

Low-Voltage, High-Speed, Quad, SPST CMOS Analog Switches

MAX4614/MAX4615/ MAX4616

General Description

The MAX4614/MAX4615/MAX4616 quad, low-voltage, high-speed, single-pole/single-throw (SPST) analog switches are pin compatible with the industry-standard 74HC4066/MAX4610 analog switches. On-resistance (10Ω max) is matched between switches to 1Ω max and is flat (1Ω max) over the specified signal range. Each switch handles V+ to GND analog signal levels. Maximum off-leakage current is only 1nA at T_A = +25°C and 6nA at T_A = +85°C.

The MAX4614 has four normally open (NO) switches, and the MAX4615 has four normally closed (NC) switches. The MAX4616 has two NO switches and two NC switches. These CMOS switches operate from a single +2V to +5.5V supply. All digital inputs have +0.8V and +2.4V logic thresholds, ensuring TTL/CMOS logic compatibility when using a single +5V supply.

Applications

- Battery-Operated Equipment
- Audio/Video Signal Routing
- Low-Voltage Data-Acquisition Systems
- Sample-and-Hold Circuits
- Communication Circuits

Features

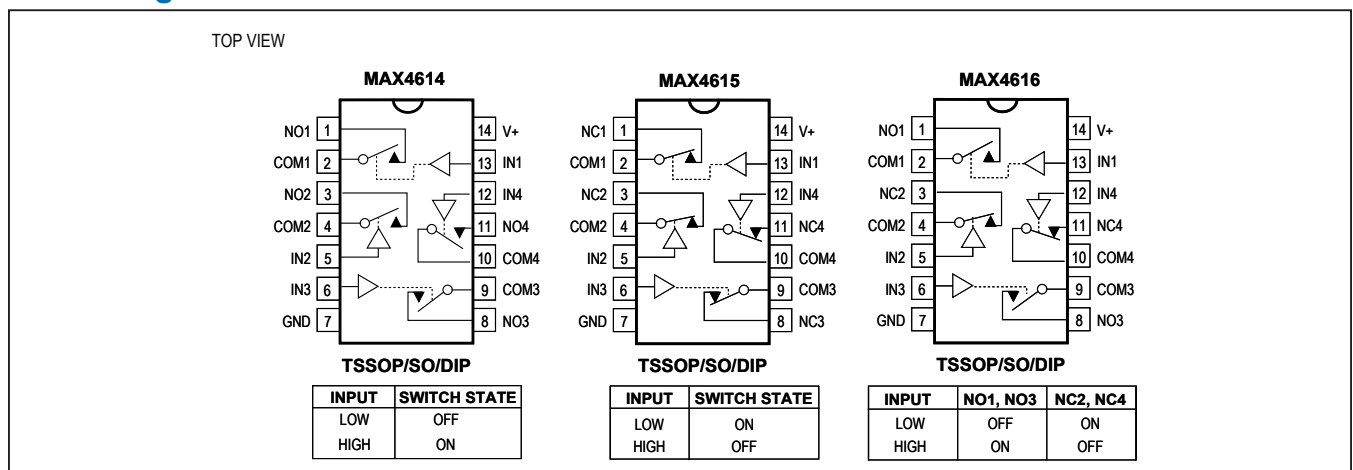
- Fast Switching Times
 - 12ns t_{ON}, 10ns t_{OFF}
- Pin Compatible with Industry-Standard 74HC4066/MAX4610
- Guaranteed On-Resistance
 - 10Ω max (+5V supply)
 - 20Ω max (+3V supply)
- Guaranteed Match Between Channels (1Ω max)
- Guaranteed Flatness Over Signal Range (1Ω max)
- <6nA Off-Leakage Current Over Temperature (T_A = +85°C)
- Rail-to-Rail® Signal Handling
- TTL/CMOS-Logic Compatible

Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|------------|----------------|----------------|
| MAX4614CUD | 0°C to +70°C | 14 TSSOP |
| MAX4614CSD | 0°C to +70°C | 14 Narrow SO |
| MAX4614CPD | 0°C to +70°C | 14 Plastic DIP |
| MAX4614EUD | -40°C to +85°C | 14 TSSOP |
| MAX4614ESD | -40°C to +85°C | 14 Narrow SO |
| MAX4614EPD | -40°C to +85°C | 14 Plastic DIP |

Ordering Information continued at end of data sheet.

Pin Configurations/Truth Tables



MAX4614/MAX4615/ MAX4616

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Absolute Maximum Ratings

(Voltages referenced to GND)

| | |
|--|-----------------------|
| V+, IN_ | -0.3V to +6V |
| COM_, NO_, NC_ (Note 1) | -0.3V to (V+ + 0.03V) |
| Continuous Current (any terminal) | ±75mA |
| Peak Current (NO_, NC_, COM_) (pulsed at 1ms, 10% duty cycle) | ±200mA |

Continuous Power Dissipation (T_A = +70°C)

| | |
|--|-----------------|
| 14-Pin TSSOP (derate 6.3mW/°C above +70°C) | 500mW |
| 14-Pin Narrow SO (derate 8.00mW/°C above +70°C) | 640mW |
| 14-Pin Plastic DIP (derate 10.00mW/°C above +70°C) | 800mW |
| Operating Temperature Ranges | |
| MAX461_C_ | 0°C to +70°C |
| MAX461_E_ | -40°C to +85°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature (soldering, 10sec) | +300°C |

Note 1: Signals on NO_, NC_, or COM_ exceeding V+ or GND 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 +5V Supply

(V+ = +5V ±10%, V_{IN_H} = 2.4V, V_{IN_L} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|--|---|---|---|-----|------|-------|----|
| ANALOG SWITCH | | | | | | | |
| Analog Signal Range (Note 3) | V _{COM_} , V _{NO_} , V _{NC_} | | 0 | | V+ | V | |
| On-Resistance | R _{ON} | V+ = 4.5V, I _{COM_} = 10mA, V _{NO_} = V _{NC_} = 3V | T _A = +25°C | 8 | 10 | Ω | |
| | | | T _A = T _{MIN} to T _{MAX} | | 13 | | |
| On-Resistance Match Between Channels (Note 4) | ΔR _{ON} | V+ = 4.5V, I _{COM_} = 10mA, V _{NO_} = V _{NC_} = 3V | T _A = +25°C | 0.2 | 1 | Ω | |
| | | | T _A = T _{MIN} to T _{MAX} | | 1.2 | | |
| On-Resistance Flatness (Note 5) | R _{FLAT(ON)} | V+ = 4.5V; I _{COM_} = 10mA; V _{NO_} = V _{NC_} = 3V, 2V, 1V | T _A = +25°C | 0.3 | 1 | Ω | |
| | | | T _A = T _{MIN} to T _{MAX} | | 1.2 | | |
| NO_ or NC_ Off-Leakage Current (Note 6) | I _{NO(OFF)} | V+ = 5.5V; V _{COM_} = 1V, 4.5V; V _{NO_} = 4.5V, 1V | T _A = +25°C | -1 | 0.01 | 1 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -6 | | 6 | |
| COM_ Off-Leakage Current (Note 6) | I _{COM(OFF)} | V+ = 5.5V; V _{COM_} = 1V, 4.5V; V _{NO_} = V _{NC_} = 4.5V, 1V | T _A = +25°C | -1 | 0.01 | 1 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -6 | | 6 | |
| COM_ On-Leakage Current (Note 6) | I _{COM(ON)} | V+ = 5.5V; V _{COM_} = 1V, 4.5V; V _{NO_} = V _{NC_} = 1V, 4.5V, or floating | T _A = +25°C | -2 | 0.02 | 2 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -12 | | 12 | |

Electrical Characteristics—Single +5V Supply (continued)

(V+ = +5V ±10%, V_{IN_H} = 2.4V, V_{IN_L} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------------|-----------------------|---|---|-------|-----|-------|
| LOGIC INPUT | | | | | | |
| Input Current with Input Voltage High | I _{IN_H} | V _{IN_} = 2.4V | -10 | 0.3 | 10 | nA |
| Input Current with Input Voltage Low | I _{IN_L} | V _{IN_} = 0.8V | -10 | 0.3 | 10 | nA |
| Input Voltage High | V _{IN_H} | | 2.4 | | | V |
| Input Voltage Low | V _{IN_L} | | | | 0.8 | V |
| SWITCH DYNAMIC | | | | | | |
| Turn-On Time (Note 3) | t _{ON} | V _{COM_} = 3V, Figure 2 | T _A = +25°C | 5 | 12 | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | |
| Turn-Off Time (Note 3) | t _{OFF} | V _{COM_} = 3V, Figure 2 | T _A = +25°C | 2.5 | 10 | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | |
| On-Channel Bandwidth | BW | Signal = 0dBm, Figure 4, 50Ω in and out, T _A = +25°C | | 70 | | MHz |
| Charge Injection | Q | Signal = 0dBm, Figure 4, 50Ω in and out, T _A = +25°C | | 6.5 | | pC |
| Off-Isolation (Note 7) | V _{ISO} | R _L = 50Ω, f = 100kHz, Figure 4, T _A = +25°C | | -85 | | dB |
| Crosstalk (Note 8) | V _{CT} | R _L = 50Ω, f = 100kHz, Figure 5, T _A = +25°C | | -96 | | dB |
| NO_ or NC_ Capacitance | C _(OFF) | f = 1MHz, Figure 6, T _A = +25°C | | 5 | | pF |
| COM_ Off-Capacitance | C _{COM(OFF)} | f = 1MHz, Figure 6, T _A = +25°C | | 5 | | pF |
| COM_ On-Capacitance | C _{COM(ON)} | f = 1MHz, Figure 6, T _A = +25°C | | 11 | | pF |
| Total Harmonic Distortion | THD | 600Ω IN and OUT, f = 20Hz to 20kHz, 2V _{P-P} , T _A = +25°C | | 0.034 | | % |
| POWER SUPPLY | | | | | | |
| Power-Supply Range | | | 2 | | 5.5 | V |
| Power-Supply Current | I+ | V _{IN} = 0 or V+, all switches on or off | -1 | 0.001 | 1 | μA |

Electrical Characteristics—Single +3.3V Supply

(V+ = +3.3V ±10%, V_{IN_H} = 2.4V, V_{IN_L} = 0.5V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|---|---|---|---|-------|-------|-------|----|
| ANALOG SWITCH | | | | | | | |
| Analog Signal Range (Note 3) | V _{COM_} , V _{NO_} , V _{NC_} | | 0 | | V+ | V | |
| On-Resistance | R _{ON} | V+ = 3V, I _{NO} = 10mA, V _{COM_} = 1.5V | T _A = +25°C | 8 | 20 | Ω | |
| | | | T _A = T _{MIN} to T _{MAX} | | 25 | | |
| On-Resistance Match Between Channels (Note 4) | ΔR _{ON} | V+ = 3V, I _{COM_} = 1mA, V _{NO_} = V _{NC_} = 1.5V | T _A = +25°C | 0.5 | 1.5 | Ω | |
| | | | T _A = T _{MIN} to T _{MAX} | | 2 | | |
| NO_ or NC_ Off-Leakage Current (Notes 3, 6) | I _{NO(OFF)} | V+ = 3.6V; V _{COM_} = 1V, 3V; V _{NO_} = V _{NC_} = 3V, 1V | T _A = +25°C | -1 | 0.002 | 1 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -10 | | 10 | |
| COM_ Off-Leakage Current (Notes 3, 6) | I _{COM(OFF)} | V+ = 3.6V; V _{COM_} = 1V, 3V; V _{NO_} = V _{NC_} = 3V, 1V | T _A = +25°C | -1 | 0.002 | 1 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -10 | | 10 | |
| COM_ On-Leakage Current (Notes 3, 6) | I _{COM(ON)} | V+ = 3.6V; V _{COM_} = 1V, 3V; V _{NO_} = V _{NC_} = 1V, 3V, or floating | T _A = +25°C | -1 | 0.002 | 1 | nA |
| | | | T _A = T _{MIN} to T _{MAX} | -10 | | 10 | |
| LOGIC INPUT | | | | | | | |
| Input Current with Input Voltage High | I _{IN_H} | V _{IN_} = 2V | -10 | 0.003 | 10 | nA | |
| Input Current with Input Voltage Low | I _{IN_L} | V _{IN_} = 0.8V | -10 | 0.003 | 10 | nA | |
| Input Voltage High | V _{IN_H} | | 2.0 | | | V | |
| Input Voltage Low | V _{IN_L} | | | | 0.8 | V | |
| SWITCH DYNAMIC (Note 3) | | | | | | | |
| Turn-On Time | t _{ON} | V _{COM_} = 1.5V, Figure 2 | T _A = +25°C | | 6 | 15 | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | 20 | |
| Turn-Off Time | t _{OFF} | V _{COM_} = 1.5V, Figure 2 | T _A = +25°C | | 4 | 12 | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | 15 | |
| Charge Injection | Q | C _L = 1nF, V _{GEN} = 0, R _{GEN} = 0, T _A = +25°C | | 6.5 | | pC | |
| POWER SUPPLY | | | | | | | |
| Power-Supply Current | I+ | V+ = 3.6V, V _{IN} = 0 or V+, all channels on or off | -1 | 0.001 | 1 | μA | |

Electrical Characteristics—Single +2.5V Supply

(V+ = +2.5V, VINH = 0.7VCC, VINL = 0.5V, TA = TMIN to TMAX, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|-------------------------------------|-------------------------|--|-------------------|-----|-----|-----|-------|
| ANALOG SWITCH | | | | | | | |
| Analog Signal Range (Note 3) | VCOM_, VNO_, VNC_ | | | 0 | | V+ | V |
| COM_ to NO_ or NC_ On-Resistance | RON | V+ = 2.5V, ICOM_ = 10mA, VNO_ = 1.2V | TA = +25°C | | 30 | 60 | Ω |
| | | | TA = TMIN to TMAX | | | 100 | |
| SWITCH DYNAMIC (Note 3) | | | | | | | |
| Turn-On Time | tON | VNO_ or VNC_ = 1V, TA = +25°C | | | 6.5 | | ns |
| Turn-Off Time | tOFF | VNO_ or VNC_ = 1V, TA = +25°C | | | 2.8 | | ns |

Note 2: 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: $\Delta R_{ON} = R_{ON}(\text{max}) - R_{ON}(\text{min})$.

Note 5: Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

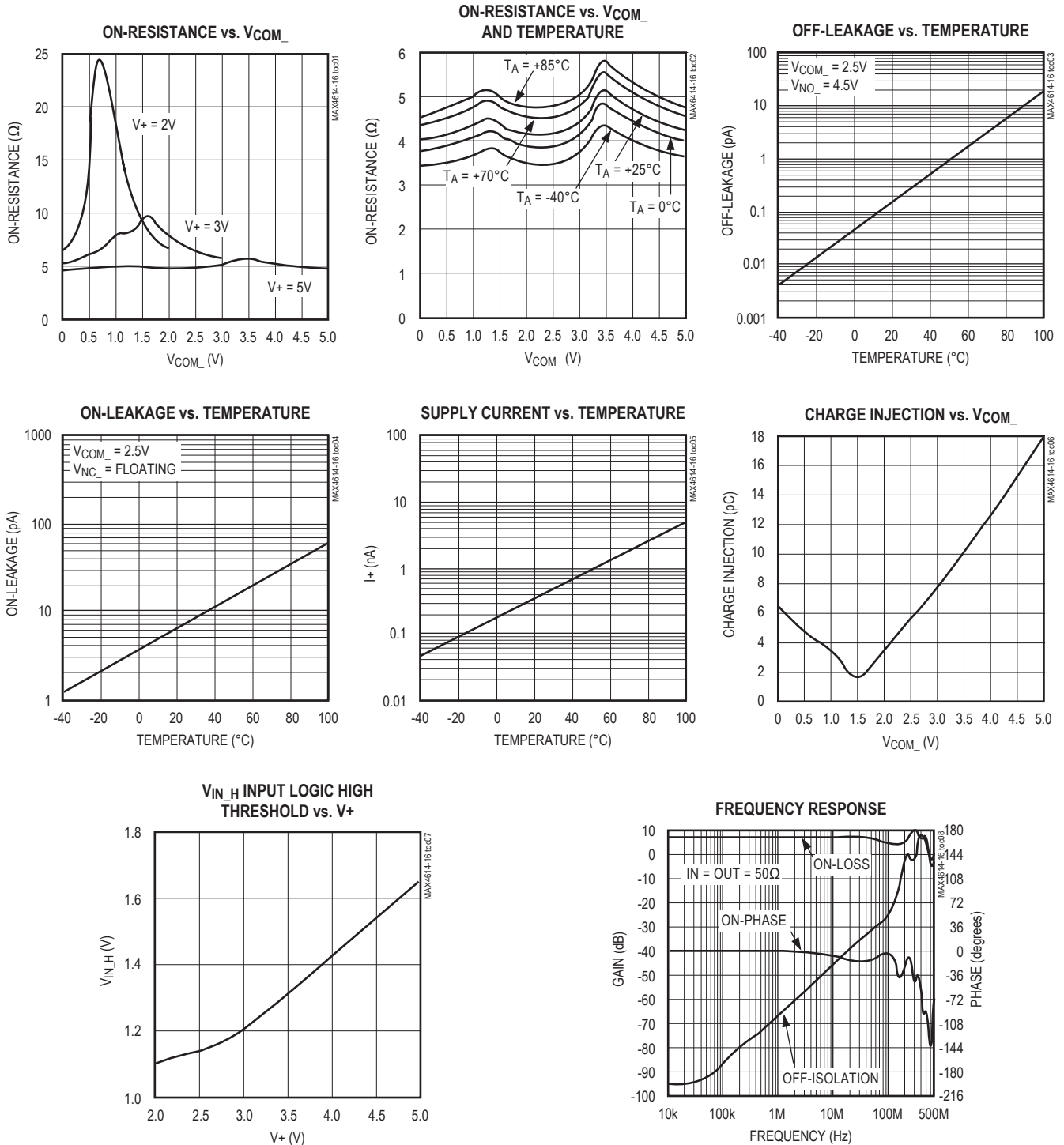
Note 6: Leakage parameters are 100% tested at maximum-rated hot temperature and guaranteed by correlation at +25°C.

Note 7: Off-Isolation = $20\log_{10}(V_{COM_} / V_{NO_})$, VCOM_ = output, VNO_ = input to off switch.

Note 8: Between any two switches.

Typical Operating Characteristics

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

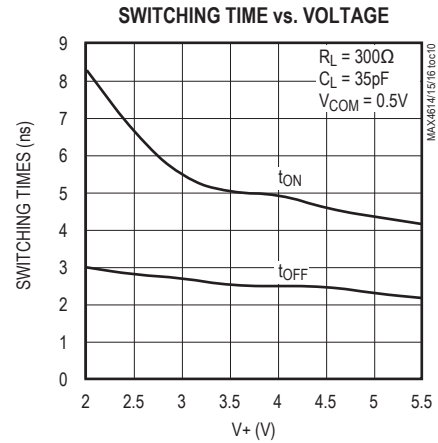
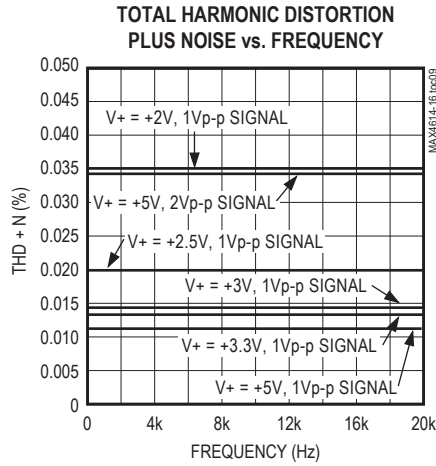


MAX4614/MAX4615/ MAX4616

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Typical Operating Characteristics (continued)

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



Pin Description

| PIN | | | NAME | FUNCTION |
|--------------|--------------|--------------|-----------|--|
| MAX4614 | MAX4615 | MAX4616 | | |
| 1, 3, 8 | — | 1, 8 | NO1–NO3 | Analog Switch Normally Open Terminal (bidirectional) |
| — | 1, 3, 8 | — | NC1–NC3 | Analog Switch Normally Closed Terminal (bidirectional) |
| — | — | 3 | NC2 | Analog Switch Normally Closed Terminal (bidirectional) |
| 2, 4, 9, 10 | 2, 4, 9, 10 | 2, 4, 9, 10 | COM1–COM4 | Analog Switch Common Terminal (bidirectional) |
| 5, 6, 12, 13 | 5, 6, 12, 13 | 5, 6, 12, 13 | IN1–IN4 | Logic Control Inputs |
| 7 | 7 | 7 | GND | Ground |
| — | 11 | 11 | NC4 | Analog Switch Normally Closed Terminal (bidirectional) |
| 11 | — | — | NO4 | Analog Switch Normally Open Terminal (bidirectional) |
| 14 | 14 | 14 | V+ | Positive Supply Voltage |

Applications Information

**Power-Supply Sequencing and
Overvoltage Protection**

Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices.

Proper power-supply sequencing is recommended for all CMOS devices. Always apply V+ before applying analog signals or logic inputs, especially if the analog or logic signals are not current limited. If this sequencing is not possible, and if the analog or logic inputs are not current limited to 20mA, add a small-signal diode (D1) as shown in Figure 1. If the analog signal can dip below GND, add D2. Adding protection diodes reduces the analog signal range to a diode drop (about 0.7V) below V+ (for D1), and to a diode drop above ground (for D2). Leakage is unaffected by adding the diodes. On-resistance increases by a small amount at low supply voltages. Maximum supply voltage (V+) must not exceed 6V.

Adding protection diodes causes the logic thresholds to be shifted relative to the power-supply rails. This can be significant when low supply voltages (+5V or less) are used. With a +5V supply, TTL compatibility is not guaranteed when protection diodes are added. Driving IN1 and IN2 all the way to the supply rails (i.e., to a

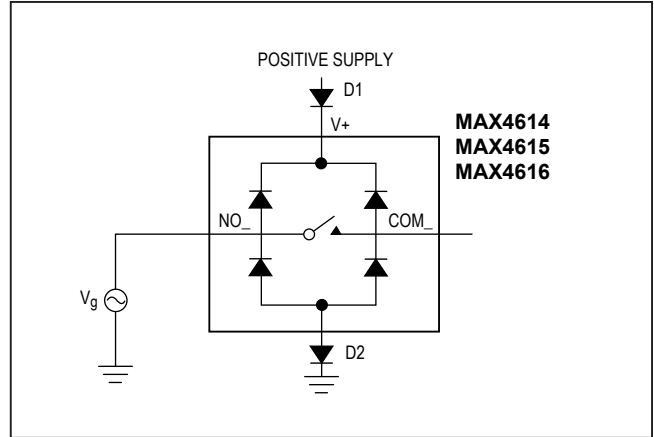


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

diode drop higher than the V+ pin, or to a diode drop lower than the GND pin) is always acceptable.

Protection diodes D1 and D2 also protect against some overvoltage situations. With Figure 1's circuit, if the supply voltage is below the absolute maximum rating, and if a fault voltage up to the absolute maximum rating is applied to an analog signal pin, no damage will result.

Test Circuits/Timing Diagrams

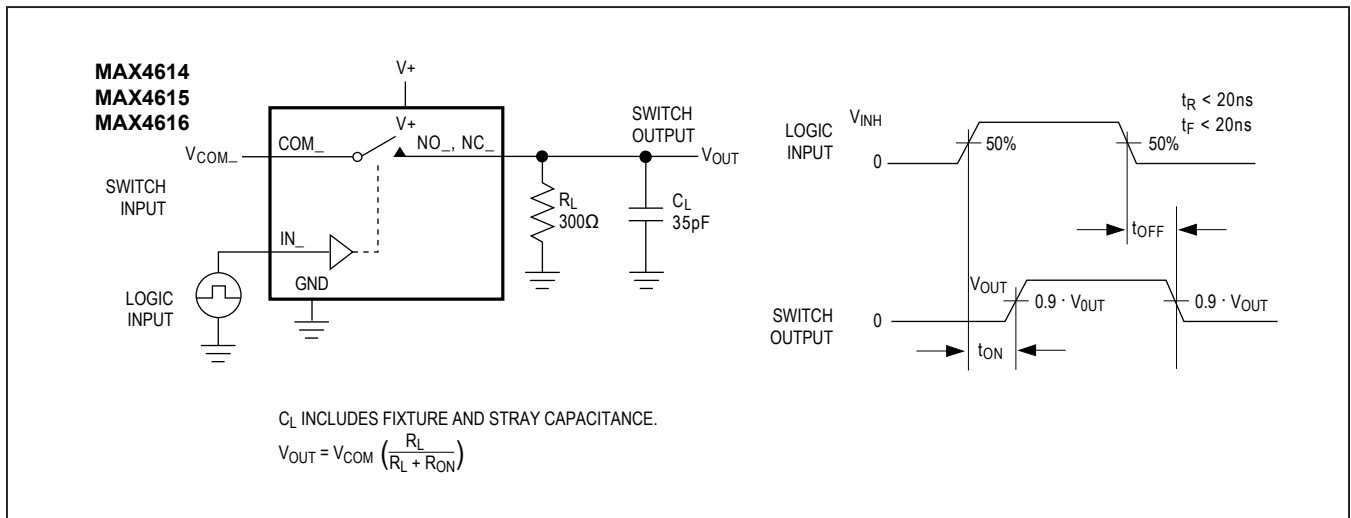


Figure 2. Switching Time

Test Circuits/Timing Diagrams (continued)

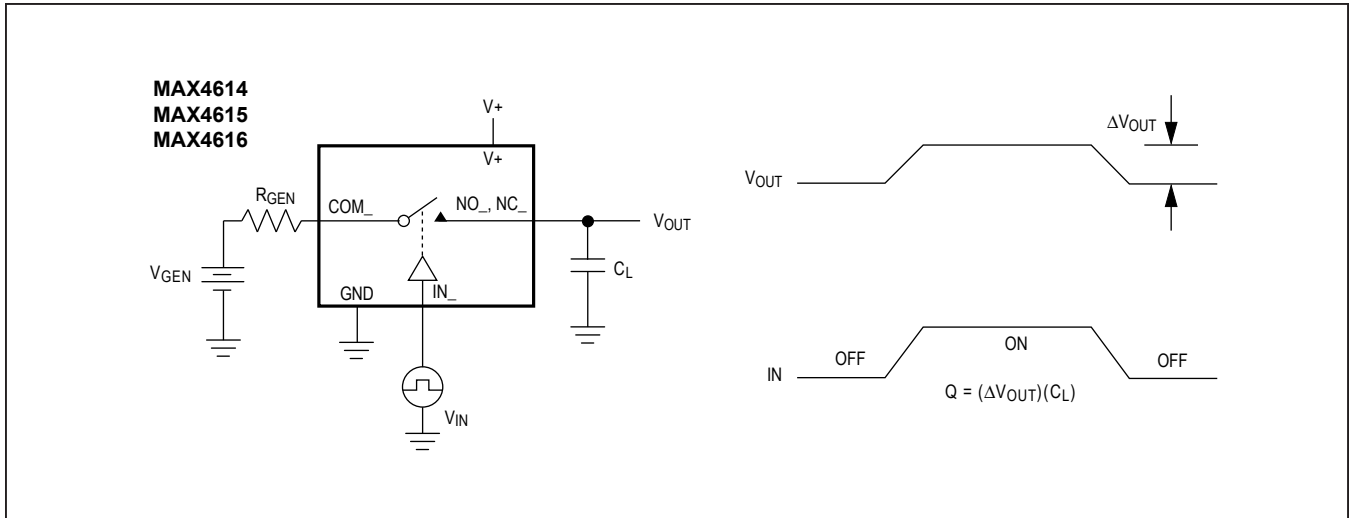


Figure 3. Charge Injection

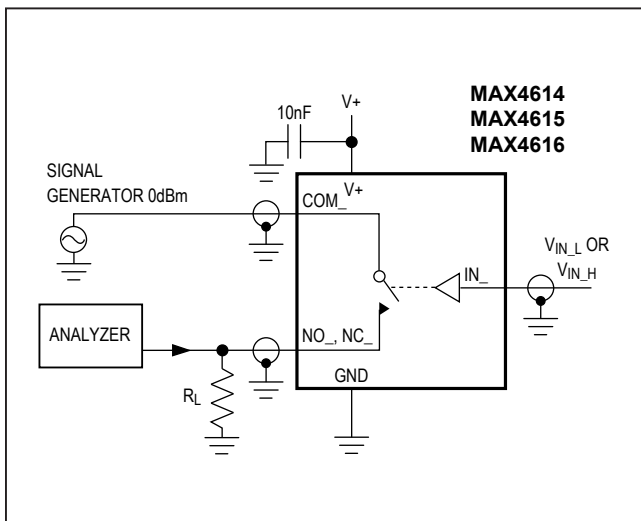


Figure 4. Off-Isolation/On-Channel Bandwidth

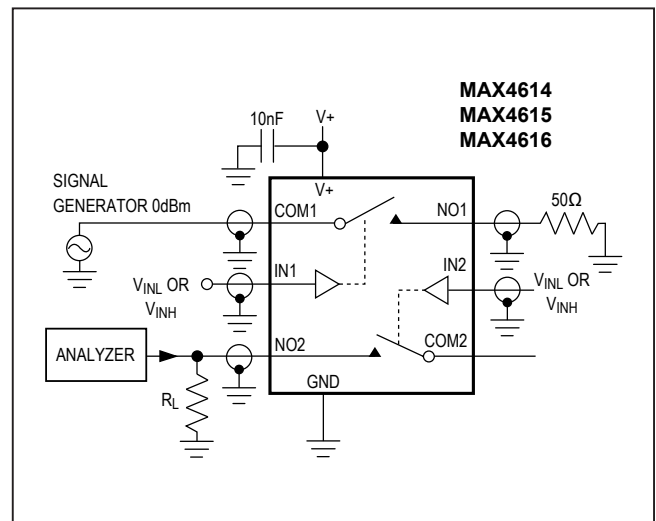


Figure 5. Crosstalk

MAX4614/MAX4615/ MAX4616

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Test Circuits/Timing Diagrams (continued)

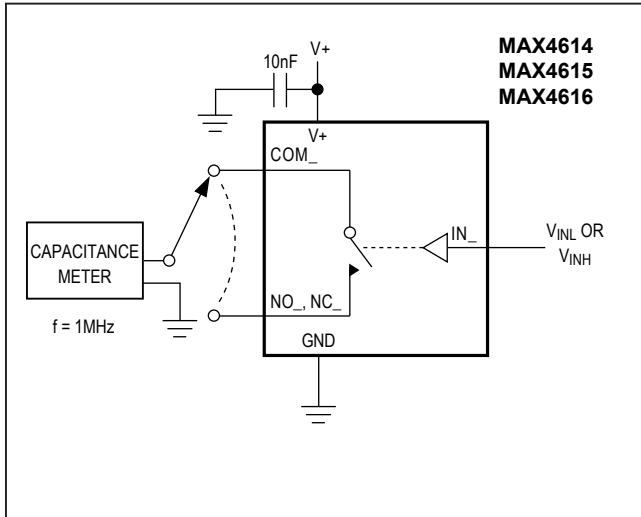


Figure 6. Channel Off/On-Capacitance

Ordering Information (continued)

| PART | TEMP. RANGE | PIN-PACKAGE |
|--------------------|----------------|----------------|
| MAX4615 CUD | 0°C to +70°C | 14 TSSOP |
| MAX4615CSD | 0°C to +70°C | 14 Narrow SO |
| MAX4615CPD | 0°C to +70°C | 14 Plastic DIP |
| MAX4615EUD | -40°C to +85°C | 14 TSSOP |
| MAX4615ESD | -40°C to +85°C | 14 Narrow SO |
| MAX4615EPD | -40°C to +85°C | 14 Plastic DIP |
| MAX4616 CUD | 0°C to +70°C | 14 TSSOP |
| MAX4616CSD | 0°C to +70°C | 14 Narrow SO |
| MAX4616CPD | 0°C to +70°C | 14 Plastic DIP |
| MAX4616EUD | -40°C to +85°C | 14 TSSOP |
| MAX4616ESD | -40°C to +85°C | 14 Narrow SO |
| MAX4616EPD | -40°C to +85°C | 14 Plastic DIP |

Chip Information

TRANSISTOR COUNT: 89

MAX4614/MAX4615/ MAX4616

Low-Voltage, High-Speed, Quad, SPST CMOS Analog Switches

Package Information


| SYMBOL | COMMON DIMENSIONS | | | |
|----------------|-------------------|------|----------------|------|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | — | 1.10 | .043 | |
| A ₁ | 0.05 | 0.15 | .002 | .006 |
| A ₂ | 0.85 | 0.95 | .033 | .037 |
| b | 0.19 | 0.30 | .007 | .012 |
| b ₁ | 0.19 | 0.25 | .007 | .010 |
| c | 0.09 | 0.20 | .004 | .008 |
| c ₁ | 0.09 | 0.14 | .004 | .006 |
| D | SEE VARIATIONS | | SEE VARIATIONS | |
| E | 4.30 | 4.50 | .169 | .177 |
| e | 0.65 BSC | | .026 BSC | |
| H | 6.25 | 6.55 | .246 | .258 |
| L | 0.50 | 0.70 | .020 | .028 |
| N | SEE VARIATIONS | | SEE VARIATIONS | |
| α | 0° | 8° | 0° | 8° |
| bbb | 0.10 MAX | | | |

| JEDEC MD-153 | N | SYMBOL | PKG. CODES | VARIATIONS | | | |
|-----------------|----|--------|--|-------------|------|--------|------|
| | | | | MILLIMETERS | | INCHES | |
| | | | | MIN. | MAX. | MIN. | MAX. |
| AB-1 | 14 | D | U14+1, U14+2, U14+3, U14M+1 U14+4, U14+5C | 4.90 | 5.10 | .193 | .201 |
| AB | 16 | D | U16+1, U16+2, U16+1F, U16M+1 U16+5 | 4.90 | 5.10 | .193 | .201 |
| AC | 20 | D | U20+1, U20+2, U20+3, U20+5, U20+1F, U20M+2 U20+7C | 6.40 | 6.60 | .252 | .260 |
| AD | 24 | D | U24+1, U24+2 | 7.70 | 7.90 | .303 | .311 |
| AE | 28 | D | U28+1, U28+2, U28+3 | 9.60 | 9.80 | .378 | .386 |

NOTES

- DIMENSIONS D AND E DO NOT INCLUDE FLASH
- MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
- CONTROLLING DIMENSION: MILLIMETER
- MEETS JEDEC OUTLINE MD-153. SEE JEDEC VARIATIONS TABLE
- "N" REFERS TO NUMBER OF LEADS
- LEAD COPLANARITY 0.10 MM MAX.
- NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY
- MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY
- BENT LEAD 0.10 MM MAX.
- MATERIAL MUST COMPLY WITH BANNED AND RESTRICTED SUBSTANCES SPEC # 10-0131.
- ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND PBFREE (+) PKG. CODES.

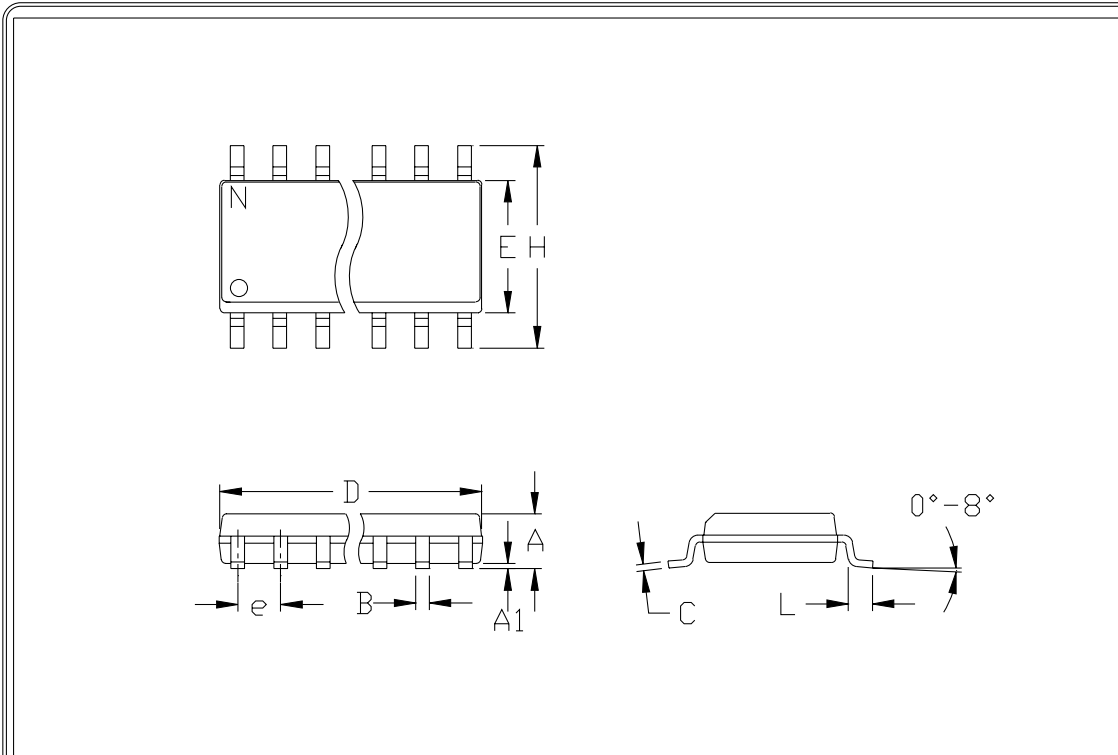
—DRAWING NOT TO SCALE—



TITLE:
PACKAGE OUTLINE,
TSSOP 4.40mm BODY

| | | | |
|----------|---------------------------------|-----------|-----|
| APPROVAL | DOCUMENT CONTROL NO. 21-0066 | REV. P | 1/1 |
|----------|---------------------------------|-----------|-----|

Package Information (continued)



SOIC .150

| | INCHES | | MILLIMETERS | |
|----|--------|-------|-------------|------|
| | MIN | MAX | MIN | MAX |
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| e | 0.050 | | 1.27 | |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
| H | 0.228 | 0.244 | 5.80 | 6.20 |
| h | 0.010 | 0.020 | 0.25 | 0.50 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |

| | INCHES | | MILLIMETERS | | N | MS012 |
|---|--------|-------|-------------|-------|----|-------|
| | MIN | MAX | MIN | MAX | | |
| D | 0.189 | 0.197 | 4.80 | 5.00 | 8 | A |
| D | 0.337 | 0.344 | 8.55 | 8.75 | 14 | B |
| D | 0.386 | 0.394 | 9.80 | 10.00 | 16 | C |

NOTES:

1. D & E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0 | 7/99 | Initial release | — |
| 1 | 12/21 | Updated <i>Package Information</i> diagram | 11 |



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