





# Low-Voltage, CMOS Analog Multiplexers/Switches

MAX4051/A, MAX4052/A, MAX4053/A

## General Description

The MAX4051/MAX4052/MAX4053 and MAX4051A/MAX4052A/MAX4053A are low-voltage, CMOS analog ICs configured as an 8-channel multiplexer (MAX4051/A), two 4-channel multiplexers (MAX4052/A), and three single-pole/double-throw (SPDT) switches (MAX4053/A). The A-suffix parts are fully characterized for on-resistance match, on-resistance flatness, and low leakage.

These CMOS devices can operate continuously with dual power supplies ranging from  $\pm 2.7V$  to  $\pm 8V$  or a single supply between  $+2.7V$  and  $+16V$ . Each switch can handle rail-to-rail analog signals. The off-leakage current is only  $0.1nA$  at  $+25^{\circ}C$  or  $5nA$  at  $+85^{\circ}C$  (MAX4051A/MAX4052A/MAX4053A).

All digital inputs have  $0.8V$  to  $2.4V$  logic thresholds, ensuring TTL/CMOS-logic compatibility when using  $\pm 5V$  or a single  $+5V$  supply.

## Applications

- Battery-Operated Equipment
- Audio and Video Signal Routing
- Low-Voltage Data-Acquisition Systems
- Communications Circuits

## Features

- ◆ Pin Compatible with Industry-Standard 74HC4051/74HC4052/74HC4053
- ◆ Guaranteed On-Resistance:  $100\Omega$  with  $\pm 5V$  Supplies
- ◆ Guaranteed Match Between Channels:  $6\Omega$  (MAX4051A–MAX4053A)  $12\Omega$  (MAX4051–MAX4053)
- ◆ Guaranteed Low Off-Leakage Currents:  $0.1nA$  at  $+25^{\circ}C$  (MAX4051A–MAX4053A)  $1nA$  at  $+25^{\circ}C$  (MAX4051–MAX4053)
- ◆ Guaranteed Low On-Leakage Currents:  $0.1nA$  at  $+25^{\circ}C$  (MAX4051A–MAX4053A)  $1nA$  at  $+25^{\circ}C$  (MAX4051–MAX4053)
- ◆ Single-Supply Operation from  $+2.0V$  to  $+16V$  Dual-Supply Operation from  $\pm 2.7V$  to  $\pm 8V$
- ◆ TTL/CMOS-Logic Compatible
- ◆ Low Distortion:  $< 0.04\%$  ( $600\Omega$ )
- ◆ Low Crosstalk:  $< -90dB$  ( $50\Omega$ )
- ◆ High Off-Isolation:  $< -90dB$  ( $50\Omega$ )

## Ordering Information

| PART        | TEMP RANGE                     | PIN-PACKAGE    |
|-------------|--------------------------------|----------------|
| MAX4051ACPE | $0^{\circ}C$ to $+70^{\circ}C$ | 16 Plastic DIP |
| MAX4051ACSE | $0^{\circ}C$ to $+70^{\circ}C$ | 16 Narrow SO   |
| MAX4051ACEE | $0^{\circ}C$ to $+70^{\circ}C$ | 16 QSOP        |

Ordering Information continued at end of data sheet.

## Pin Configurations/Functional Diagrams



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

# Low-Voltage, CMOS Analog Multiplexers/Switches

## ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND

|                                    |   |
|------------------------------------|---|
| V+                                 | -0.3V to +17V   |
| V-                                 | +0.3V to -17V   |
| V+ to V-                           | -0.3V to +17V   |
| Voltage into Any Terminal (Note 1) | (V- - 2V) to (V+ + 2V) or 30mA (whichever occurs first) |

Continuous Current into Any Terminal.....±30mA

Peak Current, NO or COM

(pulsed at 1ms, 10% duty cycle).....±100mA

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

|   |       |
|---|-------|
| Plastic DIP (derate 10.53mW/°C above +70°C) | 842mW |
| Narrow SO (derate 8.70mW/°C above +70°C)    | 696mW |
| QSOP (derate 8.00mW/°C above +70°C)         | 640mW |
| CERDIP (derate 10.00mW/°C above +70°C)      | 800mW |

Operating Temperature Ranges

|                                   |                 |
|-----------------------------------|-----------------|
| MAX405_C_E/MAX405_AC_E            | 0°C to +70°C    |
| MAX405_E_E/MAX405_AE_E            | -40°C to +85°C  |
| MAX405_MJE/MAX405_AMJE            | -55°C to +125°C |
| Storage Temperature Range         | -65°C to +150°C |
| Lead Temperature (soldering, 10s) | +300°C          |

**Note 1:** Signals on any terminal exceeding V+ or V- are clamped by internal diodes. Limit forward-diode 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+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER  | SYMBOL                             | CONDITIONS   |  | MIN                          | TYP<br>(Note 2) | MAX  | UNITS |     |    |
|--|------------------------------------|--|--|------------------------------|-----------------|------|-------|-----|----|
| <b>ANALOG SWITCH</b>                                 |                                    |  |  |                              |                 |      |       |     |    |
| Analog Signal Range                                  | V <sub>COM</sub> , V <sub>NO</sub> |  |  | C, E, M                      | V-              | V+   | V     |     |    |
| COM-NO On-Resistance                                 | R <sub>ON</sub>                    | V+ = 5V, V- = -5V, I <sub>NO</sub> = 1mA, V <sub>COM</sub> = ±3V         |  | TA = +25°C                   | 60              | 100  | Ω     |     |    |
|  |                                    |  |  | C, E, M                      |                 | 125  |       |     |    |
| COM-NO On-Resistance Match Between Channels (Note 3) | ΔR <sub>ON</sub>                   | V+ = 5V, V- = -5V, I <sub>NO</sub> = 1mA, V <sub>COM</sub> = ±3V         |  | MAX4051A, MAX4052A, MAX4053A | TA = +25°C      | 6    | Ω     |     |    |
|  |                                    |  |  | C, E, M                      |                 | 12   |       |     |    |
|  |                                    |  |  | MAX4051, MAX4052, MAX4053    | TA = +25°C      | 12   |       |     |    |
| COM-NO On-Resistance Flatness (Note 4)               | R <sub>FLAT(ON)</sub>              | V+ = 5V, V- = -5V, I <sub>NO</sub> = 1mA, V <sub>COM</sub> = -3V, 0V, 3V |  | MAX4051A, MAX4052A, MAX4053A | TA = +25°C      | 10   | Ω     |     |    |
|  |                                    |  |  | C, E, M                      |                 | 15   |       |     |    |
| NO Off-Leakage Current (Note 5)                      | I <sub>NO(OFF)</sub>               | V+ = 5.5V, V- = -5.5V, V <sub>NO</sub> = 4.5V, V <sub>COM</sub> = -4.5V  |  | MAX4051, MAX4052, MAX4053    | TA = +25°C      | -1   | 0.002 | 1   | nA |
|  |                                    |  |  | C, E                         |                 | -10  | 10    |     |    |
|  |                                    |  |  | M                            |                 | -100 | 100   |     |    |
|  |                                    | V+ = 5.5V, V- = -5.5V, V <sub>NO</sub> = -4.5V, V <sub>COM</sub> = 4.5V  |  | MAX4051A, MAX4052A, MAX4053A | TA = +25°C      | -0.1 | 0.002 | 0.1 |    |
|  |                                    |  |  | C, E                         |                 | -5   | 5     |     |    |
|  |                                    |  |  | M                            |                 | -100 | 100   |     |    |

# Low-Voltage, CMOS Analog Multiplexers/Switches

**MAX4051/A, MAX4052/A, MAX4053/A**

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                        | SYMBOL     | CONDITIONS  |                       |            | MIN   | TYP<br>(Note 2) | MAX | UNITS |
|----------------------------------|------------|---|-----------------------|------------|-------|-----------------|-----|-------|
| COM Off-Leakage Current (Note 5) | ICOM(OFF)  | V+ = 5.5V, V- = -5.5V,<br>VNO = 4.5V,<br>VCOM = -4.5V | MAX4051A              | TA = +25°C | -0.1  | 0.002           | 0.1 | nA    |
|                                  |            |   |                       | C, E       | -5    |                 | 5   |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            |   | MAX4051               | TA = +25°C | -1    | 0.002           | 1   |       |
|                                  |            |   |                       | C, E       | -10   |                 | 10  |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            |   | MAX4052A,<br>MAX4053A | TA = +25°C | -0.1  | 0.002           | 0.1 |       |
|                                  |            |   |                       | C, E       | -2.5  |                 | 2.5 |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            | MAX4052,<br>MAX4053                                   | TA = +25°C            | -1         | 0.002 | 1               |     |       |
|                                  |            |   | C, E                  | -5         |       | 5               |     |       |
|                                  |            |   | M                     | -50        |       | 50              |     |       |
|                                  |            | V+ = 5.5V, V- = -5.5V,<br>VNO = -4.5V,<br>VCOM = 4.5V | MAX4051A              | TA = +25°C | -0.1  | 0.002           | 0.1 |       |
|                                  |            |   |                       | C, E       | -5    |                 | 5   |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            |   | MAX4051               | TA = +25°C | -1    | 0.002           | 1   |       |
|                                  |            |   |                       | C, E       | -10   |                 | 10  |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
| MAX4052A,<br>MAX4053A            | TA = +25°C |   | -0.1                  | 0.002      | 0.1   |                 |     |       |
|                                  | C, E       |   | -2.5                  |            | 2.5   |                 |     |       |
|                                  | M          |   | -50                   |            | 50    |                 |     |       |
| MAX4052,<br>MAX4053              | TA = +25°C | -1  | 0.002                 | 1          |       |                 |     |       |
|                                  | C, E       | -5  |                       | 5          |       |                 |     |       |
|                                  | M          | -50   |                       | 50         |       |                 |     |       |
| COM On-Leakage Current (Note 5)  | ICOM(ON)   | V+ = 5.5V, V- = -5.5V,<br>VCOM = VNO = ±4.5V          | MAX4051A              | TA = +25°C | -0.1  | 0.002           | 0.1 | nA    |
|                                  |            |   |                       | C, E       | -5    |                 | 5   |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            |   | MAX4051               | TA = +25°C | -1    | 0.002           | 1   |       |
|                                  |            |   |                       | C, E       | -10   |                 | 10  |       |
|                                  |            |   |                       | M          | -100  |                 | 100 |       |
|                                  |            |   | MAX4052A,<br>MAX4053A | TA = +25°C | -0.1  | 0.002           | 0.1 |       |
|                                  |            |   |                       | C, E       | -2.5  |                 | 2.5 |       |
|                                  |            |   |                       | M          | -50   |                 | 50  |       |
|                                  |            |   | MAX4052,<br>MAX4053   | TA = +25°C | -1    | 0.002           | 1   |       |
|                                  |            |   |                       | C, E       | -5    |                 | 5   |       |
|                                  |            |   |                       | M          | -50   |                 | 50  |       |

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## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                                | SYMBOL                            | CONDITIONS  | MIN        | TYP<br>(Note 2) | MAX  | UNITS |    |
|--|-----------------------------------|---|------------|-----------------|------|-------|----|
| <b>DIGITAL I/O</b>                       |                                   |   |            |                 |      |       |    |
| ADD, INH Input Logic Threshold High      | V <sub>IH</sub>                   |   | C, E, M    | 2.4             |      | V     |    |
| ADD, INH Input Logic Threshold Low       | V <sub>IL</sub>                   |   | C, E, M    |                 | 0.8  | V     |    |
| ADD, INH Input Current Logic High or Low | I <sub>IH</sub> , I <sub>IL</sub> | V <sub>ADD</sub> , V <sub>INH</sub> = V+, 0V  | C, E, M    | -1              | 0.03 | 1     | μA |
| <b>SWITCH DYNAMIC CHARACTERISTICS</b>    |                                   |   |            |                 |      |       |    |
| Turn-On Time (Note 6)                    | t <sub>ON</sub>                   | Figure 3  | TA = +25°C | 50              | 175  | ns    |    |
|  |                                   |   | C, E, M    |                 | 225  |       |    |
| Turn-Off Time (Note 6)                   | t <sub>OFF</sub>                  | Figure 3  | TA = +25°C | 40              | 150  | ns    |    |
|  |                                   |   | C, E, M    |                 | 200  |       |    |
| Transition Time                          | t <sub>TRANS</sub>                | Figure 2  | TA = +25°C | 75              | 250  | ns    |    |
| Break-Before-Make Delay                  | t <sub>OPEN</sub>                 | Figure 4  | TA = +25°C | 2               | 10   | ns    |    |
| Charge Injection (Note 6)                | Q                                 | C <sub>L</sub> = 1nF, R <sub>S</sub> = 0Ω, V <sub>NO</sub> = 0V, Figure 5                               | TA = +25°C | 2               | 10   | pC    |    |
| NO Off-Capacitance                       | C <sub>NO(OFF)</sub>              | V <sub>NO</sub> = GND, f = 1MHz, Figure 7   | TA = +25°C | 2               |      | pF    |    |
| COM Off-Capacitance                      | C <sub>COM(OFF)</sub>             | V <sub>COM</sub> = GND, f = 1MHz, Figure 7  | TA = +25°C | 2               |      | pF    |    |
| Switch On-Capacitance                    | C <sub>(ON)</sub>                 | V <sub>COM</sub> = V <sub>NO</sub> = GND, f = 1MHz, Figure 7  | TA = +25°C | 8               |      | pF    |    |
| Off-Isolation                            | V <sub>ISO</sub>                  | C <sub>L</sub> = 15pF, R <sub>L</sub> = 50Ω, f = 100kHz, V <sub>NO</sub> = 1V <sub>RMS</sub> , Figure 6 | TA = +25°C | <-90            |      | dB    |    |
| Channel-to-Channel Crosstalk             | V <sub>CT</sub>                   | C <sub>L</sub> = 15pF, R <sub>L</sub> = 50Ω, f = 100kHz, V <sub>NO</sub> = 1V <sub>RMS</sub> , Figure 6 | TA = +25°C | <-90            |      | dB    |    |
| <b>POWER SUPPLY</b>                      |                                   |   |            |                 |      |       |    |
| Power-Supply Range                       | V+, V-                            |   | C, E, M    | ±2.7            | ±8   | V     |    |
| V+ Supply Current                        | I+                                | INH = ADD = 0V or V+  | TA = +25°C | -1              | 0.1  | 1     | μA |
|  |                                   |   | C, E, M    |                 |      | 10    |    |
| V- Supply Current                        | I-                                | INH = ADD = 0V or V+  | TA = +25°C | -1              | 0.1  | 1     | μA |
|  |                                   |   | C, E, M    |                 |      | -10   |    |

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 3:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 4:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges; i.e., V<sub>NO</sub> = 3V to 0V and 0V to -3V.

**Note 5:** Leakage parameters are 100% tested at maximum-rated hot operating temperature, and guaranteed by correlation at TA = +25°C.

**Note 6:** Guaranteed by design, not production tested.

# Low-Voltage, CMOS Analog Multiplexers/Switches

## ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = +4.5V to +5.5V, V- = 0V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                           | SYMBOL    | CONDITIONS                                |                         | MIN        | TYP<br>(Note 2) | MAX   | UNITS |    |
|-------------------------------------|-----------|---|-------------------------|------------|-----------------|-------|-------|----|
| <b>ANALOG SWITCH</b>                |           |   |                         |            |                 |       |       |    |
| Analog Signal Range                 | VCOM, VNO |   | C, E, M                 | V-         |                 | V+    | V     |    |
| COM-NO On-Resistance                | RON       | V+ = 5V, INO = 1mA,<br>VCOM = 3.5V        | TA = +25°C              |            | 125             | 225   | Ω     |    |
|                                     |           |   | C, E, M                 |            |                 | 280   |       |    |
| NO Off-Leakage Current<br>(Note 5)  | INO(OFF)  | V+ = 5.5V, VNO = 4.5V,<br>VCOM = 0V       | TA = +25°C              | -1         | 0.002           | 1     | nA    |    |
|                                     |           |   | C, E                    |            | -10             | 10    |       |    |
|                                     |           |   | M                       |            | -100            | 100   |       |    |
|                                     |           | V+ = 5.5V, VNO = 0V,<br>VCOM = 4.5V       | TA = +25°C              | -1         | 0.002           | 1     |       |    |
|                                     |           |   | C, E                    |            | -10             | 10    |       |    |
|                                     |           |   | M                       |            | -100            | 100   |       |    |
| COM Off-Leakage<br>Current (Note 5) | ICOM(OFF) | V+ = 5.5V, VNO = 4.5V,<br>VCOM = 0V       | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     | nA |
|                                     |           |   |                         | C, E       |                 | -10   | 10    |    |
|                                     |           |   |                         | M          |                 | -100  | 100   |    |
|                                     |           |   | MAX4052/A,<br>MAX4053/A | TA = +25°C | -1              | 0.002 | 1     |    |
|                                     |           |   |                         | C, E       |                 | -5    | 5     |    |
|                                     |           |   |                         | M          |                 | -50   | 50    |    |
|                                     |           | V+ = 5.5V, VNO = 0V,<br>VCOM = 4.5V or 0V | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     |    |
|                                     |           |   |                         | C, E       |                 | -10   | 10    |    |
|                                     |           |   |                         | M          |                 | -100  | 100   |    |
|                                     |           |   | MAX4052/A,<br>MAX4053/A | TA = +25°C | -1              | 0.002 | 1     |    |
|                                     |           |   |                         | C, E       |                 | -5    | 5     |    |
|                                     |           |   |                         | M          |                 | -50   | 50    |    |
| COM On-Leakage<br>Current (Note 5)  | ICOM(ON)  | V+ = 5.5V,<br>VCOM = VNO = 4.5V           | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     | nA |
|                                     |           |   |                         | C, E       |                 | -10   | 10    |    |
|                                     |           |   |                         | M          |                 | -100  | 100   |    |
|                                     |           |   |                         | TA = +25°C | -1              | 0.002 | 1     |    |
|                                     |           |   | MAX4052/A,<br>MAX4053/A | C, E       |                 | -10   | 10    |    |
|                                     |           |   |                         | M          |                 | -100  | 100   |    |

MAX4051/A, MAX4052/A, MAX4053/A

# Low-Voltage, CMOS Analog Multiplexers/Switches

## ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +4.5V to +5.5V, V- = 0V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                             | SYMBOL | CONDITIONS   | MIN        | TYP<br>(Note 2) | MAX | UNITS |
|---------------------------------------|--------|--|------------|-----------------|-----|-------|
| <b>SWITCH DYNAMIC CHARACTERISTICS</b> |        |  |            |                 |     |       |
| Turn-On Time (Note 6)                 | tON    | Figure 3   | TA = +25°C | 90              | 200 | ns    |
|                                       |        |  | C, E, M    |                 | 275 |       |
| Turn-Off Time (Note 6)                | tOFF   | Figure 3   | TA = +25°C | 60              | 125 | ns    |
|                                       |        |  | C, E, M    |                 | 175 |       |
| Break-Before-Make Delay               | tOPEN  | Figure 4   | TA = +25°C | 30              |     | ns    |
| Charge Injection (Note 6)             | Q      | CL = 1nF, RS = 0Ω, VNO = 0V, Figure 5                  | TA = +25°C | 2               | 10  | pC    |
| Off-Isolation                         | VISO   | CL = 15pF, RL = 50Ω, f = 100kHz, VNO = 1VRMS, Figure 6 | TA = +25°C | <-90            |     | dB    |
| Channel-to-Channel Crosstalk          | VCT    | CL = 15pF, RL = 50Ω, f = 100kHz, VNO = 1VRMS, Figure 6 | TA = +25°C | <-90            |     | dB    |

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 3:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 4:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges; i.e., VNO = 3V to 0V and 0V to -3V.

**Note 5:** Leakage parameters are 100% tested at maximum-rated hot operating temperature, and guaranteed by correlation at TA = +25°C.

**Note 6:** Guaranteed by design, not production tested.

# Low-Voltage, CMOS Analog Multiplexers/Switches

## ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +3.0V to +3.6V, V- = 0V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                                   | SYMBOL    | CONDITIONS                             |                         | MIN        | TYP<br>(Note 2) | MAX   | UNITS |    |  |   |
|---|-----------|--|-------------------------|------------|-----------------|-------|-------|----|--|---|
| <b>ANALOG SWITCH</b>                        |           |  |                         |            |                 |       |       |    |  |   |
| Analog Signal Range                         | VCOM, VNO |  | C, E, M                 | V-         |                 | V+    | V     |    |  |   |
| COM-NO On-Resistance                        | RON       | INO = 1mA, V+ = 3V,<br>VCOM = 1.5V     | TA = +25°C              |            | 250             | 525   | Ω     |    |  |   |
|   |           |  | C, E, M                 |            |                 | 700   |       |    |  |   |
| NO Off-Leakage Current<br>(Note 5)          | INO(OFF)  | V+ = 3.6V, VNO = 3V,<br>VCOM = 0V      | TA = +25°C              | -1         | 0.002           | 1     | nA    |    |  |   |
|   |           |  | C, E                    | -10        |                 | 10    |       |    |  |   |
|   |           |  | M                       | -100       |                 | 100   |       |    |  |   |
|   |           | V+ = 3.6V, VNO = 0V,<br>VCOM = 3V      | TA = +25°C              | -1         | 0.002           | 1     |       |    |  |   |
|   |           |  | C, E                    | -10        |                 | 10    |       |    |  |   |
|   |           |  | M                       | -100       |                 | 100   |       |    |  |   |
| COM Off-Leakage<br>Current (Note 5)         | ICOM(OFF) | V+ = 3.6V, VNO = 3V,<br>VCOM = 0V      | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     | nA |  |   |
|   |           |  |                         | C, E       | -10             |       | 10    |    |  |   |
|   |           |  |                         | M          | -100            |       | 100   |    |  |   |
|   |           |  | MAX4052/A,<br>MAX4053/A | TA = +25°C | -1              | 0.002 | 1     |    |  |   |
|   |           |  |                         | C, E       | -5              |       | 5     |    |  |   |
|   |           |  |                         | M          | -50             |       | 50    |    |  |   |
|   |           | V+ = 3.6V, VNO = 0V,<br>VCOM = 3V      | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     |    |  |   |
|   |           |  |                         | C, E       | -10             |       | 10    |    |  |   |
|   |           |  |                         | M          | -100            |       | 100   |    |  |   |
|   |           |  | MAX4052/A,<br>MAX4053/A | TA = +25°C | -1              | 0.002 | 1     |    |  |   |
|   |           |  |                         | C, E       | -5              |       | 5     |    |  |   |
|   |           |  |                         | M          | -50             |       | 50    |    |  |   |
| COM On-Leakage<br>Current (Note 5)          | ICOM(ON)  | V+ = 3.6V,<br>VCOM = VNO = 3V          | MAX4051/A               | TA = +25°C | -1              | 0.002 | 1     | nA |  |   |
|   |           |  |                         | C, E       | -10             |       | 10    |    |  |   |
|   |           |  |                         | M          | -100            |       | 100   |    |  |   |
|   |           |  | MAX4052/A,<br>MAX4053/A | TA = +25°C | -1              | 0.002 | 1     |    |  |   |
|   |           | C, E                                   |                         | -10        |                 | 10    |       |    |  |   |
|   |           | M                                      |                         | -100       |                 | 100   |       |    |  |   |
|   |           | <b>DIGITAL I/O</b>                     |                         |            |                 |       |       |    |  |   |
|   |           | ADD, INH Input Logic<br>Threshold High | VIH                     |            | C, E, M         | 2.4   |       |    |  | V |
| ADD, INH Input Logic<br>Threshold Low       | VIL       |  | C, E, M                 |            |                 | 0.8   | V     |    |  |   |
| ADD, INH Input Current<br>Logic High or Low | IiH, IiL  | VADD, VINH = V+, 0V                    | C, E, M                 | -1         | 0.03            | 1     | μA    |    |  |   |
| <b>POWER SUPPLY</b>                         |           |  |                         |            |                 |       |       |    |  |   |
| V+ Supply Current                           | I+        | INH = ADD = 0V or V+                   | TA = +25°C              | -1         |                 | 1     | μA    |    |  |   |
|   |           |  | C, E, M                 |            |                 | 10    |       |    |  |   |

**MAX4051/A, MAX4052/A, MAX4053/A**

# Low-Voltage, CMOS Analog Multiplexers/Switches

## ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(V+ = +3.0V to +3.6V, V- = 0V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                             | SYMBOL | CONDITIONS   | MIN        | TYP<br>(Note 2) | MAX | UNITS |
|---------------------------------------|--------|--|------------|-----------------|-----|-------|
| <b>SWITCH DYNAMIC CHARACTERISTICS</b> |        |  |            |                 |     |       |
| Turn-On Time (Note 6)                 | tON    | Figure 3   | TA = +25°C | 180             | 600 | ns    |
|                                       |        |  | C, E, M    |                 | 700 |       |
| Turn-Off Time (Note 6)                | tOFF   | Figure 3   | TA = +25°C | 100             | 300 | ns    |
|                                       |        |  | C, E, M    |                 | 400 |       |
| Break-Before-Make Delay               | tOPEN  | Figure 4   | TA = +25°C | 90              |     | ns    |
| Charge Injection (Note 6)             | Q      | CL = 1nF, RS = 0Ω, VNO = 0V, Figure 5                  | TA = +25°C | 1               | 10  | pC    |
| Off-Isolation                         | VISO   | CL = 15pF, RL = 50Ω, f = 100kHz, VNO = 1VRMS, Figure 6 | TA = +25°C | <-90            |     | dB    |
| Channel-to-Channel Crosstalk          | VCT    | CL = 15pF, RL = 50Ω, f = 100kHz, VNO = 1VRMS, Figure 6 | TA = +25°C | <-90            |     | dB    |

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 3:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 4:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges; i.e., VNO = 3V to 0V and 0V to -3V.

**Note 5:** Leakage parameters are 100% tested at maximum-rated hot operating temperature, and guaranteed by correlation at TA = +25°C.

**Note 6:** Guaranteed by design, not production tested.

# Low-Voltage, CMOS Analog Multiplexers/Switches

## Typical Operating Characteristics

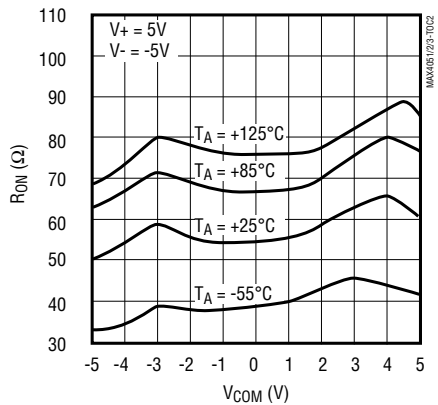
( $V_+ = +5V$ ,  $V_- = -5V$ , GND = 0V,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4051/A, MAX4052/A, MAX4053/A

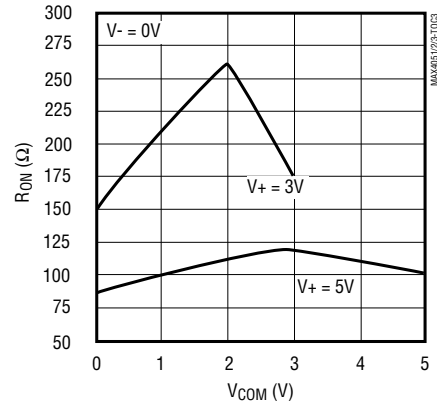
**ON-RESISTANCE vs.  $V_{COM}$  (DUAL SUPPLIES)**



**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (DUAL SUPPLIES)**



**ON-RESISTANCE vs.  $V_{COM}$  (SINGLE SUPPLY)**



**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (SINGLE SUPPLY)**



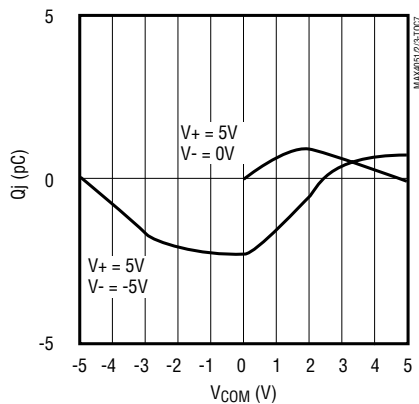
**OFF-LEAKAGE vs. TEMPERATURE**



**ON-LEAKAGE vs. TEMPERATURE**



**CHARGE INJECTION vs.  $V_{COM}$**



**SUPPLY CURRENT vs. TEMPERATURE**



# Low-Voltage, CMOS Analog Multiplexers/Switches

## Typical Operating Characteristics (continued)

(V+ = +5V, V- = -5V, GND = 0V, TA = +25°C, unless otherwise noted.)



## Pin Descriptions

| PIN                           |                      |                      | NAME      | FUNCTION   |
|-------------------------------|----------------------|----------------------|-----------|--|
| MAX4051/<br>MAX4051A          | MAX4052/<br>MAX4052A | MAX4053/<br>MAX4053A |           |  |
| 1, 2, 4, 5, 12,<br>13, 14, 15 | —                    | —                    | NO0–NO7   | Analog Switch Inputs 0–7   |
| 3                             | —                    | —                    | COM       | Analog Switch Common   |
| —                             | 1, 2, 4, 5           | —                    | NO0B–NO3B | Analog Switch “B” Inputs 0–3   |
| —                             | 3                    | 15                   | COMB      | Analog Switch “B” Common   |
| —                             | —                    | 1                    | NOB       | Analog Switch “B” Normally Open Input  |
| —                             | —                    | 2                    | NCB       | Analog Switch “B” Normally Closed Input  |
| —                             | —                    | 3                    | NOA       | Analog Switch “A” Normally Open Input  |
| —                             | —                    | 5                    | NCA       | Analog Switch “A” Normally Closed Input  |
| 6                             | 6                    | 6                    | INH       | Digital Inhibit Input. Normally connect to GND. Can be driven to logic high to set all switches off.         |
| 7                             | 7                    | 7                    | V-        | Negative Analog Supply Voltage Input. Connect to GND for single-supply operation.                            |
| 8                             | 8                    | 8                    | GND       | Ground. Connect to digital ground. (Analog signals have no ground reference; they are limited to V+ and V-.) |
| 9                             | —                    | 11                   | ADDC      | Digital Address “C” Input  |
| 10                            | 9                    | 10                   | ADDB      | Digital Address “B” Input  |
| 11                            | 10                   | 9                    | ADDA      | Digital Address “A” Input  |
| —                             | 11, 12, 14, 15       | —                    | NO0A–NO3A | Analog Switch “A” Inputs 0–3   |
| —                             | 13                   | 4                    | COMA      | Analog Switch “A” Common   |
| —                             | —                    | 12                   | NCC       | Analog Switch “C” Normally Closed Input  |
| —                             | —                    | 13                   | NOC       | Analog Switch “C” Normally Open Input  |
| —                             | —                    | 14                   | COMC      | Analog Switch “C” Common   |
| 16                            | 16                   | 16                   | V+        | Positive Analog and Digital Supply Voltage Input   |

**Note:** NO, NC, and COM pins are identical and interchangeable. Any may be considered an input or output; signals pass equally well in both directions.

# Low-Voltage, CMOS Analog Multiplexers/Switches

MAX4051/A, MAX4052/A, MAX4053/A

**Table 1. Truth Table/Switch Programming**

| INH | ADDRESS BITS |      |      | ON SWITCHES          |                         |                                    |
|-----|--------------|------|------|----------------------|-------------------------|------------------------------------|
|     | ADDC*        | ADDB | ADDA | MAX4051/<br>MAX4051A | MAX4052/<br>MAX4052A    | MAX4053/<br>MAX4053A               |
| 1   | X            | X    | X    | All switches open    | All switches open       | All switches open                  |
| 0   | 0            | 0    | 0    | COM-NO0              | COMB-NO0B,<br>COMA-NO0A | COMA-NCA,<br>COMB-NCB,<br>COMC-NCC |
| 0   | 0            | 0    | 1    | COM-NO1              | COMB-NO1B,<br>COMA-NO1A | COMA-NOA,<br>COMB-NCB,<br>COMC-NCC |
| 0   | 0            | 1    | 0    | COM-NO2              | COMB-NO2B,<br>COMA-NO2A | COMA-NCA,<br>COMB-NOB,<br>COMC-NCC |
| 0   | 0            | 1    | 1    | COM-NO3              | COMB-NO3B,<br>COMA-NO3A | COMA-NOA,<br>COMB-NOB,<br>COMC-NCC |
| 0   | 1            | 0    | 0    | COM-NO4              | COMB-NO0B,<br>COMA-NO0A | COMA-NCA,<br>COMB-NCB,<br>COMC-NOC |
| 0   | 1            | 0    | 1    | COM-NO5              | COMB-NO1B,<br>COMA-NO1A | COMA-NOA,<br>COMB-NCB,<br>COMC-NOC |
| 0   | 1            | 1    | 0    | COM-NO6              | COMB-NO2B,<br>COMA-NO2A | COMA-NCA,<br>COMB-NOB,<br>COMC-NOC |
| 0   | 1            | 1    | 1    | COM-NO7              | COMB-NO3B,<br>COMA-NO3A | COMA-NOA,<br>COMB-NOB,<br>COMC-NOC |

X = Don't care      \* ADDC not present on MAX4052.

**Note:** NO and COM pins are identical and interchangeable. Either may be considered an input or output; signals pass equally well in either direction.

## Applications Information

### Power-Supply Considerations

#### Overview

The MAX4051/MAX4052/MAX4053 and MAX4051A/MAX4052A/MAX4053A construction is typical of most CMOS analog switches. They have three supply pins: V+, V-, and GND. V+ and V- are used to drive the internal CMOS switches and set the limits of the analog voltage on any switch. Reverse ESD-protection diodes are internally connected between each analog signal pin and both V+ and V-. If any analog signal exceeds V+ or V-, one of these diodes will conduct. During normal operation, these (and other) reverse-biased ESD diodes leak, forming the only current drawn from V+ or V-.

Virtually all the analog leakage current comes from the ESD diodes. Although the ESD diodes on a given signal pin are identical, and therefore fairly well balanced, they are reverse biased differently. Each is biased by either V+ or V- and the analog signal. This means their leakages will vary as the signal varies. The *difference* in the two diode leakages to the V+ and V- pins constitutes the analog signal path leakage current. All analog leakage current flows between each pin and one of the supply terminals, not to the other switch terminal. This is why both sides of a given switch can show leakage currents of either the same or opposite polarity.

There is no connection between the analog signal paths and GND.

## Low-Voltage, CMOS Analog Multiplexers/Switches

V+ and GND power the internal logic and logic-level translators, and set both the input and output logic limits. The logic-level translators convert the logic levels into switched V+ and V- signals to drive the gates of the analog signals. This drive signal is the only connection between the logic supplies (and signals) and the analog supplies. V+ and V- have ESD-protection diodes to GND.

The logic-level thresholds are TTL/CMOS compatible when V+ is +5V. As V+ rises, the threshold increases slightly, so when V+ reaches +12V, the threshold is about 3.1V; above the TTL-guaranteed high-level minimum of 2.8V, but still compatible with CMOS outputs.

### Bipolar Supplies

These devices operate with bipolar supplies between  $\pm 3.0\text{V}$  and  $\pm 8\text{V}$ . The V+ and V- supplies need not be symmetrical, but their sum cannot exceed the absolute maximum rating of +17V.

### Single Supply

These devices operate from a single supply between +3V and +16V when V- is connected to GND. All of the bipolar precautions must be observed. At room temperature, they actually “work” with a single supply at near or below +1.7V, although as supply voltage decreases, switch on-resistance and switching times become very high.

### 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, then V-, followed by the logic inputs (NO) and by COM. If power-supply sequencing is not possible, add two small signal diodes (D1, D2) in series with the supply pins for overvoltage protection (Figure 1).

Adding diodes reduces the analog signal range to one diode drop below V+ and one diode drop above V-, but does not affect the devices' low switch resistance and low leakage characteristics. Device operation is unchanged, and the difference between V+ and V- should not exceed 17V. These protection diodes are not recommended when using a single supply if signal levels must extend to ground.



Figure 1. Overvoltage Protection Using External Blocking Diodes

### High-Frequency Performance

In  $50\Omega$  systems, signal response is reasonably flat up to 50MHz (see *Typical Operating Characteristics*). Above 20MHz, the on response has several minor peaks which are highly layout dependent. The problem is not turning the switch on, but turning it off. The off-state switch acts like a capacitor, and passes higher frequencies with less attenuation. At 10MHz, off isolation is about -45dB in  $50\Omega$  systems, becoming worse (approximately 20dB per decade) as frequency increases. Higher circuit impedances also make off isolation worse. Adjacent channel attenuation is about 3dB above that of a bare IC socket, and is entirely due to capacitive coupling.

# Low-Voltage, CMOS Analog Multiplexers/Switches

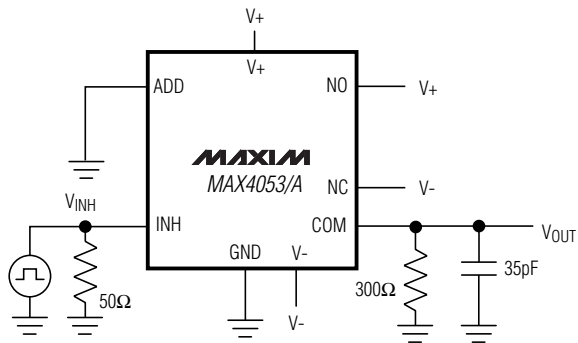
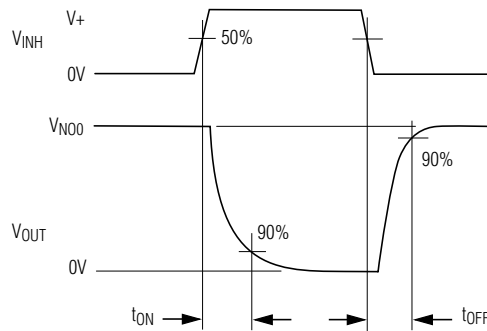
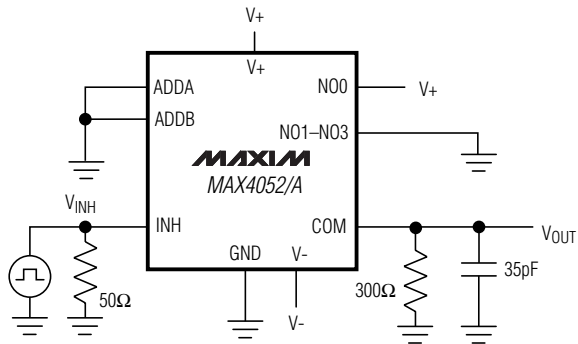
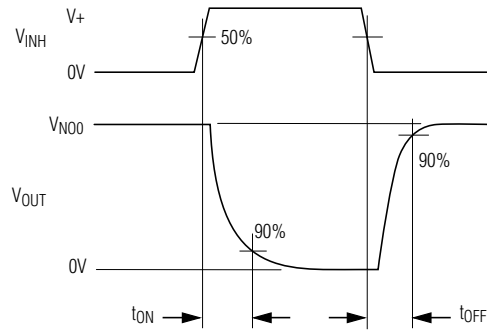
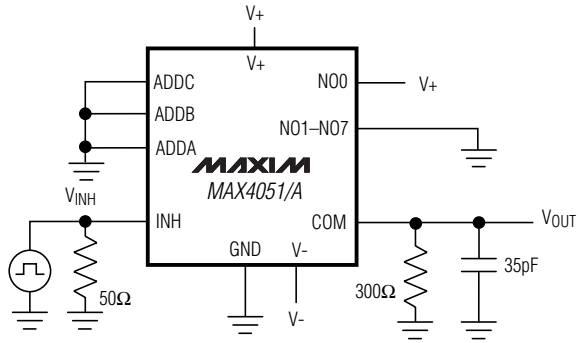
## Test Circuits/Timing Diagrams

**MAX4051/A, MAX4052/A, MAX4053/A**



Figure 2. Address Transition Time

# Low-Voltage, CMOS Analog Multiplexers/Switches



V- = 0V FOR SINGLE-SUPPLY OPERATION.  
REPEAT TEST FOR EACH SECTION.

Figure 3. Enable Switching Time

# Low-Voltage, CMOS Analog Multiplexers/Switches

MAX4051/A, MAX4052/A, MAX4053/A



Figure 4. Break-Before-Make Interval



Figure 5. Charge Injection

# Low-Voltage, CMOS Analog Multiplexers/Switches



Figure 6. Off-Isolation, On-Loss, and Crosstalk



Figure 7. NO/COM Capacitance



# Low-Voltage, CMOS Analog Multiplexers/Switches

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# Low-Voltage, CMOS Analog Multiplexers/Switches

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



SOICN LEFS



QSOP LEFS

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