19-0212; Rev 2; 9/01

MAXIM

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 (Δ3Ω 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 (±4.5V to ±20V) while retaining CMOS-logic input compatibility and fast switching. CMOS inputs provide reduced input loading.

Applications

Sample-and-Hold Circuits
Guidance and Control Systems
Heads-Up Displays
Test Equipment
Military Radios
Communications Systems
Battery-Operated Systems
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 Δ3Ω 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 (±4.5V to ±20V)**
- ♦ **TTL-/CMOS-Logic Compatibility**
- ♦ **Rail-to-Rail Analog Signal Handling Capability**

Ordering Information

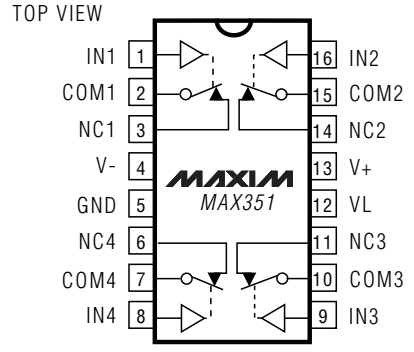
PART	TEMP RANGE	PIN-PACKAGE
MAX351CPE	0°C to +70°C	16 Plastic DIP
MAX351CSE	0°C to +70°C	16 Narrow SO
MAX351C/D	0°C to +70°C	Dice*
MAX351EGE	-40°C to +85°C	16 QFN
MAX351EPE	-40°C to +85°C	16 Plastic DIP
MAX351ESE	-40°C to +85°C	16 Narrow SO
MAX351EJE	-40°C to +85°C	16 CERDIP
MAX351MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

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

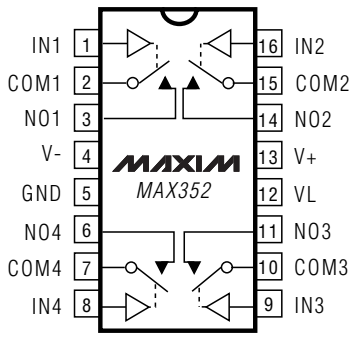
Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW



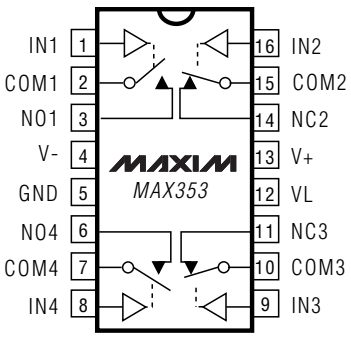
DIP/SO

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

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

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, V_{COM}, V_{NC}, V_{NO} (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 (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
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, 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)			V-		V+	V
On Resistance	R_{ON}	I_{COM} = -10mA, $V_{NO_}$ or $V_{NC_}$ = ±8.5V, V+ = 13.5V, V- = -13.5V	T_A = +25°C	C, E		17	35	Ω
				M		17	30	
			T_A = T_{MIN} to T_{MAX}				45	
On Resistance Match Between Channels (Note 5)	R_{ON}	I_{COM} = -10mA, $V_{NO_}$ or $V_{NC_}$ = ±10V, V+ = 15V, V- = - 15V	T_A = +25°C				2	Ω
			T_A = T_{MIN} to T_{MAX}				4	
On Resistance Flatness (Note 5)	R_{ON}	I_{COM} = -10mA, $V_{NO_}$ or $V_{NC_}$ = ±5V, V+ = 15V, V- = - 15V	T_A = +25°C				3	Ω
			T_A = T_{MIN} to T_{MAX}				5	
Off Leakage Current (NO_ or NC_)	I_{NO} I_{NC}	V_{COM} = -15.5V, $V_{NO_}$ or $V_{NC_}$ = 15.5V, V+ = 16.5V, V- = -16.5V	T_A = +25°C		-0.25	-0.10	0.25	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-6		6	
				M	-20		20	
COM_ Off Leakage Current	$I_{NC(OFF)}$	V_{COM} = -15.5V, $V_{NO_}$ or $V_{NC_}$ = 15.5V, V+ = 16.5V, V- = -16.5V	T_A = +25°C		-0.25	-0.10	0.25	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-6		6	
				M	-20		20	
COM_ On Leakage Current	$I_{COM(ON)}$	V_{COM} = ±15.5V, $V_{NO_}$ or $V_{NC_}$ = ±15.5V, V+ = 16.5V, V- = -16.5V	T_A = +25°C		-0.4	-0.1	0.4	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-10		10	
				M	-40		40	

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, VL = 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
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, 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_{GND}	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

ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, VL = 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	VL = 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}	VL = 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.

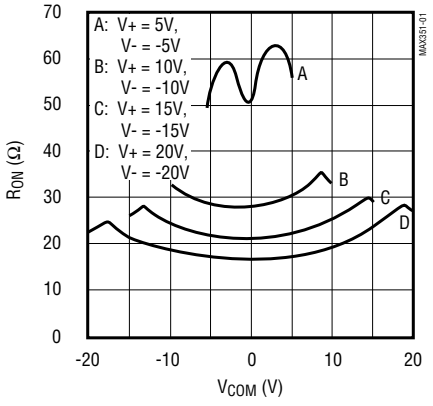
Note 6: See Figure 5. Off Isolation = 20 $\log_{10}$ [V_{COM} / ($V_{NC\ or}$ V_{NO})], V_{COM} = output, $V_{NC\ or}$ V_{NO} = input to off switch.

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

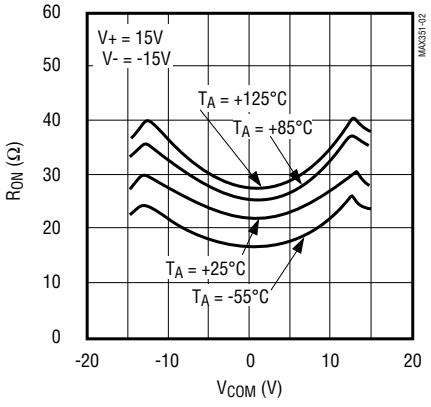
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

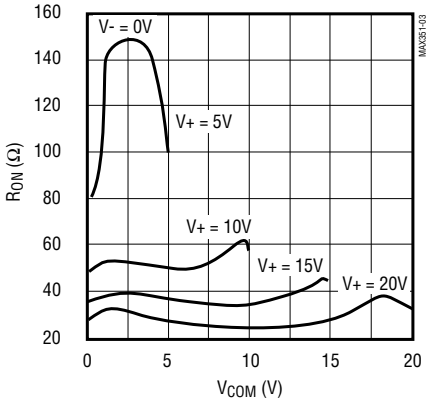
ON RESISTANCE vs. V_{COM} AND POWER-SUPPLY VOLTAGE



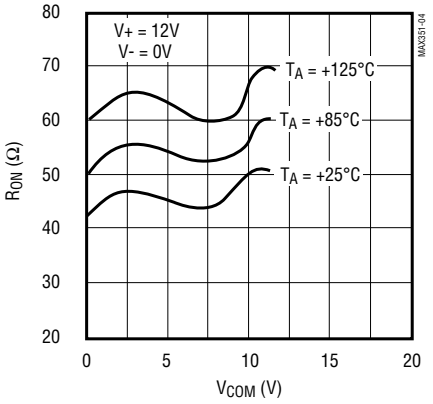
ON RESISTANCE vs. V_{COM} AND TEMPERATURE



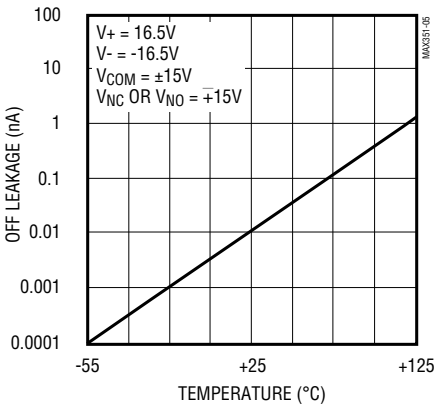
ON RESISTANCE vs. V_{COM} AND TEMPERATURE



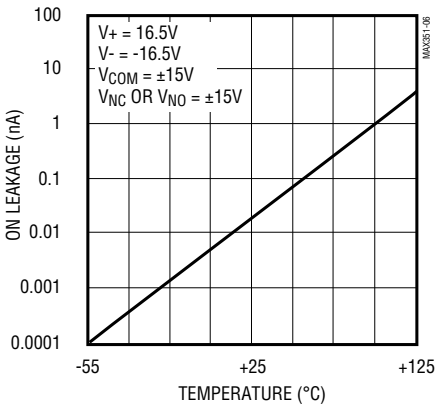
ON RESISTANCE vs. V_{COM} (SINGLE-SUPPLY)



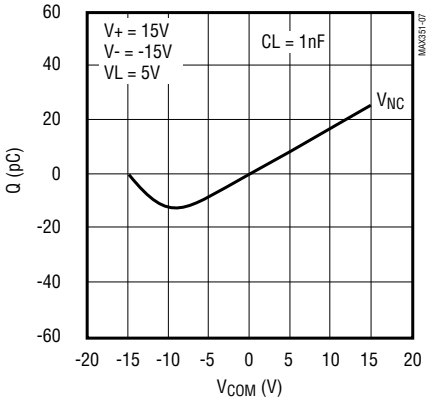
OFF LEAKAGE CURRENTS vs. TEMPERATURE



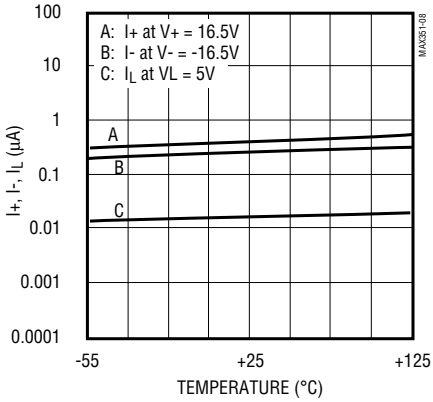
ON LEAKAGE CURRENTS vs. TEMPERATURE



CHARGE INJECTION vs. ANALOG VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



Precision, Quad, SPST Analog Switches

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. 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.

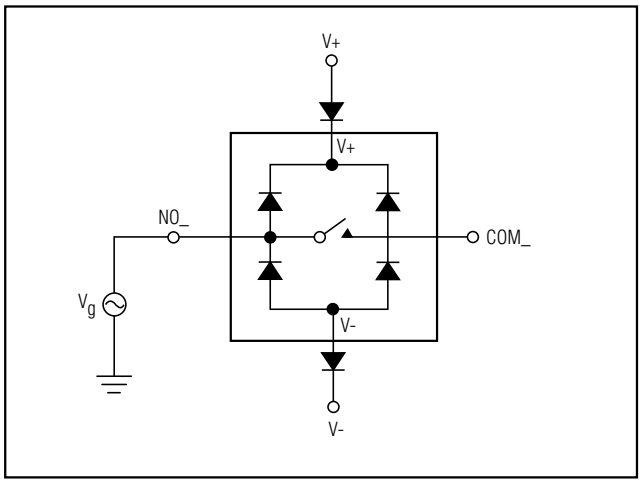


Figure 1. Overvoltage Protection Using External Blocking Diodes

Test Circuits/Timing Diagrams

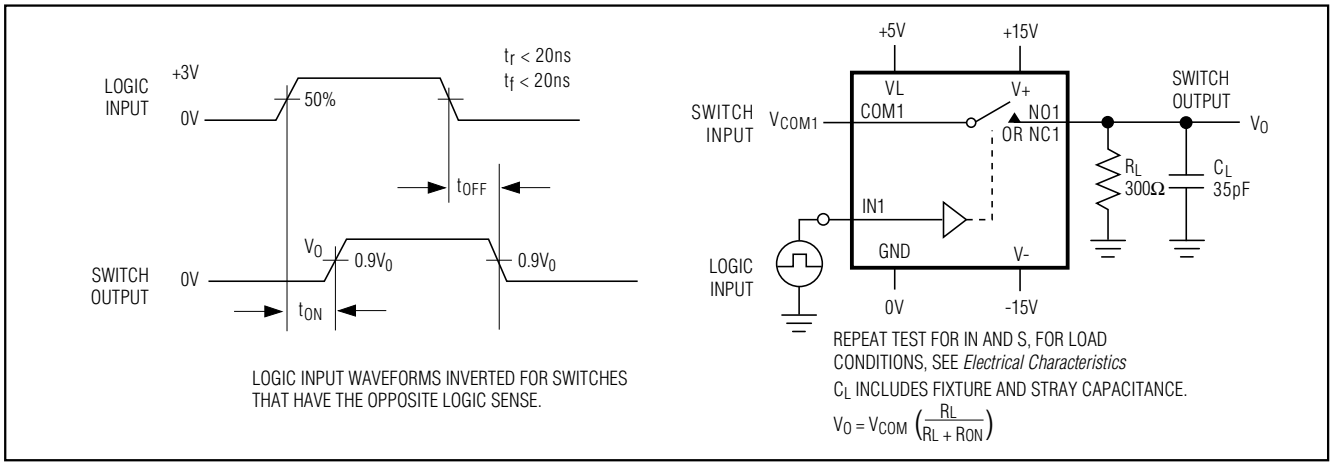


Figure 2. Switching-Time Test Circuit

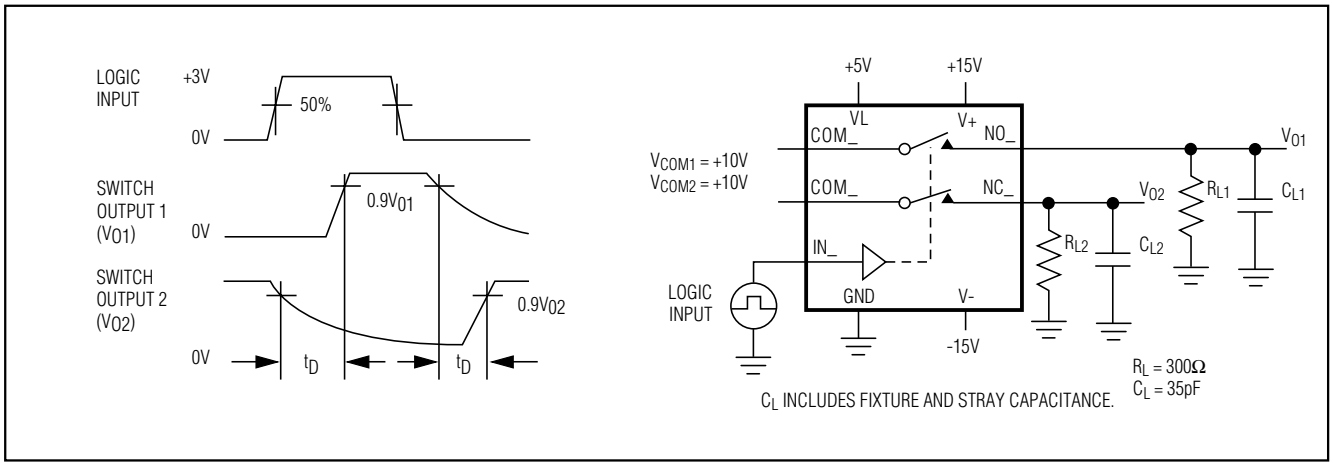


Figure 3. Break-Before-Make Test Circuit (MAX353 only)

Test Circuits/Timing Diagrams (continued)

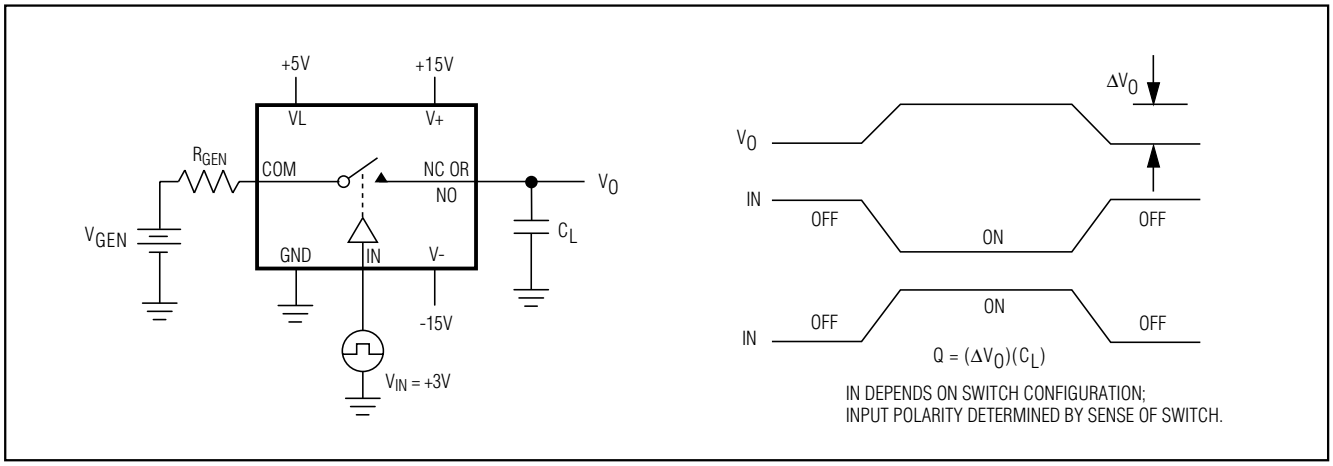


Figure 4. Charge-Injection Test Circuit

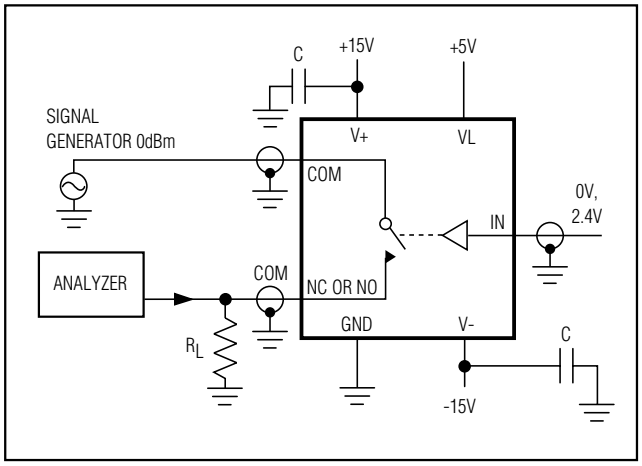


Figure 5. Off-Isolation Test Circuit

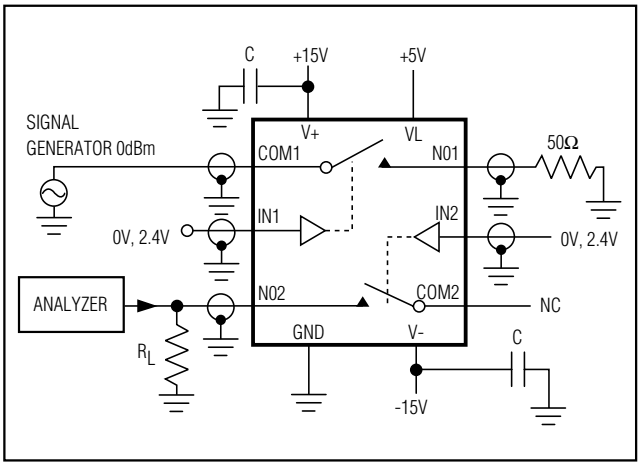


Figure 6. Crosstalk Test Circuit

Test Circuits/Timing Diagrams (continued)

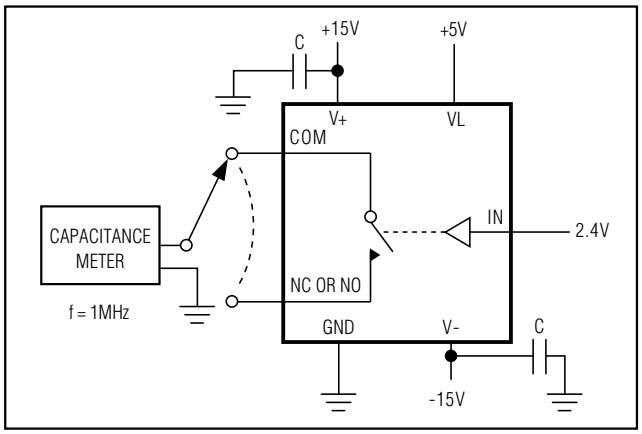


Figure 7. Channel-Off Capacitance

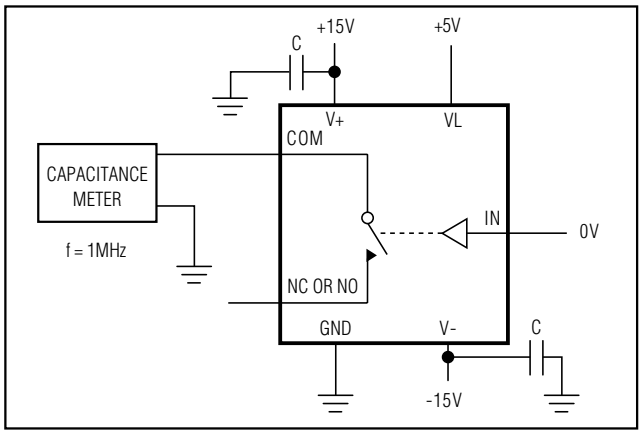
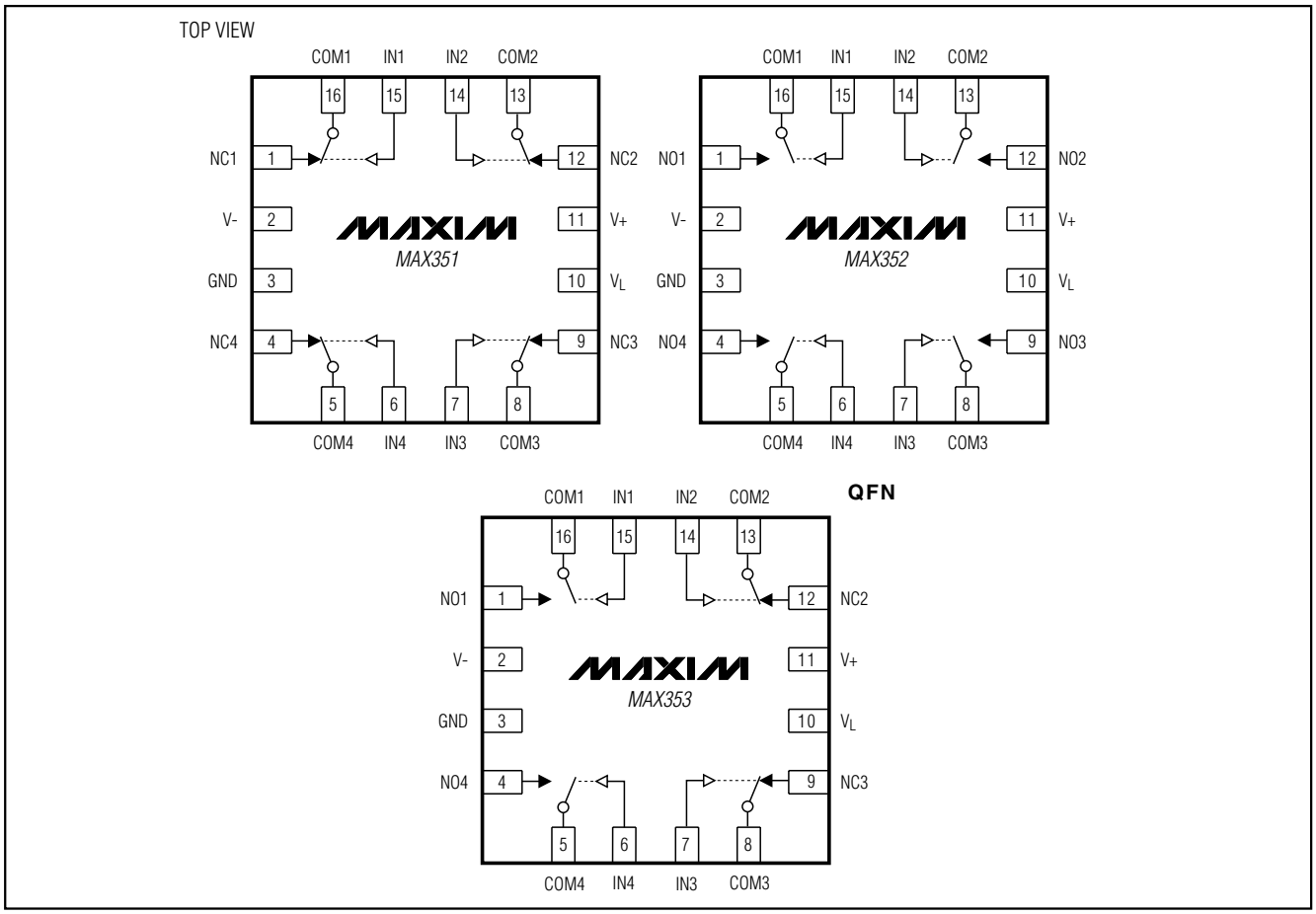


Figure 8. Channel-On Capacitance Test Circuit

Pin Configurations (continued)



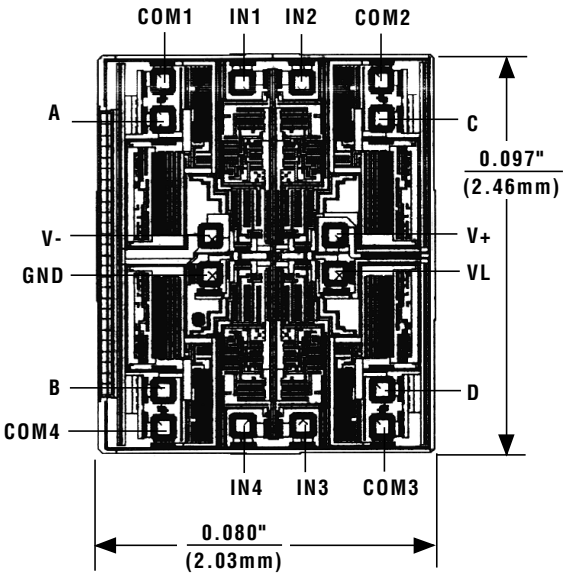
Precision, Quad, SPST Analog Switches

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



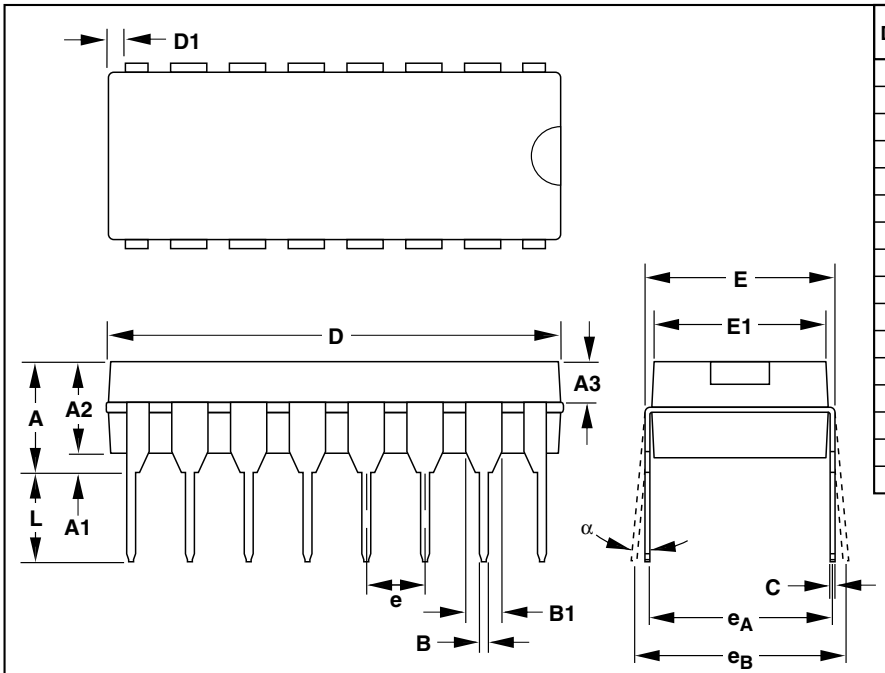
TRANSISTOR COUNT: 136

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

Package Information

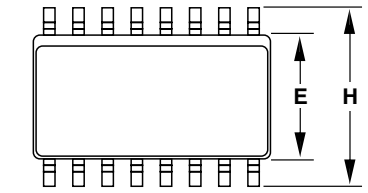
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	0.200	–	5.08
A1	0.015	–	0.38	–
A2	0.125	0.150	3.18	3.81
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.050	0.065	1.27	1.65
C	0.008	0.012	0.20	0.30
D	0.745	0.765	18.92	19.43
D1	0.005	0.030	0.13	0.76
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
e_A	0.300 BSC		7.62 BSC	
e_B	–	0.400	–	10.16
L	0.115	0.150	2.92	3.81
α	0°	15°	0°	15°

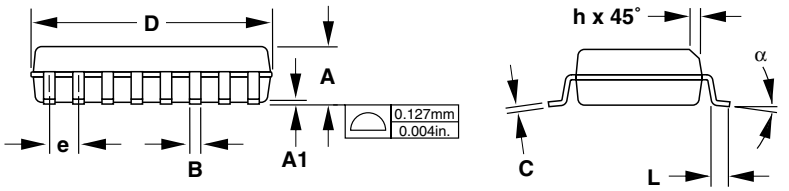
21-587A

16-PIN PLASTIC DUAL-IN-LINE PACKAGE



DIM	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
D	0.386	0.394	9.80	10.00
E	0.150	0.157	3.80	4.00
e	0.050 BSC		1.27 BSC	
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
α	0°	8°	0°	8°

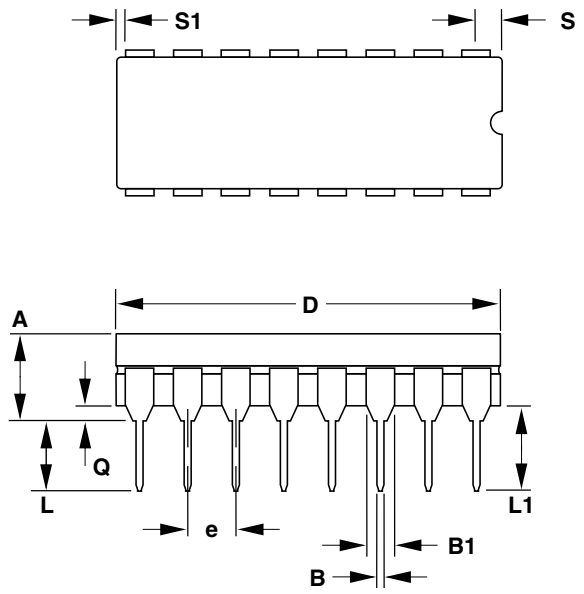
21-588B



16-PIN PLASTIC SMALL-OUTLINE (NARROW) PACKAGE

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**.)



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	0.200	–	5.08
B	0.014	0.023	0.36	0.58
B1	0.038	0.065	0.97	1.65
C	0.008	0.015	0.20	0.38
D	–	0.840	–	21.34
E	0.220	0.310	5.59	7.87
E1	0.290	0.320	7.37	8.13
e	0.100 BSC		2.54 BSC	
L	0.125	0.200	3.18	5.08
L1	0.150	–	3.81	–
Q	0.015	0.060	0.38	1.52
S	–	0.080	–	2.03
S1	0.005	–	0.13	–
α	0°	15°	0°	15°

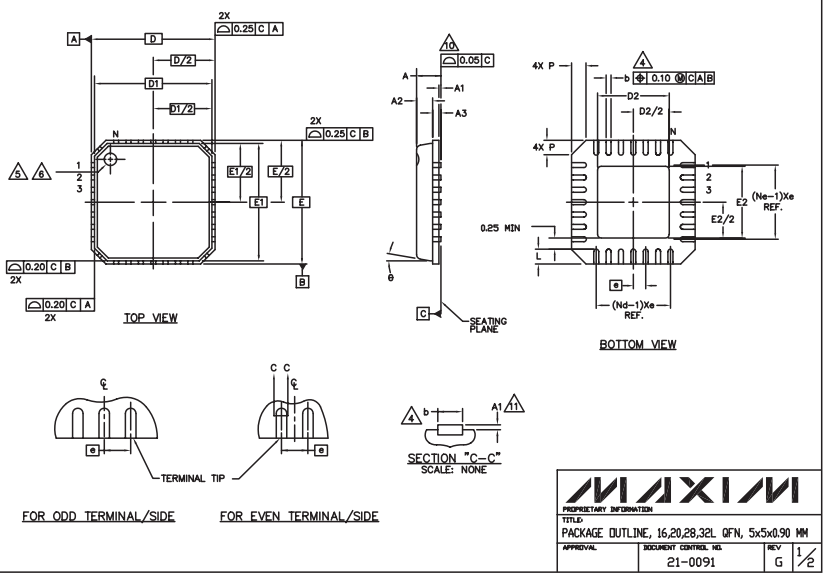
21-590B

16-PIN CERAMIC DUAL-IN-LINE PACKAGE

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**.)

32L QFN.EPS



NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
2. DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M. – 1994.
3. N IS THE NUMBER OF TERMINALS.
   Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION &
   Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/ LASER MARKED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS.
   EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220.
11. THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES) AND TO SAW SINGULATION (STRAIGHT SIDES) QFN STYLES.

SYMBOL	COMMON DIMENSIONS MIN.	NOM.	MAX.	NOTE
A	0.80	0.90	1.00	
A1	0.00	0.01	0.05	
A2	0.00	0.65	1.00	
A3		0.20 REF		
D		5.00 BSC		
D1		4.75 BSC		
E		5.00 BSC		
E1		4.75 BSC		
θ	0°	–	12°	
P	0		0.60	
D2	1.25	–	3.25	
E2	1.25	–	3.25	

SYMBOL	PITCH VARIATION B MIN.	NOM.	MAX.	NOTE
e		0.80 BSC		
N		16		3
Nd		4		3
Ne		4		3
L	0.35	0.55	0.75	
b	0.28	0.33	0.40	4

SYMBOL	PITCH VARIATION B MIN.	NOM.	MAX.	NOTE
e		0.65 BSC		
N		20		3
Nd		5		3
Ne		5		3
L	0.35	0.55	0.75	
b	0.23	0.28	0.35	4

SYMBOL	PITCH VARIATION C MIN.	NOM.	MAX.	NOTE
e		0.50 BSC		
N		28		3
Nd		7		3
Ne		7		3
L	0.35	0.55	0.75	
b	0.18	0.23	0.30	4

SYMBOL	PITCH VARIATION D MIN.	NOM.	MAX.	NOTE
e		0.50 BSC		
N		32		3
Nd		8		3
Ne		8		3
L	0.30	0.40	0.50	
b	0.18	0.23	0.30	4

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

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