



Precision, Quad, SPST Analog Switches

MAX351/MAX352/MAX353

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* |
| MAX351EGE | -40°C to +85°C | 16 QFN |
| 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 at end of data sheet.

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

Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

DIP/SO
MAX351

| LOGIC | SWITCH |
|-------|--------|
| 0 | ON |
| 1 | OFF |

DIP/SO
MAX352

| LOGIC | SWITCH |
|-------|--------|
| 0 | OFF |
| 1 | ON |

DIP/SO
MAX353

| LOGIC | SWITCHES 1, 4 | SWITCHES 2, 3 |
|-------|---------------|---------------|
| 0 | OFF | ON |
| 1 | ON | OFF |

Pin Configuration continued at end of data sheet. SWITCHES SHOWN FOR LOGIC "0" INPUT



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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_, NO_, NC_ (pulsed at 1ms, 10% duty cycle max) | 100mA |
| ESD per Method 3015.7 | >2000V |

Continuous Power Dissipation (TA = +70°C) (Note 2)

| | |
|---|--------|
| Plastic DIP (derate 10.53mW/°C above +70°C) | 842mW |
| Narrow SO (derate 8.70mW/°C above +70°C) | 696mW |
| QFN (derate 19.2mW/°C above +70°C) | 1538mW |
| 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

| | |
|---|--------|
| Lead Temperature (soldering, 10s) | +300°C |
|---|--------|

Note 1: Signals on NC_, NO_, COM_, or IN_ 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, 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) | | V- | | V+ | V | |
| On Resistance | RON | ICOM = -10mA, VNO_ or VNC_ = ±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_ or VNC_ = ±10V, V+ = 15V, V- = -15V | TA = +25°C | | | 2 | Ω | |
| | | | TA = TMIN to TMAX | | | 4 | | |
| On Resistance Flatness (Note 5) | RON | ICOM = -10mA, VNO_ or VNC_ = ±5V, V+ = 15V, V- = -15V | TA = +25°C | | | 3 | Ω | |
| | | | TA = TMIN to TMAX | | | 5 | | |
| Off Leakage Current (NO_ or NC_) | INO INC | VCOM = -15.5V, VNO_ or VNC_ = 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_ Off Leakage Current | INC(OFF) | VCOM = -15.5V, VNO_ or VNC_ = 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_ On Leakage Current | ICOM(ON) | VCOM = ±15.5V, VNO_ or VNC_ = ±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 | | |

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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} | IN ₋ = 2.4V, all others = 0.8V | -0.500 | 0.005 | 0.500 | μA | |
| Input Current with Input Voltage Low | I _{INL} | IN ₋ = 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, VIN = 0V or 5V, V+ = 16.5V V- = -16.5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Negative Supply Current | I- | All channels on or off, VIN = 0V or 5V, V+ = 16.5V V- = -16.5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Logic Supply Current | IL | All channels on or off, VIN = 0V or 5V, V+ = 16.5V V- = -16.5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Ground Current | IGND | All channels on or off, VIN = 0V or 5V, V+ = 16.5V V- = -16.5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| DYNAMIC | | | | | | | |
| Turn-On Time | t _{ON} | Figure 2, VCOM = ±10V | TA = +25°C | 110 | 175 | ns | |
| | | | TA = TMIN to TMAX | | 220 | | |
| Turn-Off Time | t _{OFF} | Figure 2, VCOM = ±10V | TA = +25°C | 100 | 145 | ns | |
| | | | TA = TMIN to TMAX | | 160 | | |
| Break-Before-Make Time Delay | t _D | MAX353 only, Figure 3, RL = 300Ω, CL = 35pF | TA = +25°C | 25 | | ns | |
| Charge Injection | Q | CL = 1.0nF, VGEN = 0V, RGEN = 0Ω, Figure 4 | TA = +25°C | 5 | 10 | pC | |
| Off Isolation (Note 6) | OIRR | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 5 | TA = +25°C | 68 | | dB | |
| Crosstalk (Note 7) | | RL = 50Ω, CL = 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 | |

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ELECTRICAL CHARACTERISTICS—Single Supply

(V₊ = 12V, V₋ = 0V, V_L = 5V, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP (Note 3) | MAX | UNITS |
|------------------------------|--|---|---|-----|-----------------|----------------|-------|
| SWITCH | | | | | | | |
| Analog Signal Range | V _{COM_} , V _{NO_} , V _{NC} | (Notes 1, 4) | | 0 | | V ₊ | V |
| Channel On Resistance | R _{ON} | I _{COM} = -10mA, V _{NC_} or V _{NO_} = 3.8V, V ₊ = 10.8V | T _A = +25°C T _A = T _{MIN} to T _{MAX} | | 40 | 80 100 | Ω |
| SUPPLY | | | | | | | |
| Positive Supply Current | I ₊ | V ₊ = 13.2V, all channels on or off, V _{IN} = 0V or 5V | T _A = +25°C T _A = T _{MAX} | -1 | 0.0001 | 1 5 | μA |
| Negative Supply Current | I ₋ | V ₊ = 13.2V, all channels on or off, V _{IN} = 0V or 5V | T _A = +25°C T _A = T _{MAX} | -1 | 0.0001 | 1 5 | μA |
| Logic Supply Current | I _L | V _L = 5.25V, all channels on or off, V _{IN} = 0V or 5V | T _A = +25°C T _A = T _{MAX} | -1 | 0.0001 | 1 5 | μA |
| Ground Current | I _{GND} | V _L = 5.25V, all channels on or off, V _{IN} = 0V or 5V | T _A = +25°C T _A = T _{MAX} | -1 | -0.0001 | 1 5 | μA |
| DYNAMIC | | | | | | | |
| Turn-On Time | t _{ON} | Figure 2, V _{NO_} or V _{NC_} = 8V | T _A = +25°C T _A = T _{MIN} to T _{MAX} | | 175 | 250 315 | ns |
| Turn-Off Time | t _{OFF} | Figure 2, V _{NO_} or V _{NC_} = 8V | T _A = +25°C T _A = T _{MIN} to T _{MAX} | | 95 | 125 140 | ns |
| Break-Before-Make Time Delay | t _D | MAX353 only, Figure 3, R _L = 300Ω, C _L = 35pF | T _A = +25°C | | 25 | | ns |
| Charge Injection | Q | Figure 8, C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0V | T _A = +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 = $20 \log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$, V_{COM} = output, V_{NC} or V_{NO} = input to off switch.

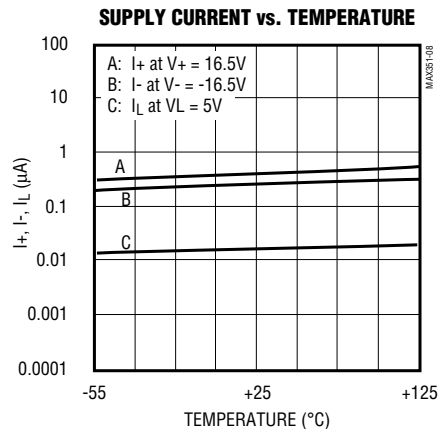
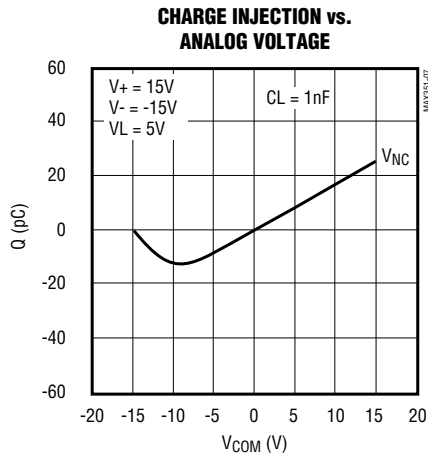
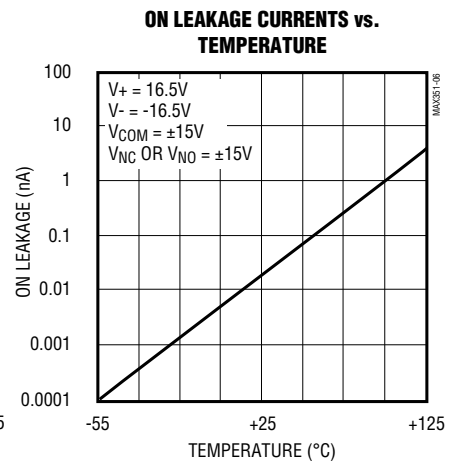
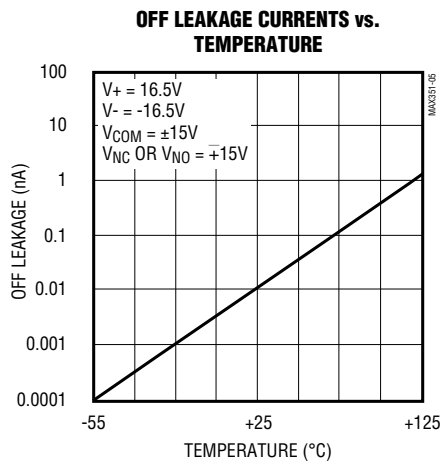
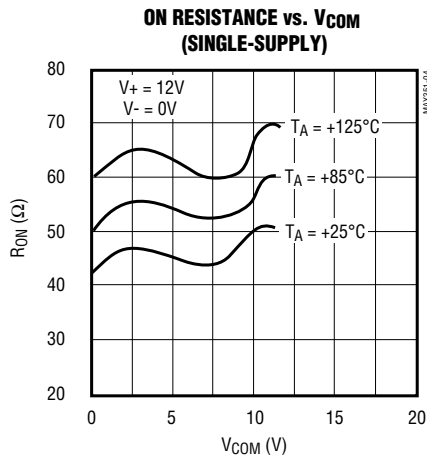
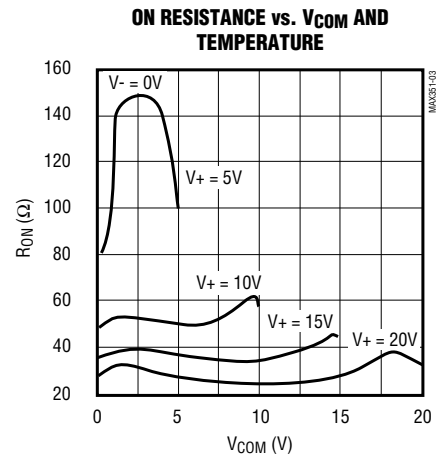
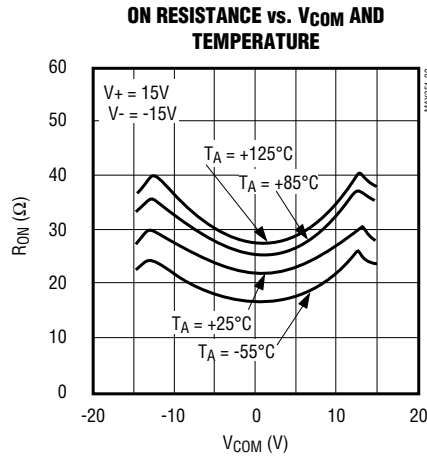
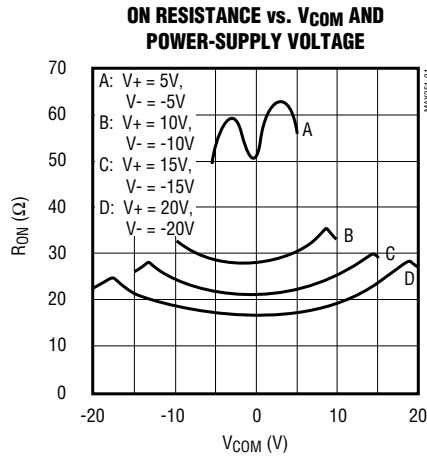
Note 7: Between any two switches. See Figure 6.

Precision, Quad, SPST Analog Switches

Typical Operating Characteristics

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

MAX3511/MAX352/MAX353



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Pin Description

| PIN | | NAME | FUNCTION |
|--------------|--------------|----------------|--|
| DIP/SO | QFN | | |
| 1, 16, 9, 8 | 15, 14, 7, 6 | IN1–N4 | Logic Control Input |
| 2, 15, 10, 7 | 16, 13, 8, 5 | COM1–COM4 | Analog Switch Common Terminal |
| 3, 15, 11, 6 | 1, 12, 9, 4 | NO or NC | Analog Switch NO or NC Terminal |
| 4 | 2 | V- | Negative-Supply Voltage Input |
| 5 | 3 | GND | Ground |
| 12 | 10 | V _L | Logic Supply Voltage |
| 13 | 11 | V+ | Positive-Supply Voltage Input—Connected To Substrate |

Applications Information

Operation with Supplies Other than ±15V

The main limitation of supply voltages other than ±15V is reduced analog-signal range. The MAX351/MAX352/MAX353 operate with ±5V to ±20V bipolar supplies. The *Typical Operating Characteristics* graphs show typical on resistance (R_{ON}) for ±15V, ±10V, and ±5V supplies. (Switching times increase by a factor of two or more for operation at ±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. V_L 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 V_L, 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.

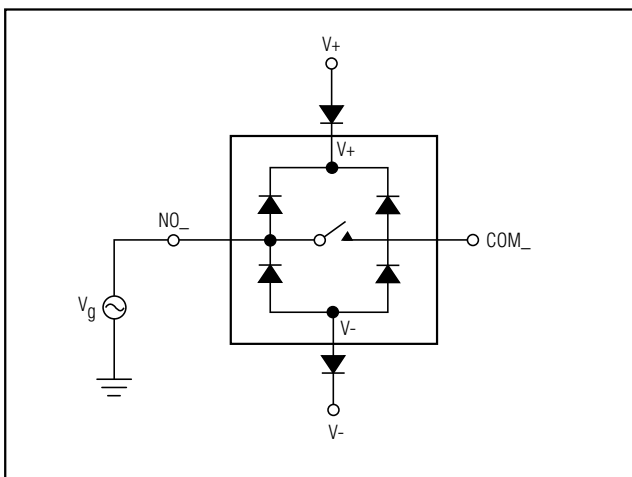


Figure 1. Overvoltage Protection Using External Blocking Diodes

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams

MAX351/MAX352/MAX353

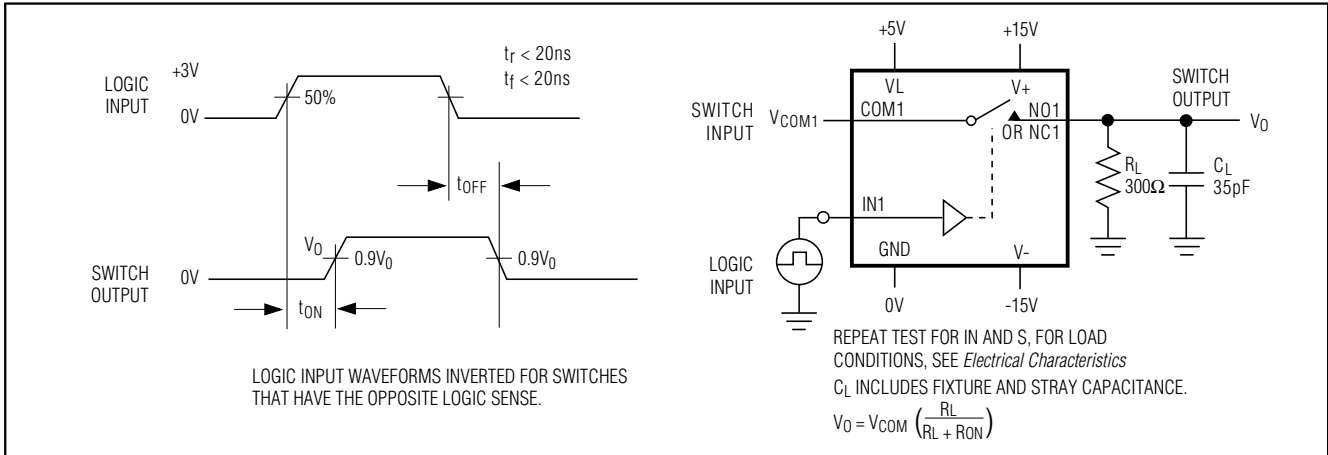


Figure 2. Switching-Time Test Circuit

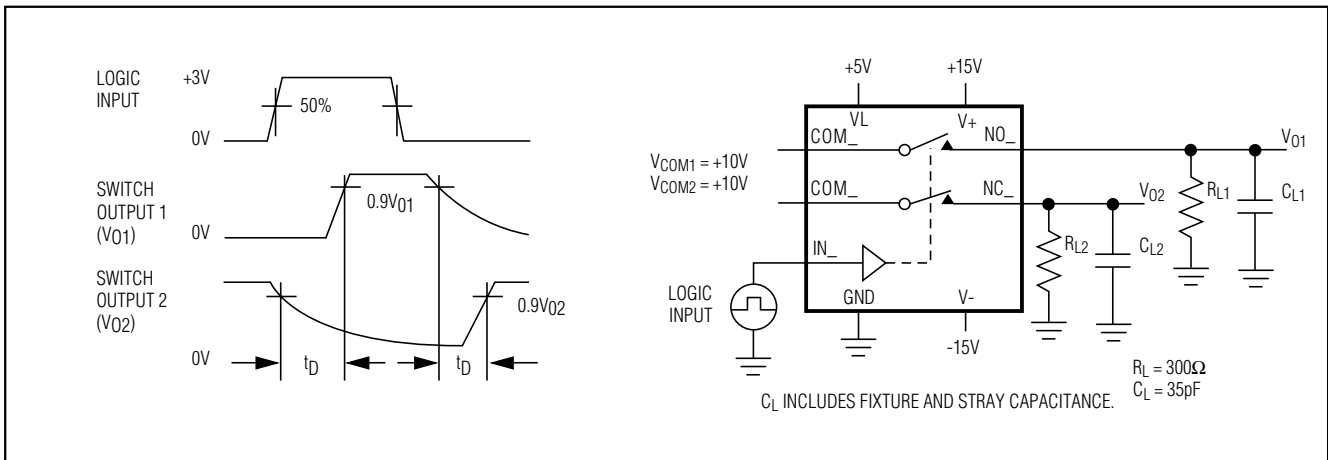


Figure 3. Break-Before-Make Test Circuit (MAX353 only)

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams (continued)

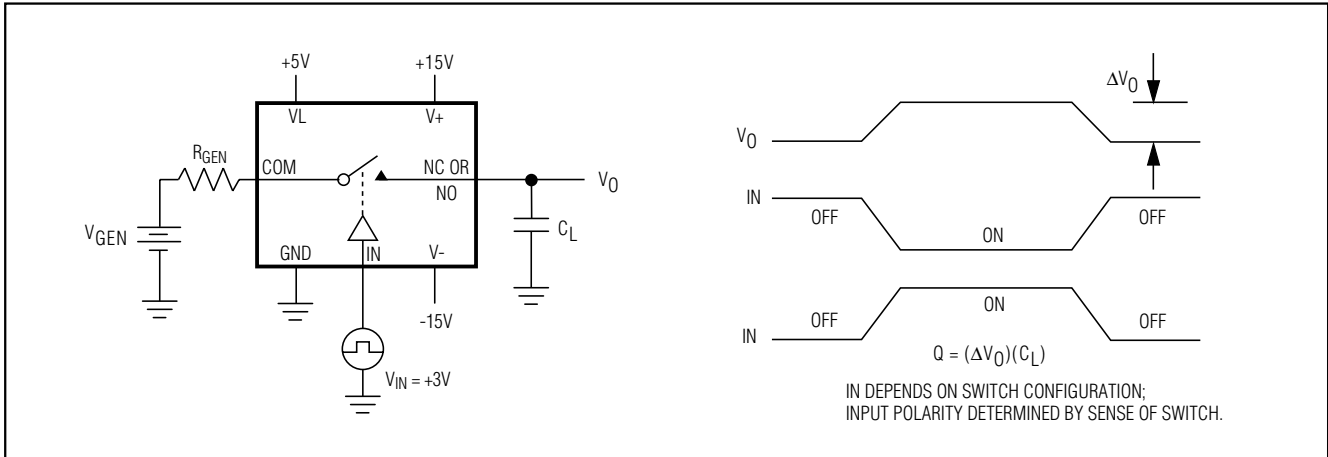


Figure 4. Charge-Injection Test Circuit

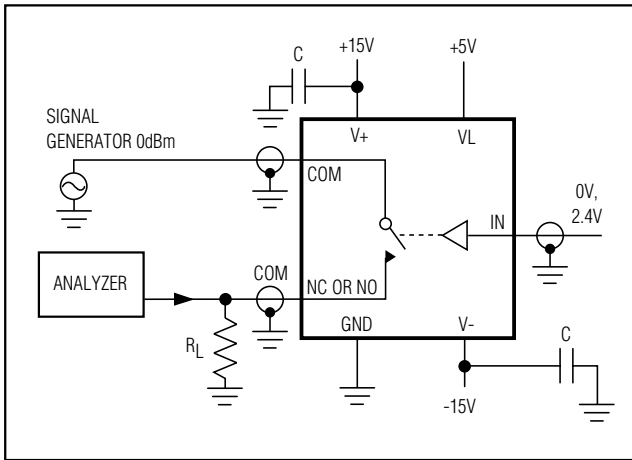


Figure 5. Off-Isolation Test Circuit

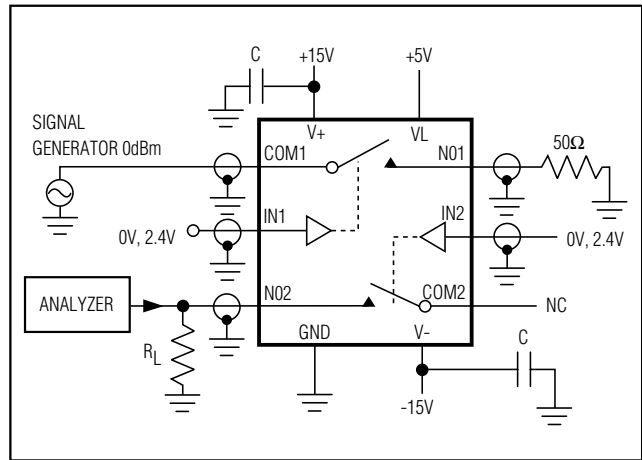


Figure 6. Crosstalk Test Circuit

Precision, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams (continued)

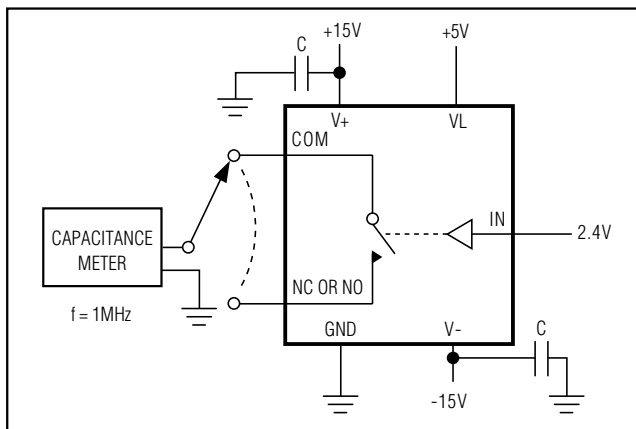


Figure 7. Channel-Off Capacitance

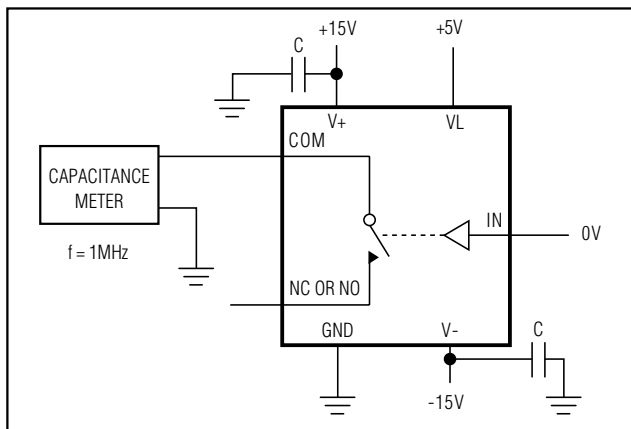
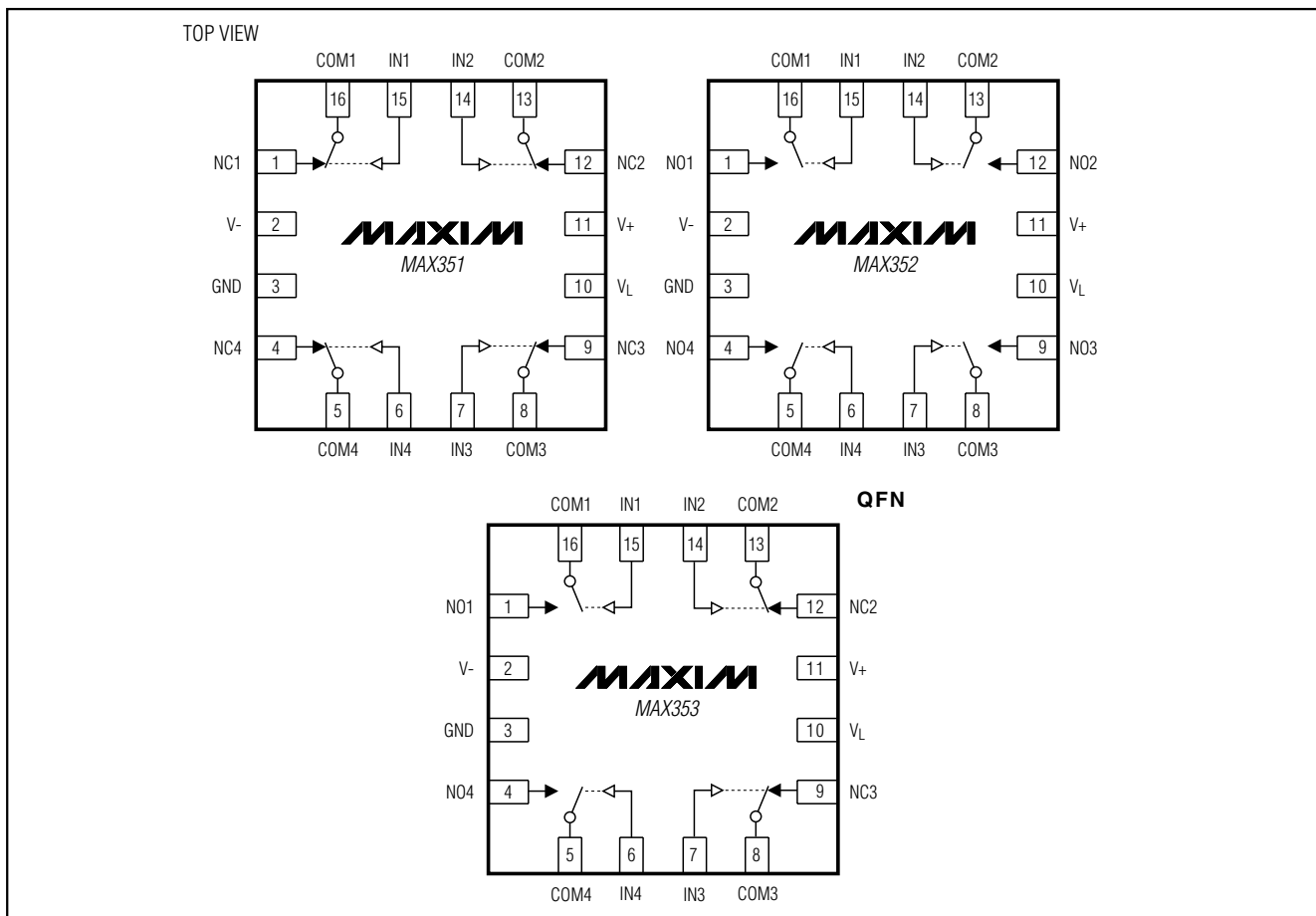


Figure 8. Channel-On Capacitance Test Circuit

Pin Configurations (continued)



MAX351/MAX352/MAX353

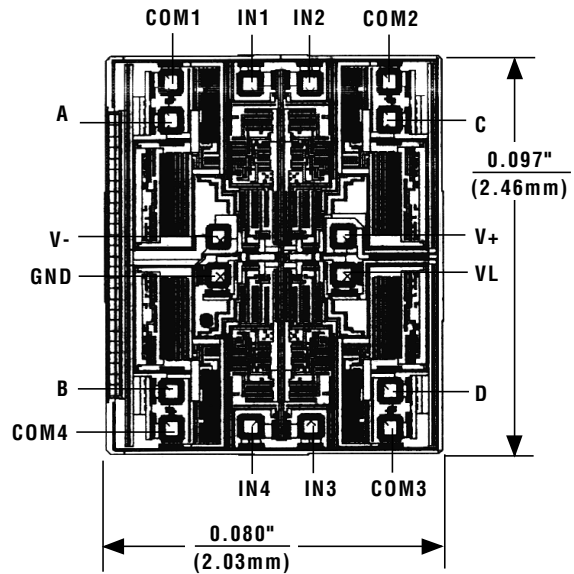
Precision, Quad, SPST Analog Switches

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* |
| MAX352EGE | -40°C to +85°C | 16 QFN |
| 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* |
| MAX353EGE | -40°C to +85°C | 16 QFN |
| 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 availability and processing to MIL-STD-883.

Chip Topography



TRANSISTOR COUNT: 136
SUBSTRATE CONNECTED TO V+

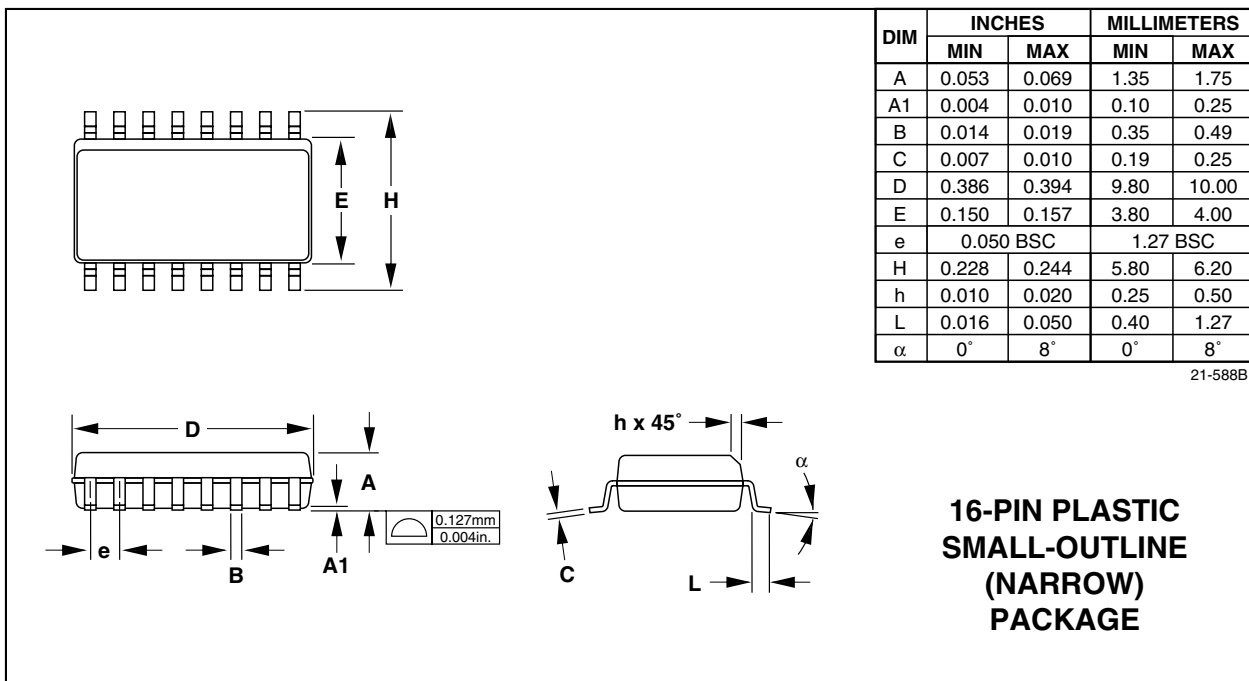
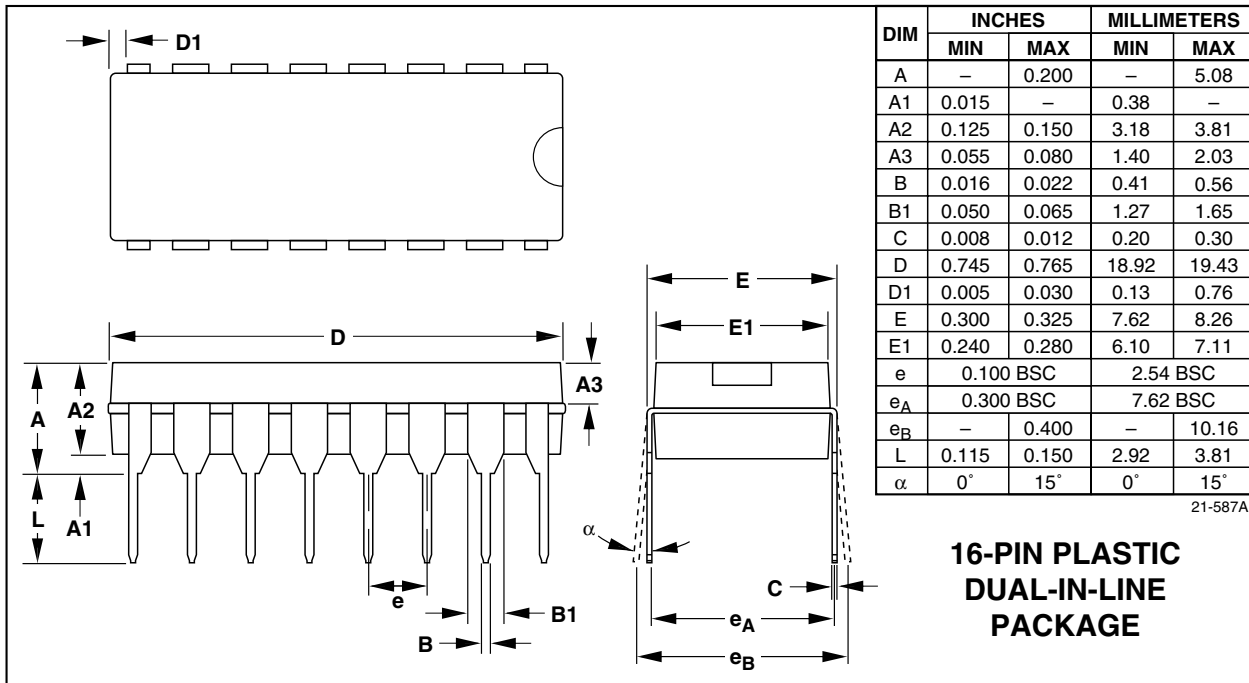
| MAX351 | | MAX352 | | MAX353 | |
|--------|------|--------|------|--------|------|
| PIN | NAME | PIN | NAME | PIN | NAME |
| A | NC | A | NO | A | NO |
| B | NC | B | NO | B | NO |
| C | NC | C | NO | C | NC |
| D | NC | D | NO | D | NC |

Precision, Quad, SPST Analog Switches

Package Information

(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.)

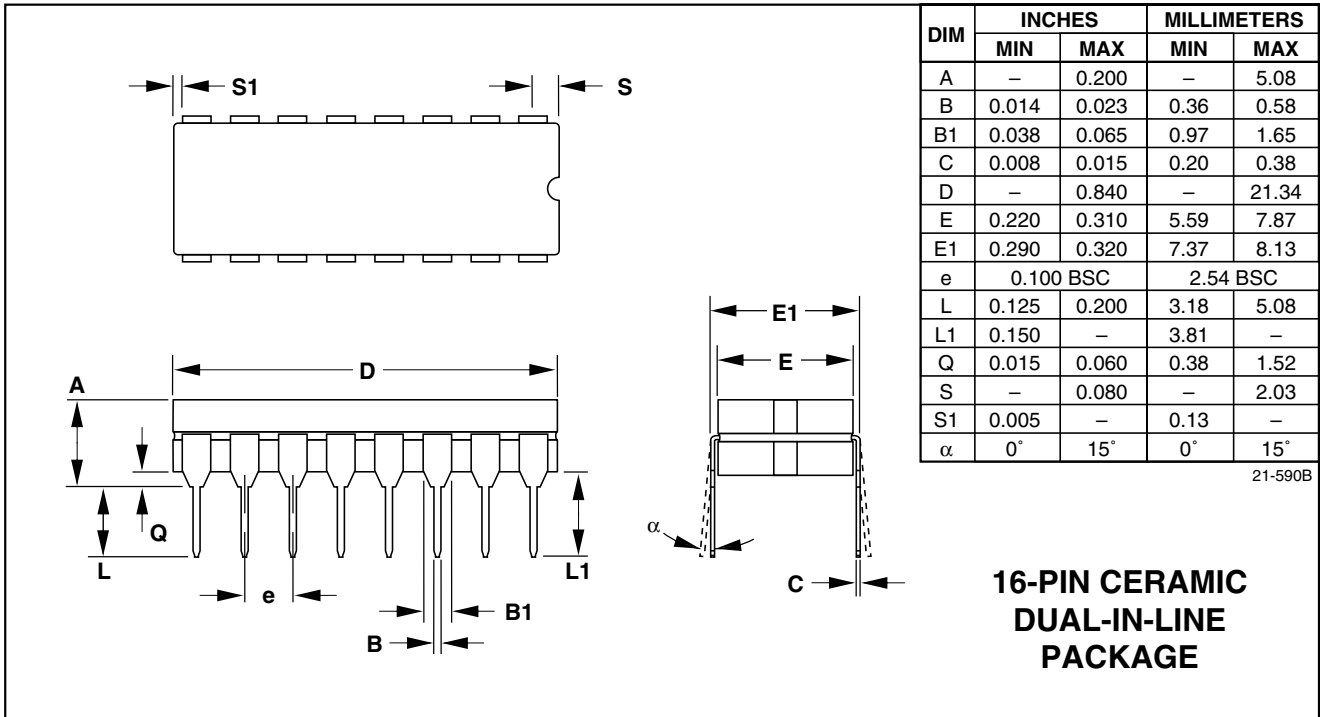
MAX351/MAX352/MAX353



Precision, Quad, SPST Analog 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.)

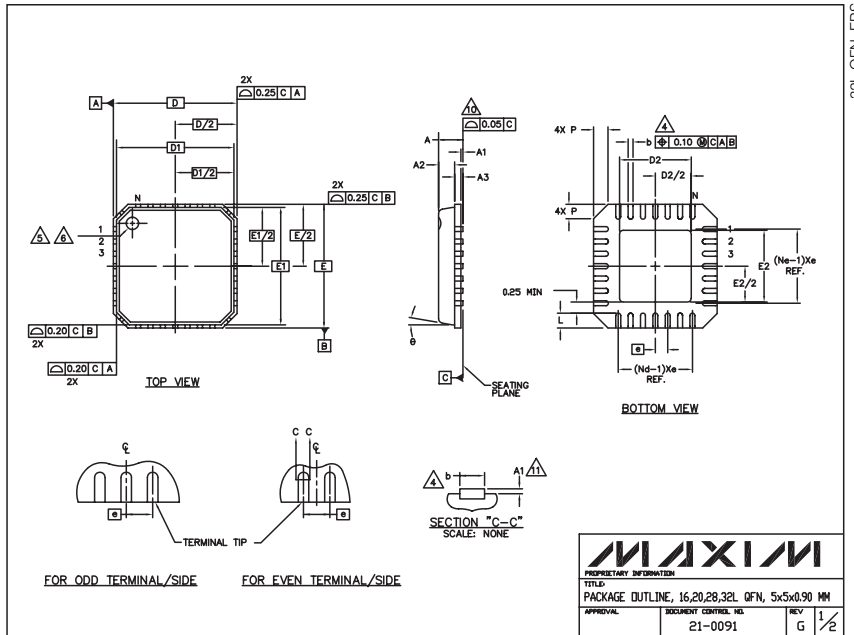


Precision, Quad, SPST Analog Switches

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.)

MAX351/MAX352/MAX353



NOTES:

- DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
- DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M - 1994.
- N IS THE NUMBER OF TERMINALS.
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION &
No IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
- DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
- THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/ LASER MARKED.
- EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
- ALL DIMENSIONS ARE IN MILLIMETERS.
- PACKAGE WARPAGE MAX 0.05mm.
- APPLIED FOR EXPOSED PAD AND TERMINALS.
EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
- MEETS JEDEC MO220.
- THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES) AND TO SAW SINGULATION (STRAIGHT SIDES) QFN STYLES.

| COMMON DIMENSIONS | | | | |
|-------------------|-----------|------|------|--|
| | MIN. | NOM. | MAX. | |
| A | 0.90 | 0.90 | 1.00 | |
| A1 | 0.00 | 0.01 | 0.05 | |
| A2 | 0.00 | 0.95 | 1.00 | |
| A3 | 0.20 REF. | | | |
| D | 5.00 BSC | | | |
| DT | 4.75 BSC | | | |
| F | 5.00 BSC | | | |
| E1 | 4.75 BSC | | | |
| B | 0° | - | 12° | |
| P | 0 | - | 0.60 | |
| D2 | 1.25 | - | 3.25 | |
| E2 | 1.25 | - | 3.25 | |

| PITCH VARIATION B | | | | PITCH VARIATION B | | | | PITCH VARIATION C | | | | PITCH VARIATION D | | | |
|-------------------|------|-------|------|-------------------|------|-------|------|-------------------|------|-------|------|-------------------|------|-------|------|
| MIN. | NOM. | MAX. | | MIN. | NOM. | MAX. | | MIN. | NOM. | MAX. | | MIN. | NOM. | MAX. | |
| 0.80 BSC | | | | 0.65 BSC | | | | 0.50 BSC | | | | 0.50 BSC | | | |
| N | 16 | 3 N | | N | 20 | 3 N | | N | 28 | 3 N | | N | 32 | 3 N | |
| Ind | 4 | 3 Ind | | Ind | 5 | 3 Ind | | Ind | 7 | 3 Ind | | Ind | 8 | 3 Ind | |
| No | 4 | 3 No | | No | 5 | 3 No | | No | 7 | 3 No | | No | 8 | 3 No | |
| L | 0.35 | 0.55 | 0.75 | L | 0.35 | 0.55 | 0.75 | L | 0.35 | 0.55 | 0.75 | L | 0.30 | 0.40 | 0.50 |
| b | 0.28 | 0.33 | 0.40 | b | 0.23 | 0.28 | 0.35 | b | 0.18 | 0.23 | 0.30 | b | 0.18 | 0.23 | 0.30 |

| MAXIMUM INFORMATION | | | |
|--|-----------------------|------|------|
| TITLE | | | |
| PACKAGE OUTLINE, 16,20,28,32L QFN, 5x5x0.90 MM | | | |
| APPROVAL | ISSUEMENT CONTROL NO. | REV. | DATE |
| | 21-0091 | G | 2/2 |

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