

## Monolithic, Quad SPST, CMOS Analog Switches

The DG444 and DG445 monolithic CMOS analog switches are drop-in replacements for the popular DG211 and DG212 series devices. They include four independent single pole single throw (SPST) analog switches and TTL and CMOS compatible digital inputs.

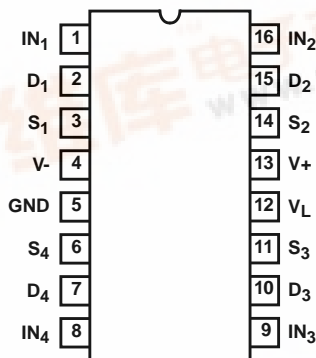
These switches feature lower analog ON resistance (<85Ω) and faster switch time ( $t_{ON}$  <250ns) compared to the DG211 and DG212. Charge injection has been reduced, simplifying sample and hold applications.

The improvements in the DG444 series are made possible by using a high voltage silicon-gate process. An epitaxial layer prevents the latch-up associated with older CMOS technologies. The 44V maximum voltage range permits controlling  $\pm 20V$  signals when operating with  $\pm 20V$  power supplies.

The four switches are bilateral, equally matched for AC or bidirectional signals. The ON resistance variation with analog signals is quite low over a  $\pm 5V$  analog input range. The switches in the DG444 and DG445 are identical, differing only in the polarity of the selection logic.

## Pinout

DG444, DG445 (PDIP, SOIC)  
TOP VIEW



## Features

- ON Resistance (Max)..... 85Ω
- Low Power Consumption ( $P_D$ ) ..... <35μW
- Fast Switching Action
  - $t_{ON}$  (Max) ..... 250ns
  - $t_{OFF}$  (Max, DG444) ..... 140ns
- Low Charge Injection
- Upgrade from DG211/DG212
- TTL, CMOS Compatible
- Single or Split Supply Operation

## Applications

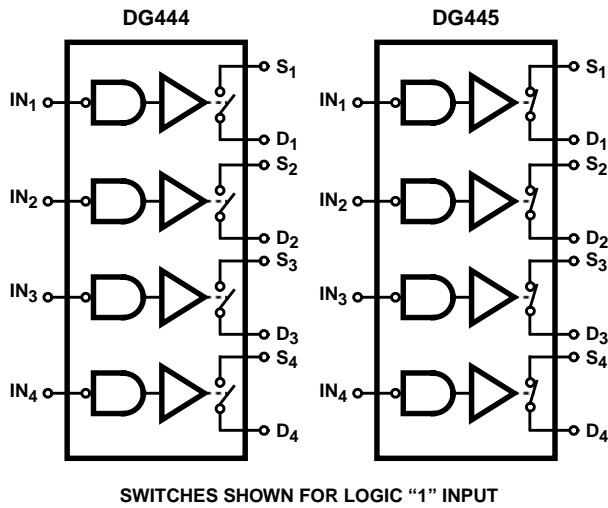
- Audio Switching
- Battery Operated Systems
- Data Acquisition
- Hi-Rel Systems
- Sample and Hold Circuits
- Communication Systems
- Automatic Test Equipment

## Ordering Information

| PART NUMBER | TEMP. RANGE (°C) | PACKAGE    | PKG. NO. |
|-------------|------------------|------------|----------|
| DG444DJ     | -40 to 85        | 16 Ld PDIP | E16.3    |
| DG444DY     | -40 to 85        | 16 Ld SOIC | M16.15   |
| DG445DJ     | -40 to 85        | 16 Ld PDIP | E16.3    |
| DG445DY     | -40 to 85        | 16 Ld SOIC | M16.15   |

## DG444, DG445

### Functional Diagrams



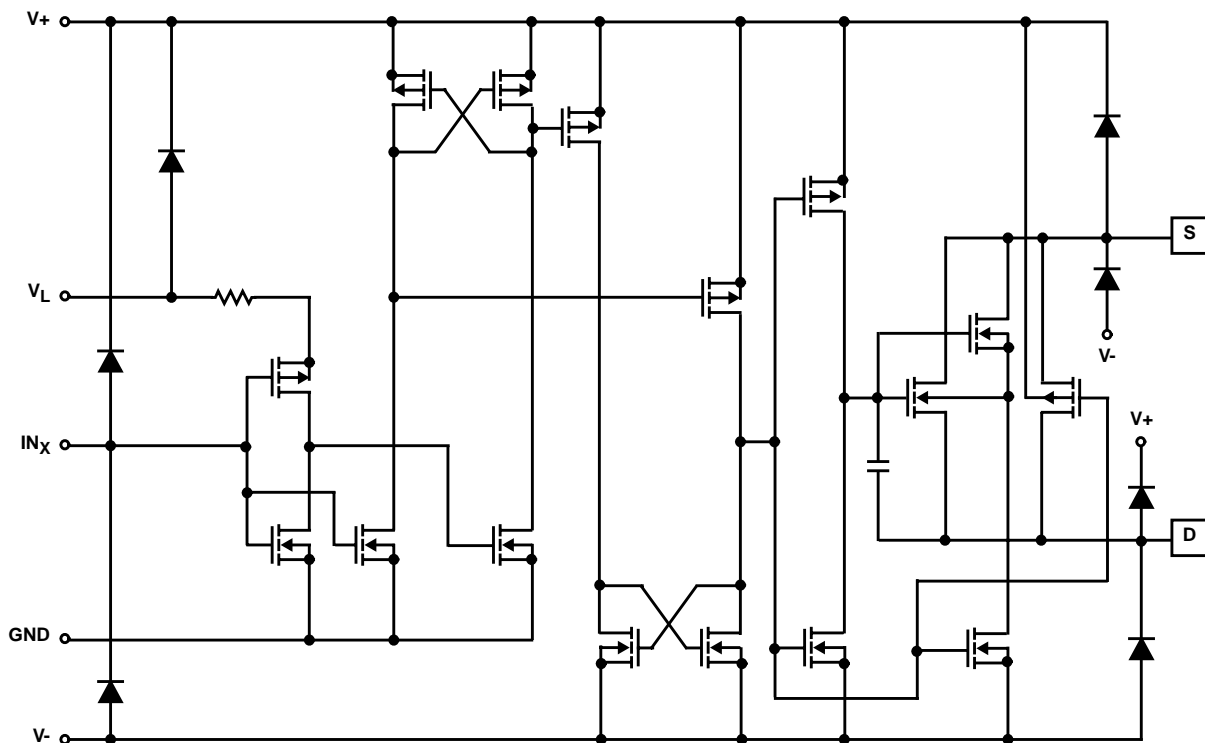
TRUTH TABLE

| LOGIC | $V_{IN}$    | DG444 | DG445 |
|-------|-------------|-------|-------|
| 0     | $\leq 0.8V$ | ON    | OFF   |
| 1     | $\geq 2.4V$ | OFF   | ON    |

### Pin Descriptions

| PIN | SYMBOL          | DESCRIPTION                                |
|-----|-----------------|--|
| 1   | IN <sub>1</sub> | Logic Control for Switch 1                 |
| 2   | D <sub>1</sub>  | Drain (Output) Terminal for Switch 1       |
| 3   | S <sub>1</sub>  | Source (Input) Terminal for Switch 1       |
| 4   | V-              | Negative Power Supply Terminal             |
| 5   | GND             | Ground Terminal (Logic Common)             |
| 6   | S <sub>4</sub>  | Source (Input) Terminal for Switch 4       |
| 7   | D <sub>4</sub>  | Drain (Output) Terminal for Switch 4       |
| 8   | IN <sub>4</sub> | Logic Control for Switch 4                 |
| 9   | IN <sub>3</sub> | Logic Control for Switch 3                 |
| 10  | D <sub>3</sub>  | Drain (Output) Terminal for Switch 3       |
| 11  | S <sub>3</sub>  | Source (Input) Terminal for Switch 3       |
| 12  | V <sub>L</sub>  | Logic Reference Voltage.                   |
| 13  | V+              | Positive Power Supply Terminal (Substrate) |
| 14  | S <sub>2</sub>  | Source (Input) Terminal for Switch 2       |
| 15  | D <sub>2</sub>  | Drain (Output) Terminal for Switch 2       |
| 16  | IN <sub>2</sub> | Logic Control for Switch 2                 |

### Schematic Diagram (One Channel)



## DG444, DG445

### Absolute Maximum Ratings

|  |  |
|--|--|
| V+ to V-   | 44V  |
| GND to V-  | 25V  |
| V <sub>L</sub>   | (GND - 0.3V) to (V+) + 0.3V                              |
| Digital Inputs, V <sub>S</sub> , V <sub>D</sub> (Note 1) | (V-) -2V to (V+) + 2V or 30mA,<br>Whichever Occurs First |
| Continuous Current (Any Terminal)                        | 30mA   |
| Peak Current, S or D (Pulsed 1ms, 10% Duty Cycle Max)    | 100mA  |

### Thermal Information

|   |                                  |
|---|----------------------------------|
| Thermal Resistance (Typical, Note 2)            | $\theta_{JA}$ (°C/W)             |
| PDIP Package                                    | 90                               |
| SOIC Package                                    | 115                              |
| Maximum Junction Temperature (Plastic Packages) | 150°C                            |
| Maximum Storage Temperature Range               | -65°C to 150°C                   |
| Maximum Lead Temperature (Soldering 10s)        | 300°C<br>(SOIC - Lead Tips Only) |

### Operating Conditions

|                          |                |
|--------------------------|----------------|
| Temperature Range        | -40°C to 85°C  |
| Voltage Range            | ±20V (Max)     |
| Temperature Range        | -55°C to 125°C |
| Input Low Voltage        | 0.8V (Max)     |
| Input High Voltage       | 2.4V (Min)     |
| Input Rise and Fall Time | ≤20ns          |

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

#### 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.
- $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

### Electrical Specifications

Test Conditions: V+ = +15V, V- = -15V, V<sub>L</sub> = 5V, V<sub>IN</sub> = 2.4V, 0.8V (Note 3),  
Unless Otherwise Specified

| PARAMETER   | TEST CONDITIONS  | TEMP (°C)                                    | (NOTE 4) MIN | (NOTE 5) TYP | (NOTE 4) MAX | UNITS    |
|---|--|--|--------------|--------------|--------------|----------|
| <b>DYNAMIC CHARACTERISTICS</b>                                  |  |  |              |              |              |          |
| Turn-ON Time, t <sub>ON</sub>                                   | R <sub>L</sub> = 1k $\Omega$ , C <sub>L</sub> = 35pF, V <sub>S</sub> = ±10V (Figure 1) | 25   | -            | 120          | 250          | ns       |
| Turn-OFF Time, t <sub>OFF</sub>                                 |  | 25   | -            | 110          | 140          | ns       |
| DG444   |  | 25   | -            | 160          | 210          | ns       |
| Charge Injection, Q (Figure 2)                                  | C <sub>L</sub> = 1nF, V <sub>G</sub> = 0V, R <sub>G</sub> = 0 $\Omega$                 | 25   | -            | -1           | -            | pC       |
| OFF Isolation (Figure 4)  | R <sub>L</sub> = 50 $\Omega$ , C <sub>L</sub> = 5pF, f = 1MHz                          | 25   | -            | 60           | -            | dB       |
| Crosstalk (Channel-to-Channel) (Figure 3)                       |  | 25   | -            | -100         | -            | dB       |
| Source OFF Capacitance, C <sub>S(OFF)</sub>                     |  | f = 1MHz, V <sub>ANALOG</sub> = 0 (Figure 5) | 25           | -            | 4            | -        |
| Drain OFF Capacitance, C <sub>D(OFF)</sub>                      |  | 25   | -            | 4            | -            | pF       |
| Channel ON Capacitance, C <sub>D(ON)</sub> + C <sub>S(ON)</sub> |  | 25   | -            | 16           | -            | pF       |
| <b>DIGITAL INPUT CHARACTERISTICS</b>                            |  |  |              |              |              |          |
| Input Current V <sub>IN</sub> Low, I <sub>IL</sub>              | V <sub>IN</sub> Under Test = 0.8V,<br>All Others = 2.4V                                | Full   | -0.5         | -0.00001     | 0.5          | $\mu$ A  |
| Input Current V <sub>IN</sub> High, I <sub>IH</sub>             | V <sub>IN</sub> Under Test = 2.4V,<br>All Others = 0.8V                                | Full   | -0.5         | 0.00001      | 0.5          | $\mu$ A  |
| <b>ANALOG SWITCH CHARACTERISTICS</b>                            |  |  |              |              |              |          |
| Analog Signal Range, V <sub>ANALOG</sub>                        |  | Full   | -15          | -            | 15           | V        |
| Drain-Source ON Resistance, r <sub>DS(ON)</sub>                 | I <sub>S</sub> = $\mp$ 10mA, V <sub>D</sub> = ±8.5V,<br>V+ = 13.5V, V- = -13.5V        | 25   | -            | 50           | 85           | $\Omega$ |
|   |  | Full   | -            | -            | 100          | $\Omega$ |
| Source OFF Leakage Current, I <sub>S(OFF)</sub>                 | V+ = 16.5V, V- = -16.5V,<br>V <sub>D</sub> = ±15.5V, V <sub>S</sub> = $\mp$ 15.5V      | 25   | -0.5         | 0.01         | 0.5          | nA       |
|   |  | 85   | -5           | -            | 5            | nA       |

## DG444, DG445

**Electrical Specifications** Test Conditions:  $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_L = 5V$ ,  $V_{IN} = 2.4V$ ,  $0.8V$  (Note 3),  
Unless Otherwise Specified **(Continued)**

| PARAMETER   | TEST CONDITIONS   | TEMP (°C) | (NOTE 4) MIN | (NOTE 5) TYP | (NOTE 4) MAX | UNITS   |
|---|---|-----------|--------------|--------------|--------------|---------|
| Drain OFF Leakage Current, $I_{D(OFF)}$             | $V_+ = 16.5V$ , $V_- = -16.5V$ ,<br>$V_D = \pm 15.5V$ , $V_S = \mp 15.5V$ | 25        | -0.5         | 0.01         | 0.5          | nA      |
|   |   | 85        | -5           | -            | 5            | nA      |
| Channel ON Leakage Current, $I_{D(ON)} + I_{S(ON)}$ | $V_+ = 16.5V$ , $V_- = -16.5V$ ,<br>$V_S = V_D = \pm 15.5V$               | 25        | -0.5         | 0.08         | 0.5          | nA      |
|   |   | 85        | -10          | -            | 10           | nA      |
| <b>POWER SUPPLY CHARACTERISTICS</b>                 |   |           |              |              |              |         |
| Positive Supply Current, $I_+$                      | $V_+ = 16.5V$ , $V_- = -16.5V$ ,<br>$V_{IN} = 0V$ or $5V$                 | 25        | -            | 0.001        | 1            | $\mu A$ |
|   |   | 85        | -            | -            | 5            | $\mu A$ |
| Negative Supply Current, $I_-$                      |   | 25        | -1           | -0.0001      | -            | $\mu A$ |
|   |   | 85        | -5           | -            | -            | $\mu A$ |
| Logic Supply Current, $I_L$                         |   | 25        | -            | 0.001        | 1            | $\mu A$ |
|   |   | 85        | -            | -            | 5            | $\mu A$ |
| Ground Current, $I_{GND}$                           |   | 25        | -1           | -0.001       | -            | $\mu A$ |
|   |   | 85        | -5           | -            | -            | $\mu A$ |

**Electrical Specifications** (Single Supply) Test Conditions:  $V_+ = 12V$ ,  $V_- = 0V$ ,  $V_L = 5V$ ,  $V_{IN} = 2.4V$ ,  $0.8V$  (Note 3),  
Unless Otherwise Specified

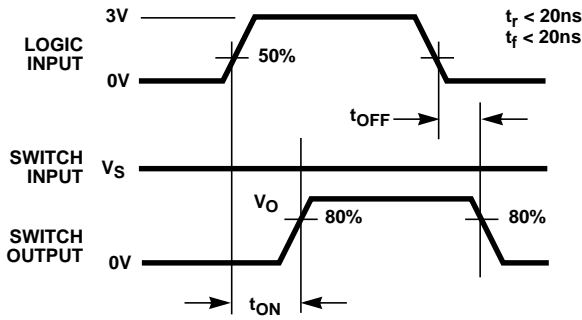
| PARAMETER                                | TEST CONDITIONS  | TEMP (°C) | (NOTE 4) MIN | (NOTE 5) TYP | (NOTE 4) MAX | UNITS    |
|--|--|-----------|--------------|--------------|--------------|----------|
| <b>DYNAMIC CHARACTERISTICS</b>           |  |           |              |              |              |          |
| Turn-ON Time, $t_{ON}$                   | $R_L = 1k\Omega$ , $C_L = 35pF$ , $V_S = 8V$<br>(Figure 1)         | 25        | -            | 300          | 450          | ns       |
| Turn-OFF Time, $t_{OFF}$                 |  | 25        | -            | 60           | 200          | ns       |
| Charge Injection, $Q$ (Figure 2)         | $C_L = 1nF$ , $V_G = 6V$ , $R_G = 0\Omega$                         | 25        | -            | 2            | -            | pC       |
| <b>ANALOG SWITCH CHARACTERISTICS</b>     |  |           |              |              |              |          |
| Analog Signal Range, $V_{ANALOG}$        |  | Full      | 0            | -            | 12           | V        |
| Drain-Source ON Resistance, $r_{DS(ON)}$ | $I_S = -10mA$ , $V_D = 3V$ , $8V$<br>$V_+ = 10.8V$ , $V_L = 5.25V$ | 25        | -            | 100          | 160          | $\Omega$ |
|  |  | Full      | -            | -            | 200          | $\Omega$ |
| <b>POWER SUPPLY CHARACTERISTICS</b>      |  |           |              |              |              |          |
| Positive Supply Current, $I_+$           | $V_+ = 13.2V$ , $V_{IN} = 0V$ or $5V$ ,<br>$V_L = 5.25V$           | 25        | -            | 0.001        | 1            | $\mu A$  |
|  |  | Full      | -            | -            | 5            | $\mu A$  |
| Negative Supply Current, $I_-$           |  | 25        | -1           | -0.0001      | -            | $\mu A$  |
|  |  | Full      | -5           | -            | -            | $\mu A$  |
| Logic Supply Current, $I_L$              |  | 25        | -            | 0.001        | 1            | $\mu A$  |
|  |  | Full      | -            | -            | 5            | $\mu A$  |
| Ground Current, $I_{GND}$                |  | 25        | -1           | -0.001       | -            | $\mu A$  |
|  |  | Full      | -5           | -            | -            | $\mu A$  |

**NOTES:**

3.  $V_{IN}$  = input voltage to perform proper function.
4. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
5. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.

**Test Circuits and Waveforms**

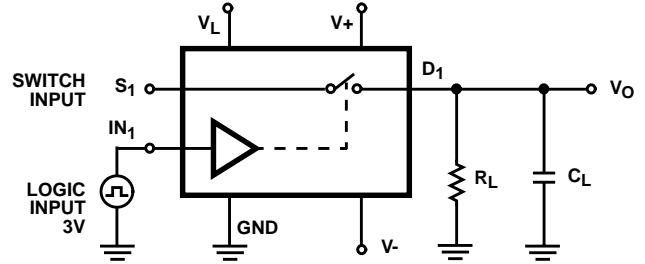
$V_O$  is the steady state output with the switch on. Feedthrough via switch capacitance may result in spikes at the leading and trailing edge of the output waveform.



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

FIGURE 1A. MEASUREMENT POINTS

FIGURE 1. SWITCHING TIMES



Repeat test for Channels 2, 3 and 4.

For load conditions, see Specifications.  $C_L$  includes fixture and stray capacitance.

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

FIGURE 1B. TEST CIRCUIT

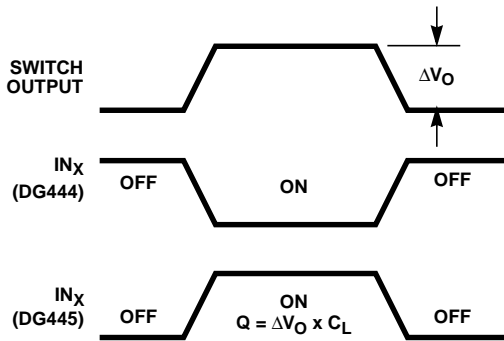


FIGURE 2A. MEASUREMENT POINTS

FIGURE 2. CHARGE INJECTION

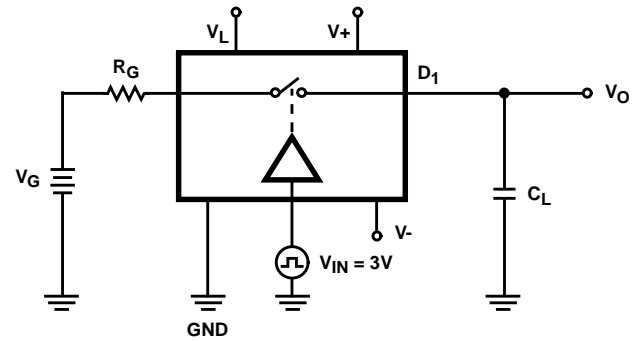


FIGURE 2B. TEST CIRCUIT

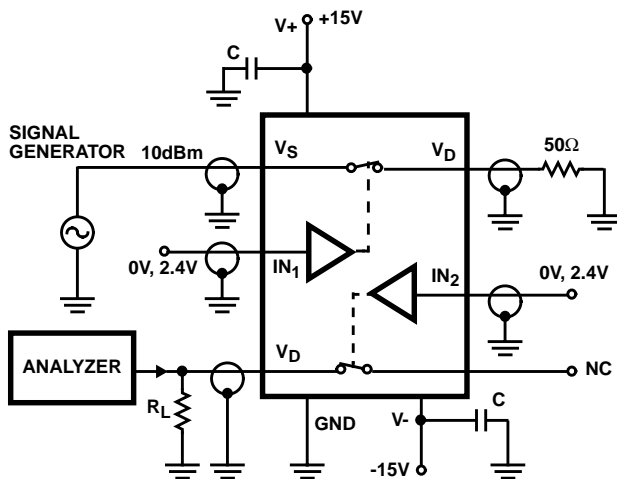


FIGURE 3. CROSSTALK TEST CIRCUIT

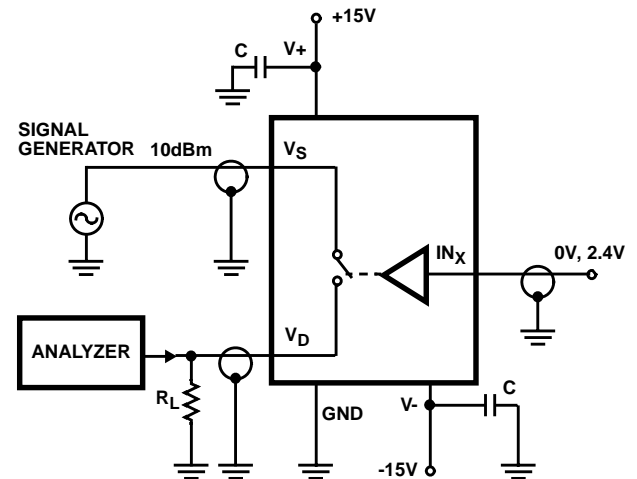


FIGURE 4. OFF ISOLATION TEST CIRCUIT

Test Circuits and Waveforms (Continued)

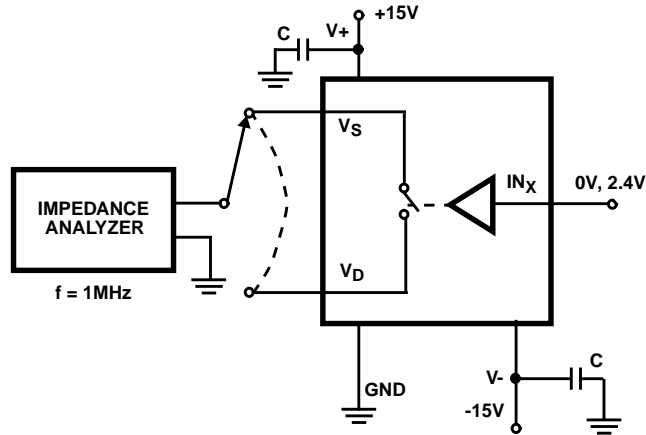
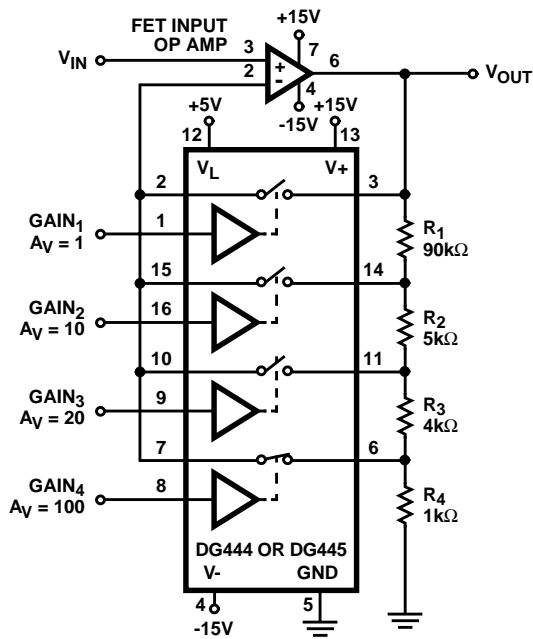


FIGURE 5. SOURCE/DRAIN CAPACITANCES TEST CIRCUIT

Application Information



GAIN ERROR IS DETERMINED ONLY BY THE RESISTOR TOLERANCE, OP AMP OFFSET AND CMRR WILL LIMIT ACCURACY OF CIRCUIT

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_1 + R_2 + R_3 + R_4}{R_4} = 100$$

WITH SW<sub>4</sub> CLOSED

FIGURE 6. PRECISION WEIGHTED RESISTOR PROGRAMMABLE GAIN AMPLIFIER

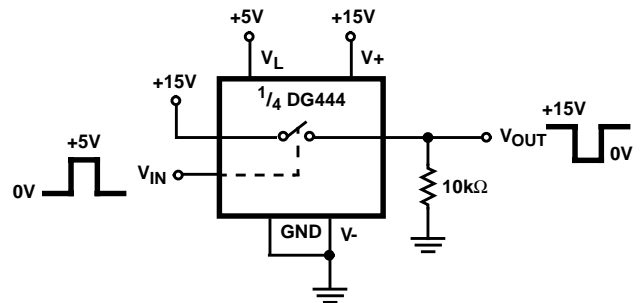


FIGURE 7. LEVEL SHIFTER

Typical Performance Curves

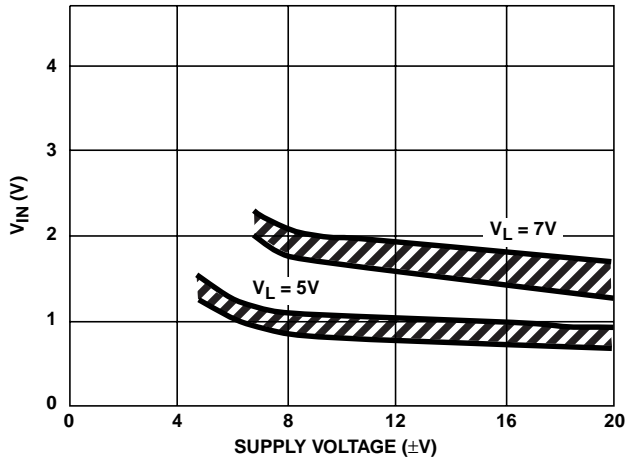


FIGURE 8. SWITCHING THRESHOLD vs SUPPLY VOLTAGE

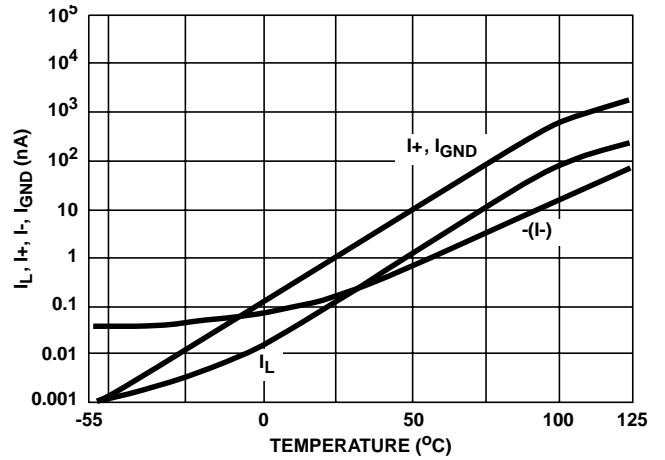


FIGURE 9. SUPPLY CURRENT vs TEMPERATURE

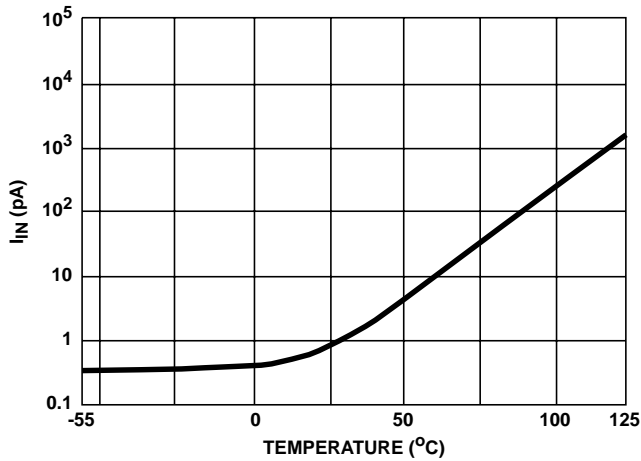


FIGURE 10. INPUT CURRENT vs TEMPERATURE

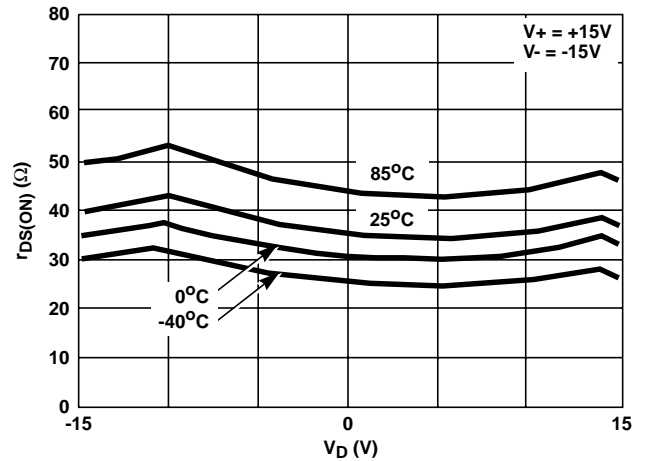


FIGURE 11.  $r_{DS(ON)}$  vs  $V_D$  AND TEMPERATURE

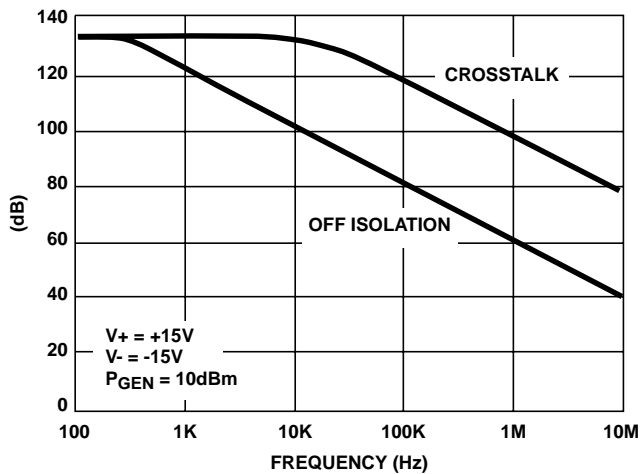


FIGURE 12. CROSSTALK REJECTION AND OFF ISOLATION vs FREQUENCY

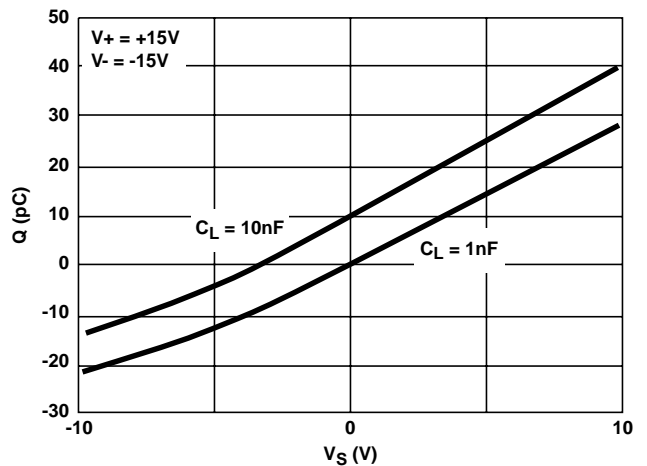


FIGURE 13. CHARGE INJECTION vs SOURCE VOLTAGE

## DG444, DG445

### Typical Performance Curves (Continued)

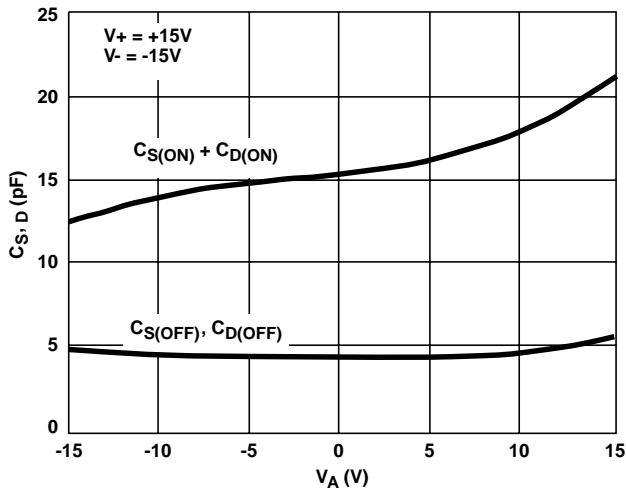


FIGURE 14. SOURCE/DRAIN CAPACITANCE vs ANALOG VOLTAGE

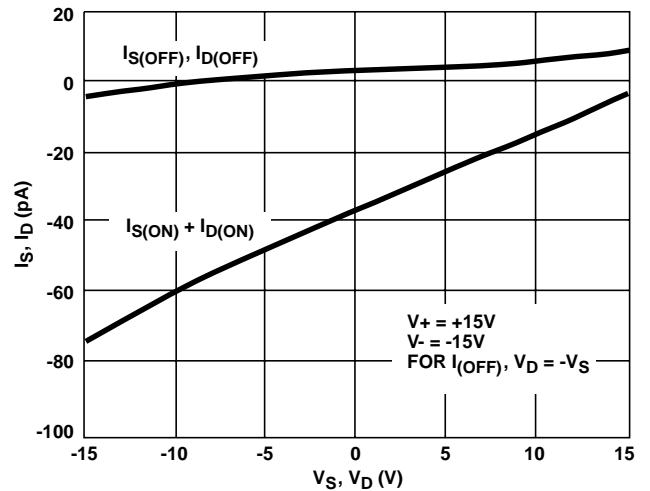


FIGURE 15. LEAKAGE CURRENTS vs ANALOG VOLTAGE

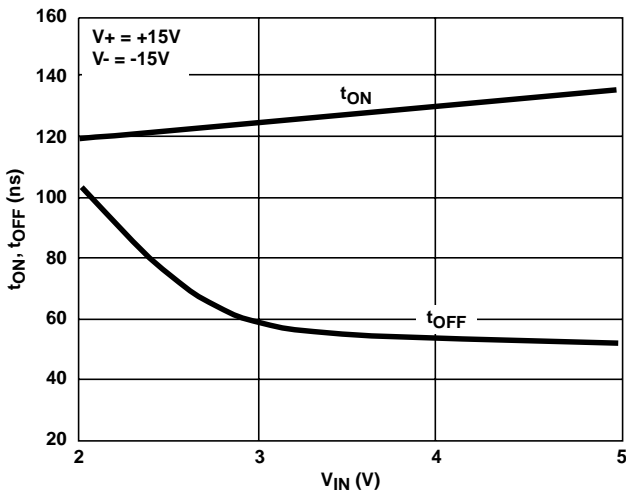


FIGURE 16. SWITCHING TIME vs INPUT VOLTAGE (DG444)

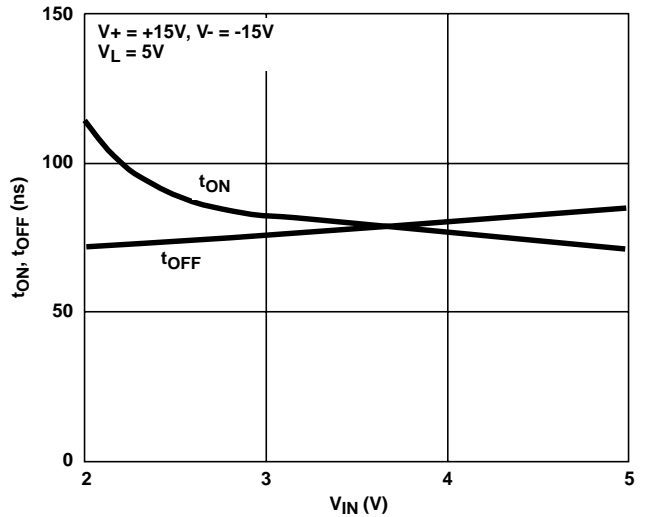


FIGURE 17. SWITCHING TIME vs INPUT VOLTAGE (DG445)

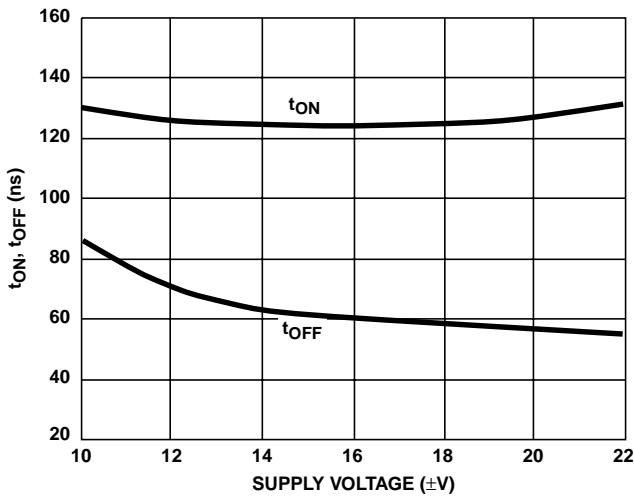


FIGURE 18. SWITCHING TIME vs POWER SUPPLY VOLTAGE (DG444)

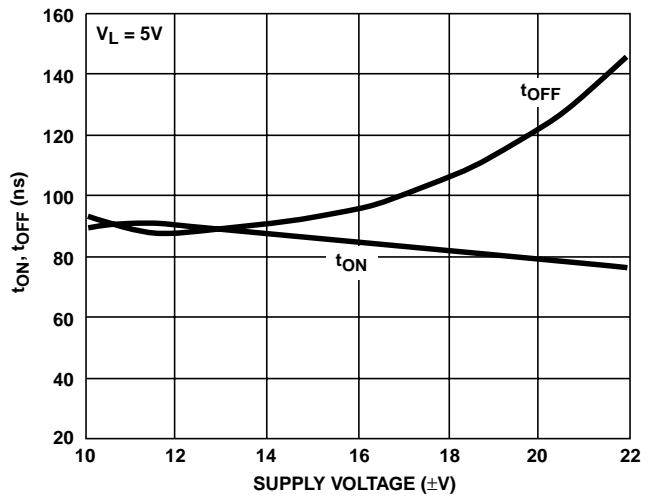


FIGURE 19. SWITCHING TIME vs POWER SUPPLY VOLTAGE (DG445)



# DG444, DG445

## Typical Performance Curves (Continued)

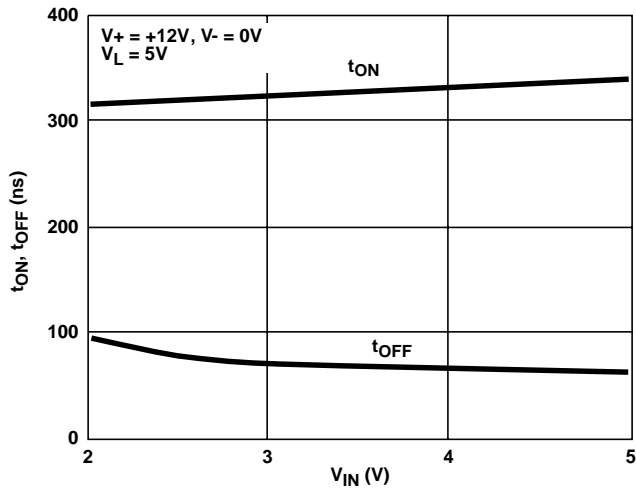


FIGURE 20. SWITCHING TIME vs INPUT VOLTAGE (DG444) (SINGLE 12V SUPPLY)

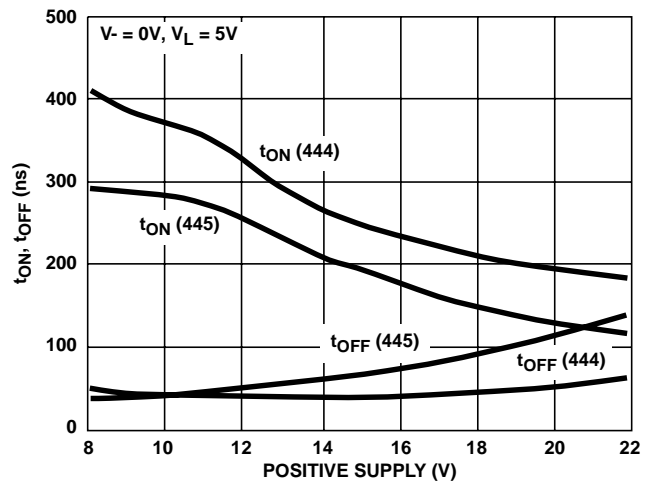


FIGURE 21. SWITCHING TIMES vs SINGLE SUPPLY VOLTAGE

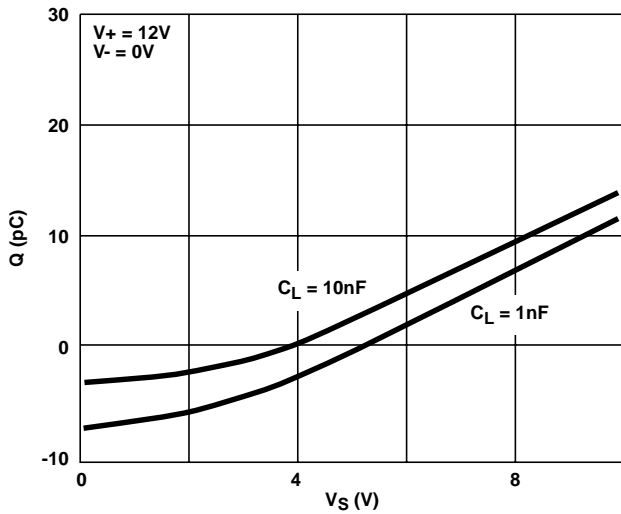


FIGURE 22. CHARGE INJECTION vs SOURCE VOLTAGE (SINGLE 12V SUPPLY)

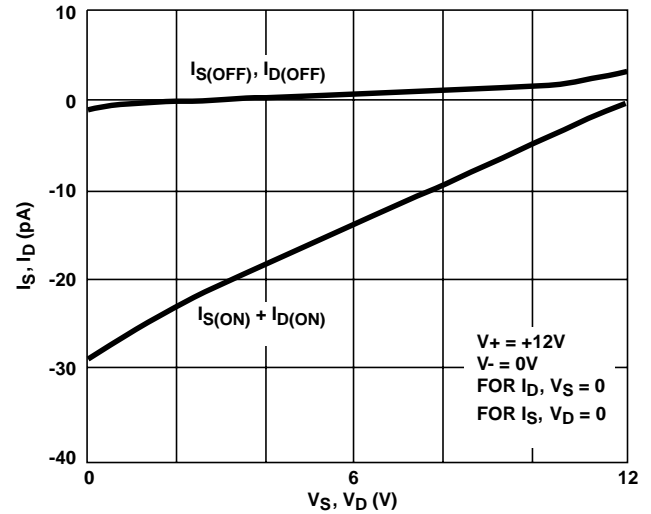


FIGURE 23. SOURCE/DRAIN LEAKAGE CURRENTS (SINGLE 12V SUPPLY)

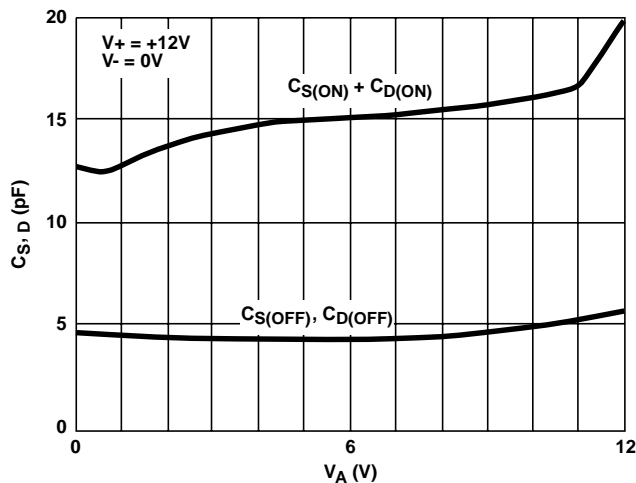


FIGURE 24. SOURCE/DRAIN CAPACITANCE vs ANALOG VOLTAGE (SINGLE 12V SUPPLY)

## DG444, DG445

### Die Characteristics

#### DIE DIMENSIONS:

2160 $\mu\text{m}$  x 1760 $\mu\text{m}$  x 485

#### METALLIZATION:

Type: SiAl  
Thickness: 12k $\text{\AA}$   $\pm$  1k $\text{\AA}$

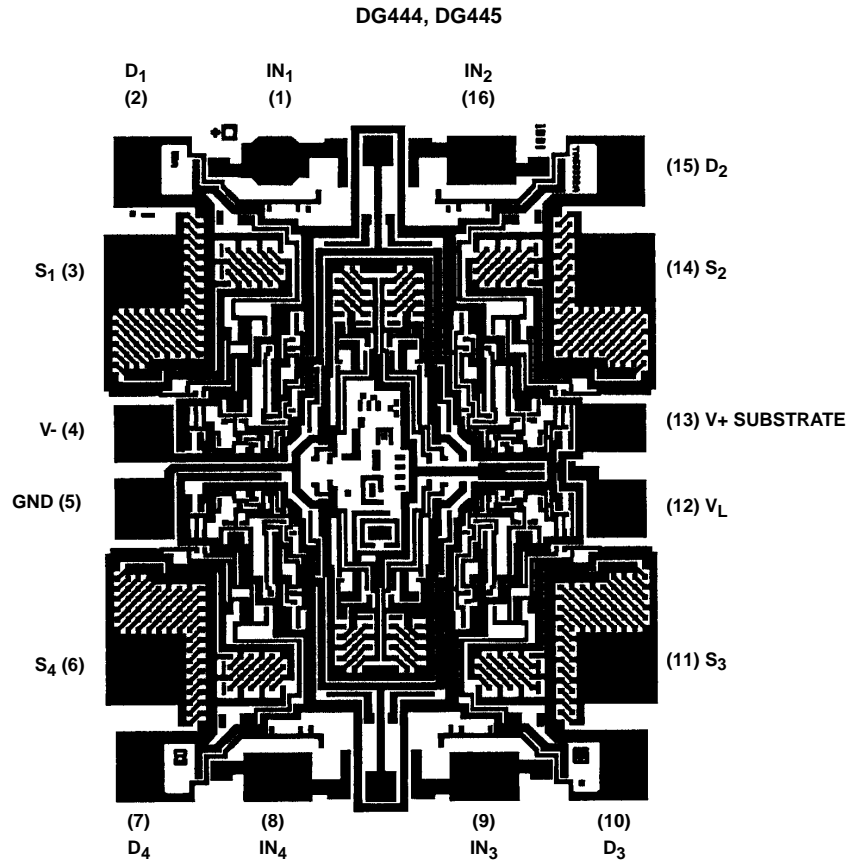
#### PASSIVATION:

Type: Nitride  
Thickness: 8k $\text{\AA}$   $\pm$  1k $\text{\AA}$

#### WORST CASE CURRENT DENSITY:

9.1 x 10<sup>4</sup> A/cm<sup>2</sup>

### Metallization Mask Layout



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