



# Improved, Quad, SPST Analog Switches

## General Description

Maxim's redesigned DG441/DG442 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 ( $1.65\text{mW}$ ), 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 DG441/DG442 are quad, single-pole/single-throw (SPST) analog switches. The DG441 has four normally closed switches, and the DG442 has four normally open switches. Switching times are less than  $250\text{ns}$  for  $t_{\text{ON}}$  and less than  $170\text{ns}$  for  $t_{\text{OFF}}$ . These devices operate 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 DG441/DG442 continue to be fabricated with a  $44\text{V}$  silicon-gate process.

## Applications

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

## New Features

- ◆ Plug-In Upgrades for Industry-Standard DG441/DG442
- ◆ Improved  $r_{\text{DS(ON)}}$  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 ( $1.65\text{mW}$  max)
- ◆ Rail-to-Rail Signal Handling
- ◆ TTL/CMOS-Logic Compatible

## Ordering Information

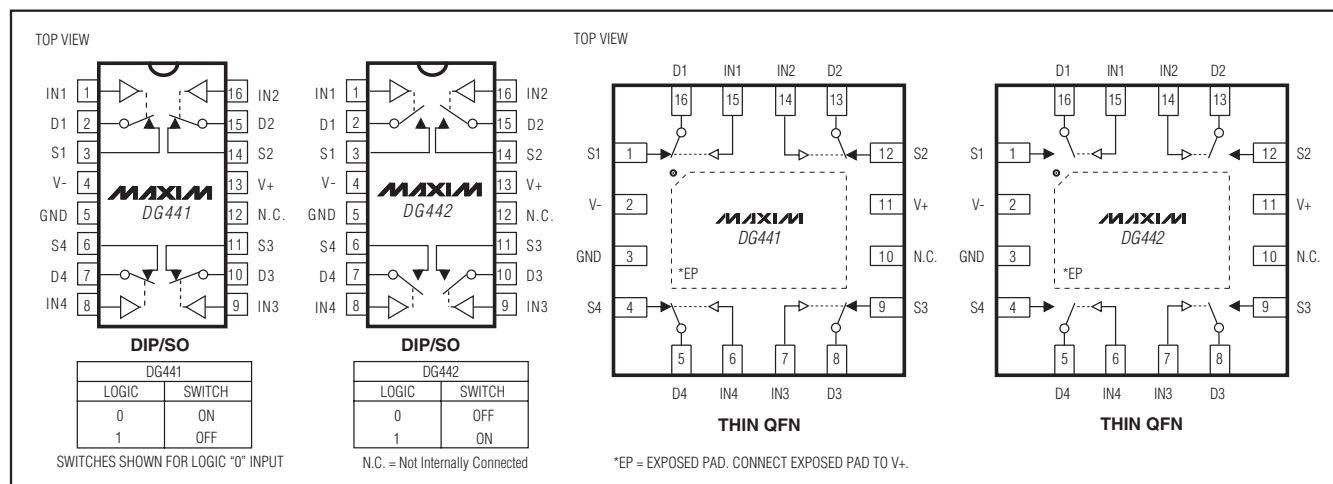
| PART     | TEMP RANGE                                 | PIN-PACKAGE    |
|----------|--------------------------------------------|----------------|
| DG441CJ  | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Plastic DIP |
| DG441CY  | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Narrow SO   |
| DG441C/D | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | Dice*          |
| DG441DJ  | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Plastic DIP |
| DG441DY  | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Narrow SO   |

Ordering Information continued at end of data sheet.

**Note:** Devices are available in both leaded and lead(Pb)-free packaging. Specify lead-free by adding the + symbol at the end of the part number when ordering.

\*Contact factory for dice specifications.

## Pin Configurations/Functional Diagrams/Truth Tables



DG441/DG442

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## 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  
(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)

Plastic DIP (derate 10.53mW/°C above +70°C) .....842mW

Thin QFN (derate 20.8mW/°C above +70°C) .....1667mW

Narrow SO (derate 8.70mW/°C above +70°C) .....696mW

CERDIP (derate 10.00mW/°C above +70°C) .....800mW

Operating Temperature Ranges

DG441C/DG442C .....0°C to +70°C

DG441D, E/DG442D, E .....-40°C to +85°C

DG441AK, MY/DG442AK, MY .....-55°C to +125°C

Storage Temperature Range .....-65°C to +150°C

Lead Temperature (soldering, 10s) .....+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 ratings.

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>GND</sub> = 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 On-Resistance                       | r <sub>DS(ON)</sub>                            | V <sub>+</sub> = 13.5V, V <sub>-</sub> = -13.5V,<br>I <sub>S</sub> = -10mA,<br>V <sub>D</sub> = 8.5V or -8.5V | 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>+</sub> = 15V, V <sub>-</sub> = -15V,<br>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<br>(Note 4)               | r <sub>FLAT(ON)</sub>                          | V <sub>+</sub> = 15V, V <sub>-</sub> = -15V,<br>V <sub>D</sub> = 5V or -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 Off-Leakage Current<br>(Note 5)           | I <sub>S(OFF)</sub>                            | V <sub>+</sub> = 16.5V, V <sub>-</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>MAX</sub>                     | C, D | -5    |                 | 5    |       |
|                                                  |                                                |                                                                                                               |                                                       | A    | -20   |                 | 20   |       |
| Drain Off-Leakage Current<br>(Note 5)            | I <sub>D(OFF)</sub>                            | V <sub>+</sub> = 16.5V, V <sub>-</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>MAX</sub>                     | C, D | -5    |                 | 5    |       |
|                                                  |                                                |                                                                                                               |                                                       | A    | -20   |                 | 20   |       |
| Drain On-Leakage Current<br>(Note 5)             | I <sub>D(ON)</sub><br>or<br>I <sub>S(ON)</sub> | V <sub>+</sub> = 16.5V, V <sub>-</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>MAX</sub>                     | C, D | -10   |                 | 10   |       |
|                                                  |                                                |                                                                                                               |                                                       | A    | -20   |                 | 20   |       |
| DIGITAL                                          |                                                |                                                                                                               |                                                       |      |       |                 |      |       |
| Input Current with<br>Input Voltage High         | I <sub>INH</sub>                               | V <sub>IN</sub> = 2.4V                                                                                        |                                                       |      | -500  | 0.01            | 500  | nA    |
| Input Current with<br>Input Voltage Low          | I <sub>INL</sub>                               | V <sub>IN</sub> = 0.8V                                                                                        |                                                       |      | -500  | 0.01            | 500  | nA    |

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## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, V<sub>GND</sub> = 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 |
|----------------------------------------|---------|-----------------------------------------------------------------|-------------------|------|-----------------|-------|-------|
| SUPPLY                                 |         |                                                                 |                   |      |                 |       |       |
| Power-Supply Range                     | V+, V-  |                                                                 |                   | ±4.5 |                 | ±20.0 | V     |
| Positive Supply Current                | I+      | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V |                   |      | 15              | 100   | μA    |
| Negative Supply Current                | I-      | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V | TA = +25°C        | -1   | -0.0001         | 1     | μA    |
|                                        |         |                                                                 | TA = TMIN to TMAX | -5   |                 | 5     |       |
| Ground Current                         | IGND    | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V |                   | -100 | -15             |       | μA    |
| DYNAMIC                                |         |                                                                 |                   |      |                 |       |       |
| Turn-On Time                           | tON     | VS = ±10V, RL = 1kΩ, Figure 2                                   | TA = +25°C        |      | 150             | 250   | ns    |
| Turn-Off Time                          | tOFF    | DG441, VD = ±10V, Figure 2                                      | TA = +25°C        |      | 90              | 120   | ns    |
|                                        |         | DG442, VD = ±10V, Figure 2                                      | TA = +25°C        |      | 110             | 170   |       |
| Charge Injection (Note 3)              | Q       | CL = 1nF, VGEN = 0V, RGEN = 0Ω, Figure 3                        | TA = +25°C        |      | 5               | 10    | pC    |
| Off-Isolation Rejection Ratio (Note 6) | OIRR    | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 4                          | TA = +25°C        |      | 60              |       | dB    |
| Crosstalk (Note 7)                     |         | RL = 50Ω, CL = 5pF, 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    |
| Drain On-Capacitance                   | CD(ON)  | f = 1MHz, Figure 6                                              | TA = +25°C        |      | 16              |       | pF    |

DG441/DG442

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## ELECTRICAL CHARACTERISTICS—Single Supply

( $V_+ = 12V$ ,  $V_- = 0V$ ,  $V_{GND} = 0V$ ,  $V_{INH} = 2.4V$ ,  $V_{INL} = 0.8V$ ,  $T_A = T_{MIN}$  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, V <sub>D</sub> = 3V, 8V,<br>I <sub>S</sub> = 1.0mA | 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>      |                                                                            |                                                       | 10   |                 | 30  | V     |
| Positive Supply Current       | I <sub>+</sub>      | All channels on or off, V <sub>IN</sub> = 0V or 5V                         |                                                       |      | 15              | 100 | μA    |
| 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   |       |
| Ground Current                | I <sub>GND</sub>    | All channels on or off, V <sub>IN</sub> = 0V or 5V                         |                                                       | -100 | -15             |     | μA    |
| 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                                | 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 is 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 range.

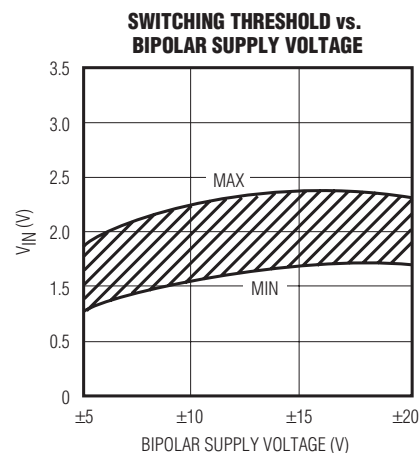
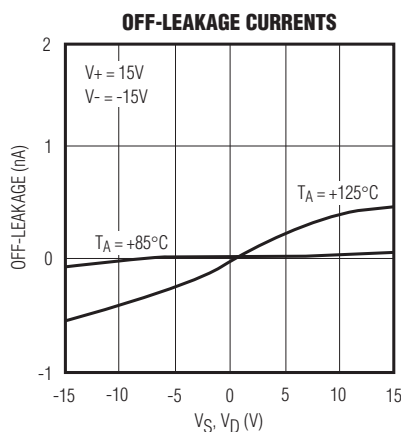
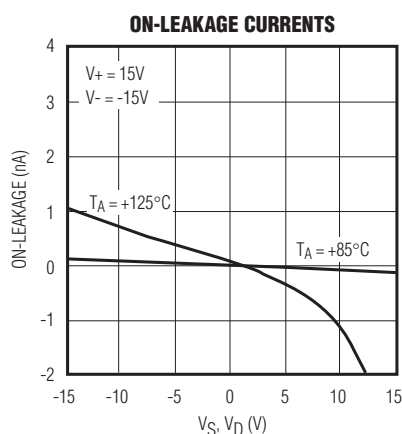
**Note 5:** Leakage parameters  $I_{S(OFF)}$ ,  $I_{D(OFF)}$ , and  $I_{D(ON)}$  are 100% tested at the maximum rated hot temperature and guaranteed by correlation at  $+25^\circ C$ .

**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.)



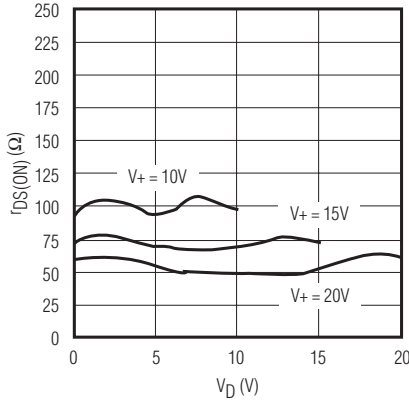
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DG441/DG442

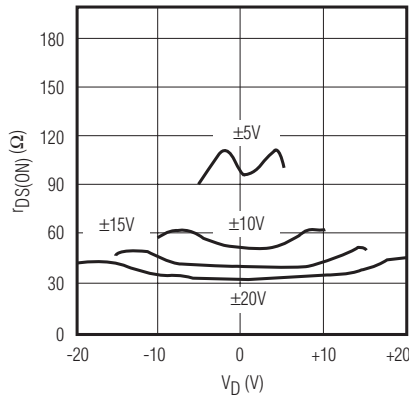
## Typical Operating Characteristics (continued)

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

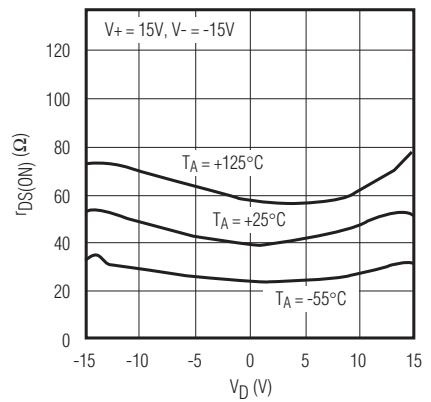
**ON-RESISTANCE vs.  $V_D$  AND UNIPOLAR SUPPLY VOLTAGE**



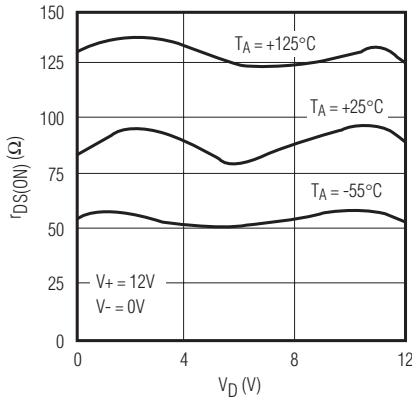
**ON-RESISTANCE vs.  $V_D$  AND BIPOLAR SUPPLY VOLTAGE**



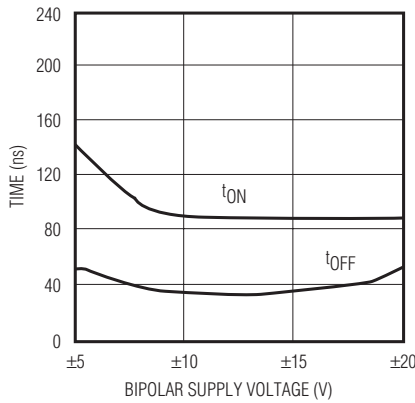
**ON-RESISTANCE vs.  $V_D$  AND BIPOLAR VOLTAGE AND TEMPERATURE**



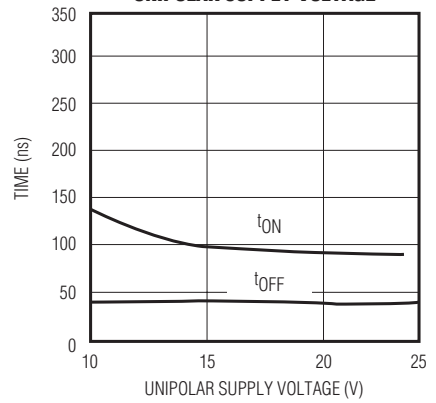
**ON-RESISTANCE vs.  $V_D$  AND UNIPOLAR SUPPLY VOLTAGE AND TEMPERATURE**



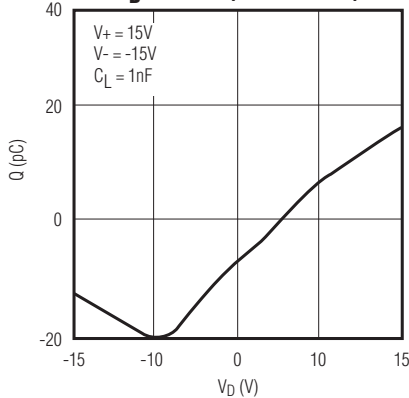
**SWITCHING TIMES vs. BIPOLAR SUPPLY VOLTAGE**



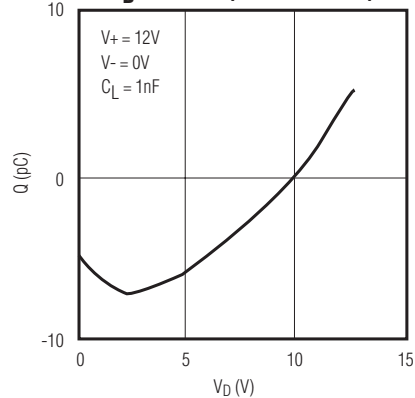
**SWITCHING TIMES vs. UNIPOLAR SUPPLY VOLTAGE**



**CHARGE INJECTION vs.  $V_D$  VOLTAGE (DUAL SUPPLY)**



**CHARGE INJECTION vs.  $V_D$  VOLTAGE (SINGLE SUPPLY)**



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## Pin Description

| PIN          |              | NAME    | FUNCTION                                                                                       |
|--------------|--------------|---------|------------------------------------------------------------------------------------------------|
| DIP/SO       | THIN QFN-EP  |         |                                                                                                |
| 1, 16, 9, 8  | 15, 14, 7, 6 | IN1–IN4 | Input                                                                                          |
| 2, 15, 10, 7 | 16, 13, 8, 5 | D1–D4   | Analog Switch Drain Terminal                                                                   |
| 3, 14, 11, 6 | 1, 12, 9, 4  | S1–S4   | Analog Switch Source Terminal                                                                  |
| 4            | 2            | V-      | Negative-Supply Voltage Input                                                                  |
| 5            | 3            | GND     | Ground                                                                                         |
| 12           | 10           | N.C.    | Not Internally Connected                                                                       |
| 13           | 11           | V+      | Positive-Supply Voltage Input—Connected to Substrate                                           |
| —            | —            | EP      | Exposed Pad. Connect EP to V+. Do not use EP as a sole V+ connection. (Thin QFN package only.) |

## Applications Information

### Operation with Supply Voltages Other Than $\pm 15\text{V}$

Using supply voltages other than  $\pm 15\text{V}$  reduces the analog signal range. The DG441/DG442 switches operate with  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  bipolar supplies or with a  $+10\text{V}$  to  $+30\text{V}$  single supply; connect V- to  $0\text{V}$  when operating with a single supply. Also, all device types can operate with unbalanced supplies such as  $+24\text{V}$  and  $-5\text{V}$ . The *Typical Operating Characteristics* graphs show typical on-resistance with  $\pm 20\text{V}$ ,  $\pm 15\text{V}$ ,  $\pm 10\text{V}$ , and  $\pm 5\text{V}$  sup-

plies. (Switching times increase by a factor of two or more for operation at  $\pm 5\text{V}$ .)

### 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 can cause permanent damage to the devices. Always sequence V+ on first, followed by 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 external diodes reduces the analog-signal range to  $1\text{V}$  below V+ and  $1\text{V}$  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  $+44\text{V}$ .

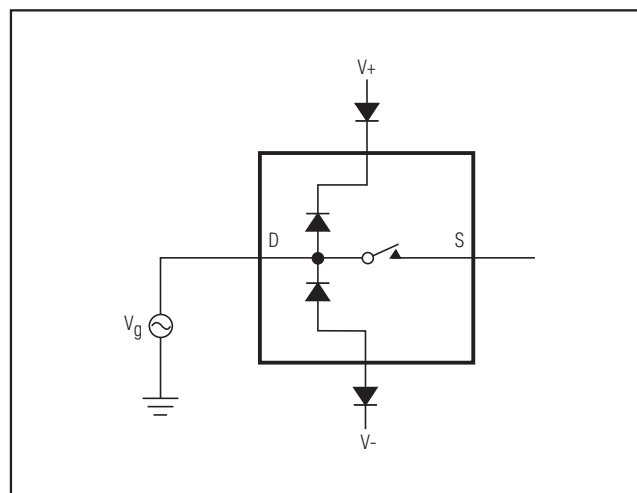


Figure 1. Overvoltage Protection Using External Blocking Diodes

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## Timing Diagrams/Test Circuits

DG441/DG442

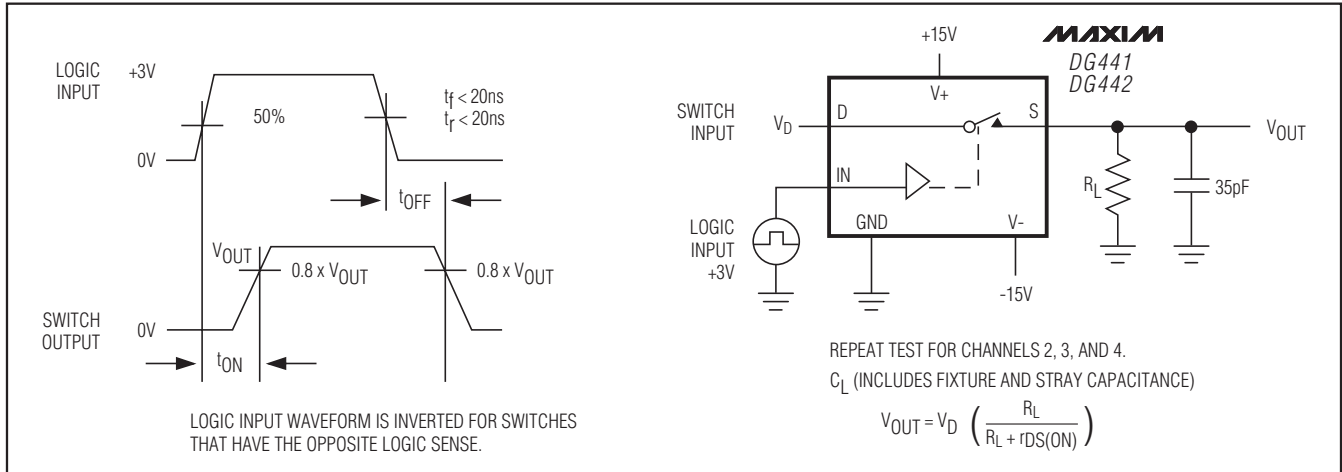


Figure 2. Switching Time

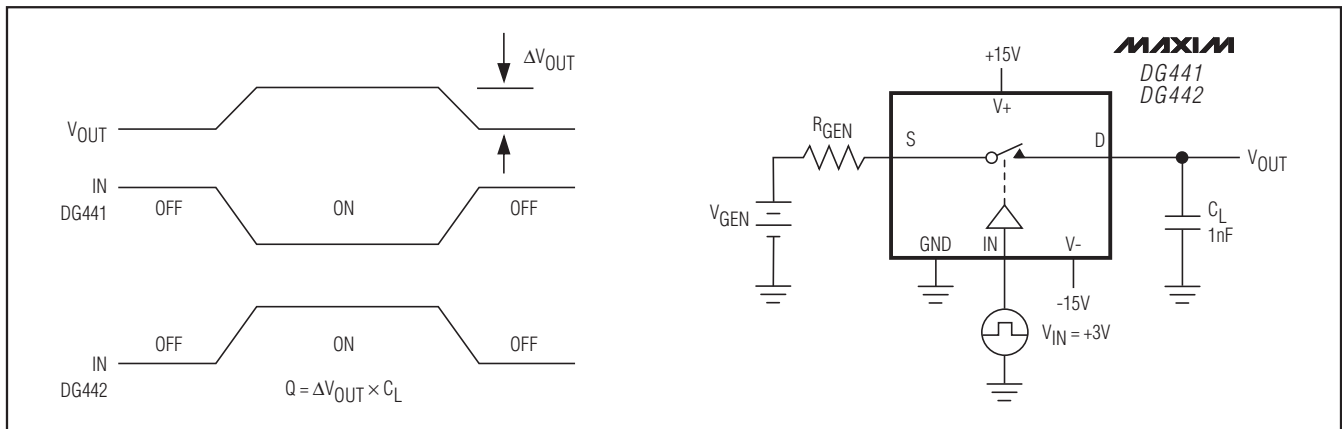


Figure 3. Charge Injection

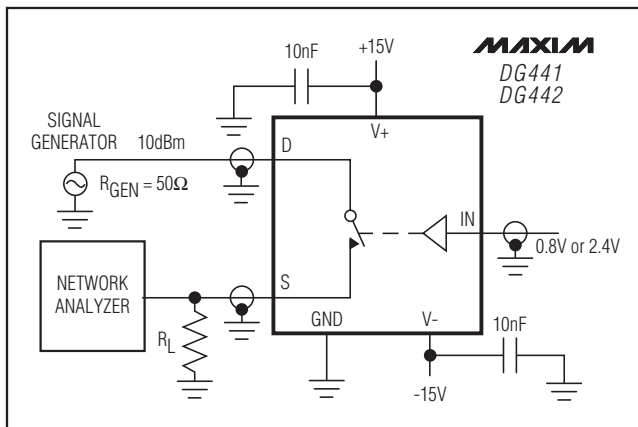


Figure 4. Off-Isolation Rejection Ratio

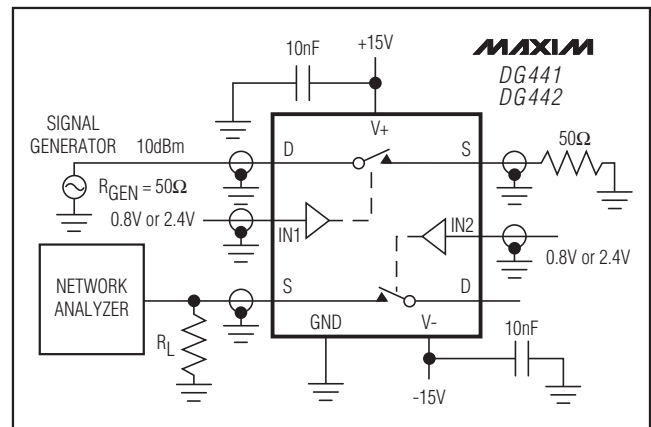


Figure 5. Crosstalk (repeat for channels 3 and 4)

# Improved, Quad, SPST Analog Switches

## Timing Diagrams/ Test Circuits (continued)

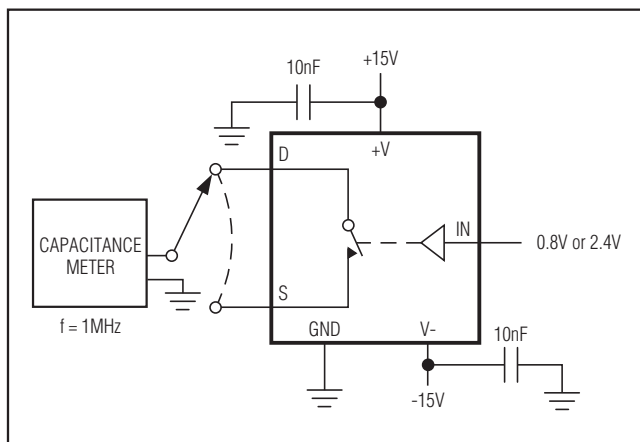


Figure 6. Source/Drain-On/Off Capacitance

## Ordering Information (continued)

| PART           | TEMP RANGE      | PIN-PACKAGE      |
|----------------|-----------------|------------------|
| DG441DK        | -40°C to +85°C  | 16 CERDIP        |
| DG441ETE       | -40°C to +85°C  | 16 Thin QFN-EP** |
| DG441AK        | -55°C to +125°C | 16 CERDIP***     |
| DG441MY/PR     | -55°C to +125°C | 16 Narrow SO     |
| <b>DG442CJ</b> | 0°C to +70°C    | 16 Plastic DIP   |
| DG442CY        | 0°C to +70°C    | 16 Narrow SO     |
| DG442C/D       | 0°C to +70°C    | Dice*            |
| DG442DJ        | -40°C to +85°C  | 16 Plastic DIP   |
| DG442DY        | -40°C to +85°C  | 16 Narrow SO     |
| DG442DK        | -40°C to +85°C  | 16 CERDIP        |
| DG442ETE       | -40°C to +85°C  | 16 Thin QFN-EP** |
| DG442AK        | -55°C to +125°C | 16 CERDIP***     |
| DG442MY/PR     | -55°C to +125°C | 16 Narrow SO     |

**Note:** Devices are available in both leaded and lead(Pb)-free packaging. Specify lead-free by adding the + symbol at the end of the part number when ordering.

\*Contact factory for dice specifications.

\*\*EP = Exposed pad.

\*\*\*Contact factory for availability and processing to MIL-STD-883B. Not available in lead-free.

## Package Information

For the latest package outline information and land patterns, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).

| PACKAGE TYPE               | PACKAGE CODE | DOCUMENT NO.            |
|----------------------------|--------------|-------------------------|
| 16 Plastic DIP             | P16-1        | <a href="#">21-0043</a> |
| 16 Narrow SO               | S16-3        | <a href="#">21-0041</a> |
| 16 CERDIP                  | J16-3        | <a href="#">21-0045</a> |
| 16 Thin QFN-EP (5mm x 5mm) | T1655-2      | <a href="#">21-0140</a> |

# Improved, Quad, SPST Analog Switches

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION               | PAGES<br>CHANGED |
|--------------------|------------------|---------------------------|------------------|
| 5                  | 5/09             | Added ruggedized plastic. | 1, 2, 6, 8       |

DG441/DG442

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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