



Precision, Quad, SPST Analog Switches

General Description

The MAX351/MAX352/MAX353 are precision, quad, single-pole single-throw (SPST) analog switches. The MAX351 has four normally closed (NC), and the MAX352 has four normally open (NO) switches. The MAX353 has two NO and two NC switches. All three parts offer low on resistance (less than 35Ω), guaranteed to match within 2Ω between channels and to remain flat over the analog signal range ($\Delta 3\Omega$ max). They also offer low leakage (less than 250pA at +25°C and less than 6nA at +85°C) and fast switching (turn-on time less than 175ns and turn-off time less than 145ns).

The MAX351/MAX352/MAX353 are fabricated with Maxim's new improved 44V silicon-gate process. Design improvements guarantee extremely low charge injection (10pC), low power consumption (35µW), and electrostatic discharge (ESD) greater than 2000V. The 44V maximum breakdown voltage allows rail-to-rail analog signal handling.

These monolithic switches operate with a single positive supply (+10V to +30V) or with split supplies ($\pm 4.5V$ to $\pm 20V$) while retaining CMOS-logic input compatibility and fast switching. CMOS inputs provide reduced input loading.

Applications

| | |
|------------------------------|--------------------------|
| Sample-and-Hold Circuits | Military Radios |
| Guidance and Control Systems | Communications Systems |
| Heads-Up Displays | Battery-Operated Systems |
| Test Equipment | PBX, PABX |

Features

- ◆ Low On Resistance < 22Ω Typical (35Ω Max)
- ◆ Guaranteed Matched On Resistance Between Channels < 2Ω
- ◆ Guaranteed Flat On Resistance Over Analog Signal Range $\Delta 3\Omega$ Max
- ◆ Guaranteed Charge Injection < 10pC
- ◆ Guaranteed Off-Channel Leakage < 6nA at +85°C
- ◆ ESD Guaranteed > 2000V per Method 3015.7
- ◆ Single-Supply Operation (+10V to +30V)
Bipolar-Supply Operation ($\pm 4.5V$ to $\pm 20V$)
- ◆ TTL-/CMOS-Logic Compatibility
- ◆ Rail-to-Rail Analog Signal Handling Capability

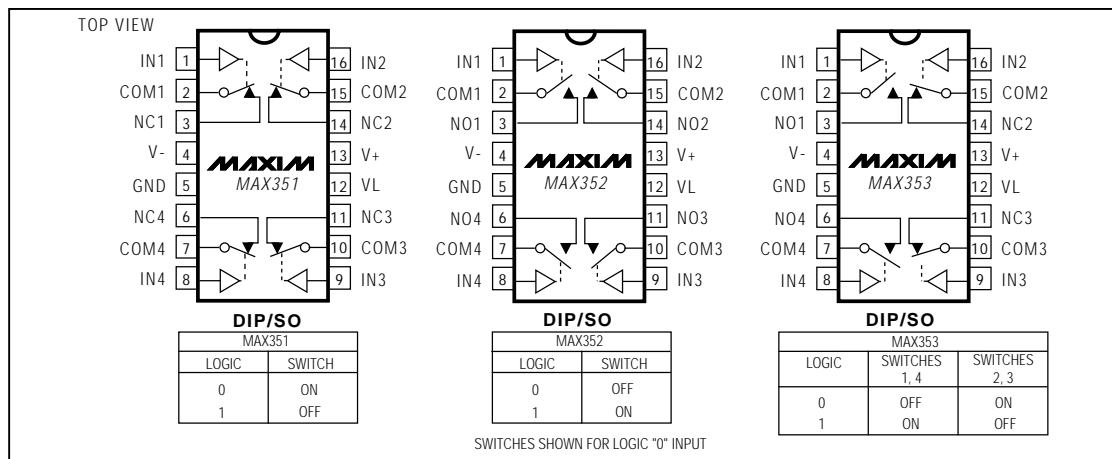
Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|-----------|-----------------|----------------|
| MAX351CPE | 0°C to +70°C | 16 Plastic DIP |
| MAX351CSE | 0°C to +70°C | 16 Narrow SO |
| MAX351C/D | 0°C to +70°C | Dice* |
| MAX351EPE | -40°C to +85°C | 16 Plastic DIP |
| MAX351ESE | -40°C to +85°C | 16 Narrow SO |
| MAX351EJE | -40°C to +85°C | 16 CERDIP |
| MAX351MJE | -55°C to +125°C | 16 CERDIP |

Ordering Information continued on last page.

* Contact factory for availability and processing to MIL-STD-883.

Pin Configurations/Functional Diagrams/Truth Tables



Precision, Quad, SPST Analog Switches

ABSOLUTE MAXIMUM RATINGS

| | |
|---|----------------------------------|
| Voltage Referenced to V- | |
| V+ | 44V |
| GND | 25V |
| VL | (GND - 0.3V) to (V+ + 0.3V) |
| Digital Inputs, VCOM, VNC, VNO (Note 1) | (V- - 2V) to (V+ + 2V) |
| | or 30mA (whichever occurs first) |
| Current (any terminal) | 30mA |
| Peak Current COM _n , NO _n , NC _n | 100mA |
| (pulsed at 1ms, 10% duty cycle max) | >2000V |
| ESD per Method 3015.7 | |

| | |
|--|-----------------|
| Continuous Power Dissipation (T _A = +70°C) (Note 2) | |
| Plastic DIP (derate 10.53mW/°C above +70°C) | 842mW |
| Narrow SO (derate 8.70mW/°C above +70°C) | 696mW |
| CERDIP (derate 10.00mW/°C above +70°C) | 800mW |
| Operating Temperature Ranges: | |
| MAX35_C_ | 0°C to +70°C |
| MAX35_E_ | -40°C to +85°C |
| MAX35_MJE | -55°C to +125°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature (soldering, 10sec) | +300°C |

Note 1: Signals on NC_n, NO_n, COM_n, or IN_n exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current rating.

Note 2: All leads are soldered or welded to PC board.

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, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP (Note 3) | MAX | UNITS | |
|---|---|--|-------------------|------|-----------------|-------|-------|----|
| SWITCH | | | | | | | | |
| Analog Signal Range | VCOM _n , VNO _n , VNC _n | (Notes 1, 4) | | V- | | V+ | V | |
| On Resistance | RON | ICOM = -10mA, VNO _n or VNC _n = ±8.5V, V+ = 13.5V, V- = -13.5V | TA = +25°C | C, E | 17 | 35 | Ω | |
| | | | | M | 17 | 30 | | |
| | | | TA = TMIN to TMAX | | | 45 | | |
| On Resistance Match Between Channels (Note 5) | RON | ICOM = -10mA, VNO _n or VNC _n = ±10V, V+ = 15V, V- = -15V | TA = +25°C | | | 2 | Ω | |
| | | | TA = TMIN to TMAX | | | 4 | | |
| On Resistance Flatness (Note 5) | RON | ICOM = -10mA, VNO _n or VNC _n = ±5V, V+ = 15V, V- = -15V | TA = +25°C | | | 3 | Ω | |
| | | | TA = TMIN to TMAX | | | 5 | | |
| Off Leakage Current (NO _n or NC _n) | INO INC | VCOM = -15.5V, VNO _n or VNC _n = 15.5V, V+ = 16.5V, V- = -16.5V | TA = +25°C | | -0.25 | -0.10 | 0.25 | nA |
| | | | TA = TMIN to TMAX | C, E | -6 | | 6 | |
| | | | | M | -20 | | 20 | |
| COM _n Off Leakage Current | INC(OFF) | VCOM = -15.5V, VNO _n or VNC _n = 15.5V, V+ = 16.5V, V- = -16.5V | TA = +25°C | | -0.25 | -0.10 | 0.25 | nA |
| | | | TA = TMIN to TMAX | C, E | -6 | | 6 | |
| | | | | M | -20 | | 20 | |
| COM _n On Leakage Current | ICOM(ON) | VCOM = ±15.5V, VNO _n or VNC _n = ±15.5V, V+ = 16.5V, V- = -16.5V | TA = +25°C | | -0.4 | -0.1 | 0.4 | nA |
| | | | TA = TMIN to TMAX | C, E | -10 | | 10 | |
| | | | | M | -40 | | 40 | |

Precision, Quad, SPST Analog Switches

MAX351/MAX352/MAX353

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

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

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP (Note 3) | MAX | UNITS | |
|---------------------------------------|--------------------|---|---|-----------------|---------|-------|----|
| INPUT | | | | | | | |
| Input Current with Input Voltage High | I _{INH} | I _{N-} = 2.4V, all others = 0.8V | -0.500 | 0.005 | 0.500 | μA | |
| Input Current with Input Voltage Low | I _{INL} | I _{N-} = 0.8V, all others = 2.4V | -0.500 | 0.005 | 0.500 | μA | |
| SUPPLY | | | | | | | |
| Power-Supply Range | | | ±4.5 | | ±20.0 | V | |
| Positive Supply Current | I ₊ | All channels on or off, V _{IN} = 0V or 5V, V ₊ = 16.5V V ₋ = -16.5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = T _{MIN} to T _{MAX} | -5 | | 5 | |
| Negative Supply Current | I ₋ | All channels on or off, V _{IN} = 0V or 5V, V ₊ = 16.5V V ₋ = -16.5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = T _{MIN} to T _{MAX} | -5 | | 5 | |
| Logic Supply Current | I _L | All channels on or off, V _{IN} = 0V or 5V, V ₊ = 16.5V V ₋ = -16.5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = T _{MIN} to T _{MAX} | -5 | | 5 | |
| Ground Current | I _{GND} | All channels on or off, V _{IN} = 0V or 5V, V ₊ = 16.5V V ₋ = -16.5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = T _{MIN} to T _{MAX} | -5 | | 5 | |
| DYNAMIC | | | | | | | |
| Turn-On Time | t _{ON} | Figure 2, V _{COM} = ±10V | TA = +25°C | | 110 | 175 | ns |
| | | | TA = T _{MIN} to T _{MAX} | | | 220 | |
| Turn-Off Time | t _{OFF} | Figure 2, V _{COM} = ±10V | TA = +25°C | | 100 | 145 | ns |
| | | | TA = T _{MIN} to T _{MAX} | | | 160 | |
| Break-Before-Make Time Delay | t _D | MAX353 only, Figure 3, R _L = 300Ω, C _L = 35pF | TA = +25°C | | 25 | | ns |
| Charge Injection | Q | C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω, Figure 4 | TA = +25°C | | 5 | 10 | pC |
| Off Isolation (Note 6) | OIRR | R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 5 | TA = +25°C | | 68 | | dB |
| Crosstalk (Note 7) | | R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 6 | TA = +25°C | | 85 | | dB |
| NC or NO Capacitance | C _(OFF) | f = 1MHz, Figure 7 | TA = +25°C | | 9 | | pF |
| COM Off Capacitance | C _(COM) | f = 1MHz, Figure 7 | TA = +25°C | | 9 | | pF |
| On Capacitance | C _(COM) | f = 1MHz, Figure 8 | TA = +25°C | | 35 | | pF |

Precision, Quad, SPST Analog Switches

MAX351/MAX352/MAX353

ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP (Note 3) | MAX | UNITS |
|------------------------------|------------------------|---|---------------------------------|----------|-----------------|------------|-------|
| SWITCH | | | | | | | |
| Analog Signal Range | VCOM-, VNO-, VNC | (Notes 1, 4) | | 0 | | V+ | V |
| Channel On Resistance | RON | I _{COM} = -10mA, VNC- or VNO- = 3.8V, V+ = 10.8V | TA = +25°C TA = TMIN to TMAX | | 40 80 | 100 | Ω |
| SUPPLY | | | | | | | |
| Positive Supply Current | I+ | V+ = 13.2V, all channels on or off, VIN = 0V or 5V | TA = +25°C TA = TMAX | -1 -5 | 0.0001 | 1 5 | μA |
| Negative Supply Current | I- | V+ = 13.2V, all channels on or off, VIN = 0V or 5V | TA = +25°C TA = TMAX | -1 -5 | 0.0001 | 1 5 | μA |
| Logic Supply Current | IL | VL = 5.25V, all channels on or off, VIN = 0V or 5V | TA = +25°C TA = TMAX | -1 -5 | 0.0001 | 1 5 | μA |
| Ground Current | IGND | VL = 5.25V, all channels on or off, VIN = 0V or 5V | TA = +25°C TA = TMAX | -1 -5 | -0.0001 | 1 5 | μA |
| DYNAMIC | | | | | | | |
| Turn-On Time | tON | Figure 2, VNO- or VNC- = 8V | TA = +25°C TA = TMIN to TMAX | | 175 | 250 315 | ns |
| Turn-Off Time | tOFF | Figure 2, VNO- or VNC- = 8V | TA = +25°C TA = TMIN to TMAX | | 95 | 125 140 | ns |
| Break-Before-Make Time Delay | tD | MAX353 only, Figure 3, RL = 300Ω, CL = 35pF | TA = +25°C | | 25 | | ns |
| Charge Injection | Q | Figure 8, CL = 1.0nF, VGEN = 0V, RGEN = 0V | TA = +25°C | | 5 | 10 | pC |

Note 3: 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 4: Guaranteed by design.

Note 5: $\Delta R_{ON} = \Delta R_{ON\ max} - \Delta R_{ON\ min}$. On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation.

Note 6: See Figure 5. Off Isolation = $20 \log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$, VCOM = output, VNC or VNO = input to off switch.

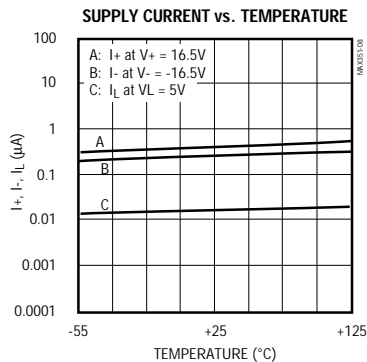
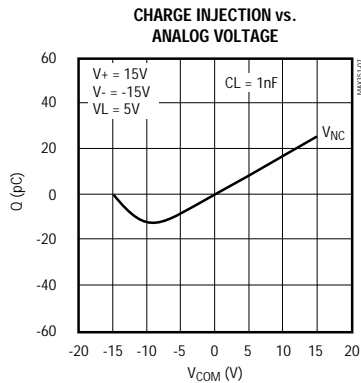
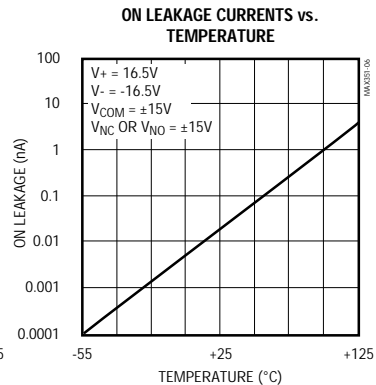
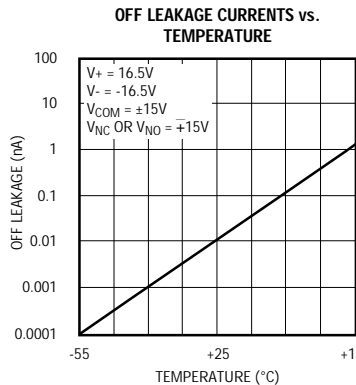
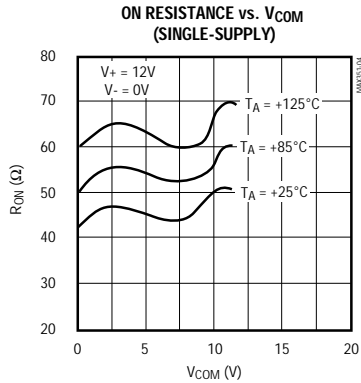
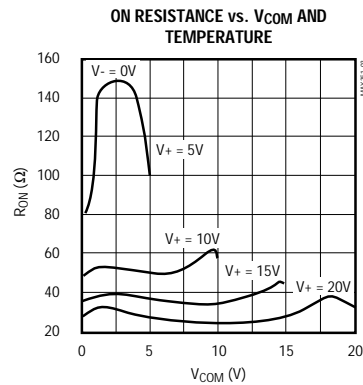
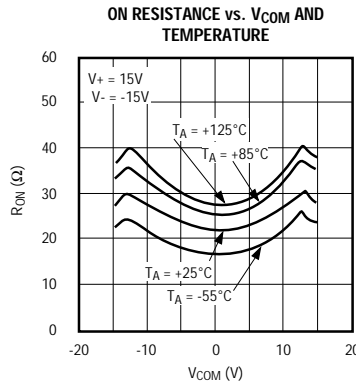
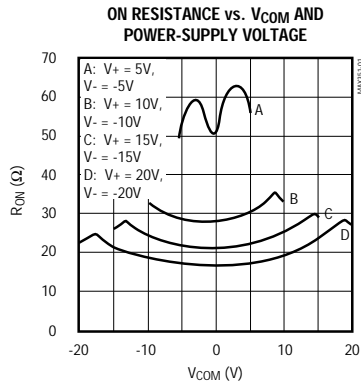
Note 7: Between any two switches. See Figure 6.

Precision, Quad, SPST Analog Switches

Typical Operating Characteristics

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

MAX351/MAX352/MAX353



Precision, Quad, SPST Analog Switches

Pin Description

| PIN | NAME | FUNCTION |
|--------------|-----------|--|
| 1, 8, 9, 16 | IN1-IN4 | Inputs |
| 2, 7, 10, 15 | COM1-COM4 | Analog Switch Common Terminal |
| 3, 6, 11, 14 | NO or NC | Switch Inputs |
| 4 | V- | Negative Supply-Voltage Input |
| 5 | GND | Ground |
| 12 | VL | Logic Supply Voltage |
| 13 | V+ | Positive Supply-Voltage Input—connected to substrate |

Applications Information

Operation with Supplies Other than $\pm 15V$
 The main limitation of supply voltages other than $\pm 15V$ is reduced analog-signal range. The MAX351/MAX352/MAX353 operate with $\pm 5V$ to $\pm 20V$ bipolar supplies. The *Typical Operating Characteristics* graphs show typical on resistance (R_{ON}) for $\pm 15V$, $\pm 10V$, and $\pm 5V$ supplies. (Switching times increase by a factor of two or more for operation at $\pm 5V$.) The MAX351/MAX352/MAX353 can operate from $+10V$ to $+30V$ unipolar supplies. Each device can also be powered from unbalanced supplies such as $+24V$ and $-5V$. Connect V^- to $0V$ when operating with a single supply. VL must be connected to $+5V$ to be TTL compatible or to V^+ for CMOS-logic input levels.

Overvoltage Protection

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

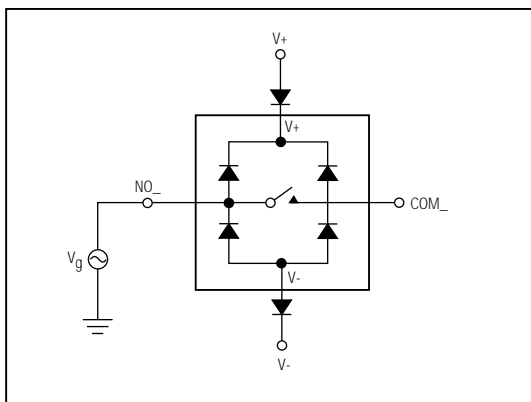


Figure 1. Overvoltage Protection Using External Blocking Diodes

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams

MAX351/MAX352/MAX353

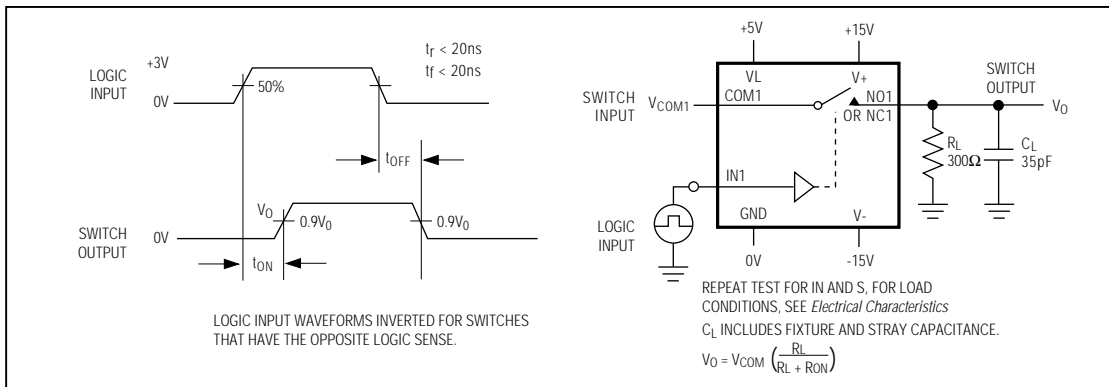


Figure 2. Switching-Time Test Circuit

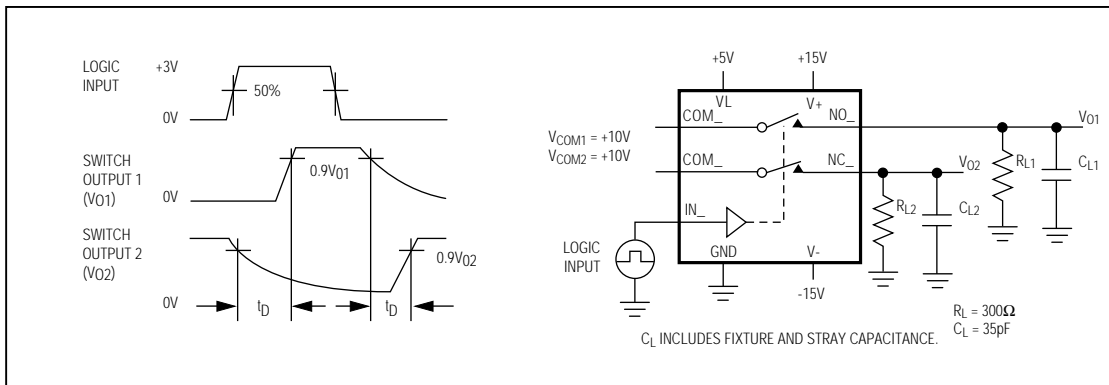


Figure 3. Break-Before-Make Test Circuit (MAX353 only)

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams (continued)

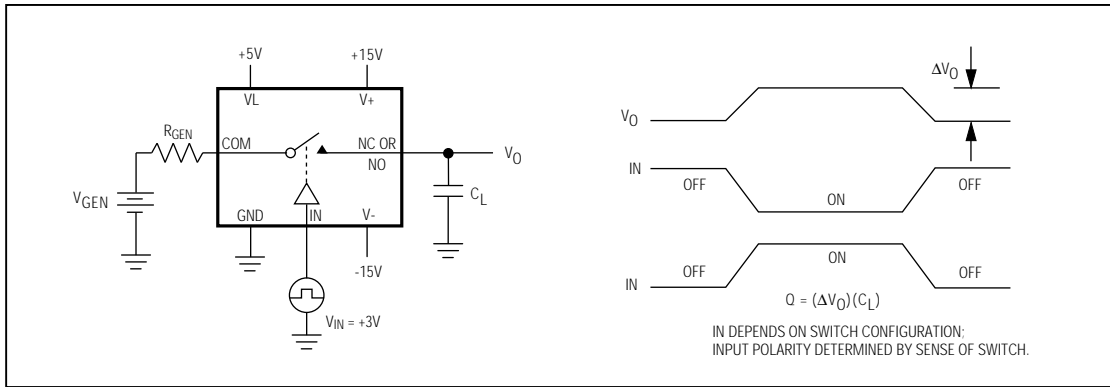


Figure 4. Charge-Injection Test Circuit

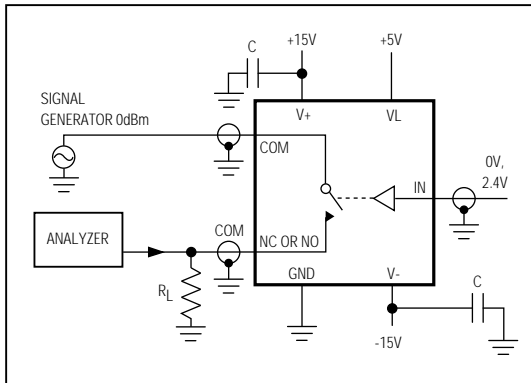


Figure 5. Off-Isolation Test Circuit

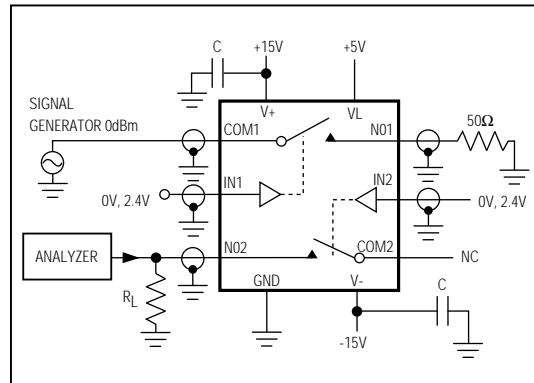


Figure 6. Crosstalk Test Circuit

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams (continued)

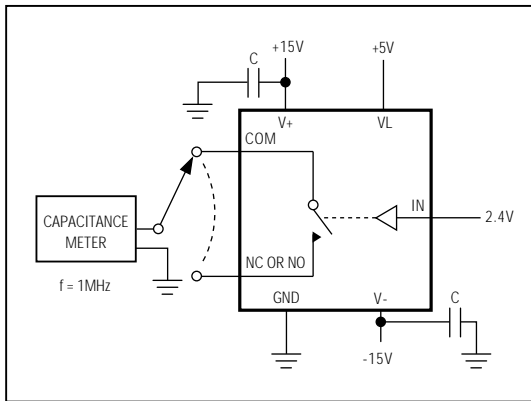


Figure 7. Channel-Off Capacitance

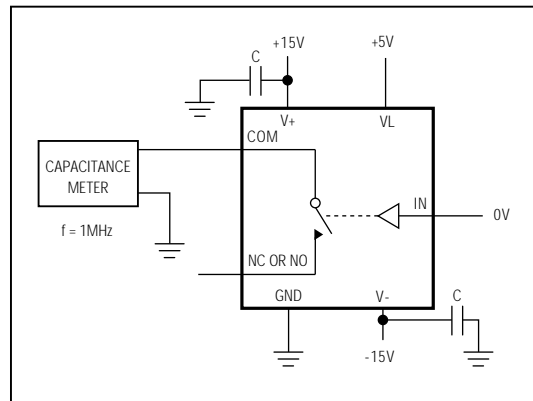


Figure 8. Channel-On Capacitance Test Circuit

MAX351/MAX352/MAX353

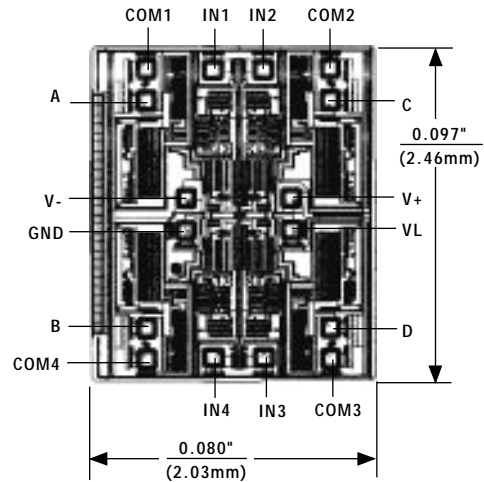
Precision, Quad, SPST Analog Switches

Ordering Information (continued)

| PART | TEMP. RANGE | PIN-PACKAGE |
|-----------|-----------------|----------------|
| MAX352CPE | 0°C to +70°C | 16 Plastic DIP |
| MAX352CSE | 0°C to +70°C | 16 Narrow SO |
| MAX352C/D | 0°C to +70°C | Dice* |
| MAX352EPE | -40°C to +85°C | 16 Plastic DIP |
| MAX352ESE | -40°C to +85°C | 16 Narrow SO |
| MAX352EJE | -40°C to +85°C | 16 CERDIP |
| MAX352MJE | -55°C to +125°C | 16 CERDIP |
| MAX353CPE | 0°C to +70°C | 16 Plastic DIP |
| MAX353CSE | 0°C to +70°C | 16 Narrow SO |
| MAX353C/D | 0°C to +70°C | Dice* |
| MAX353EPE | -40°C to +85°C | 16 Plastic DIP |
| MAX353ESE | -40°C to +85°C | 16 Narrow SO |
| MAX353EJE | -40°C to +85°C | 16 CERDIP |
| MAX353MJE | -55°C to +125°C | 16 CERDIP |

* Contact factory for dice specifications.

Chip Topography



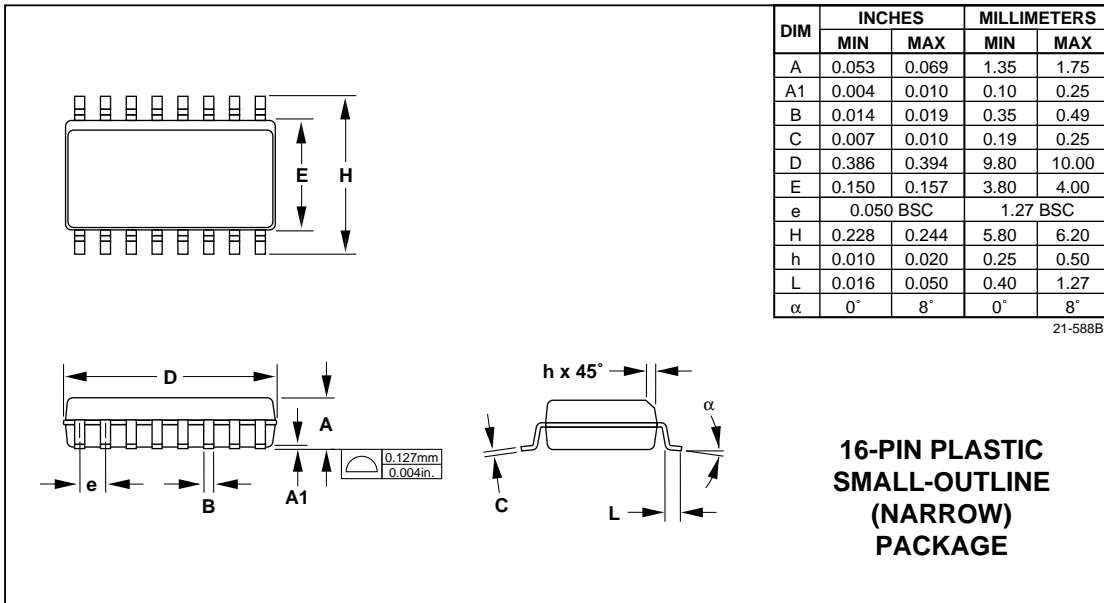
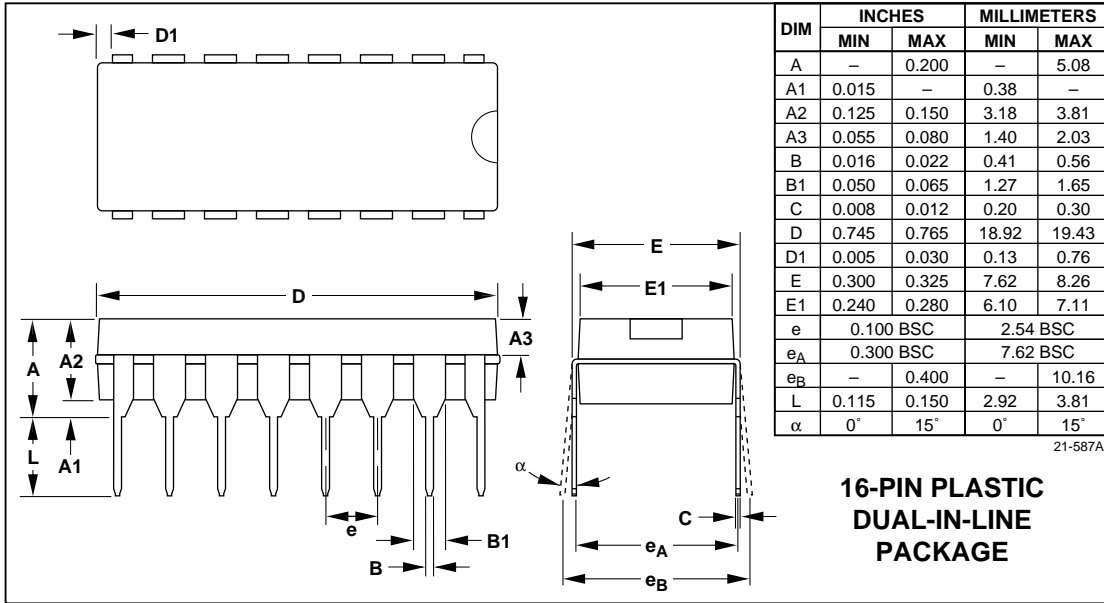
TRANSISTOR COUNT: 136;
SUBSTRATE CONNECTED TO V+.

| MAX351 | | MAX352 | | MAX353 | |
|--------|------|--------|------|--------|------|
| PIN | NAME | PIN | NAME | PIN | NAME |
| A | NC | A | NO | A | NO |
| B | NC | B | NO | B | NO |
| C | NC | C | NO | C | NC |
| D | NC | D | NO | D | NC |

Precision, Quad, SPST Analog Switches

Package Information

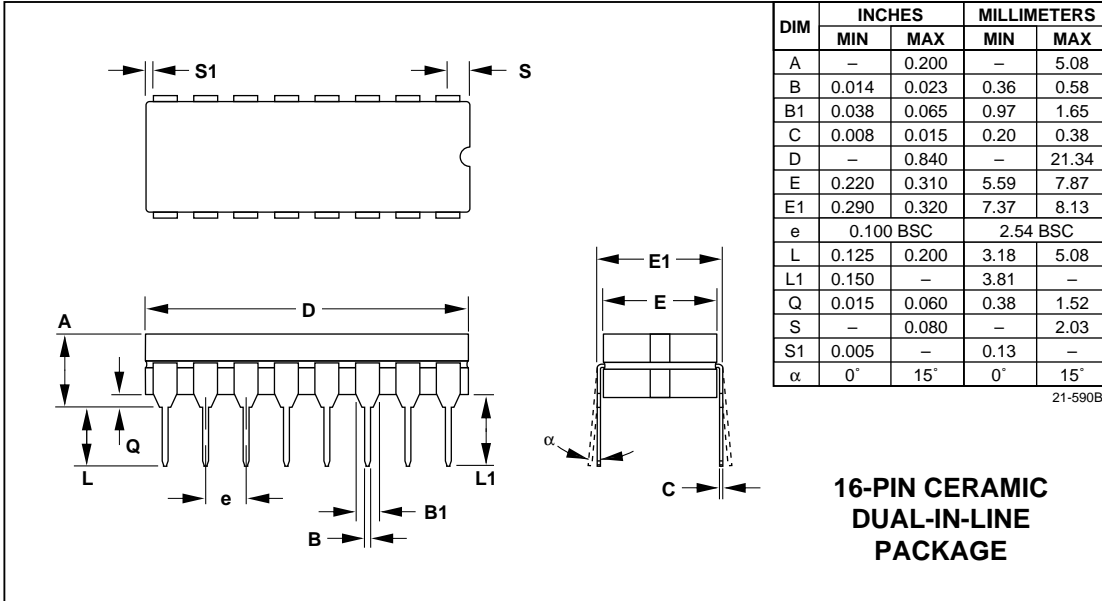
MAX351/MAX352/MAX353



Precision, Quad, SPST Analog Switches

MAX351/MAX352/MAX353

Package Information (continued)



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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