# Quad SPST CMOS Analog Switches

## DESCRIPTION

The DG444, DG445 monolithic quad analog switches are designed to provide high speed, low error switching of analog signals. The DG444 has a normally closed function. The DG445 has a normally open function. Combining low power (22 nW, typ.) with high speed ($t_{on}$: 120 ns, typ.), the DG444, DG445 are ideally suited for upgrading DG211, DG212 sockets. Charge injection has been minimized on the drain for use in sample-and-hold circuits.

To achieve high-voltage ratings and superior switching performance, the DG444, DG445 are built on Vishay 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 to the supply levels when off.

## BENEFITS

- Low signal errors and distortion
- Reduced power supply requirements
- Faster throughput
- Improved reliability
- Reduced pedestal errors
- Simple interfacing
- Wide supply ranges
  - Single supply: +5 V to 36 V
  - Dual supplies: ± 5 V to ± 20 V

## FEATURES

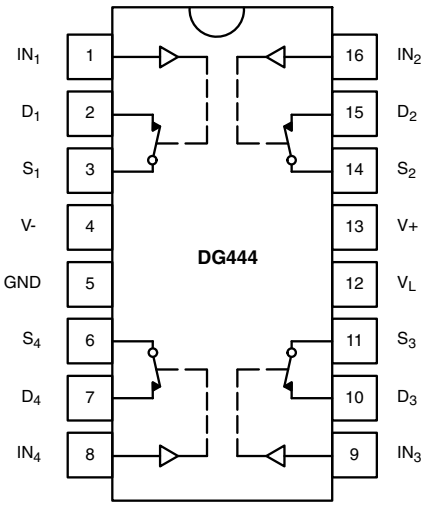
- Low on-resistance: 50 Ω
- Low leakage: 80 pA
- Low power consumption: 22 nW
- Fast switching action - $t_{on}$: 120 ns
- Low charge injection
- DG211, DG212 upgrades
- TTL/CMOS logic compatible

## APPLICATIONS

- Audio switching
- Battery powered systems
- Data acquisition
- Sample-and-hold circuits
- Telecommunication systems
- Automatic test equipment
- Single supply circuits
- Hard disk drives

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION

Dual-In-Line and SOIC




Top View

| TRUTH TABLE | | |
|---|---|---|
| LOGIC | DG444 | DG445 |
| 0 | On | Off |
| 1 | Off | On |

**Note**

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

| ORDERING INFORMATION | | |
|---|---|---|
| TEMP. RANGE | PACKAGE | PART NUMBER |
| -40 °C to +85 °C | 16-pin plastic DIP | DG444DJ |
| | | DG445DJ |
| | 16-pin narrow SOIC | DG444DY |
| | | DG445DY |

| **ABSOLUTE MAXIMUM RATINGS** ($T_A$ = 25 °C, unless otherwise noted) | | | |
|---|---|---|---|
| **PARAMETER** | | **LIMIT** | **UNIT** |
| V+ to V- | | 44 | V |
| GND to V- | | 25 | |
| $V_L$ | | (GND - 0.3) to (V+) +0.3 | |
| Digital Inputs [a], $V_S$, $V_D$ | | (V-) -2 to (V+) +2<br>or 30 mA, whichever occurs first | |
| Continuous current (any terminal) | | 30 | mA |
| Current, S or D (pulsed at 1 ms, 10 % duty cycle) | | 100 | |
| Storage temperature | | -65 to +125 | °C |
| Power dissipation (package) [b] | 16-pin plastic DIP [c] | 450 | mW |
| | 16-pin narrow body SOIC [d] | 640 | |

**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 welded or soldered to PC board
c. Derate 6 mW/°C above 75 °C
d. Derate 8 mW/°C above 75 °C

| **SPECIFICATIONS** (dual supplies) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS UNLESS OTHERWISE SPECIFIED** V+ = 15 V, V- = -15 V, $V_L$ = 5 V, $V_{IN}$ = 2.4 V, 0.8 V [e] | **TEMP.** [a] | **D SUFFIX** -40 °C TO +85 °C | | | **UNIT** |
| | | | | **MIN.** [b] | **TYP.** [c] | **MAX.** [b] | |
| **Analog Switch** | | | | | | | |
| Analog signal range [d] | $V_{ANALOG}$ | | Full | -15 | - | 15 | V |
| Drain-source on-resistance | $R_{DS(on)}$ | $I_S$ = -10 mA, $V_D$ = ± 8.5 V, V+ = 13.5 V, V- = -13.5 V | Room | - | 50 | 85 | Ω |
| | | | Full | - | - | 100 | |
| Switch off leakage current | $I_{S(off)}$ | V+ = 16.5, V- = -16.5 V, $V_D$ = ± 15.5 V, $V_S$ = ± 15.5 V | Room | -0.5 | ± 0.01 | 0.5 | nA |
| | | | Full | -5 | ± 0.01 | 5 | |
| | $I_{D(off)}$ | | Room | -0.5 | ± 0.01 | 0.5 | |
| | | | Full | -5 | ± 0.01 | 5 | |
| Channel on leakage current | $I_{D(on)}$ | V+ = 16.5 V, V- = -16.5 V, $V_S$ = $V_D$ = ± 15.5 V | Room | -0.5 | ± 0.08 | 0.5 | |
| | | | Full | -10 | ± 0.08 | 10 | |
| **Digital Control** | | | | | | | |
| Input current $V_{IN}$ low | $I_{IL}$ | $V_{IN}$ under test = 0.8 V, all other = 2.4 V | Full | -500 | -0.01 | 500 | nA |
| Input current $V_{IN}$ high | $I_{IH}$ | $V_{IN}$ under test = 2.4 V, all other = 0.8 V | Full | -500 | 0.01 | 500 | |
| **Dynamic Characteristics** | | | | | | | |
| Turn-on time | $t_{ON}$ | $R_L$ = 1 kΩ, $C_L$ = 35 pF, $V_S$ = ± 10 V, See Figure 2 | Room | - | 120 | 250 | ns |
| Turn-off time | $t_{OFF}$ | DG444 | Room | - | 110 | 140 | |
| | | DG445 | Room | - | 160 | 210 | |
| Charge injection [e] | Q | $C_L$ = 1 nF, $V_S$ = 0 V, $V_{gen}$ = 0 V, $R_{gen}$ = 0 Ω | Room | - | -1 | - | pC |
| Off isolation [e] | OIRR | $R_L$ = 50 Ω, $C_L$ = 5 pF, f =1 MHz | Room | - | 60 | - | dB |
| Crosstalk (channel-to-channel) [d] | $X_{TALK}$ | | Room | - | 100 | - | |
| Source off capacitance | $C_{S(off)}$ | f = 1 MHz | Room | - | 4 | - | pF |
| Drain off capacitance | $C_{D(off)}$ | | Room | - | 4 | - | |
| Channel on capacitance | $C_{D(on)}$ | $V_{ANALOG}$ = 0 V | Room | - | 16 | - | |

| **SPECIFICATIONS** (dual supplies) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS UNLESS OTHERWISE SPECIFIED** V+ = 15 V, V- = -15 V, $V_L$ = 5 V, $V_{IN}$ = 2.4 V, 0.8 V [e] | **TEMP.** [a] | **D SUFFIX** -40 °C TO +85 °C | | | **UNIT** |
| | | | | **MIN.** [b] | **TYP.** [c] | **MAX.** [b] | |
| **Power Supplies** | | | | | | | |
| Positive supply current | I+ | V+ = 16.5 V, V- = -16.5 V, $V_{IN}$ = 0 V or 5 V | Room | - | 0.001 | 1 | µA |
| | | | Full | - | - | 5 | |
| Negative supply current | I- | | Room | -1 | -0.0001 | - | |
| | | | Full | -5 | - | - | |
| Logic supply current | $I_L$ | | Room | - | 0.001 | 1 | |
| | | | Full | - | 0.001 | 5 | |
| Ground current | $I_{GND}$ | | Room | -1 | -0.001 | - | |
| | | | Full | -5 | -0.001 | - | |

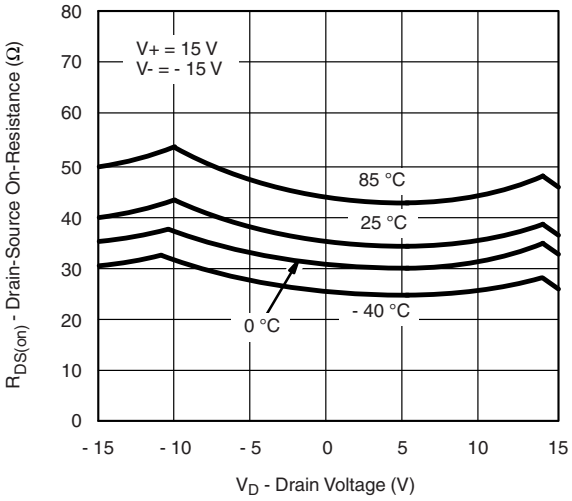
| **SPECIFICATIONS** for Unipolar Supplies | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS UNLESS OTHERWISE SPECIFIED** V+ = 12 V, V- = 0 V, $V_L$ = 5 V, $V_{IN}$ = 2.4 V, 0.8 V [e] | **TEMP.** [a] | **LIMITS** -40 °C TO 85 °C | | | **UNIT** |
| | | | | **MIN.** [b] | **TYP.** [c] | **MAX.** [b] | |
| **Analog Switch** | | | | | | | |
| Analog signal range [d] | $V_{ANALOG}$ | | Full | 0 | - | 12 | V |
| Drain-source on-resistance [d] | $R_{DS(on)}$ | $I_S$ = -10 mA, $V_D$ = 3 V, 8 V, V+ = 10.8 V, $V_L$ = 5.25 V | Room | - | 100 | 160 | Ω |
| | | | Full | - | - | 200 | |
| **Dynamic Characteristics** | | | | | | | |
| Turn-on time | $t_{ON}$ | $R_L$ = 1 kΩ, $C_L$ = 35 pF, $V_S$ = 8 V, see Fig. 2 | Room | - | 300 | 450 | ns |
| Turn-off time | $t_{OFF}$ | | Room | - | 60 | 200 | |
| Charge injection | Q | $C_L$ = 1 nF, $V_{gen}$ = 6 V, $R_{gen}$ = 0 Ω | Room | - | 2 | - | pC |
| **Power Supplies** | | | | | | | |
| Positive supply current | I+ | V+ = 13.2 V, $V_{IN}$ = 0 V or 5 V | Room | - | 0.001 | 1 | µA |
| | | | Full | - | - | 5 | |
| Negative supply current | I- | $V_{IN}$ = 0 V or 5 V | Room | -1 | -0.0001 | - | |
| | | | Full | -5 | - | - | |
| Logic supply current | $I_L$ | $V_L$ = 5.25 V, $V_{IN}$ = 0 V or 5 V | Room | - | 0.001 | 1 | |
| | | | Full | - | - | 5 | |
| Ground current | $I_{GND}$ | $V_{IN}$ = 0 V or 5 V | Room | -1 | -0.001 | - | |
| | | | Full | -5 | - | - | |

**Notes**

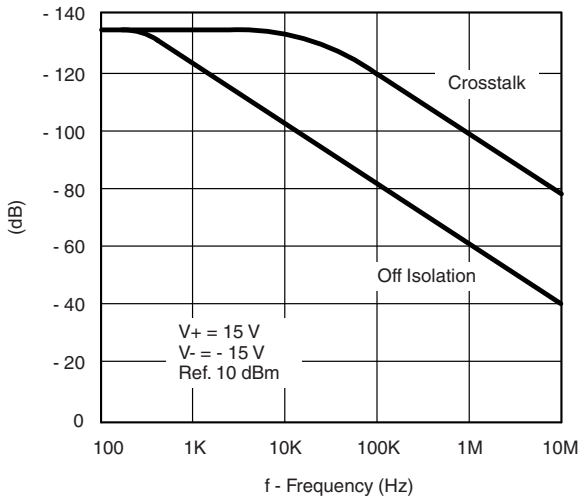
a. Room = 25 °C, full = as determined by the operating temperature suffix
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet
c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing
d. Guaranteed by design, not subject to production test
e. $V_{IN}$ = input voltage to perform proper function

*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.*

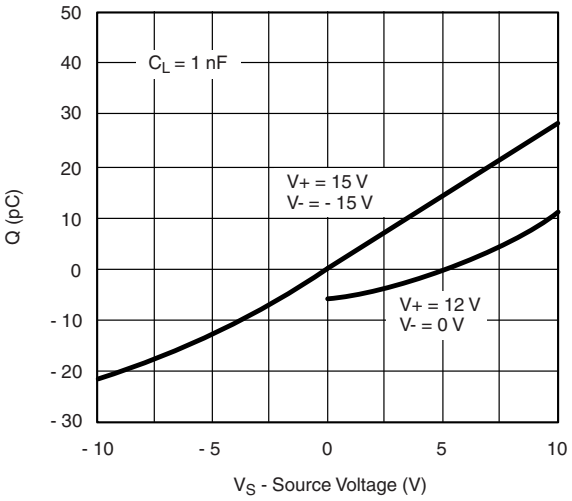
## TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



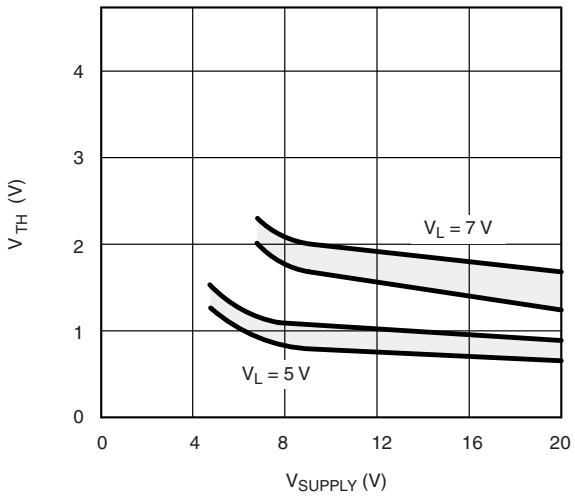

**$R_{DS(on)}$ vs. $V_D$ and Temperature**



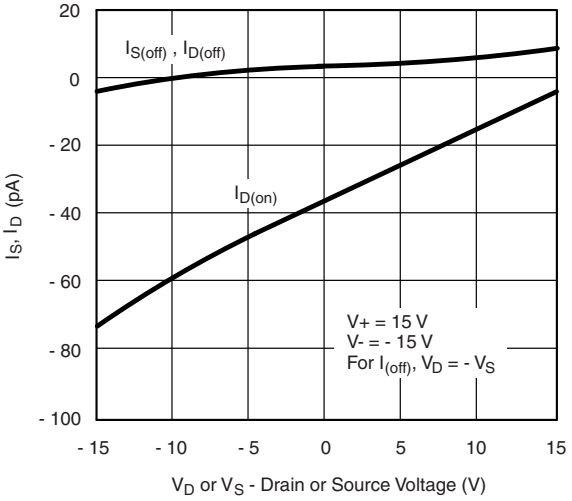

**Crosstalk and Off Isolation vs. Frequency**



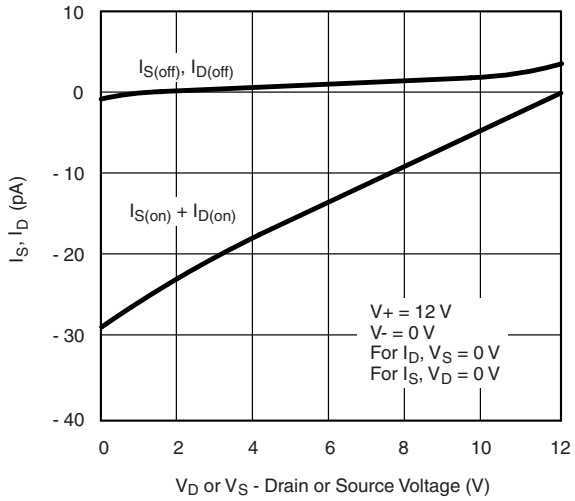

**Charge Injection vs. Source Voltage**




**Switching Threshold vs. Supply Voltage**

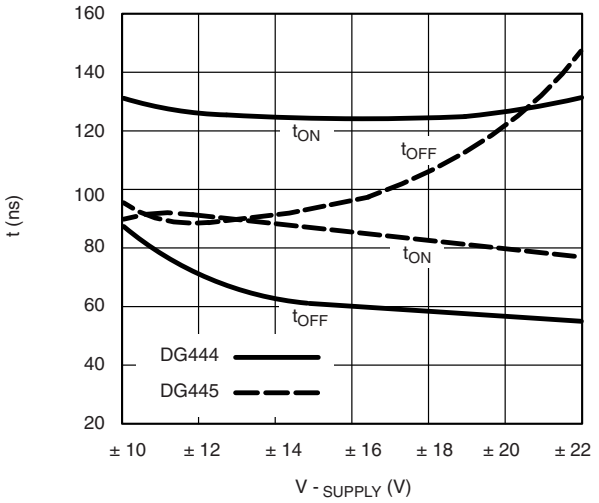



**Source/Drain Leakage Currents**

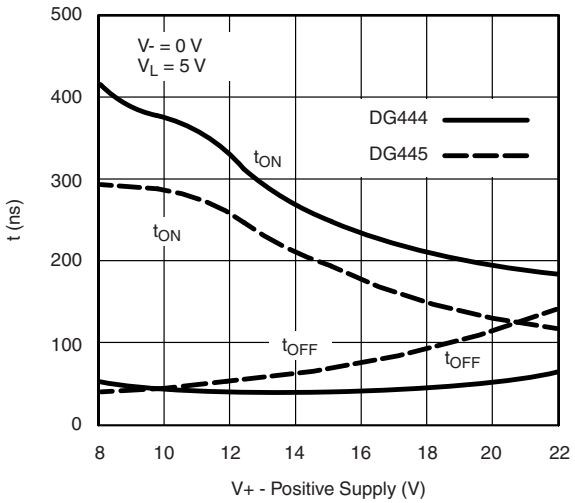



**Source/Drain Leakage Currents (Single 12-V Supply)**

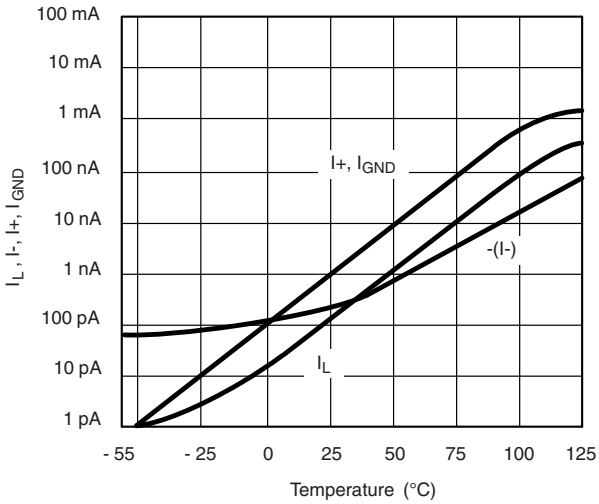
## TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



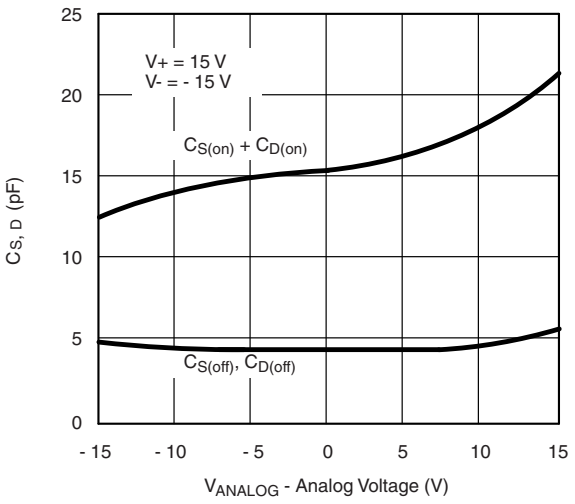

**Switching Time vs. Power Supply Voltage**



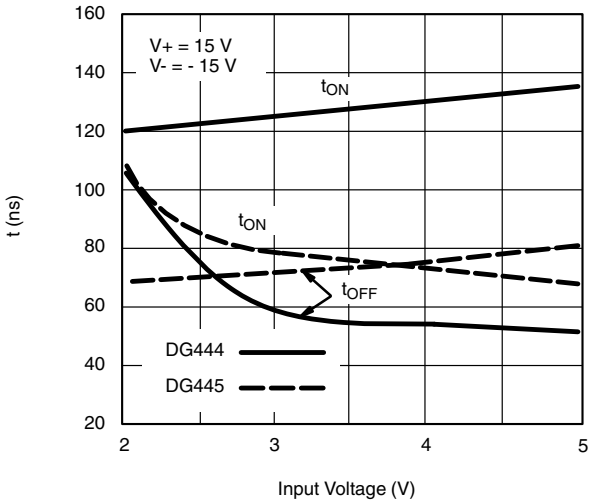

**Switching Times vs. Power Supply Voltage**




**Supply Current vs. Temperature**




**Source/Drain Capacitance vs. Analog Voltage**




**Switching Time vs. Input Voltage**

## SCHEMATIC DIAGRAM TYPICAL CHANNEL

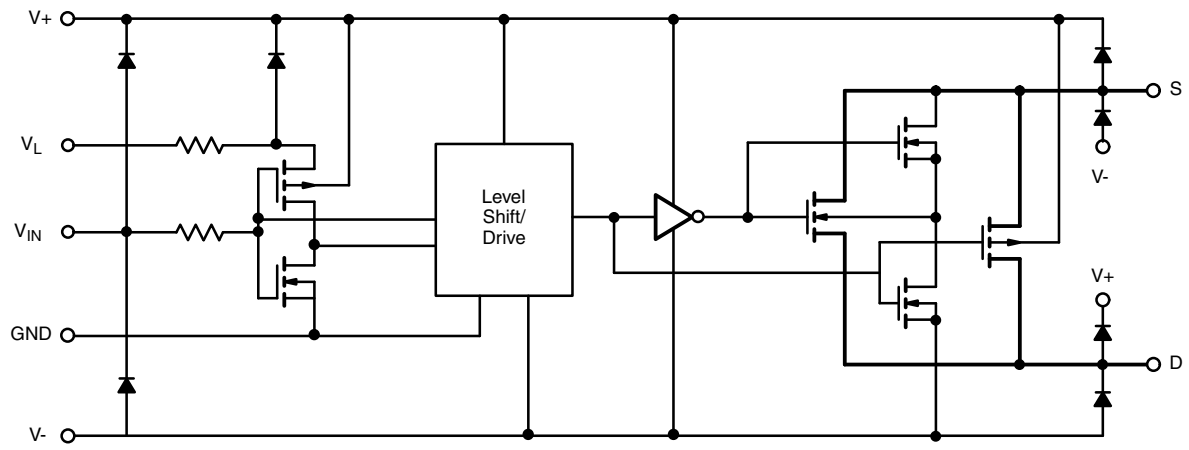
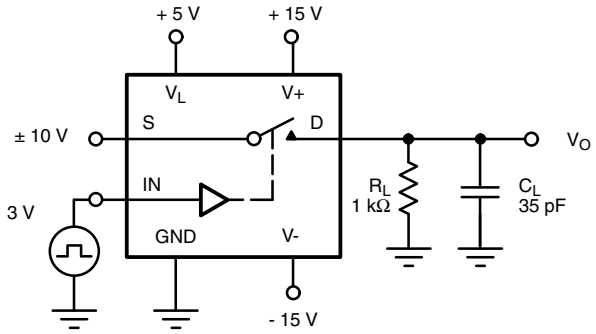
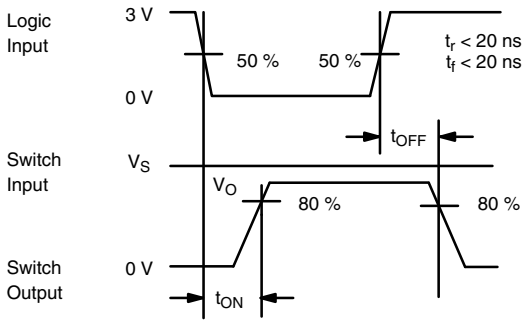



**Fig. 1**

## TEST CIRCUITS

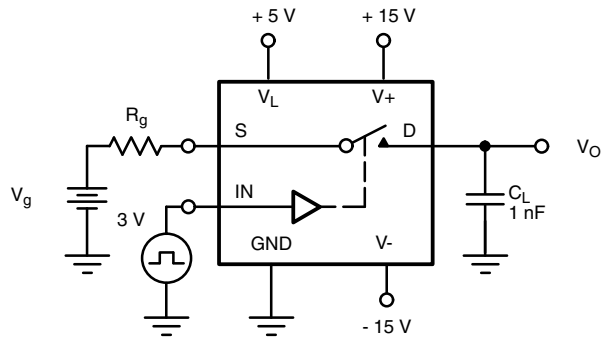



$C_L$ (includes fixture and stray capacitance)




Note: Logic input waveform is inverted for DG445.

**Fig. 2 - Switching Time**



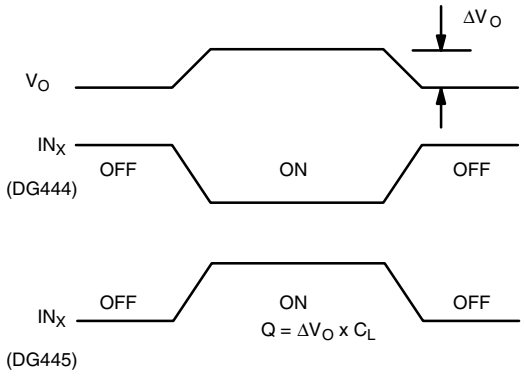




**Fig. 3 - Charge Injection**

## TEST CIRCUITS

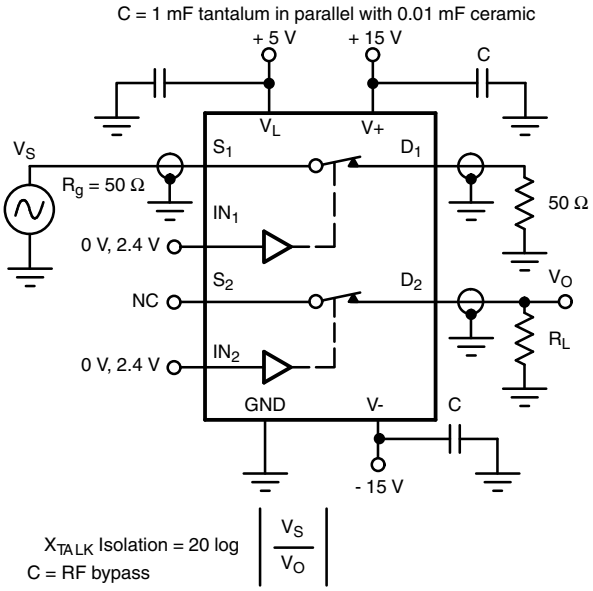



**Fig. 4 - Crosstalk**

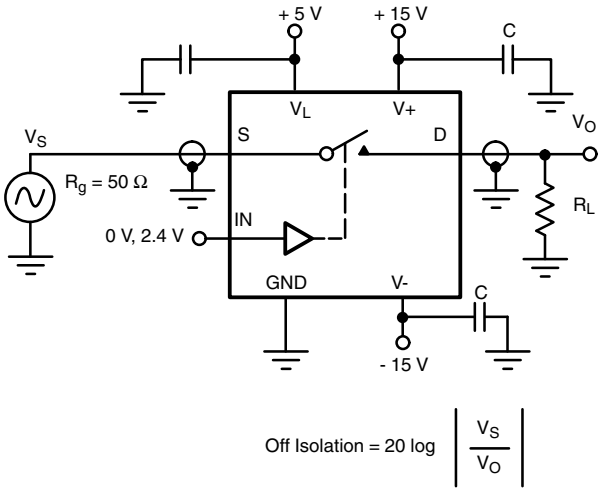



**Fig. 5 - Off Isolation**

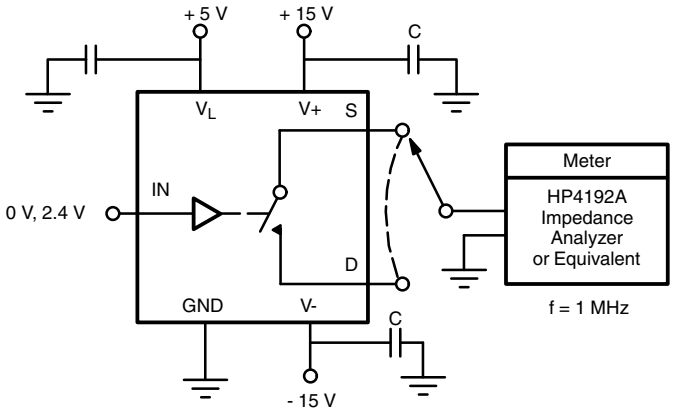



**Fig. 6 - Source/Drain Capacitances**

## APPLICATIONS

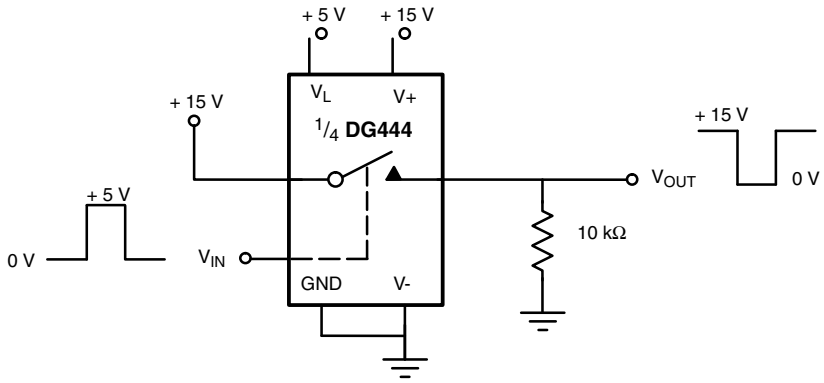



**Fig. 7 - Level Shifter**

## APPLICATIONS

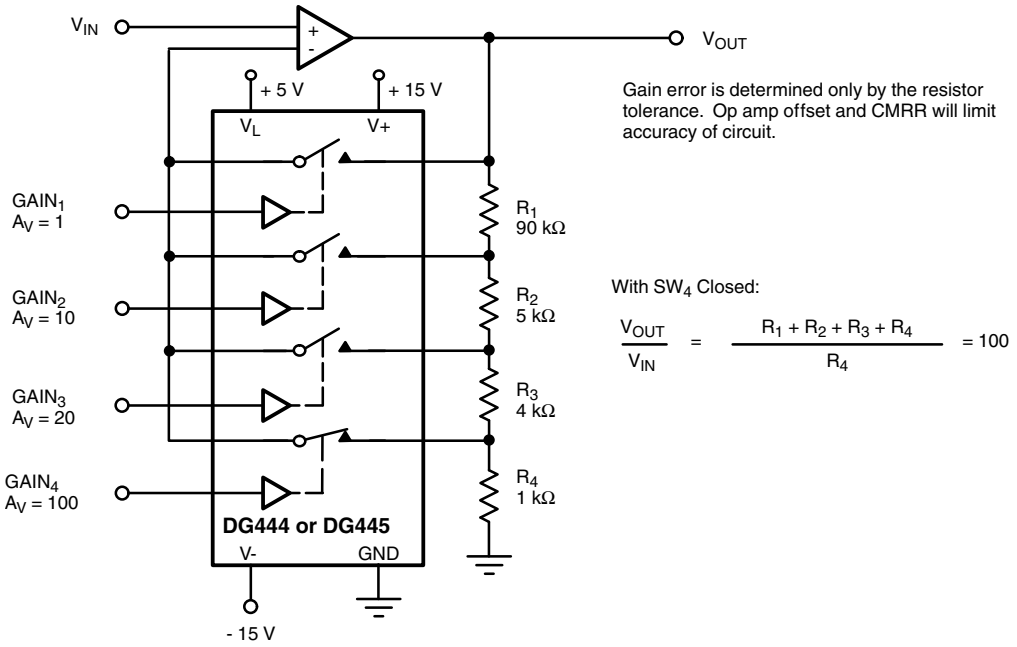



**Fig. 8 - Precision-Weighted Resistor Programmable-Gain Amplifier**

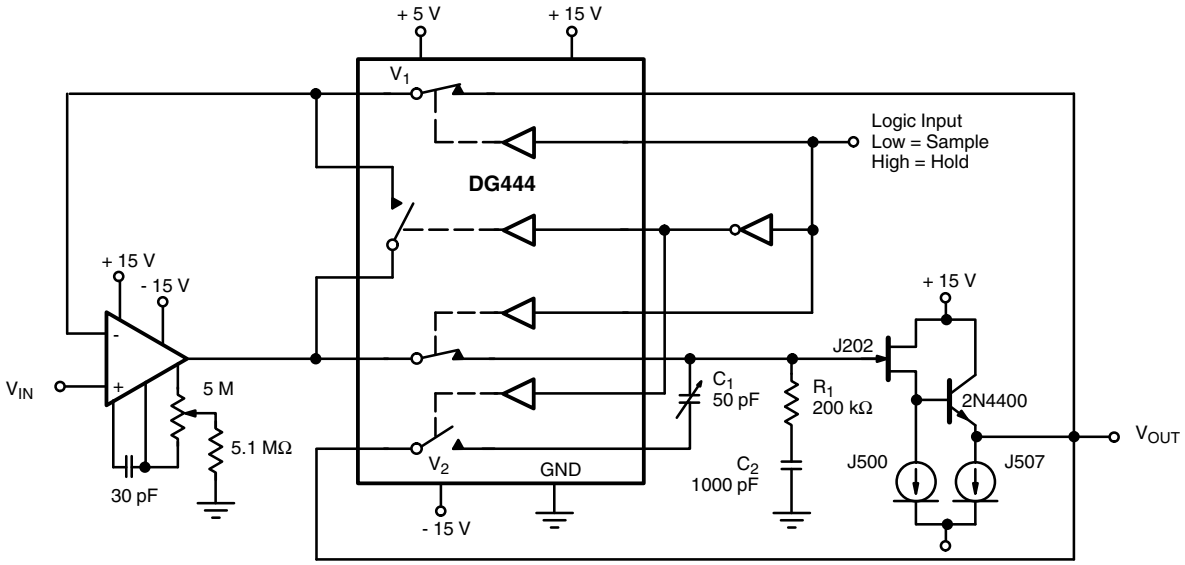


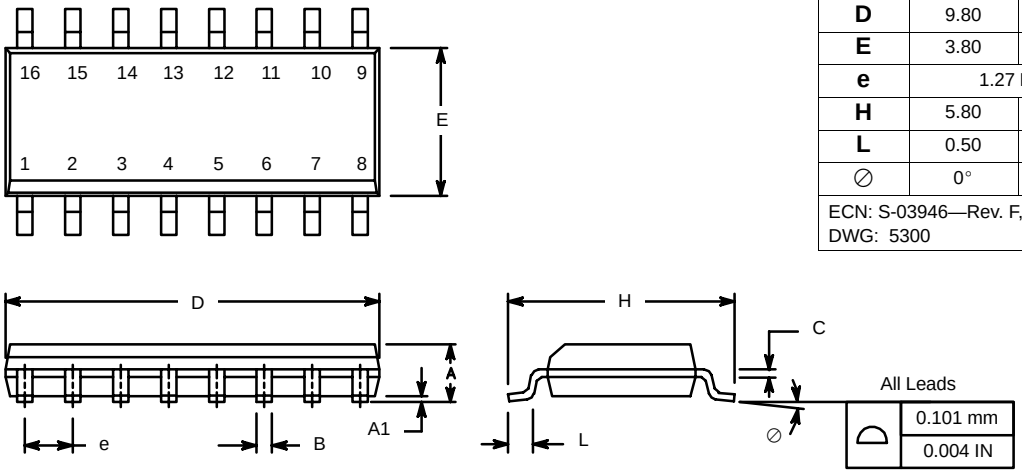

**Fig. 9 - Precision Sample-and-Hold**

| PRODUCT SUMMARY | | | | |
|---|---|---|---|---|
| Part number | DG444 | DG444 | DG445 | DG445 |
| Status code | 2 | 2 | 2 | 2 |
| Configuration | SPST x 4, NC | SPST x 4, NC | SPST x 4, NO | SPST x 4, NO |
| Single supply min. (V) | 5 | 5 | 5 | 5 |
| Single supply max. (V) | 36 | 36 | 36 | 36 |
| Dual supply min. (V) | 5 | 5 | 5 | 5 |
| Dual supply max. (V) | 22 | 22 | 22 | 22 |
| On-resistance (Ω) | 50 | 50 | 50 | 50 |
| Charge injection (pC) | -1 | -1 | -1 | -1 |
| Source on capacitance (pF) | 16 | 16 | 16 | 16 |
| Source off capacitance (pF) | 4 | 4 | 4 | 4 |
| Leakage switch on typ. (nA) | 0.08 | 0.08 | 0.08 | 0.08 |
| Leakage switch off max. (nA) | 0.5 | 0.5 | 0.5 | 0.5 |
| -3 dB bandwidth (MHz) | - | - | - | - |
| Package | SO-16 (narrow) AS | Plastic DIP-16 | SO-16 (narrow) AS | Plastic DIP-16 |
| Functional circuit / applications | Multi purpose, instrumentation, medical and healthcare | Multi purpose, instrumentation, medical and healthcare | Multi purpose, instrumentation, medical and healthcare | Multi purpose, instrumentation, medical and healthcare |
| Interface | Parallel | Parallel | Parallel | Parallel |
| Single supply operation | Yes | Yes | Yes | Yes |
| Dual supply operation | Yes | Yes | Yes | Yes |
| Turn on time max. (ns) | 450 | 450 | 450 | 450 |
| Crosstalk and off isolation | -60 | -60 | -60 | -60 |

*Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see www.vishay.com/ppg?70054.*

## SOIC (NARROW): 16-LEAD

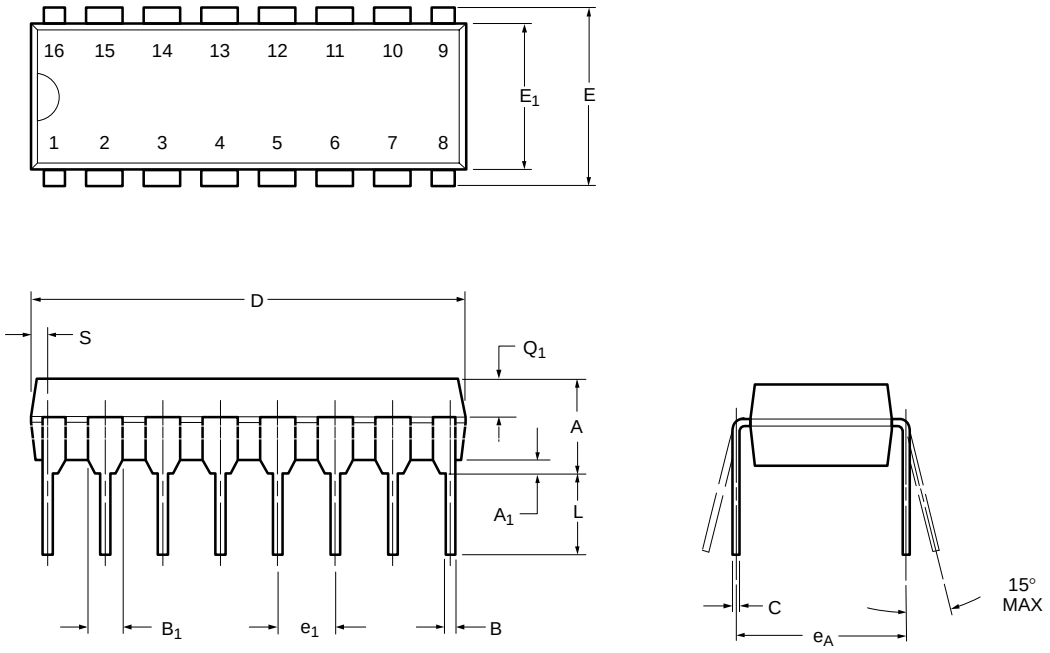
**JEDEC Part Number: MS-012**




| Dim | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.35 | 1.75 | 0.053 | 0.069 |
| $A_1$ | 0.10 | 0.20 | 0.004 | 0.008 |
| B | 0.38 | 0.51 | 0.015 | 0.020 |
| C | 0.18 | 0.23 | 0.007 | 0.009 |
| D | 9.80 | 10.00 | 0.385 | 0.393 |
| E | 3.80 | 4.00 | 0.149 | 0.157 |
| e | 1.27 BSC | | 0.050 BSC | |
| H | 5.80 | 6.20 | 0.228 | 0.244 |
| L | 0.50 | 0.93 | 0.020 | 0.037 |
| ⊘ | 0° | 8° | 0° | 8° |

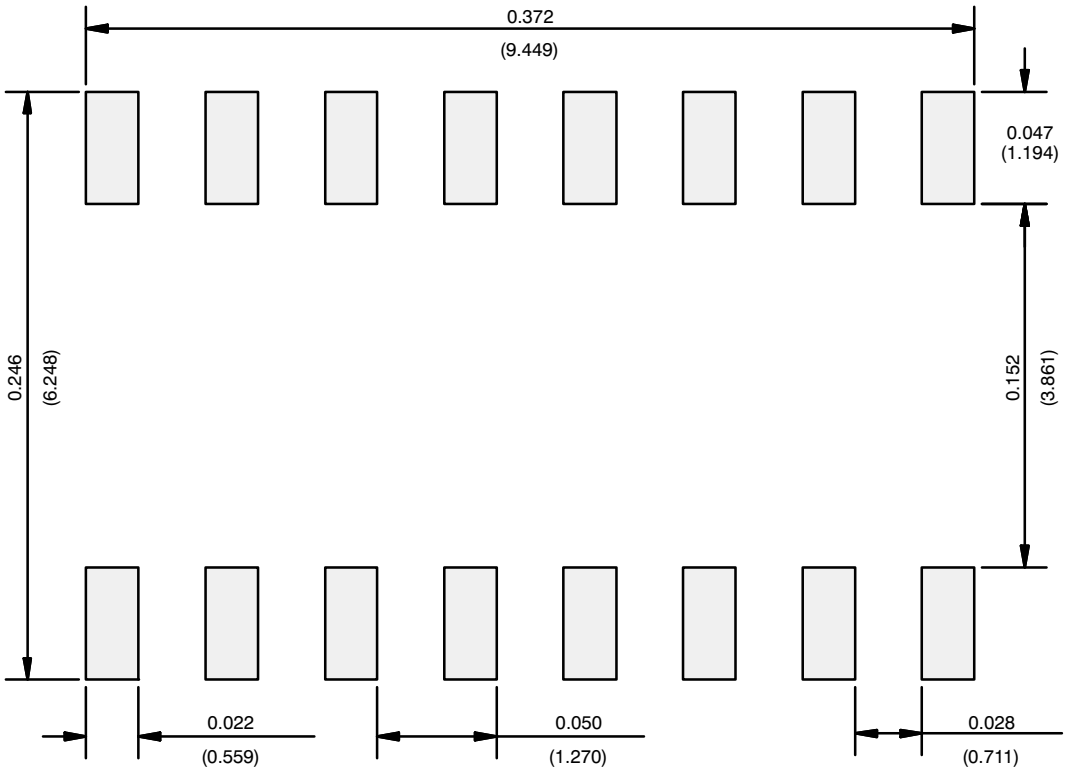
ECN: S-03946—Rev. F, 09-Jul-01
DWG: 5300

## PDIP: 16-LEAD




| Dim | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| **A** | 3.81 | 5.08 | 0.150 | 0.200 |
| **$A_1$** | 0.38 | 1.27 | 0.015 | 0.050 |
| **B** | 0.38 | 0.51 | 0.015 | 0.020 |
| **$B_1$** | 0.89 | 1.65 | 0.035 | 0.065 |
| **C** | 0.20 | 0.30 | 0.008 | 0.012 |
| **D** | 18.93 | 21.33 | 0.745 | 0.840 |
| **E** | 7.62 | 8.26 | 0.300 | 0.325 |
| **$E_1$** | 5.59 | 7.11 | 0.220 | 0.280 |
| **$e_1$** | 2.29 | 2.79 | 0.090 | 0.110 |
| **$e_A$** | 7.37 | 7.87 | 0.290 | 0.310 |
| **L** | 2.79 | 3.81 | 0.110 | 0.150 |
| **$Q_1$** | 1.27 | 2.03 | 0.050 | 0.080 |
| **S** | 0.38 | 1.52 | .015 | 0.060 |
| ECN: S-03946—Rev. D, 09-Jul-01<br>DWG: 5482 | | | | |

## RECOMMENDED MINIMUM PADS FOR SO-16




Recommended Minimum Pads
Dimensions in Inches/(mm)

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