



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

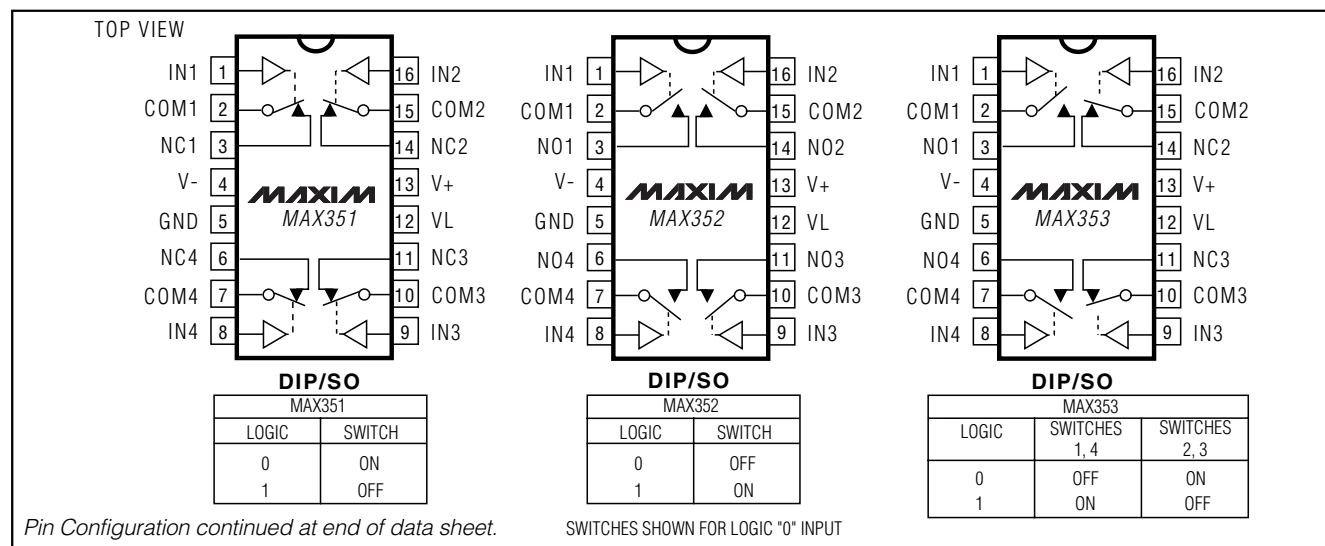
Ordering Information

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*
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



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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	-65°C to +150°C
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		
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		
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		

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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}	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	T _A = +25°C	-1	0.0001	1	μA
			T _A = 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	T _A = +25°C	-1	-0.0001	1	μA
			T _A = 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	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
Ground Current	I _{IGND}	All channels on or off, V _{IN} = 0V or 5V, V ₊ = 16.5V V ₋ = -16.5V	T _A = +25°C	-1	-0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
DYNAMIC							
Turn-On Time	t _{ON}	Figure 2, V _{COM} = ±10V	T _A = +25°C	110	175	ns	
			T _A = T _{MIN} to T _{MAX}		220		
Turn-Off Time	t _{OFF}	Figure 2, V _{COM} = ±10V	T _A = +25°C	100	145	ns	
			T _A = T _{MIN} to T _{MAX}		160		
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	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω, Figure 4	T _A = +25°C	5	10	pC	
Off Isolation (Note 6)	OIRR	R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 5	T _A = +25°C	68		dB	
Crosstalk (Note 7)		R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 6	T _A = +25°C	85		dB	
NC or NO Capacitance	C _(OFF)	f = 1MHz, Figure 7	T _A = +25°C	9		pF	
COM Off Capacitance	C _(COM)	f = 1MHz, Figure 7	T _A = +25°C	9		pF	
On Capacitance	C _(COM)	f = 1MHz, Figure 8	T _A = +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	40	80		Ω
			T _A = T _{MIN} to T _{MAX}		100		
SUPPLY							
Positive Supply Current	I+	V+ = 13.2V, all channels on or off, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Negative Supply Current	I-	V+ = 13.2V, all channels on or off, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Logic Supply Current	I _L	V _L = 5.25V, all channels on or off, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Ground Current	I _{GND}	V _L = 5.25V, all channels on or off, V _{IN} = 0V or 5V	T _A = +25°C	-1	-0.0001	1	μA
			T _A = T _{MAX}	-5		5	
DYNAMIC							
Turn-On Time	t _{ON}	Figure 2, V _{NO_} or V _{NC_} = 8V	T _A = +25°C	175	250		ns
			T _A = T _{MIN} to T _{MAX}		315		
Turn-Off Time	t _{OFF}	Figure 2, V _{NO_} or V _{NC_} = 8V	T _A = +25°C	95	125		ns
			T _A = T _{MIN} to T _{MAX}		140		
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: ΔR_{ON} = ΔR_{ON} max - ΔR_{ON} min. On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation.

Note 6: See Figure 5. Off Isolation = 20 log₁₀ [V_{COM} / (V_{NC} or V_{NO})], V_{COM} = output, V_{NC} or V_{NO} = input to off switch.

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

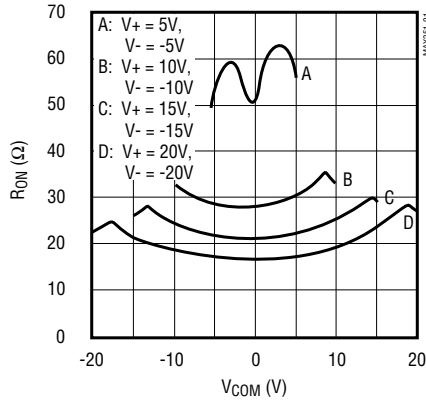
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Typical Operating Characteristics

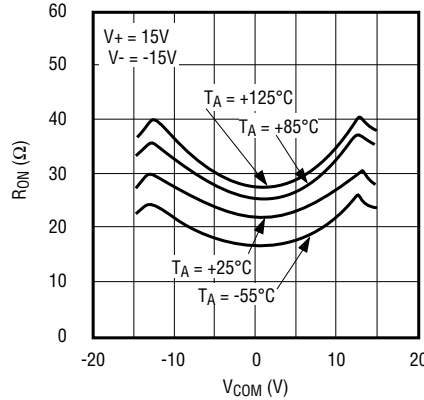
($T_A = +25^\circ\text{C}$, unless otherwise noted.)

MAX351/MAX352/MAX353

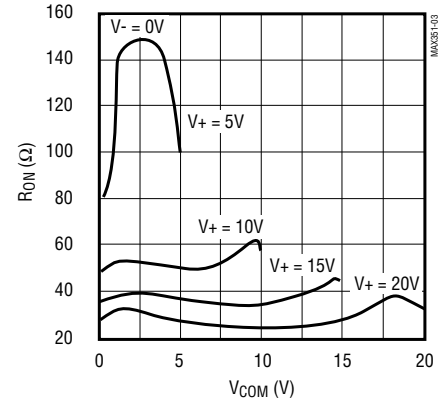
ON RESISTANCE vs. V_{COM} AND POWER-SUPPLY VOLTAGE



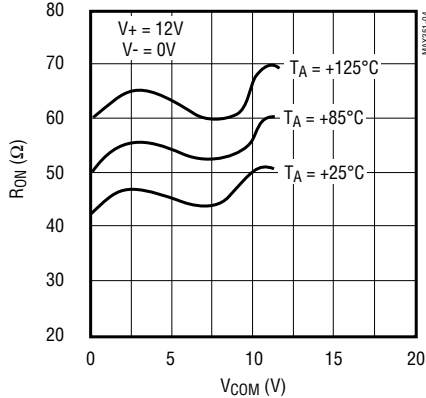
ON RESISTANCE vs. V_{COM} AND TEMPERATURE



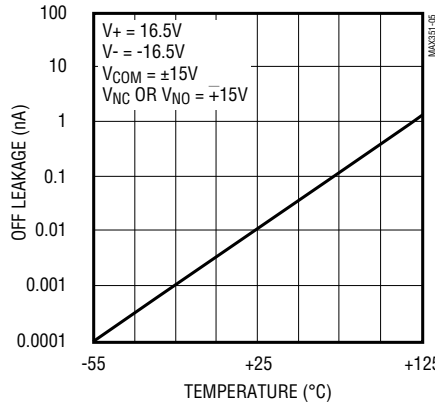
ON RESISTANCE vs. V_{COM} AND TEMPERATURE



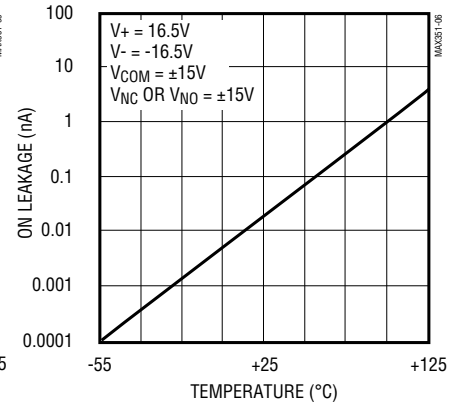
ON RESISTANCE vs. V_{COM} (SINGLE-SUPPLY)



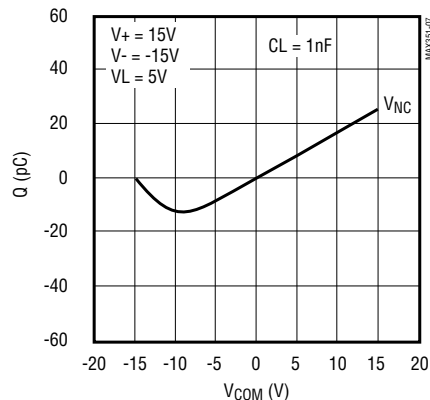
OFF LEAKAGE CURRENTS vs. TEMPERATURE



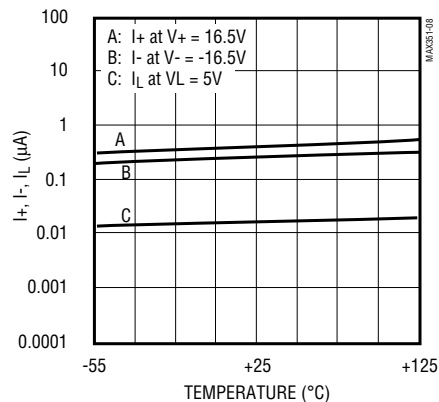
ON LEAKAGE CURRENTS vs. TEMPERATURE



CHARGE INJECTION vs. ANALOG VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



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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 $\pm 15\text{V}$

The main limitation of supply voltages other than $\pm 15\text{V}$ is reduced analog-signal range. The MAX351/MAX352/MAX353 operate with $\pm 5\text{V}$ to $\pm 20\text{V}$ bipolar supplies. The *Typical Operating Characteristics* graphs show typical on resistance (R_{ON}) for $\pm 15\text{V}$, $\pm 10\text{V}$, and $\pm 5\text{V}$ supplies. (Switching times increase by a factor of two or more for operation at $\pm 5\text{V}$.) The MAX351/MAX352/MAX353 can operate from $+10\text{V}$ to $+30\text{V}$ unipolar supplies. Each device can also be powered from unbalanced supplies such as $+24\text{V}$ and -5V . Connect V- to 0V when operating with a single supply. V_L must be connected to $+5\text{V}$ 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 $+44\text{V}$.

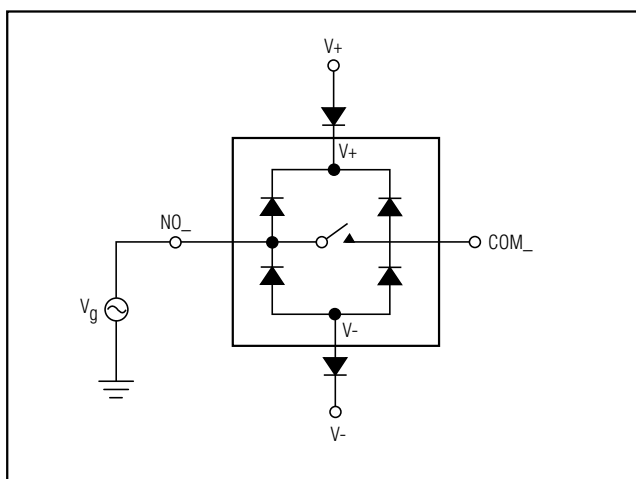


Figure 1. Overvoltage Protection Using External Blocking Diodes

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Test Circuits/Timing Diagrams

MAX351/MAX352/MAX353

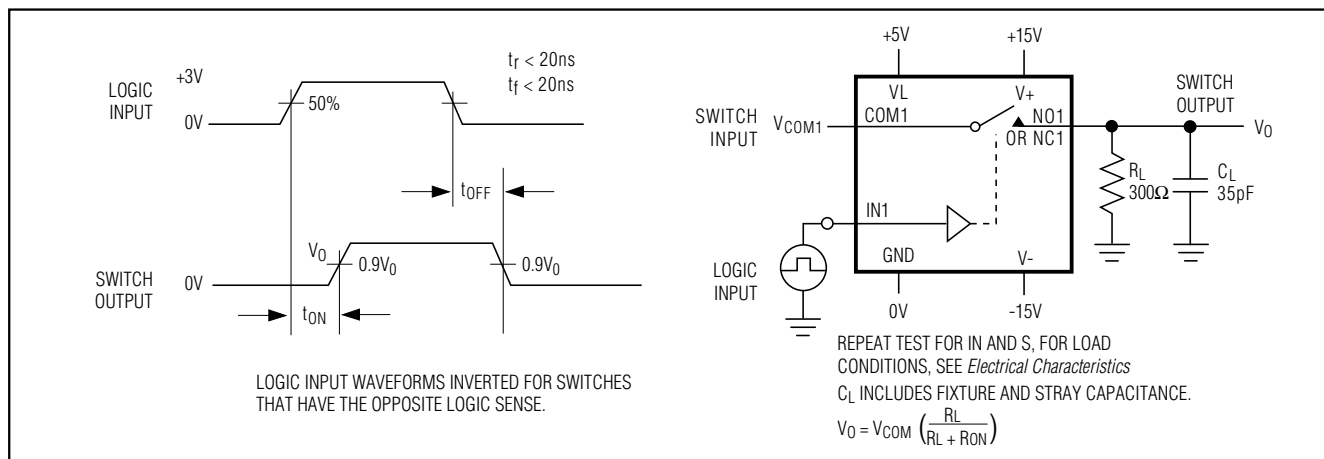


Figure 2. Switching-Time Test Circuit

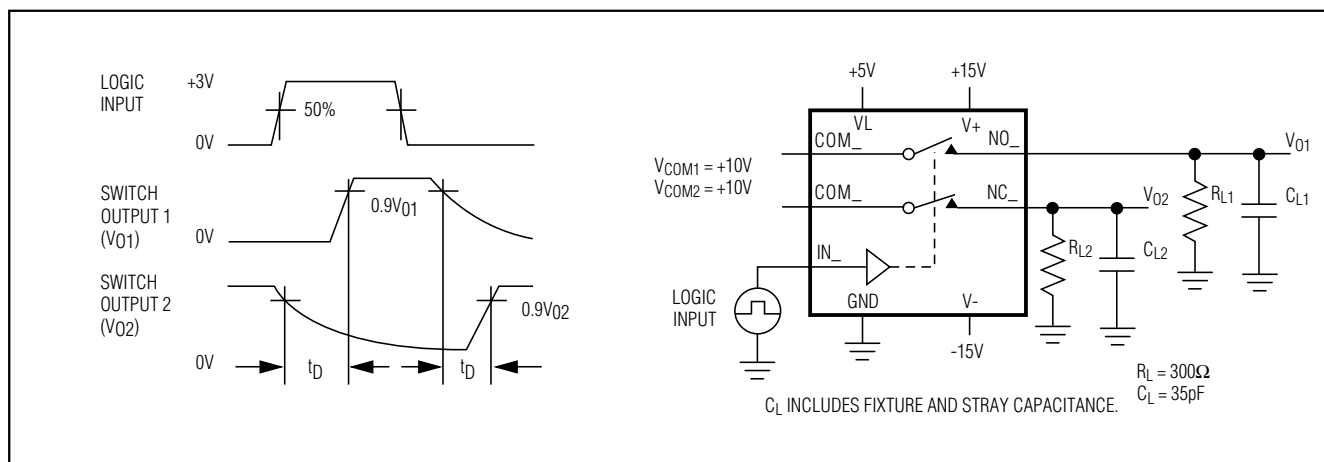


Figure 3. Break-Before-Make Test Circuit (MAX353 only)

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Test Circuits/Timing Diagrams (continued)

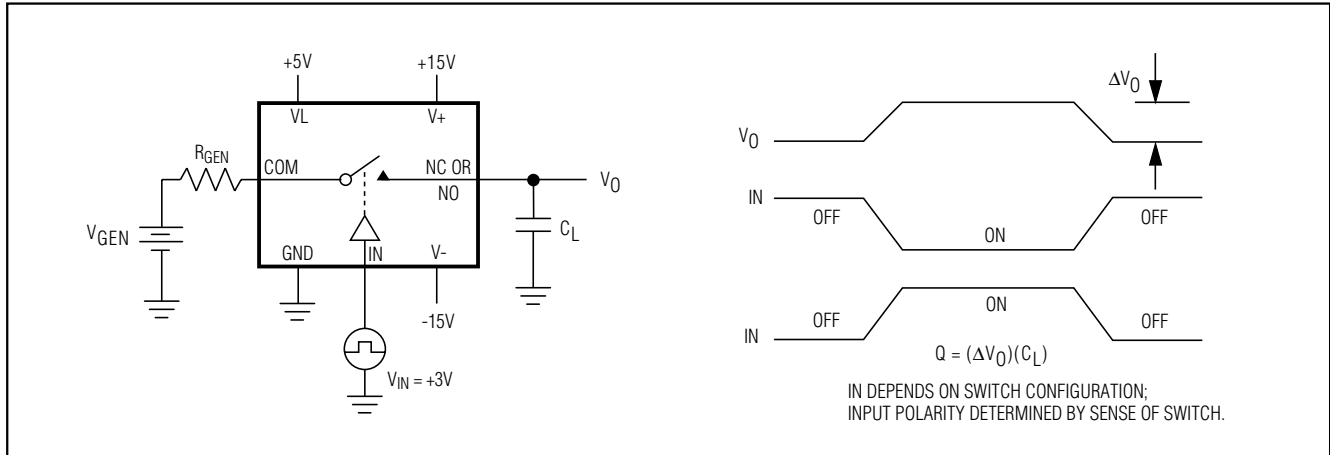


Figure 4. Charge-Injection Test Circuit

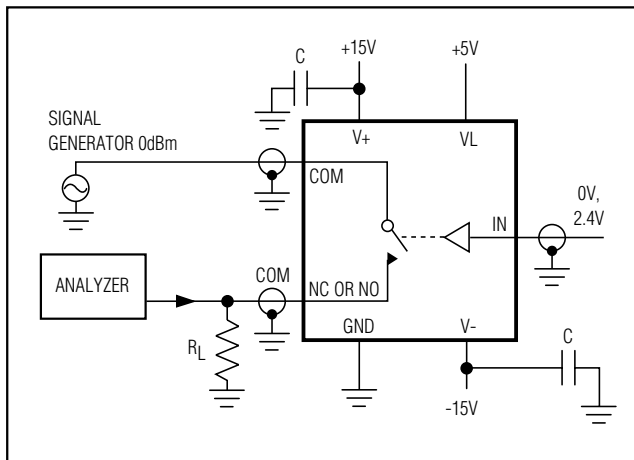


Figure 5. Off-Isolation Test Circuit

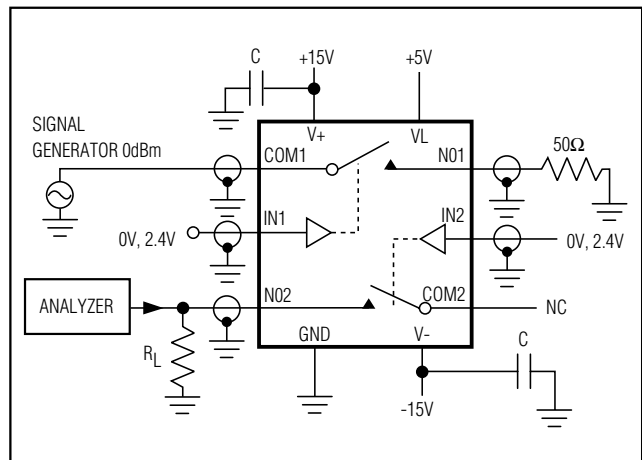


Figure 6. Crosstalk Test Circuit

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Test Circuits/Timing Diagrams (continued)

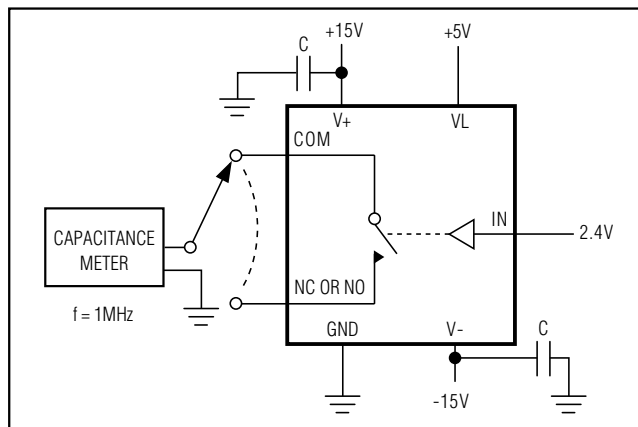


Figure 7. Channel-Off Capacitance

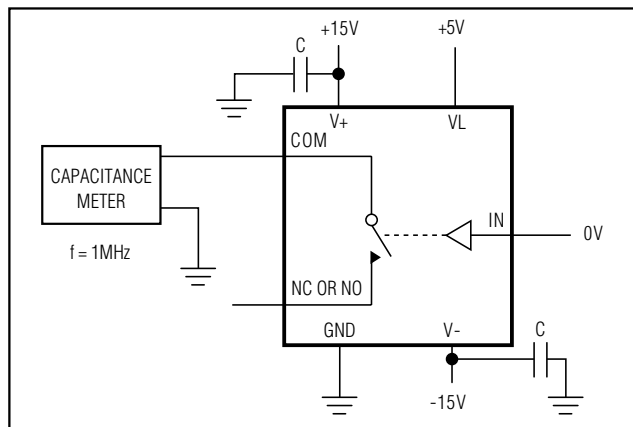
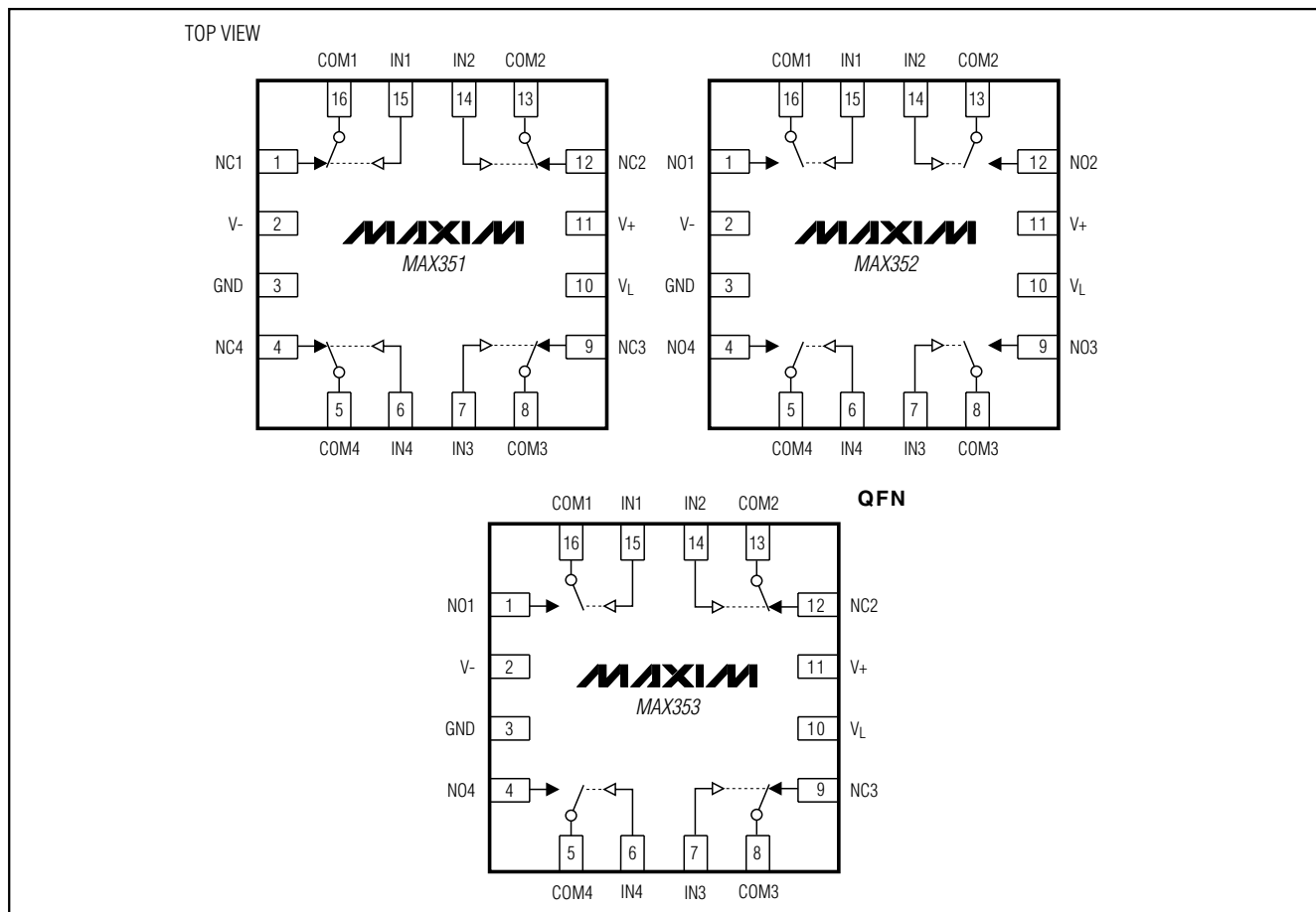


Figure 8. Channel-On Capacitance Test Circuit

Pin Configurations (continued)



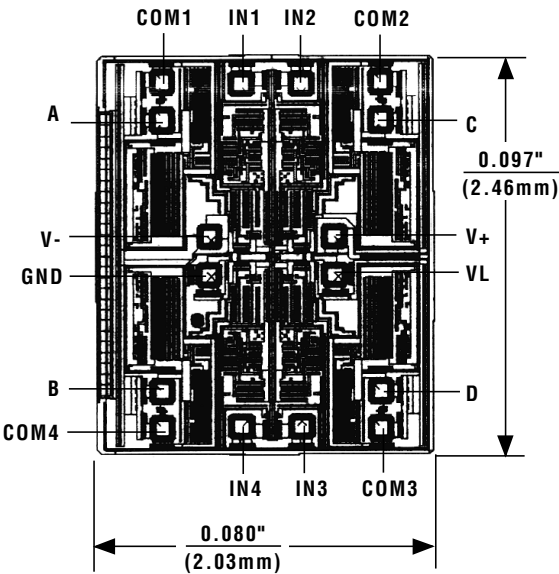
Precision, Quad, SPST Analog Switches

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+

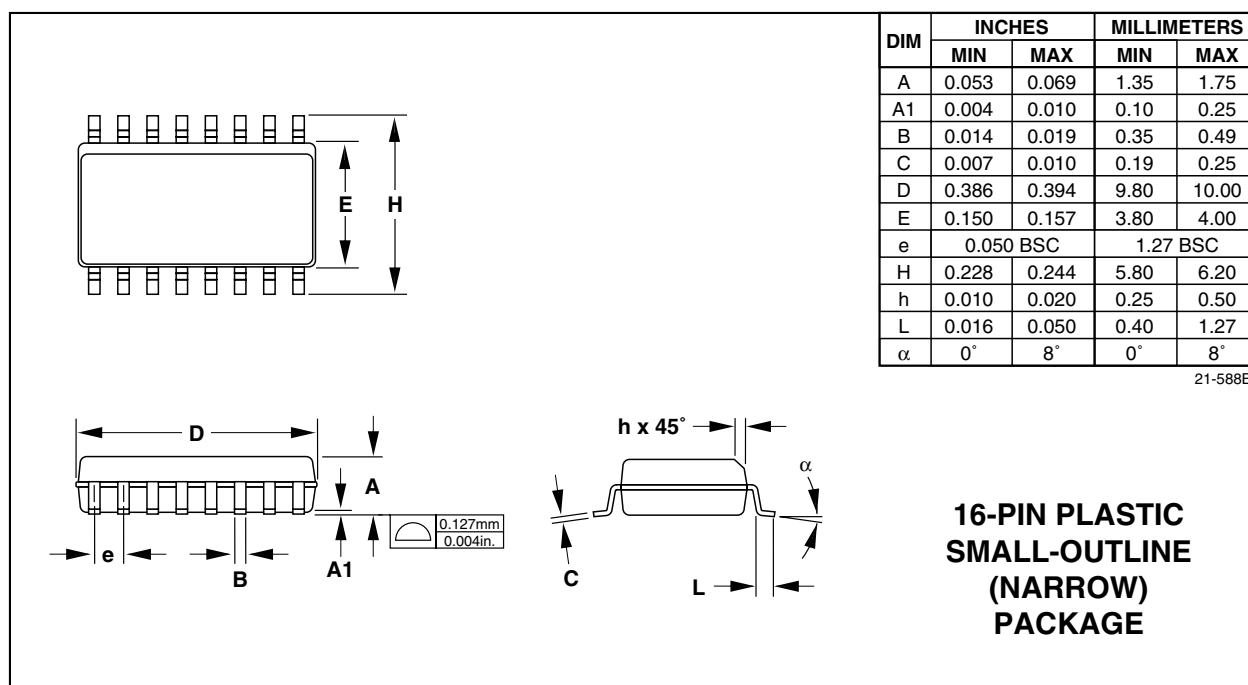
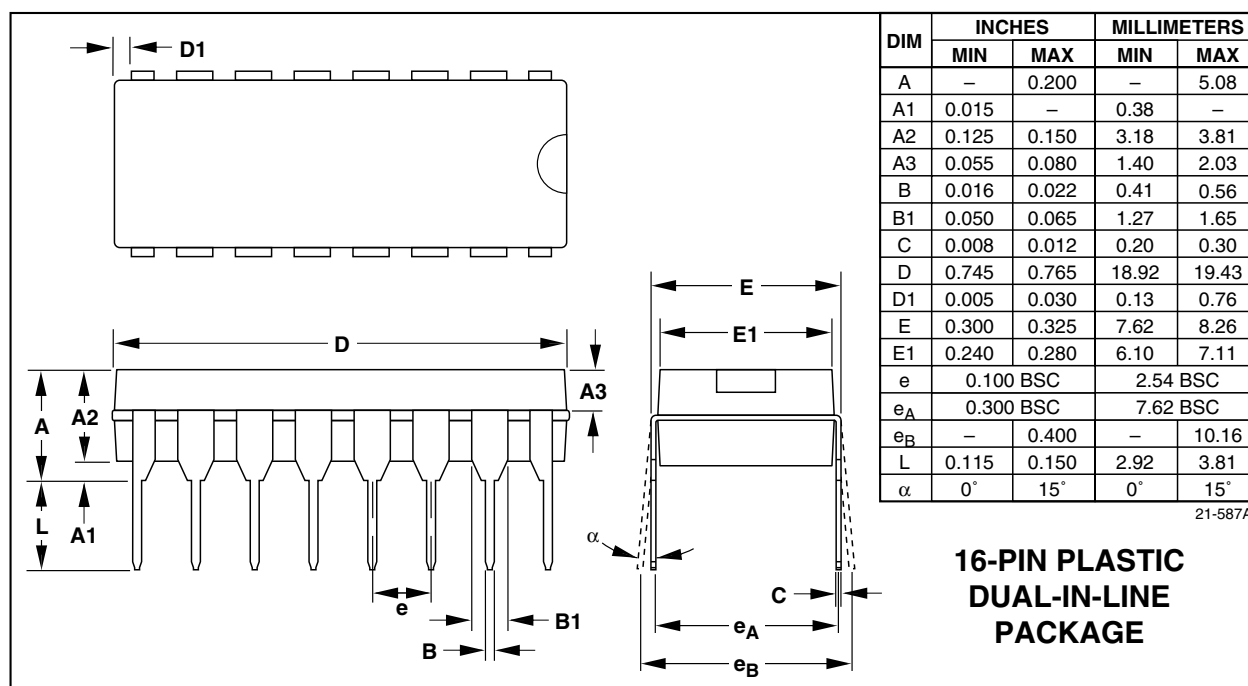
MAX351		MAX352		MAX353	
PIN	NAME	PIN	NAME	PIN	NAME
A	NC	A	NO	A	NO
B	NC	B	NO	B	NO
C	NC	C	NO	C	NC
D	NC	D	NO	D	NC

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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.)

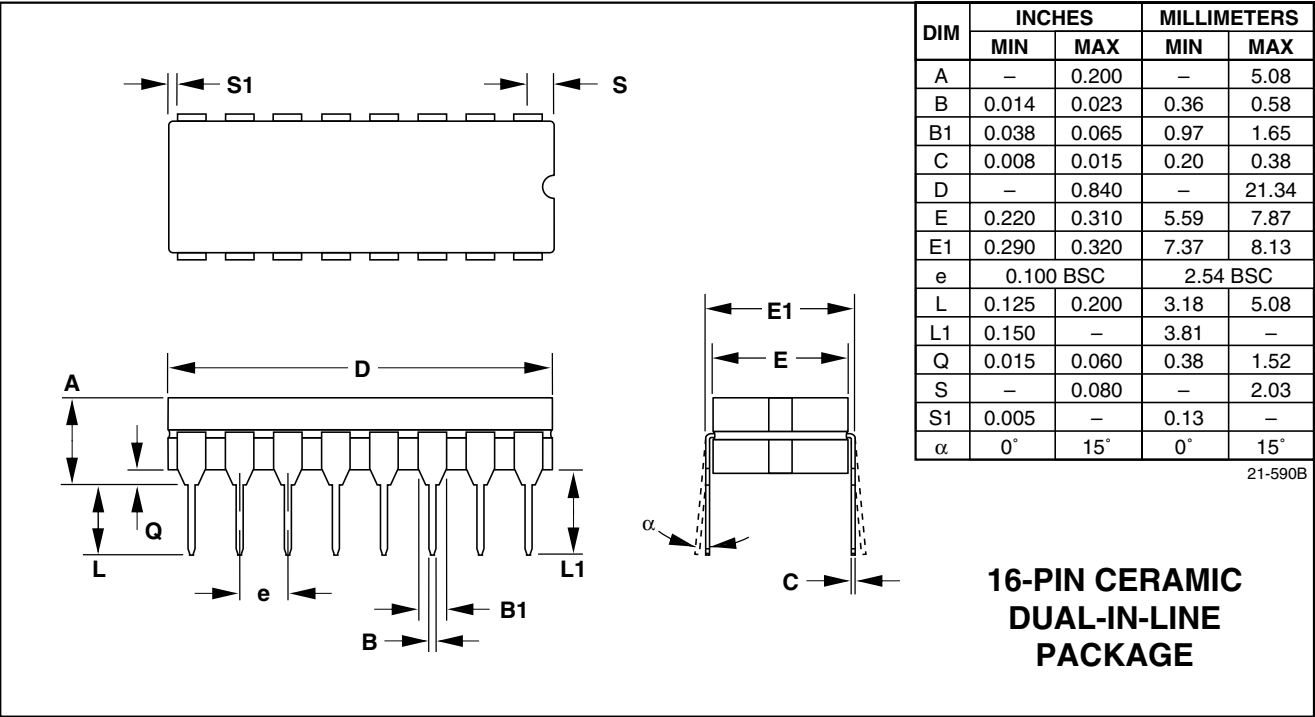
MAX351/MAX352/MAX353



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Package Information (continued)

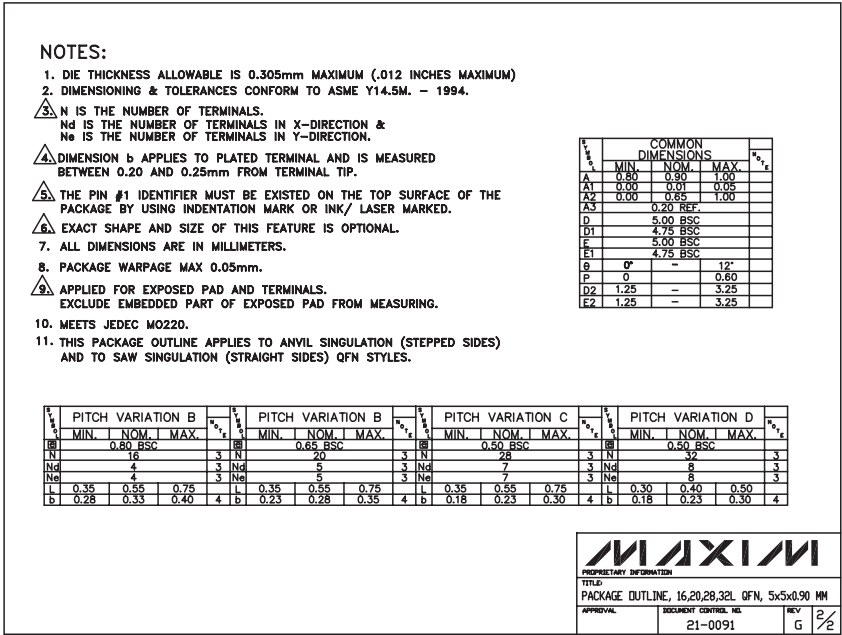
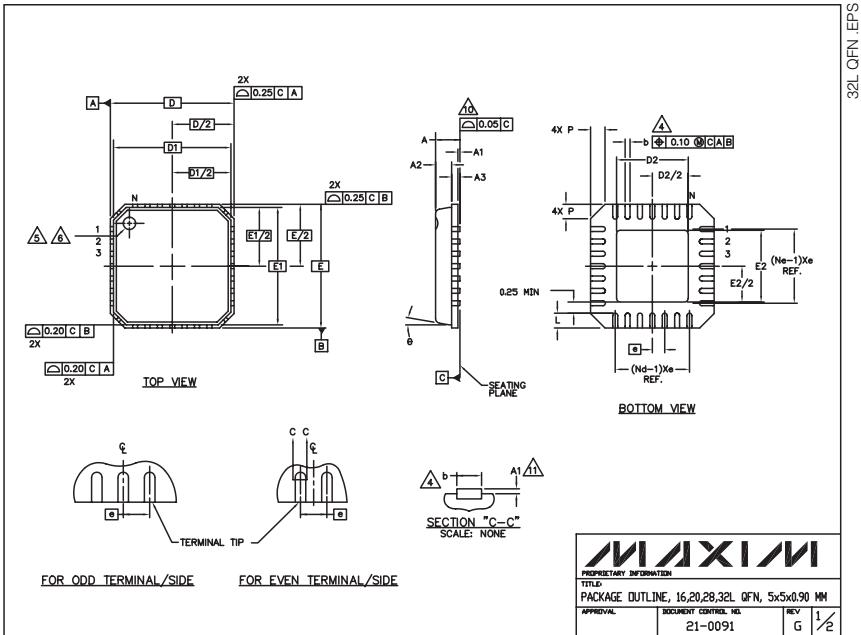
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



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.)



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