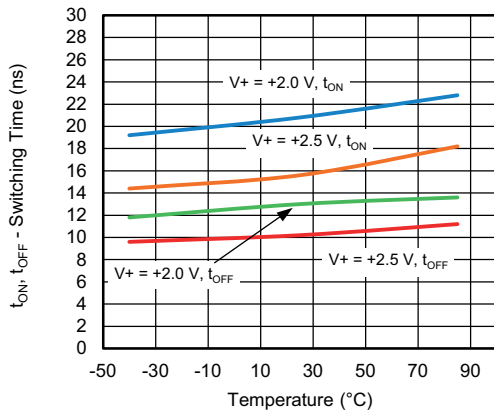
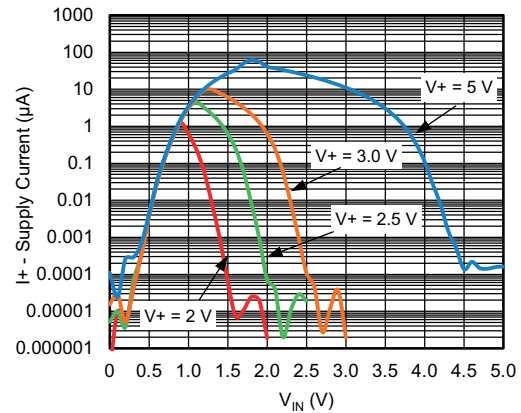
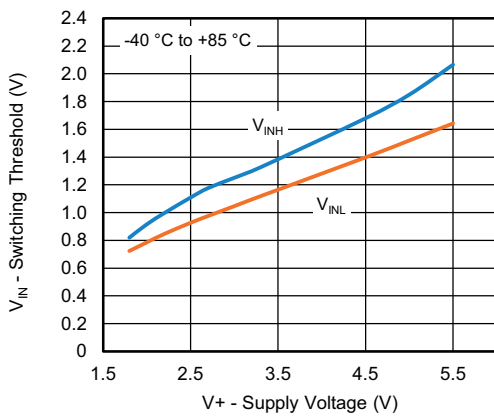
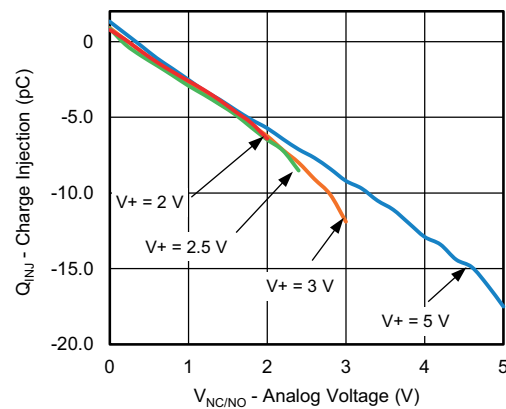
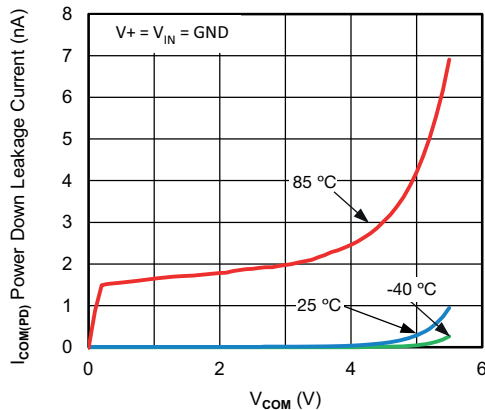
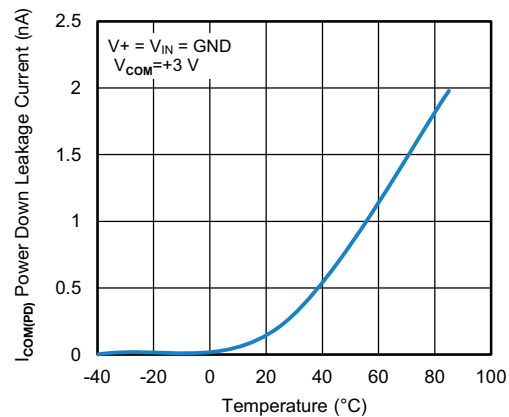
Supply Current vs. Input Switching Frequency



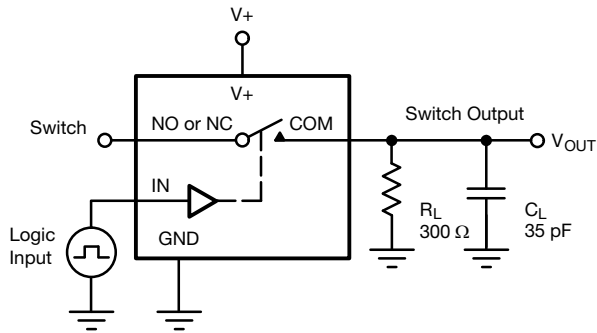
Supply Current vs. Temperature



Switching Time vs. Temperature

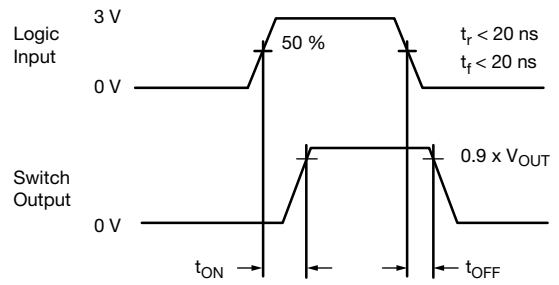
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

Switching Time vs. Temperature

Supply Current vs. Enable Input Voltage

Switching Threshold vs. Supply Voltage

Charge Injection vs. Analog Voltage

Power Down Leakage Current vs V_{COM}

Power Down Leakage Current vs Temperature

TEST CIRCUITS



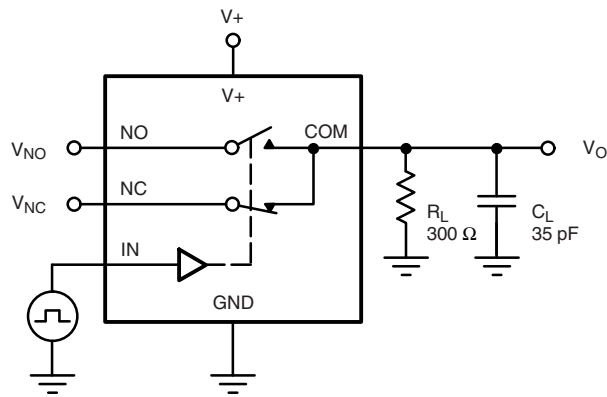
C_L (includes fixture and stray capacitance)

$$V_{OUT} = V_{COM} \left(\frac{R_L}{R_L + R_{ON}} \right)$$



Logic "1" = switch on
Logic input waveforms inverted for switches that have the opposite logic sense.

Fig. 1 - Switching Time



C_L (includes fixture and stray capacitance)

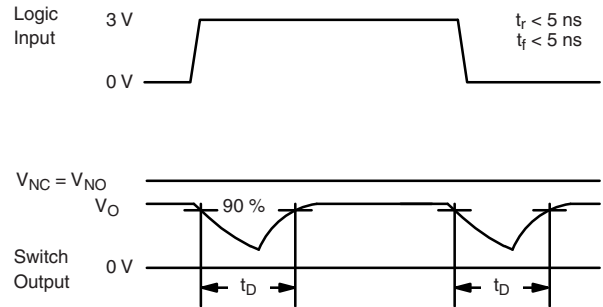
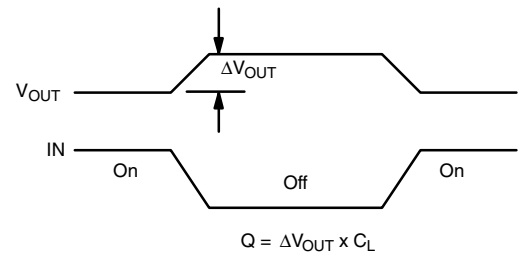
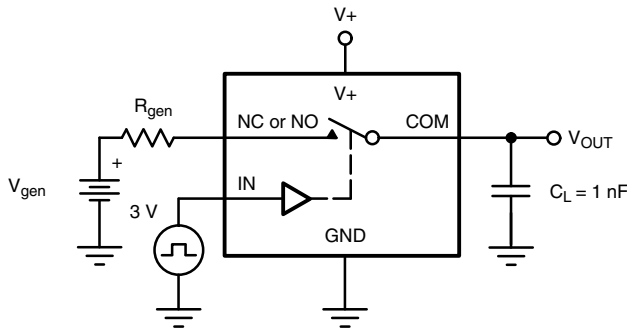


Fig. 2 - Break-Before-Make Interval



IN depends on switch configuration: input polarity determined by sense of switch.

Fig. 3 - Charge Injection

TEST CIRCUITS

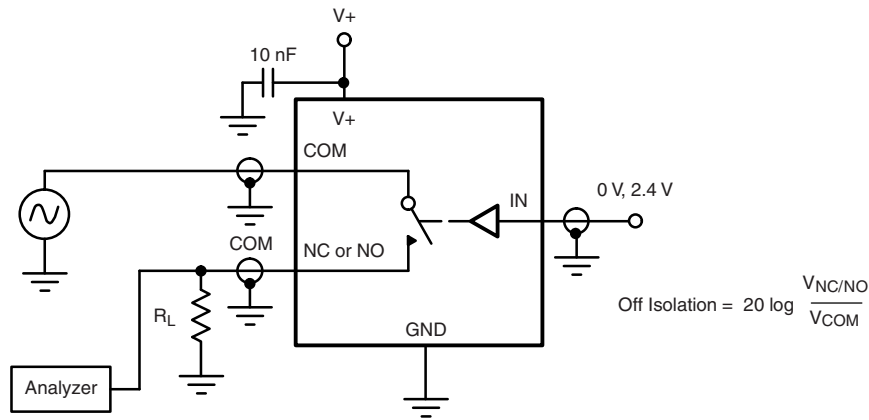


Fig. 4 - Off-Isolation

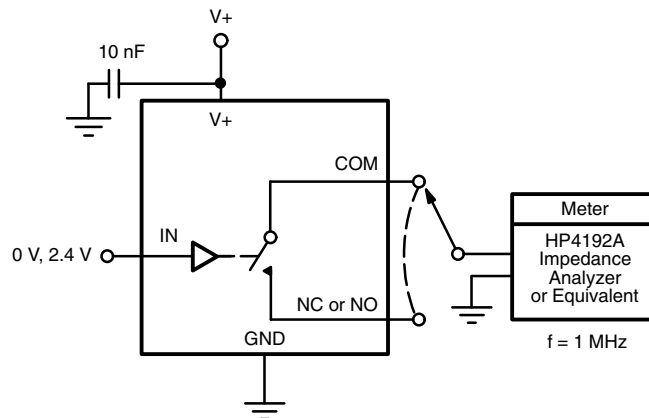


Fig. 5 - Channel Off / On Capacitance

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