# MAX4524L/MAX4525L

# Low-Voltage, Single-Supply Analog Multiplexers/Switches

## General Description

The MAX4524L/MAX4525L are low-voltage, single-supply CMOS analog switches configured as a 4-channel multi-plexer/demultiplexer (MAX4524L) and a double-pole/dou-ble-throw (DPDT) switch (MAX4525L). The MAX4524L/MAX4525L have an inhibit input to simultaneously open all switches.

These devices operate from a single supply of +2V to +12V. They are optimized for operation with a +12V sup-ply. The on-resistance is 100Ω with a +12V supply. Each switch can handle Rail-to-Rail analog signals. Off-leakage current measures only 2nA at +25°C. All digital inputs have 0.8V to 2.0V logic thresholds to ensure TTL/CMOS-logic compatibility when using a +12V supply.

## Applications

- Audio and Video Signal Routing
- Data-Acquisition Systems
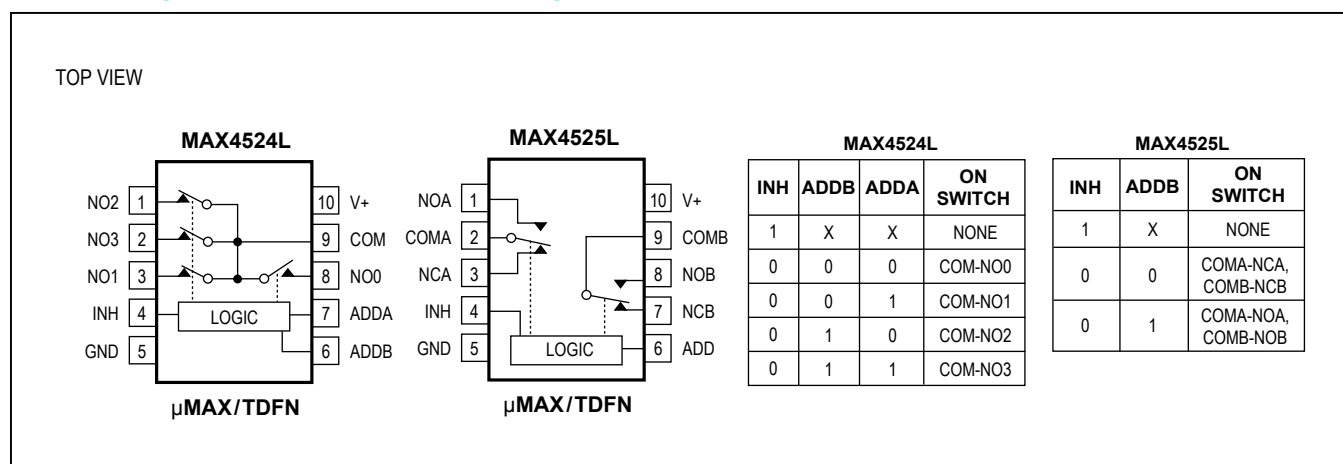    Communications Circuits
    DSL Modems

## Features

- +3V Logic-Compatible Inputs ($V_{IH}$ = 2.0V, $V_{IL}$ = 0.8V)
- +2V to +12V Supply Operation
- 100Ω On-Resistance with +12V Supply
- Guaranteed 10Ω On-Resistance Match at +12V
- Guaranteed 2nA Maximum Off-Leakage at +12V
- TTL/CMOS-Logic Compatible
- Tiny 10-Pin TDFN (3mm x 3mm) and 10-Pin μMAX Packages

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX4524**LEUB | -40°C to +85°C | 10 μMAX | — |
| MAX4524LETB | -40°C to +85°C | 10 TDFN-EP* (3mm x 3mm) | AAL |
| **MAX4525**LEUB | -40°C to +85°C | 10 μMAX | — |
| MAX4525LETB | -40°C to +85°C | 10 TDFN-EP* (3mm x 3mm) | AAM |

*EP = Exposed pad.

## Pin Configurations/Functional Diagrams/Truth Tables



**MAX4524L**

| INH | ADDB | ADDA | ON SWITCH |
|---|---|---|---|
| 1 | X | X | NONE |
| 0 | 0 | 0 | COM-NO0 |
| 0 | 0 | 1 | COM-NO1 |
| 0 | 1 | 0 | COM-NO2 |
| 0 | 1 | 1 | COM-NO3 |

**MAX4525L**

| INH | ADDB | ON SWITCH |
|---|---|---|
| 1 | X | NONE |
| 0 | 0 | COMA-NCA, COMB-NCB |
| 0 | 1 | COMA-NOA, COMB-NOB |

## Absolute Maximum Ratings

(All Voltages Referenced to GND, Unless Otherwise Noted.)

V+ .................................................................-0.3V to +13V
Voltage at Any Pin (Note 1)........................-0.3V to (V+ + 0.3V)
Continuous Current into Any Terminal.............................±20mA
Peak Current NO_, NC_ or COM_
   (pulsed at 1ms, 10% duty cycle) ................................±40mA
ESD per Method 3015.7.................................................>2000V

Continuous Power Dissipation ($T_A$ = +70°C)
   10-Pin μMAX (derate 5.6mW/°C above +70°C)..........444mW
   10-Pin TDFN (derate 24.4mW/°C above +70°C) ......1951mW
Operating Temperature Range
   MAX452_E_ _ ............................................... -40°C to +85°C
Storage Temperature Range........................... -65°C to +150°C
Junction Temperature.......................................................+150°C
Lead Temperature (soldering, 10s) ................................+300°C

**Note 1:** Voltages exceeding V+ or GND on any signal terminal 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–Single +12V Supply

(V+ = 12V ±5%, GND = 0V, $V_{IH}$ = 2.0V, $V_{IL}$ = 0.8V, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.)
(Notes 2, 3)

| PARAMETER | SYMBOL | CONDITIONS | | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| **ANALOG SWITCH** | | | | | | | | |
| Analog Signal Range | $V_{COM}$, $V_{NO\_}$ | | | -40°C to +85°C | 0 | | V+ | V |
| COM-NO/NC On-Resistance | $R_{ON}$ | V+ = 11.4V, $I_{COM}$ = 1mA, $V_{COM}$ = 10V | | +25°C | | 45 | 80 | Ω |
| | | | | -40°C to +85°C | | | 100 | |
| COM-NO/NC On-Resistance Match Between Channels | $\Delta R_{ON}$ | V+ = 11.4V, $I_{COM}$ = 1mA, $V_{COM}$ = 10V (Note 4) | | +25°C | | 2 | 10 | Ω |
| | | | | -40°C to +85°C | | | 15 | |
| COM-NO/NC On- Resistance Flatness | $R_{FLAT}$ | V+ = 11.4V, $I_{COM}$ = 1mA, $V_{COM}$ = 1.5V, 6.0V, 10V (Note 5) | | +25°C | | 5 | 12 | Ω |
| NO/NC Off-Leakage | $I_{NO(OFF)}$ $I_{NC(OFF)}$ | V+ = 12.6V, $V_{NO}$ = 1.0V, 10V, $V_{COM}$ = 10V, 1.0V (Note 6) | | +25°C | -2 | | +2 | nA |
| | | | | -40°C to +85°C | -10 | | +10 | |
| COM Off-Leakage | $I_{COM(OFF)}$ | V+ = 12.6V, $V_{NO}$ = 1V, 10V; $V_{COM}$ = 10V, 1V (Note 6) | MAX4524L | +25°C | -2 | | +2 | nA |
| | | | | -40°C to +85°C | -50 | | +50 | |
| | | | MAX4525L | +25°C | -2 | | +2 | |
| | | | | -40°C to +85°C | -25 | | +25 | |
| COM ON-Leakage | $I_{COM(ON)}$ | V+ = 12.6V, $V_{COM}$ = 10V, 1V (Note 6) | MAX4524L | +25°C | -2 | | +2 | nA |
| | | | | -40°C to +85°C | -50 | | +50 | |
| | | | MAX4525L | +25°C | -2 | | +2 | |
| | | | | -40°C to +85°C | -25 | | +25 | |
| **DIGITAL I/O (INH, ADD_)** | | | | | | | | |
| Logic-Input Threshold High | $V_{IH}$ | | | -40°C to +85°C | | 1.5 | 2.0 | V |
| Logic-Input Threshold Low | $V_{IL}$ | | | -40°C to +85°C | 0.18 | 1.5 | | V |
| Input Current High | $I_{IH}$ | $V_{ADD\_}$ = $V_{INH}$ = 2.0V | | +25°C | -1 | | +1 | μA |
| Input Current Low | $I_{IL}$ | $V_{ADD\_}$ = $V_{INH}$ = 0.8V | | +25°C | -1 | | +1 | μA |

## Electrical Characteristics (continued)

(V+ = 12V ±5%, GND = 0V, $V_{IH}$ = 2.0V, $V_{IL}$ = 0.8V, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Notes 2, 3)

| PARAMETER | SYMBOL | CONDITIONS | | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| **SWITCH DYNAMIC CHARACTERISTICS** | | | | | | | | |
| Inhibit Turn-On Time | $t_{ON}$ | $V_{NO\_}$ = 10V, $R_L$ = 300Ω, $C_L$ = 35pF, Figure 1 | | +25°C | | 90 | 150 | ns |
| | | | | -40°C to +85°C | | | 200 | |
| Inhibit Turn-Off Time | $t_{OFF}$ | $V_{NO\_}$ = 10V, $R_L$ = 300Ω, $C_L$ = 35pF, Figure 1 | | +25°C | | 40 | 120 | ns |
| | | | | -40°C to +85°C | | | 180 | |
| Address Transition Time | $t_{TRANS}$ | $V_{NO\_}$ = 10V, $R_L$ = 300Ω, $C_L$ = 35pF, Figure 2 | | +25°C | | 90 | 150 | ns |
| | | | | -40°C to +85°C | | | 200 | |
| Break-Before-Make Time | $t_{BBM}$ | $V_{NO\_}$ = 10V, $R_L$ = 300Ω, $C_L$ = 35pF, Figure 3 | | +25°C | | 20 | | ns |
| Charge Injection | Q | C = 1nF, Figure 4 (Note 7) | | +25°C | | 0.8 | | pC |
| NO/NC Off-Capacitance | $C_{NO(OFF)}$ | $V_{NO\_}$ = 0V, $f$ = 1MHz, Figure 5 | | +25°C | | 4 | | pF |
| COM Off-Capacitance | $C_{COM(OFF)}$ | $V_{NO\_}$ = 0V, $f$ = 1MHz, Figure 5 | MAX4524L | +25°C | | 14 | | pF |
| | | | MAX4525L | +25°C | | 6 | | |
| COM On-Capacitance | $C_{COM(ON)}$ | $V_{NO\_}$ = 0V, $f$ = 1MHz, Figure 5 | MAX4524L | +25°C | | 20 | | pF |
| | | | MAX4525L | +25°C | | 12 | | |
| Off-Isolation | $V_{ISO}$ | $R_L$ = 50Ω, $f$ = 1MHz, Figure 6 | | +25°C | | 92 | | dB |
| Channel-to-Channel Crosstalk (MAX4525L) | $V_{CT}$ | $R_L$ = 50Ω, $f$ = 1MHz, Figure 6 | | +25°C | | 96 | | dB |
| On-Channel -3dB Bandwidth | BW | Figure 6 | | +25°C | | 200 | | MHz |
| Total Harmonic Distortion | THD | $R_L$ = 600Ω, $V_{COM}$ = 2.5$V_{P-P}$, 20Hz to 20kHz BW | | +25°C | | 0.02 | | % |
| **POWER SUPPLY** | | | | | | | | |
| Power-Supply Range | V+ | | | -40°C to +85°C | 2 | | 12.6 | V |
| Power-Supply Current | I+ | V+ = 12.6V, $V_{ADD\_}$ = $V_{INH}$ = V+ or 0V | | +25°C | -1 | | +1 | μA |
| | | | | -40°C to +85°C | -10 | | +10 | |

**Note 2:** The TDFN package is production tested at $T_A$ = +25°C. Limits over temperature are guaranteed by design.
**Note 3:** The algebraic convention used in this data sheet is where the most negative value is a minimum column.
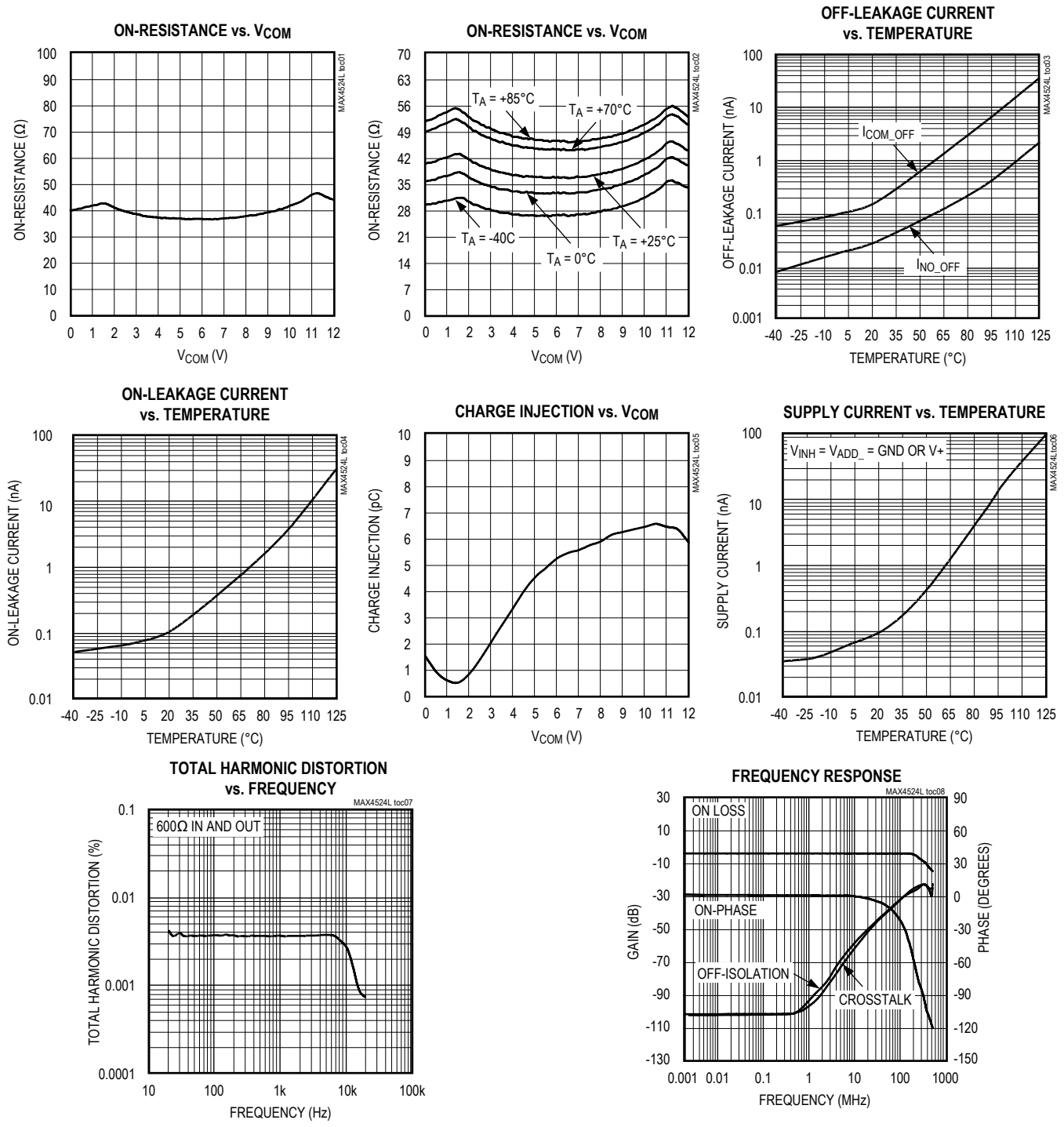**Note 4:** $\Delta R_{ON}$ = $R_{ON(MAX)}$ - $R_{ON(MIN)}$.
**Note 5:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.
**Note 6:** Leakage parameters are 100% tested at maximum-rated hot operating temperature and guaranteed by design at $T_A$ = +25°C
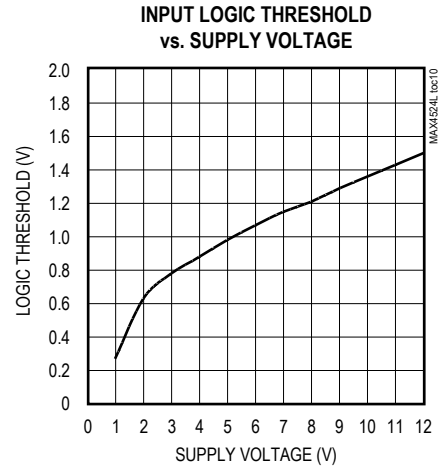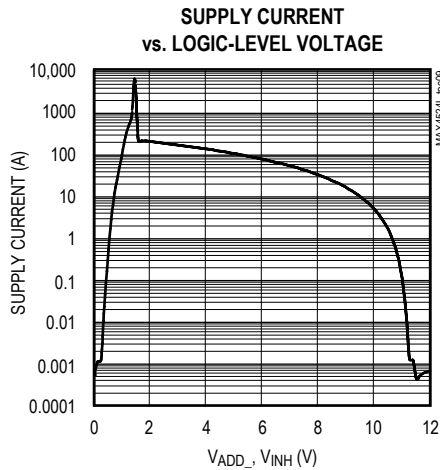**Note 7:** Guaranteed by design, not production tested.

# Typical Operating Characteristics

(V+ = 12V, $V_{INH}$ = GND, $T_A$ = +25°C, unless otherwise noted.)

**ON-RESISTANCE vs. $V_{COM}$**

**ON-RESISTANCE vs. $V_{COM}$**

**OFF-LEAKAGE CURRENT vs. TEMPERATURE**

**ON-LEAKAGE CURRENT vs. TEMPERATURE**

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

**SUPPLY CURRENT vs. TEMPERATURE**

**TOTAL HARMONIC DISTORTION vs. FREQUENCY**

**FREQUENCY RESPONSE**

## Typical Operating Characteristics (continued)

(V+ = 12V, $V_{INH}$ = GND, $T_A$ = +25°C, unless otherwise noted.)

**SUPPLY CURRENT
vs. LOGIC-LEVEL VOLTAGE**

**INPUT LOGIC THRESHOLD
vs. SUPPLY VOLTAGE**

## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| MAX4524L | MAX4525L | | |
| 1 | — | NO2 | Analog Switch Normally Open Input 2 |
| — | 1 | NOA | Analog Switch A Normally Open Input |
| 2 | — | NO3 | Analog Switch Normally Open Input 3 |
| — | 2 | COMA | Analog Switch A Common |
| 3 | — | NO1 | Analog Switch Normally Open Input 1 |
| — | 3 | NCA | Analog Switch A Normally Closed Input |
| 4 | 4 | INH | Inhibit. Drive INH low or connect to GND for normal operation. Drive INH high or connect to V+ to turn all switches off. |
| 5 | 5 | GND | Ground. Connect to digital ground (analog signals have no ground reference, but are limited to V+ and GND). |
| 6 | — | ADDB | Logic-Level  Address Input (see *Truth Tables*) |
| — | 6 | ADD | Logic-Level  Address Input (see *Truth Tables*) |
| 7 | — | ADDA | Logic-Level  Address Input (see *Truth Tables*) |
| — | 7 | NCB | Analog Switch B Normally Closed Input |
| 8 | — | NO0 | Analog Switch Normally Open Input 0 |
| — | 8 | NOB | Analog Switch B Normally Open Input |
| 9 | — | COM | Analog Switch Common |
| — | 9 | COMB | Analog Switch A Common |
| 10 | 10 | V+ | Positive Analog and Digital Supply Voltage. Bypass with a 0.1µF capacitor  to GND. |
| EP | EP | Exposed PAD | The bottom of the IC (TDFN package  only) contains an exposed pad that must be connected externally to V+. |

## Detailed Description

The MAX4524L/MAX4525L are low-voltage, single-supply CMOS analog switches that operate from a single supply of +2V to +12V. Operation with a +12V supply optimizes the performance by reducing their on-resistance to 100Ω. The MAX4524L is configured as a 4-channel multiplexer/demultiplexer and the MAX4525L is a double-pole/double-throw (DPDT) switch. These devices have an inhibit input (INH) to simultaneously open all signal paths. Each switch can handle rail-to-rail analog signals. The off-leakage current is typically only 0.1nA at +25°C and 10nA (max) over temperature. All digital inputs have 0.8V to 2.0V logic-level thresholds, ensuring TTL/CMOS-logic compatibility when using a single +12V supply.

## Applications Information

### Power-Supply Considerations

The MAX4524L/MAX4525Ls' construction is typical of most CMOS analog switches. The supply input, V+, is used to power 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 GND. If any analog signal exceeds V+ or goes below GND, one of these diodes conducts. During normal operation, these reverse-biased ESD diodes leak, forming the only current drawn from V+ or GND. 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 GND and the analog signal. This means that leakage varies as the signal varies. The difference in the two diode leakages to the V+ and GND 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. 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 GND 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.
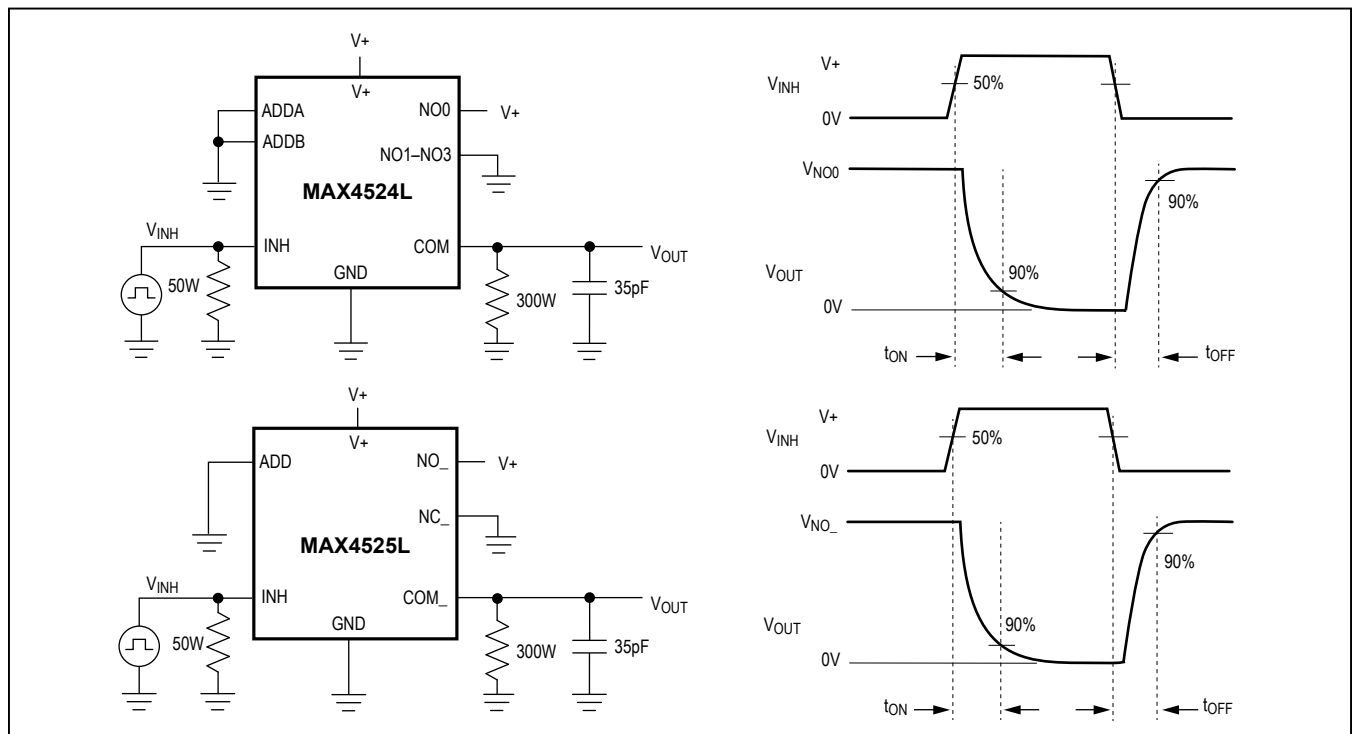
## Test Circuits/Timing Diagrams



Figure 1. Inhibit Switching Times
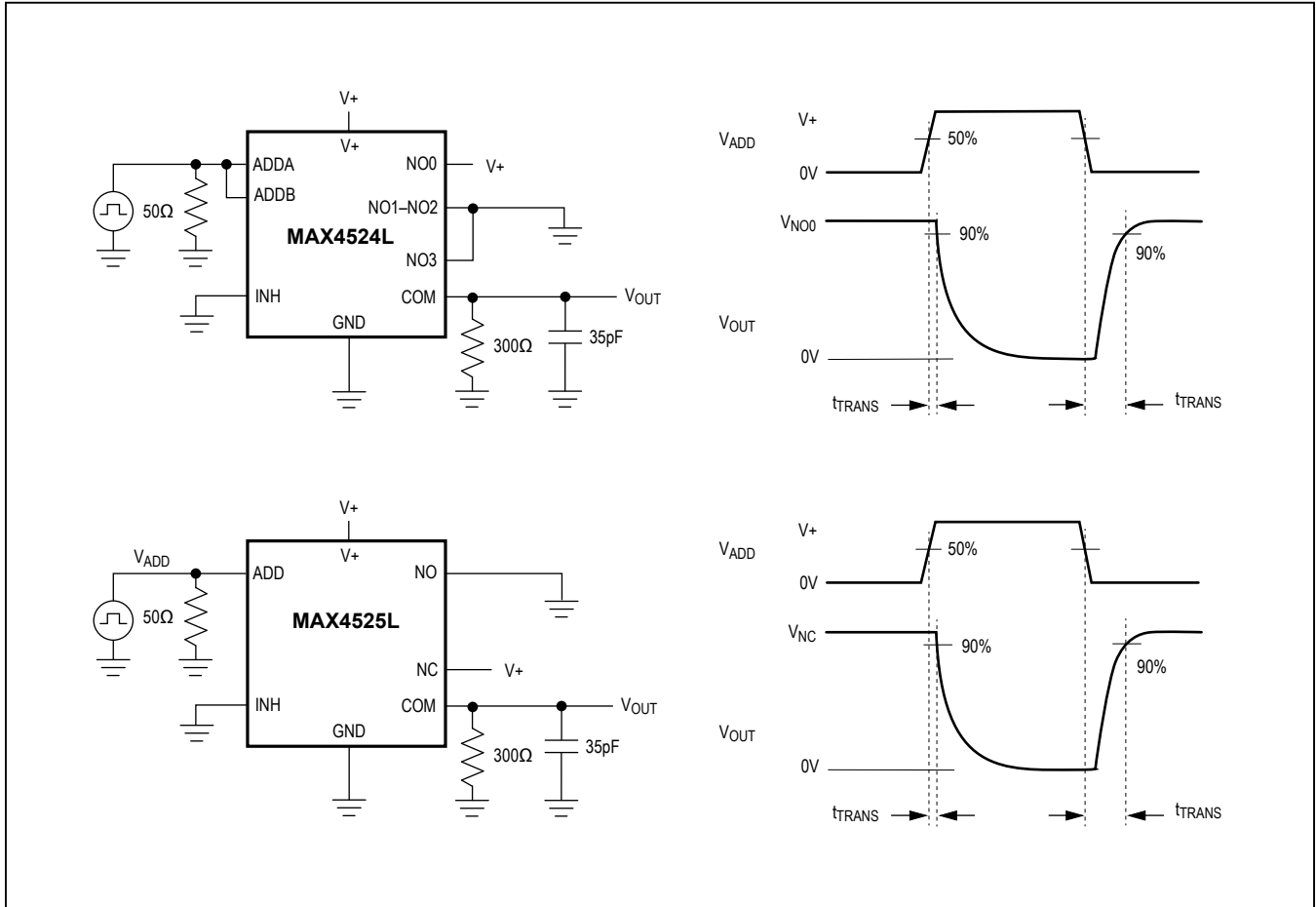
## Test Circuits/Timing Diagrams (continued)



*Figure 2. Address Transition Time*
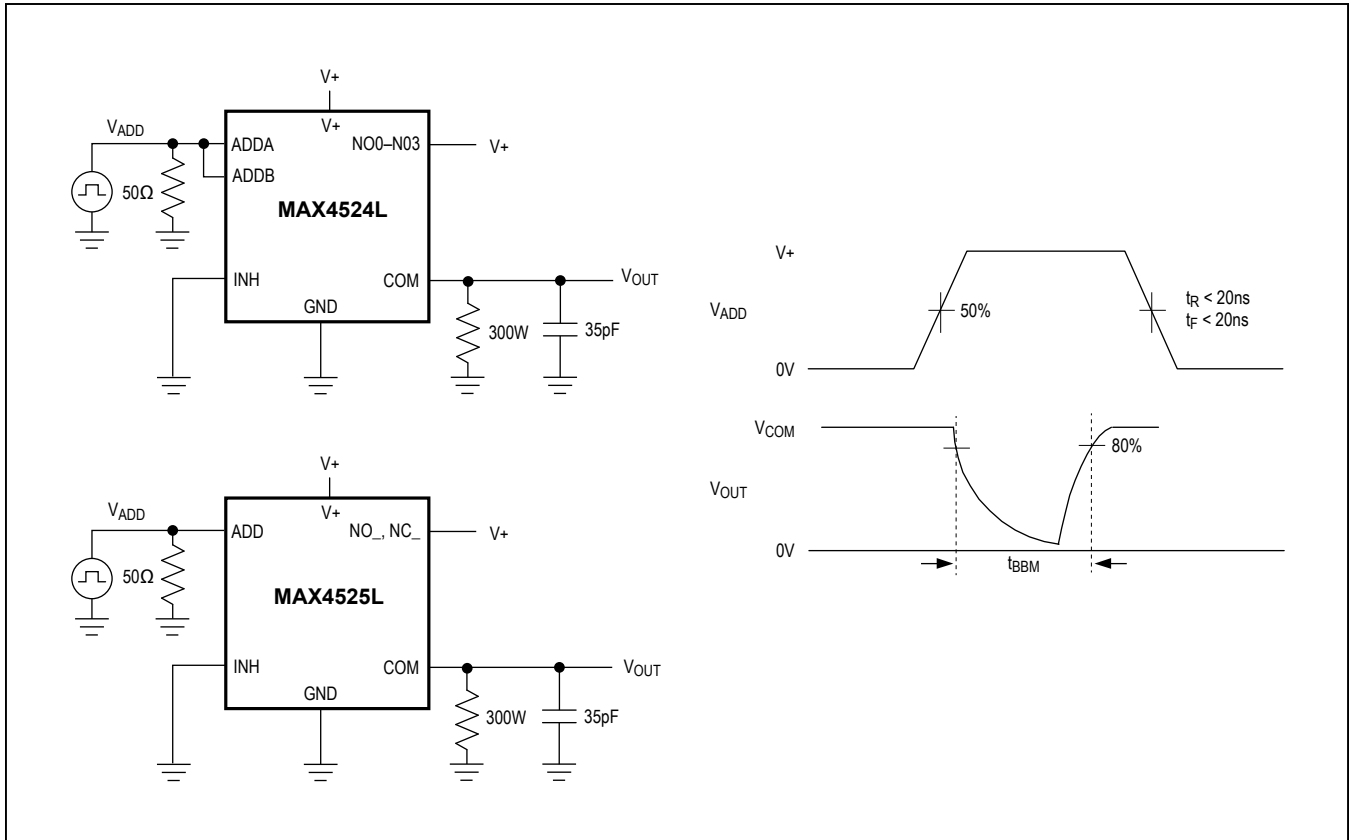
## Test Circuits/Timing Diagrams (continued)
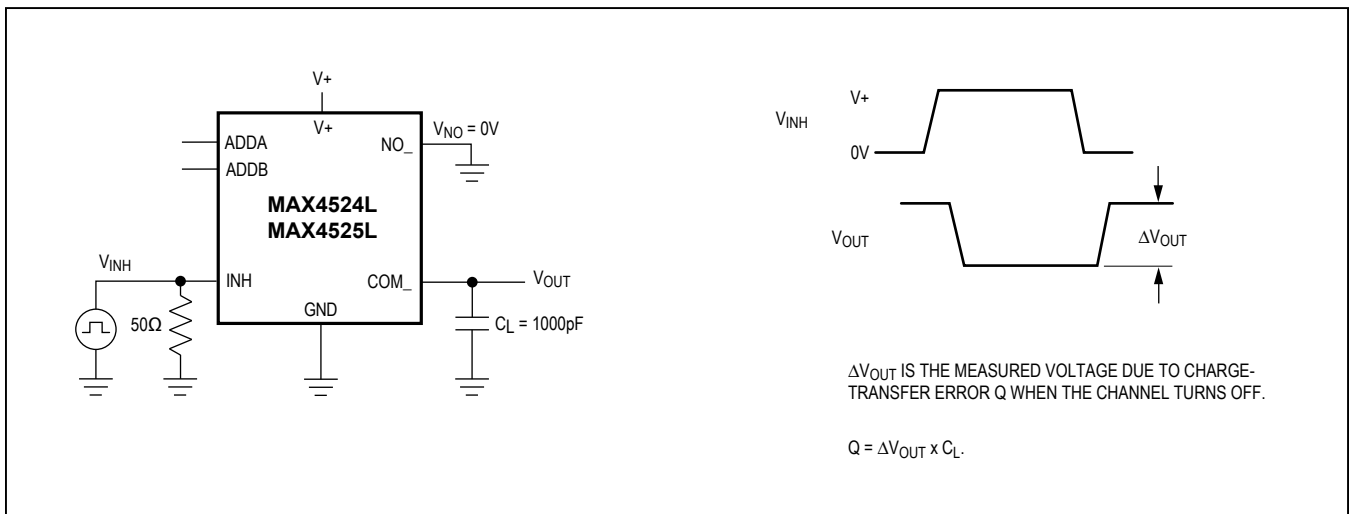


Figure 3. Break-Before-Make Interval



$\Delta V_{OUT}$ IS THE MEASURED VOLTAGE DUE TO CHARGE-
TRANSFER ERROR Q WHEN THE CHANNEL TURNS OFF.

$Q = \Delta V_{OUT} \times C_L$.

Figure 4. Charge Injection

## Test Circuits/Timing Diagrams (continued)
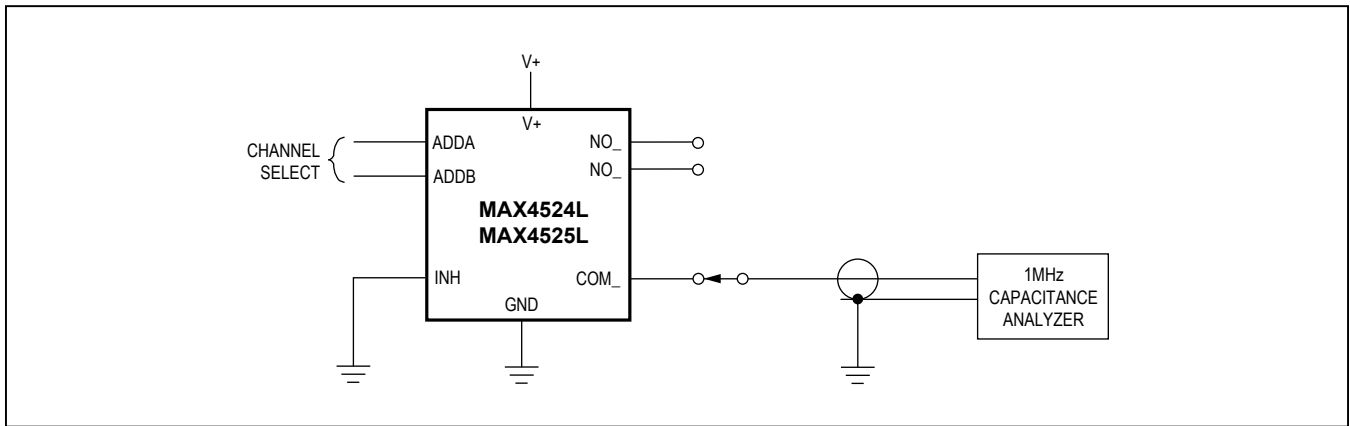


Figure 5. NO/COM Capacitance



$$OFF\text{-}ISOLATION = 20log \times \frac{V_{OUT}}{V_{IN}}$$

$$ON\text{-}LOSS = 20log \times \frac{V_{OUT}}{V_{IN}}$$

$$CROSSTALK = 20log \times \frac{V_{OUT}}{V_{IN}}$$

MEASUREMENTS ARE STANDARDIZED AGAINST SHORT AT SOCKET TERMINALS.
OFF-ISOLATION IS MEASURED BETWEEN COM AND "OFF" NO TERMINAL ON EACH SWITCH.
ON-LOSS IS MEASURED BETWEEN COM AND "ON" NO TERMINAL ON EACH SWITCH.
CROSSTALK (MAX4524L) IS MEASURED FROM ONE CHANNEL (A, B) TO OTHER CHANNEL
SIGNAL DIRECTION THROUGH SWITCH IS REVERSED; WORST VALUES ARE RECORDED.

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

## Chip Information

TRANSISTOR COUNT: 219
PROCESS: CMOS

## Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. | LAND PATTERN NO. |
|---|---|---|---|
| 10 µMAX | U10-2 | 21-0061 | Refer to **Application Note 1891** |
| 10 TDFN | T1033-1 | 21-0137 | |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 1 | 6/07 | Pages changed | 1, 5, 6, 11, 12 |
| 2 | 4/14 | Removed automotive reference in *Applications* section | 1 |

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