



## Improved, Quad, SPST Analog Switches

DG444/DG445

### General Description

Maxim's redesigned DG444/DG445 analog switches now feature on-resistance matching ( $4\Omega$  max) between switches and guaranteed on-resistance flatness over the signal range ( $9\Omega$  max). These low on-resistance switches conduct equally well in either direction. They guarantee low charge injection ( $10\text{pC}$  max), low power consumption ( $35\mu\text{W}$  max), and an ESD tolerance of  $2000\text{V}$  minimum per Method 3015.7. The new design offers lower off leakage current over temperature (less than  $5\text{nA}$  at  $+85^\circ\text{C}$ ).

The DG444/DG445 are quad, single-pole/single-throw (SPST) analog switches. The DG444 has 4 normally closed switches and the DG445 has 4 normally open switches. Switching times are less than  $250\text{ns}$  for  $t_{\text{ON}}$  and less than  $70\text{ns}$  for  $t_{\text{OFF}}$ . Operation is from a single  $+10\text{V}$  to  $+30\text{V}$  supply, or bipolar  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  supplies. Maxim's improved DG444/DG445 continue to be fabricated with a  $44\text{V}$  silicon-gate process.

### Applications

|                              |                          |
|------------------------------|--------------------------|
| Sample-and-Hold Circuits     | Communication Systems    |
| Test Equipment               | Battery-Operated Systems |
| Heads-Up Displays            | PBX, PABX                |
| Guidance and Control Systems | Audio Signal Routing     |
| Military Radios              | Modems/Faxes             |

### New Features

- ♦ Plug-In Upgrades for Industry-Standard DG444/DG445
- ♦ Improved  $r_{\text{ON}}$  Match Between Channels ( $4\Omega$  max)
- ♦ Guaranteed  $r_{\text{FLAT(ON)}}$  Over Signal Range ( $9\Omega$  max)
- ♦ Improved Charge Injection ( $10\text{pC}$  max)
- ♦ Improved Off Leakage Current Over Temperature ( $<5\text{nA}$  at  $+85^\circ\text{C}$ )
- ♦ Withstand Electrostatic Discharge ( $2000\text{V}$  min) per Method 3015.7

### Existing Features

- ♦ Low  $r_{\text{DS(ON)}}$  ( $85\Omega$  max)
- ♦ Single-Supply Operation  $+10\text{V}$  to  $+30\text{V}$   
Bipolar-Supply Operation  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$
- ♦ Low Power Consumption ( $35\mu\text{W}$  max)
- ♦ Rail-to-Rail Signal Handling
- ♦ TTL/CMOS-Logic Compatible

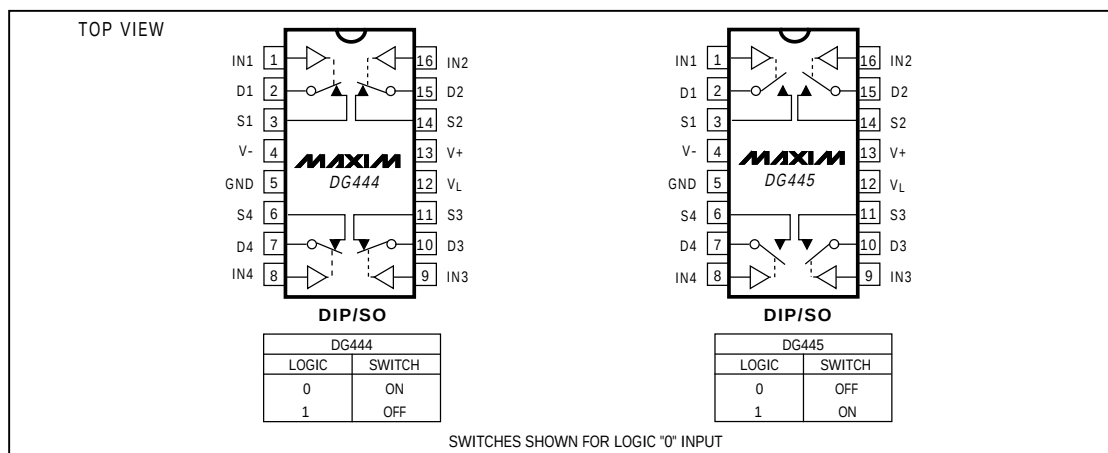
### Ordering Information

| PART     | TEMP. RANGE                                | PIN-PACKAGE    |
|----------|--------------------------------------------|----------------|
| DG444CJ  | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Plastic DIP |
| DG444DY  | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Narrow SO   |
| DG444C/D | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | Dice*          |
| DG444DJ  | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Plastic DIP |
| DG444DY  | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Narrow SO   |

Ordering Information continued at end of data sheet.

\* Contact factory for dice specifications.

### Pin Configurations/Functional Diagrams/Truth Tables



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## Improved, Quad, SPST Analog Switches

### ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

|                                                          |                                                          |
|----------------------------------------------------------|----------------------------------------------------------|
| V+                                                       | 44V                                                      |
| GND                                                      | 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 at 1ms, 10% duty cycle max) | 100mA                                                    |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|                                                    |                 |
|----------------------------------------------------|-----------------|
| 16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) | 842mW           |
| 16-Pin Narrow SO (derate 8.70mW/°C above +70°C)    | 696mW           |
| Operating Temperature Ranges                       |                 |
| DG444C/DG445C                                      | 0°C to +70°C    |
| DG444D/DG445D                                      | -40°C to +85°C  |
| Storage Temperature Range                          | -65°C to +150°C |
| Lead Temperature (soldering, 10sec)                | +300°C          |

**Note 1:** Signals on S, D, or IN exceeding V+ or V- are clamped by internal diodes. Limit forward current to maximum current rating.

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.

### ELECTRICAL CHARACTERISTICS—Dual Supplies

(V+ = 15V, V- = -15V, V<sub>L</sub> = 5V, GND = 0V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

| PARAMETER                                        | SYMBOL                                         | CONDITIONS                                                                                              |                                                       | MIN   |      | TYP<br>(Note 2) | MAX  | UNITS |
|--------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-------|------|-----------------|------|-------|
| SWITCH                                           |                                                |                                                                                                         |                                                       |       |      |                 |      |       |
| Analog Signal Range                              | V <sub>ANALOG</sub>                            | (Note 3)                                                                                                |                                                       | -15   |      |                 | 15   | V     |
| Drain-Source<br>On-Resistance                    | r <sub>DS(ON)</sub>                            | V <sub>D</sub> = 13.5V, V <sub>S</sub> = -13.5V,<br>V <sub>D</sub> = ±8.5V,<br>I <sub>S</sub> = -10mA   | T <sub>A</sub> = +25°C                                | 50    |      |                 | 85   | Ω     |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |      | 100             |      |       |
| On-Resistance Match<br>Between Channels (Note 4) | Δr <sub>DS(ON)</sub>                           | V <sub>D</sub> = ±10V,<br>I <sub>S</sub> = -10mA                                                        | T <sub>A</sub> = +25°C                                |       |      |                 | 4    | Ω     |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |      | 5               |      |       |
| On-Resistance Flatness (Note 4)                  | r <sub>FLAT(ON)</sub>                          | V <sub>D</sub> = ±5V,<br>I <sub>S</sub> = -10mA                                                         | T <sub>A</sub> = +25°C                                |       |      |                 | 9    | Ω     |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |      | 15              |      |       |
| Source Leakage Current<br>(Note 5)               | I <sub>S(OFF)</sub>                            | V <sub>D</sub> = 16.5V, V <sub>S</sub> = -16.5V,<br>V <sub>D</sub> = ±15.5V,<br>V <sub>S</sub> = ±15.5V | T <sub>A</sub> = +25°C                                | -0.50 | 0.01 |                 | 0.50 | nA    |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5    |      | 5               |      |       |
| Drain-Off Leakage Current<br>(Note 5)            | I <sub>D(OFF)</sub>                            | V <sub>D</sub> = 16.5V, V <sub>S</sub> = -16.5V,<br>V <sub>D</sub> = ±15.5V,<br>V <sub>S</sub> = ±15.5V | T <sub>A</sub> = +25°C                                | -0.50 | 0.01 |                 | 0.50 | nA    |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5    |      | 5               |      |       |
| Drain-On Leakage Current<br>(Note 5)             | I <sub>D(ON)</sub><br>or<br>I <sub>S(ON)</sub> | V <sub>D</sub> = 16.5V, V <sub>S</sub> = -16.5V,<br>V <sub>D</sub> = ±15.5V,<br>V <sub>S</sub> = ±15.5V | T <sub>A</sub> = +25°C                                | -0.50 | 0.08 |                 | 0.50 | nA    |
|                                                  |                                                |                                                                                                         | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -10   |      | 10              |      |       |
| INPUT                                            |                                                |                                                                                                         |                                                       |       |      |                 |      |       |
| Input Current with<br>Input Voltage High         | I <sub>INH</sub>                               | V <sub>IN</sub> = 2.4V, all others = 0.8V                                                               |                                                       | -0.5  |      | -0.00001        | 0.5  | μA    |
| Input Current with<br>Input Voltage Low          | I <sub>INL</sub>                               | V <sub>IN</sub> = 0.8V, all others = 2.4V                                                               |                                                       | -0.5  |      | -0.00001        | 0.5  | μA    |

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### ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER                              | SYMBOL  | CONDITIONS                                                            |                   | MIN  | TYP<br>(Note 2) | MAX   | UNITS |
|----------------------------------------|---------|-----------------------------------------------------------------------|-------------------|------|-----------------|-------|-------|
| SUPPLY                                 |         |                                                                       |                   |      |                 |       |       |
| Power-Supply Range                     | V+, V-  |                                                                       |                   | ±4.5 |                 | ±20.0 | V     |
| Positive Supply Current                | I+      | All channels on or off,<br>V+ = 16.5V, V- = -16.5V,<br>VIN = 0V or 5V | TA = +25°C        | -1   | 0.001           | 1     | μA    |
|                                        |         |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| Negative Supply Current                | I-      | All channels on or off,<br>V+ = 16.5V, V- = -16.5V,<br>VIN = 0V or 5V | TA = +25°C        | -1   | -0.0001         | 1     | μA    |
|                                        |         |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| Logic Supply Current                   | IL      | All channels on or off,<br>V+ = 16.5V, V- = -16.5V,<br>VIN = 0V or 5V | TA = +25°C        | -1   | 0.001           | 1     | μA    |
|                                        |         |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| Ground Current                         | IGND    | All channels on or off,<br>V+ = 16.5V, V- = -16.5V,<br>VIN = 0V or 5V | TA = +25°C        | -1   | -0.0001         | 1     | μA    |
|                                        |         |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| DYNAMIC                                |         |                                                                       |                   |      |                 |       |       |
| Turn-On Time                           | tON     | VS = ±10V, Figure 2                                                   | TA = +25°C        |      | 150             | 250   | ns    |
| Turn-Off Time                          | tOFF    | DG444, VS = ±10V, Figure 2                                            | TA = +25°C        |      | 90              | 120   | ns    |
|                                        |         | DG445, VS = ±10V, Figure 2                                            | TA = +25°C        |      | 110             | 170   | ns    |
| Charge Injection (Note 3)              | Q       | CL = 1nF, VGEN = 0V,<br>RGEN = 0Ω, Figure 3                           | TA = +25°C        |      | 5               | 10    | pC    |
| Off-Isolation Rejection Ratio (Note 6) | OIRR    | RL = 50Ω, CL = 5pF,<br>f = 1MHz, Figure 4                             | TA = +25°C        |      | 60              |       | dB    |
| Crosstalk (Note 7)                     |         | RL - 50Ω, CL = 5pF,<br>f = 1MHz, Figure 5                             | TA = +25°C        |      | 100             |       | dB    |
| Source-Off Capacitance                 | CS(OFF) | f = 1MHz, Figure 6                                                    | TA = +25°C        |      | 4               |       | pF    |
| Drain-Off Capacitance                  | CD(OFF) | f = 1MHz, Figure 6                                                    | TA = +25°C        |      | 4               |       | pF    |
| Source-On Capacitance                  | CS(ON)  | f = 1MHz, Figure 7                                                    | TA = +25°C        |      | 16              |       | pF    |
| Drain-On Capacitance                   | CD(ON)  | f = 1MHz, Figure 7                                                    | TA = +25°C        |      | 16              |       | pF    |

DG444/DG445

# Improved, Quad, SPST Analog Switches

## ELECTRICAL CHARACTERISTICS—Single Supply

( $V^+ = 12V$ ,  $V^- = 0V$ ,  $V_L = 5V$ ,  $GND = 0V$ ,  $V_{INH} = 2.4V$ ,  $V_{INL} = 0.8V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

| PARAMETER                     | SYMBOL                          | CONDITIONS                                                                                               |                                                       | MIN  | TYP<br>(Note 2) | MAX  | UNITS |
|-------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------|-----------------|------|-------|
| SWITCH                        |                                 |                                                                                                          |                                                       |      |                 |      |       |
| Analog Signal Range           | V <sub>ANALOG</sub>             | (Note 3)                                                                                                 |                                                       | 0    |                 | 12   | V     |
| Drain-Source<br>On-Resistance | r <sub>DS(ON)</sub>             | V <sub>+</sub> = 10.8V,<br>V <sub>L</sub> = 5.25V,<br>V <sub>D</sub> = 3V, 8V,<br>I <sub>S</sub> = -10mA | T <sub>A</sub> = +25°C                                |      | 100             | 160  | Ω     |
|                               |                                 |                                                                                                          | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      |                 | 200  |       |
| SUPPLY                        |                                 |                                                                                                          |                                                       |      |                 |      |       |
| Power-Supply Range            | V <sub>+</sub> , V <sub>-</sub> |                                                                                                          |                                                       | 10.8 |                 | 24.0 | V     |
| Power-Supply Current          | I <sub>+</sub>                  | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                    | T <sub>A</sub> = +25°C                                | -1   | 0.001           | 1    | μA    |
|                               |                                 |                                                                                                          | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Negative Supply Current       | I <sub>-</sub>                  | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                    | T <sub>A</sub> = +25°C                                | -1   | -0.0001         | 1    | μA    |
|                               |                                 |                                                                                                          | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Logic Supply Current          | I <sub>L</sub>                  | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                    | T <sub>A</sub> = +25°C                                | -1   | 0.001           | 1    | μA    |
|                               |                                 |                                                                                                          | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Ground Current                | I <sub>GND</sub>                | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                    | T <sub>A</sub> = +25°C                                | -1   | -0.0001         | 1    | μA    |
|                               |                                 |                                                                                                          | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| DYNAMIC                       |                                 |                                                                                                          |                                                       |      |                 |      |       |
| Turn-On Time                  | t <sub>ON</sub>                 | V <sub>S</sub> = 8V, Figure 2                                                                            | T <sub>A</sub> = +25°C                                |      | 300             | 400  | ns    |
| Turn-Off Time                 | t <sub>OFF</sub>                | V <sub>S</sub> = 8V, Figure 2                                                                            | T <sub>A</sub> = +25°C                                |      | 60              | 200  | ns    |
| Charge Injection (Note 3)     | Q                               | C <sub>L</sub> = 1nF, V <sub>GEN</sub> = 0V,<br>R <sub>GEN</sub> = 0Ω, Figure 3                          | T <sub>A</sub> = +25°C                                |      | 5               | 10   | pC    |

**Note 2:** Typical values are for **design aid only**, are not guaranteed and are not subject to production testing. The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.

**Note 3:** Guaranteed by design.

**Note 4:** On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation. Flatness is defined as the difference between the maximum and the minimum value of on-resistance as measured at the extremes of the specified analog signal range.

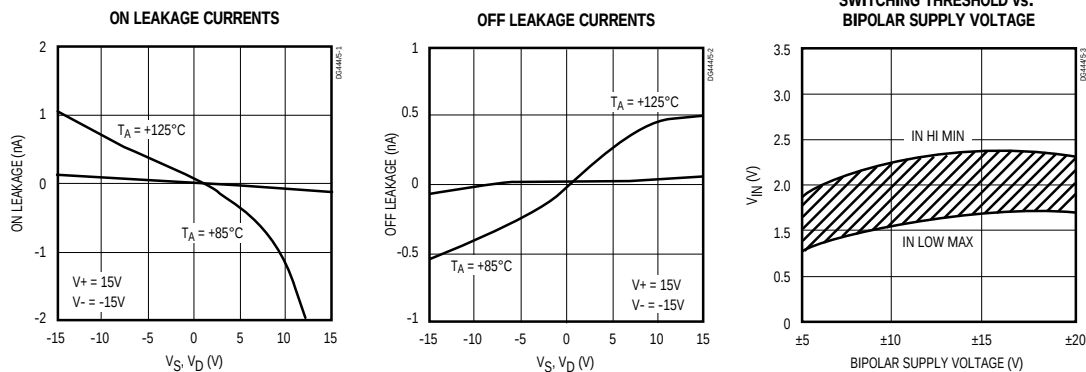
**Note 5:** Leakage parameters  $I_{S(OFF)}$ ,  $I_{D(OFF)}$ ,  $I_{D(ON)}$ , and  $I_{S(ON)}$ , are 100% tested at the maximum rated hot temperature and guaranteed at  $+25^\circ C$ .

**Note 6:** Off-Isolation Rejection Ratio =  $20\log(V_D/V_S)$ ,  $V_D$  = output,  $V_S$  = input to off switch.

**Note 7:** Between any two switches.

## Typical Operating Characteristics

( $T_A = +25^\circ C$ , unless otherwise noted.)

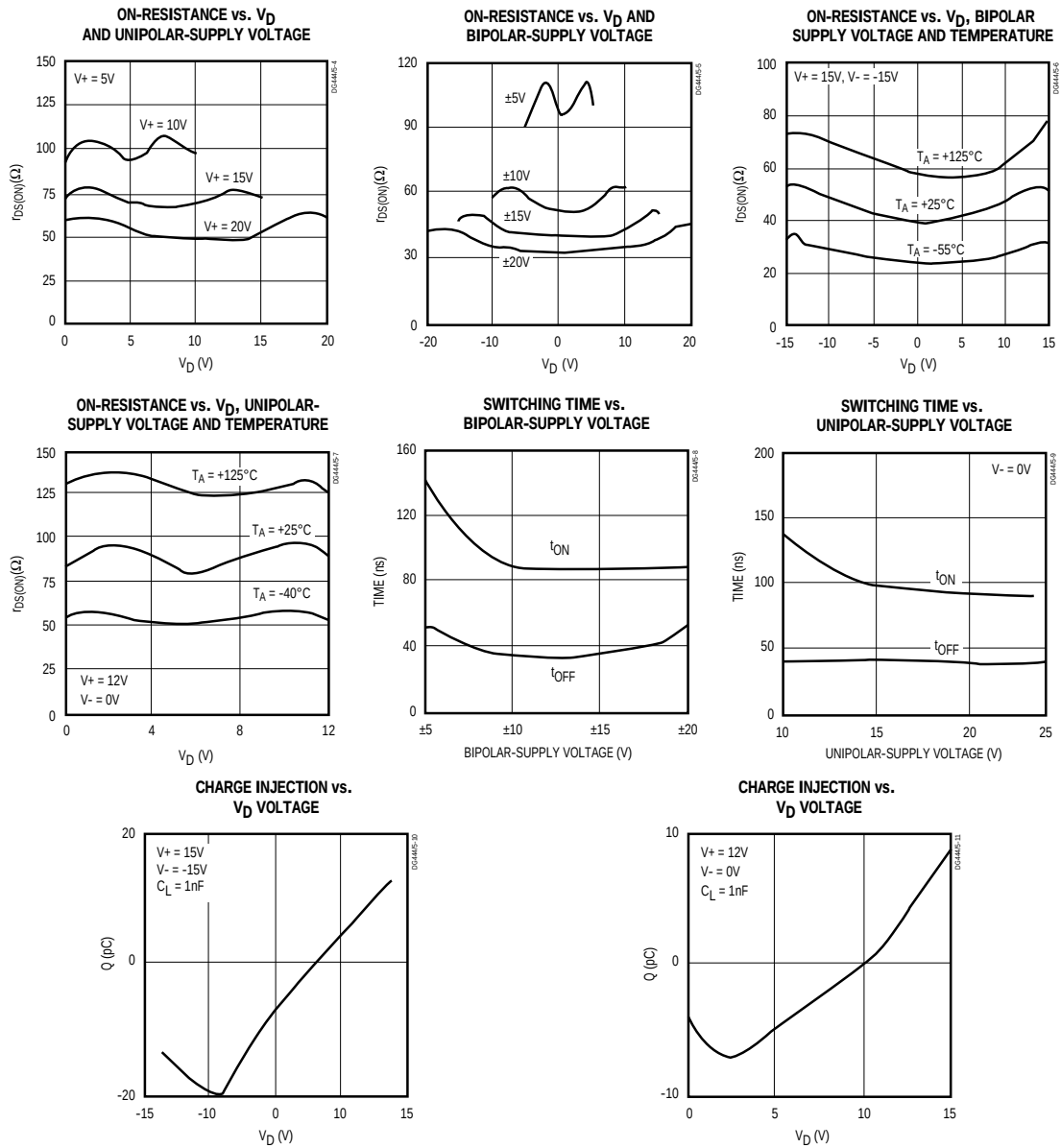


# Improved, Quad, SPST Analog Switches

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

DG4444/DG4445



# Improved, Quad, SPST Analog Switches

## Pin Description

| PIN          | NAME           | FUNCTION                                             |
|--------------|----------------|------------------------------------------------------|
| 1, 16, 9, 8  | IN1-IN4        | Logic Control Inputs                                 |
| 2, 15, 10, 7 | D1-D4          | Drain Outputs                                        |
| 3, 14, 11, 6 | S1-S4          | Source Outputs                                       |
| 4            | V-             | Negative Supply-Voltage Input                        |
| 5            | GND            | Ground                                               |
| 12           | V <sub>L</sub> | Logic Supply-Voltage Input                           |
| 13           | V+             | Positive Supply-Voltage Input—connected to substrate |

## Applications Information

### General Operation

- Switches are open when power is off.
- IN, D, and S should not exceed V+ or V-, even with the power off.
- Switch leakage is from each analog switch terminal to V+ or V-, not to other switch terminals.

### Operation with Supply Voltages Other Than ±15V

Using supply voltages other than ±15V will reduce the analog signal range. The DG444/DG445 switches operate with ±4.5V to ±20V bipolar supplies or with a +10V to +30V single supply; connect V- to 0V when operating with a single supply. Also, all device types can operate with unbalanced supplies such as +24V and -5V. V<sub>L</sub> must be connected to +5V to be TTL compatible, or to V+ for CMOS-logic level inputs. The Typical Operating

Characteristics graphs show typical on-resistance with ±20V, ±15V, ±10V, and ±5V supplies. (Switching times increase by a factor of two or more for operation at ±5V.)

### Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V+ on first, followed by V<sub>L</sub>, V-, and logic inputs. If power-supply sequencing is not possible, add two small, external signal diodes in series with supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below V+ and 1V above V-, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ and V- should not exceed +44V.

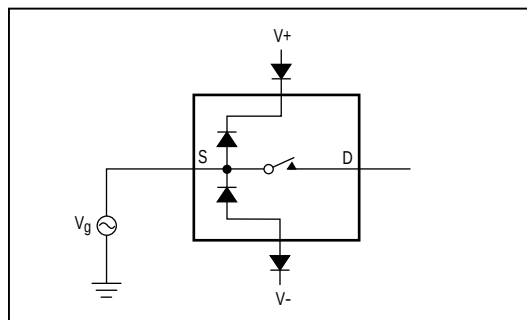


Figure 1. Overvoltage Protection Using External Blocking Diodes

## Timing Diagrams/Test Circuits

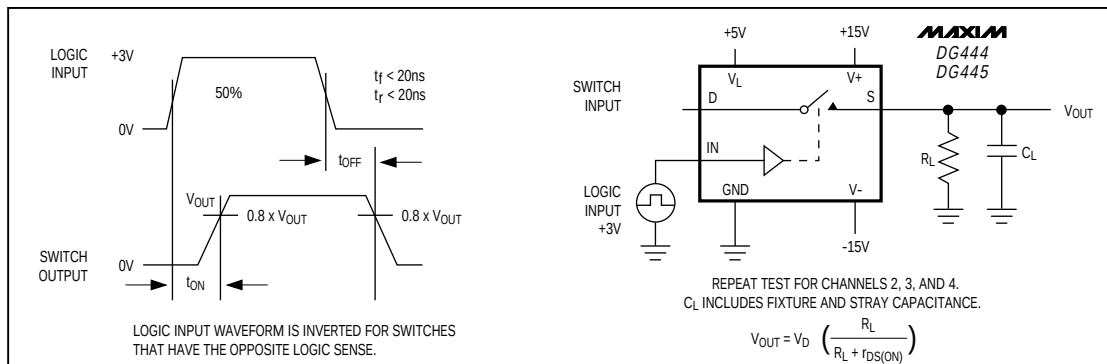


Figure 2. Switching Time

# Improved, Quad, SPST Analog Switches

## Timing Diagrams/Test Circuits (continued)

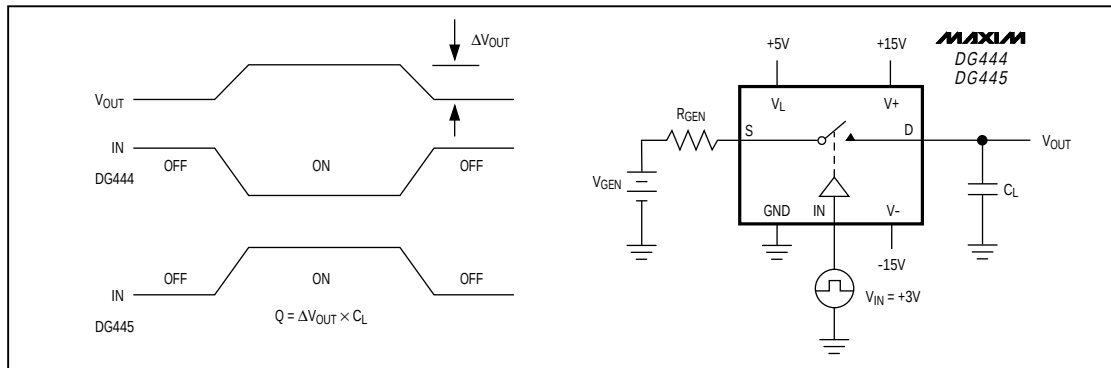


Figure 3. Charge Injection

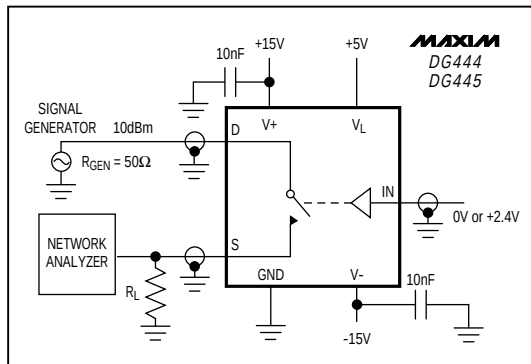


Figure 4. Off-Isolation Rejection Ratio

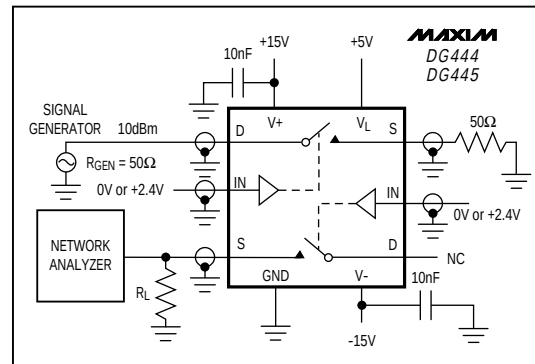


Figure 5. Crosstalk

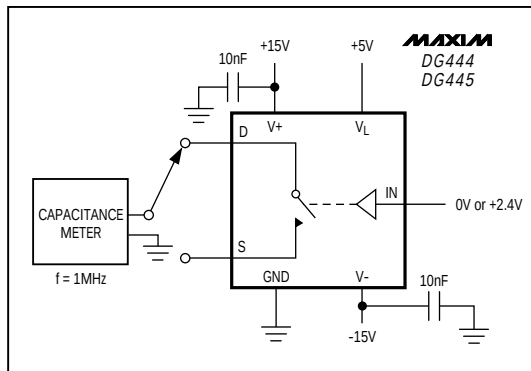


Figure 6. Source/Drain-Off Capacitance

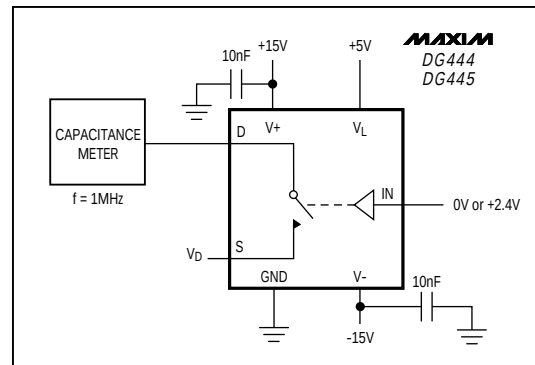


Figure 7. Source/Drain-On Capacitance

DG444/DG445

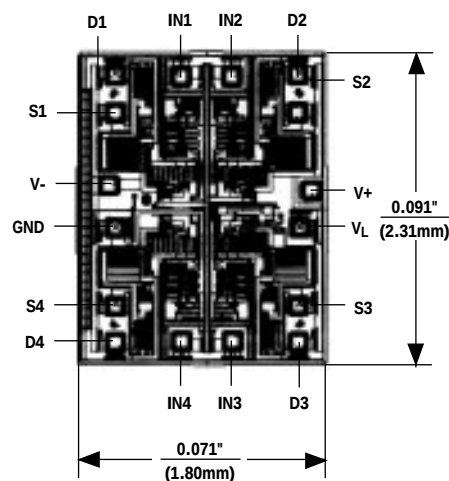
# Improved, Quad, SPST Analog Switches

## Ordering Information (continued)

| PART     | TEMP. RANGE    | PIN-PACKAGE    |
|----------|----------------|----------------|
| DG445CJ  | 0°C to +70°C   | 16 Plastic DIP |
| DG445CY  | 0°C to +70°C   | 16 Narrow SO   |
| DG445C/D | 0°C to +70°C   | Dice*          |
| DG445DJ  | -40°C to +85°C | 16 Plastic DIP |
| DG445DY  | -40°C to +85°C | 16 Narrow SO   |

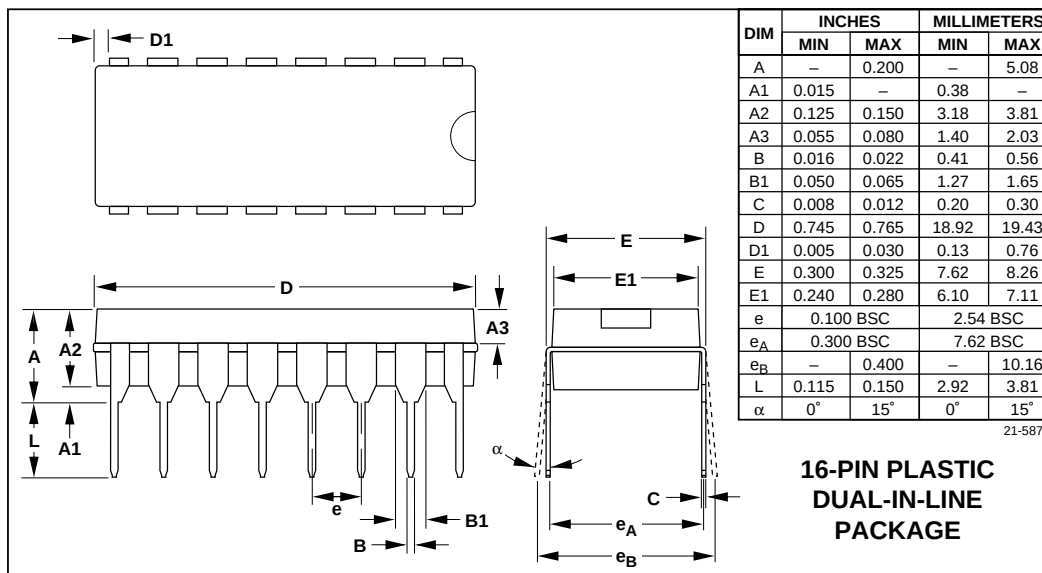
\* Contact factory for dice specifications.

## Chip Topography



TRANSISTOR COUNT: 126  
SUBSTRATE CONNECTED TO V+

## Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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