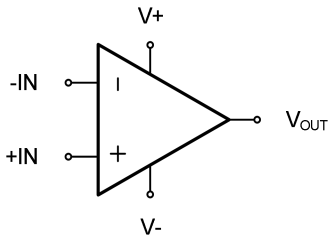
LM331/LM391/LM2903/LM2901
High-Voltage Open-Drain Output Comparator

1 Features	2 Application
- Supply Range: +2V to +32V - Low Supply Current 45μA (TYP) per channel at VS = 5V - Common-Mode Input Voltage Range Includes Ground - Low Output Saturation Voltage - Open-Drain Output for Maximum Flexibility - Specified up to +125°C - Micro Size Packages: SOP8, MSOP8	- Hysteresis Comparators - Factory Automation&Contral - Industrial Equipment - Test and Measurement - Cordless Power Tool - Vacuum Robot - Wireless Infrastructure

3 Description	Circuit Diagram
The LM2903 is the dual comparator version, and the outputs can be connected to other open-collector outputs to achieve wired-AND relationships. It can operate from 2V to 32V, and have low power consuming 45μA (TYP) per channel. The LM2903 consist of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Quiescent current is independent of the supply voltage. The device is the most cost-effective solutions for applications where low offset voltage, high supply voltage capability.low supply current, and space saving are the primary specifications in circuit design for portable consumer products. The LM2903 is available in Green SOP8, MSOP8 packages. It operates over an ambient temperature range of -40°C to +125°C.	

4 Device Summary, Pin and Packages

Table 4-1. Device Summary(1)

Serial Name	Part Name	Package	Body Size (Nom)	Marking(2)	MSL(3)	Package Qty
LM391	LM391S5	SOT23-5	2.90mm×1.60mm×1.10mm	GT391 XXXXX	3	Tape and Reel,3000
LM331	LM331S5	SOT23-5	2.90mm×1.60mm×1.10mm	GT331 XXXXX	3	Tape and Reel,3000
	LM331US5	SOT23-5	2.90mm×1.60mm×1.10mm	GT331 XXXXX	3	Tape and Reel,3000
LM2903	LM2903P8	SOP8	4.90mm×3.90mm×1.75mm	GT2903 XXXXXXX	3	Tape and Reel,4000
	LM2903T8	TSSOP8	3.00mm×4.40mm×1.10mm	GT2903 XXXXXXX	3	Tape and Reel,5000
	LM2903M8	MSOP8	3.00mm×3.00mm×1.10mm	GT2903 XXXXXXX	3	Tape and Reel,4000
LM2901	LM2901PD	SOP14	8.65mm×3.90mm×1.75mm	GT2901 XXXXXXX	3	Tape and Reel,4000
	LM2901TD	TSSOP14	5.00mm×4.40mm×1.20mm	GT2901 XXXXXXX	3	Tape and Reel,4000

(1) For all available packages, please contact product sales.

(2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

(3) MSL, The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications.

(4) "XXXXX" in Marking will be appeared as the batch code.

4 Device Summary, Pin and Packages(Continued)

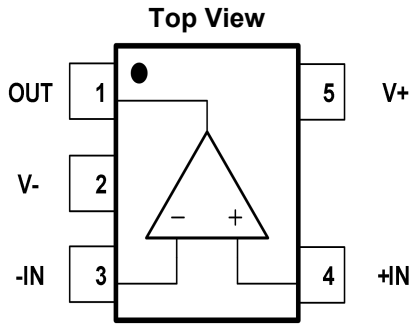


Fig.4-1. LM391: S5(SOT23-5) Package

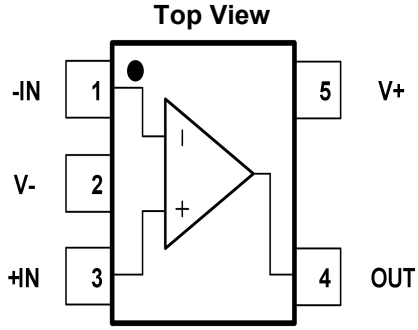


Fig.4-2. LM331: S5(SOT23-5) Package

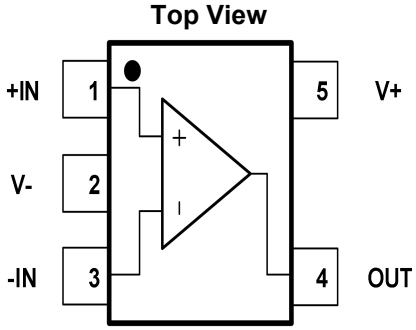


Fig.4-3. LM331U: S5(SOT23-5) Package

Table 4-2 Pin Definition

Name	Pin			I/O	Description
	391S5	331S5	331US5		
-IN	3	1	3	I	Negative (inverting) input
+IN	4	3	1	I	Positive(noninverting) input
NC	-	-	-	-	No internal connection (can be left floating)
OUT	1	4	4	O	Output
V-	2	2	2	-	Negative (lowest) power supply
V+	5	5	5	-	Positive (highest) power supply

* It is suggested to leave the unconnected pins floating.

4 Device Summary, Pin and Packages(Continued)

Top View

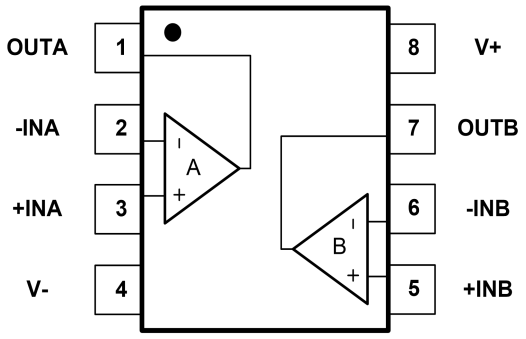


Fig.4-4. LM2903: P8(SOP8) Package

LM2903: M8(MSOP8) Package

LM2903: T8(TSSOP8) Package

Table 4-3 Pin Definition

Name	Pin	I/O	Description
	P8 M8 T8		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V-	4	-	Negative (lowest) power supply
V+	8	-	Positive (highest) power supply

* It is suggested to leave the unconnected pins floating

4 Device Summary, Pin and Packages(Continued)

Top View

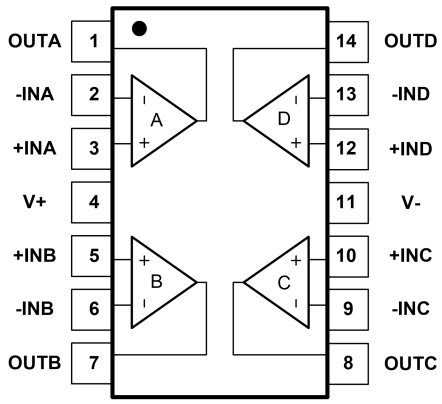


Fig.4-5.LM2901: TD(TSSOP14) Package

LM2901: PD(SOP14) Package

Table 4-4 Pin Definition

Name	Pin	I/O	Description
	PD TD		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
-INC	9	I	Inverting input, channel C
+INC	10	I	Noninverting input, channel C
-IND	13	I	Inverting input, channel D
+IND	12	I	Noninverting input, channel D
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
OUTC	8	O	Output, channel C
OUTD	14	O	Output, channel D
V-	11	-	Negative (lowest) power supply
V+	4	-	Positive (highest) power supply

* It is suggested to leave the unconnected pins floating.

5 Voltage, Temperature, ESD and Thermal Ratings

5.1 Absolute Maximum Ratings(1) (2)

Parameters	Min.	Max.	Unit
Supply Voltage, V_S=(V+) - (V-)		36	V
Input Voltage	(V-)-0.3	(V+)+0.3	V
Maximum Junction Temperature	-55	150	°C
Storage Temperature Range	-55	150	°C

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3V beyond the supply rails should be current- limited to 10mA or less.

5.2 ESD Ratings

ESD			Value	Unit
V(ESD)	Electrostatic Discharge	Human-Body Model (HBM)(1)	±6.5K	V
		Charged-Device Model (CDM)(2)	±2K	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

Symbol	Parameters	Min	Max	Unit
V_S	Single-Supply, V_S=(V+) - (V-)	2	32	V
	Dual-Supply,V_S=(V+) - (V-)	±1	±16	V
TA	Operating Temperature	-40	125	°C

5.4 Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP8	210	45	°C/W
SOP8	158	43	°C/W

6 Electrical Specifications

At T_A = +25°C, V_{CM}=(V_S/2), V_S=5V,. Typical values are at T_A = +25°C. FULL = –40°C to +125°C (unless otherwise noted)

Parameter	Symbol	Test Conditions	Vs	TA	Min	Typ	Max	Units
Operating Voltage	V_S		2V to 32V	FULL	2		32	V
Input Common Mode Voltage Range	V_{CM}		2V to 32V	+25°C	V(-)		V(+)-1.5	V
			2V to 32V	FULL	V(-)		V(+)-2.0	
Input Offset Voltage	V_{OS}		2V to 32V	+25°C	-3.5	±0.8	3.5	mV
			2V to 32V	FULL	-4		4	
Quiescent Current (per Comparator)	IQ	no load	32V	+25°C		45	90	μA
		no load	32V	FULL		90		
Input Hysteresis Voltage	V_{HYST}	V_{CM}=1.2V	5V	+25°C		7		mV
Input Bias Current	I_B			+25°C		10	50	pA
				FULL			100	
Input Offset Current	I_{OS}			+25°C		10	50	pA
				FULL			100	nA
Large signal differential voltag amplification	A_{VD}	V_O=1.4V to 11.4V R_L≥15k to (V+)	15V	FULL	50	145		dB
Low-Level Output Voltage	V_{OL}	I_{sink}≤4mA,V_{ID}=-1V		FULL		200	300	mV
Output Current(sinking)	$I_{SINKING}$	I_{sink}≤4mA,V_{ID}=-1V	5V	FULL	6	39		mA
High-Level Output Leakage Current	I_{OH-LKG}	(V+)=VO=3V;VID=1V		FULL		2.0	400	nA
		(V+)=VO=30V;VID=1V		FULL		2.8	500	nA
Propagation Delay (Low-to-High)	T_{PLH}	RPU=5.1KΩ Overdrive=10mV	3V	FULL		0.47		μs
		RPU=5.1KΩ Overdrive=100mV				0.4		
		RPU=5.1KΩ Overdrive=10mV	32V	FULL		0.81		
		RPU=5.1KΩ Overdrive=100mV				0.80		
Propagation Delay (High-to-Low)	T_{PHL}	RPU=5.1KΩ Overdrive=10mV	3V	FULL		0.19		
		RPU=5.1KΩ Overdrive=100mV				0.10		
		RPU=5.1KΩ Overdrive=10mV	32V	FULL		0.19		
		RPU=5.1KΩ Overdrive=100mV				0.10		

7 Typical Characteristics

V_S=5V, C_L=10pF, and V_{CM} = 0 , TA=+25°C. (unless otherwise noted)

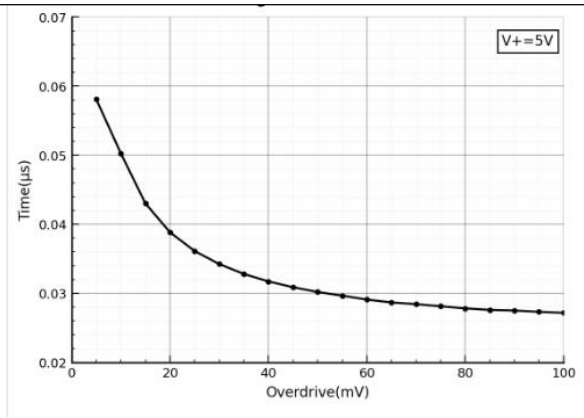


Fig.7-1. Response Time vs Input Overdrives Negative Transition

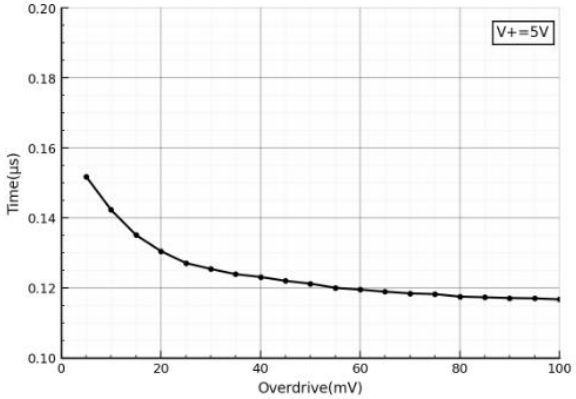


Fig.7-2. Response Time vs Input Overdrives Positive Transition

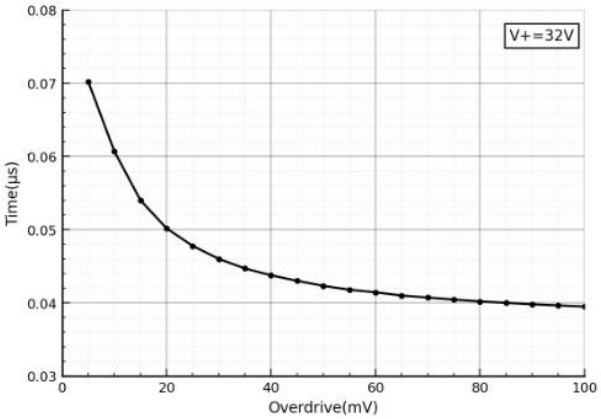


Fig.7-3. Response Time vs Input Overdrives Negative Transition

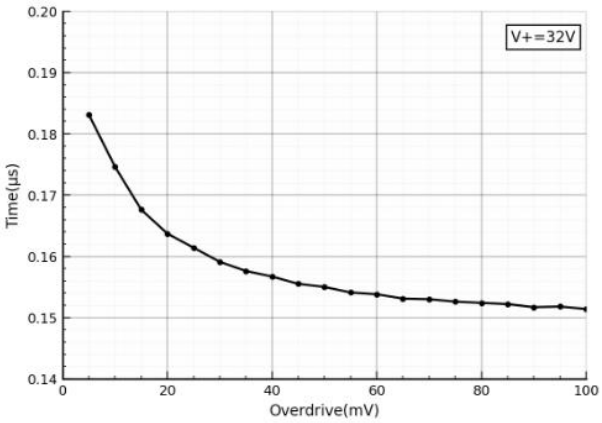


Fig.7-4. Response Time vs Input Overdrives Positive Transition

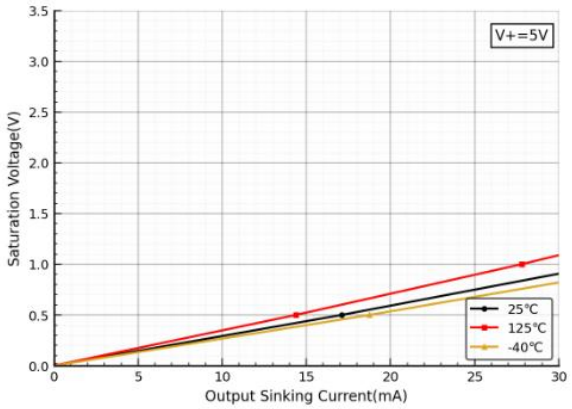


Fig.7-5. Saturation Voltage vs Output Sink Current

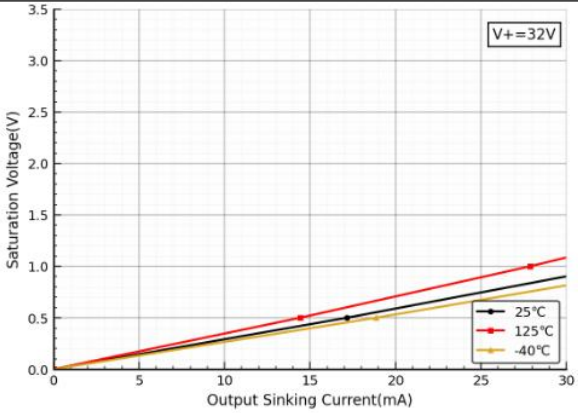


Fig.7-6. Saturation Voltage vs Output Sink Current

8 Detailed Description

The LM2903 family of comparators can operate up to 32V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to its low power and high speed. The open-drain output allows the user to configure the output's logic low voltage (VOL) and can be utilized to enable the comparator to be used in AND functionality.

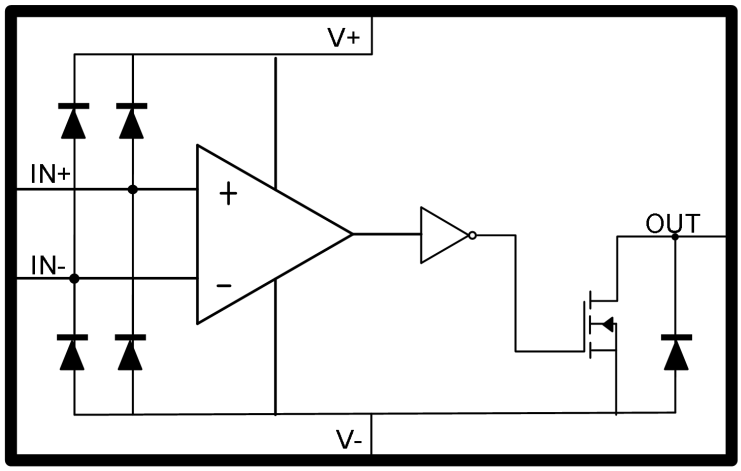


Fig 8-1. Functional Block Diagram

9 Application Note

LM2903 is typically used to compare a single signal to a reference or two signals against each other. Many users take advantage of the open drain output (logic high with pull-up) to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes this comparator optimal for level shifting to a higher or lower voltage.

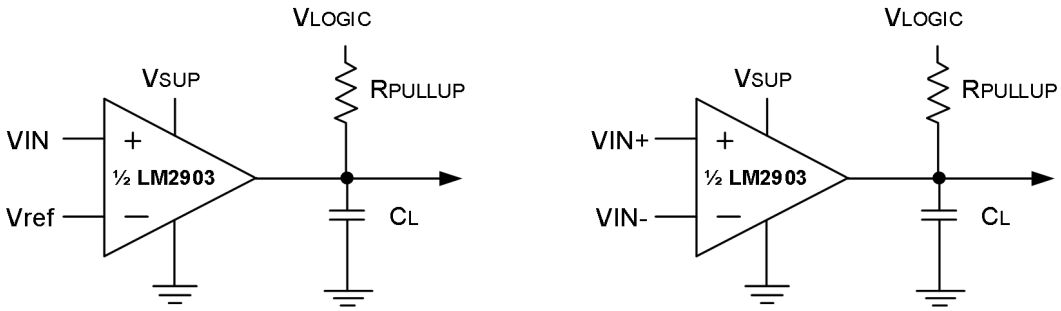


Fig 9-1. Single-Ended and Differential Comparator Configurations

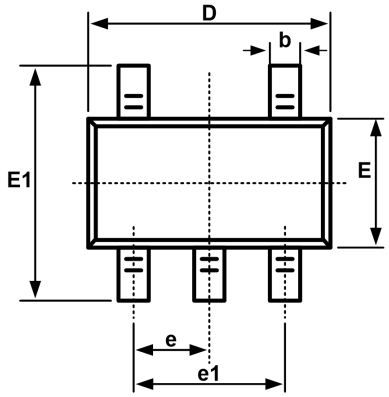
When using the device in a general comparator application, determine the following:

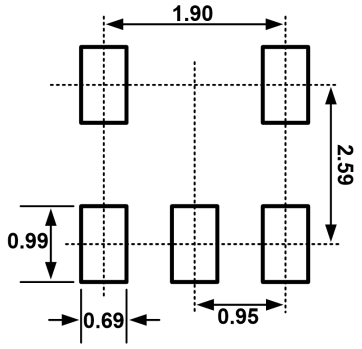
- Input Voltage Range
- Minimum Overdrive Voltage
- Output and Drive Current
- Response Time

When choosing the input voltage range, the input common mode voltage range (V_{ICR}) must be taken in to account. If temperature operation is below 25°C the V_{ICR} can range from 0 V to V_{CC} – 2.0 V. This limits the input voltage range to as high as V_{CC} – 2.0 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

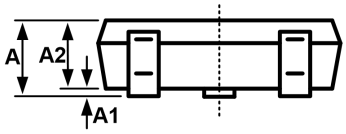
10 Package Outline Dimension

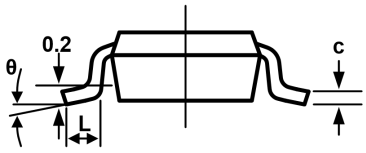
SOT23-5





Recommended Land Pattern (Unit: mm)

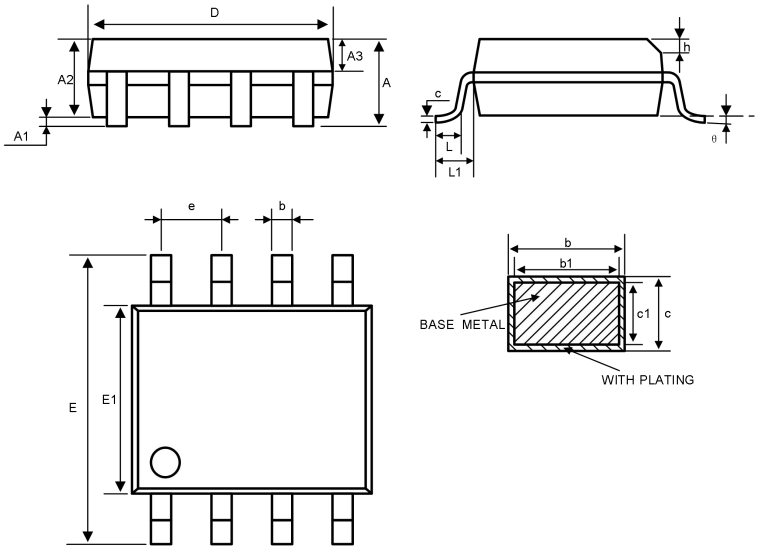




Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

10 Package Outline Dimension(Continued)

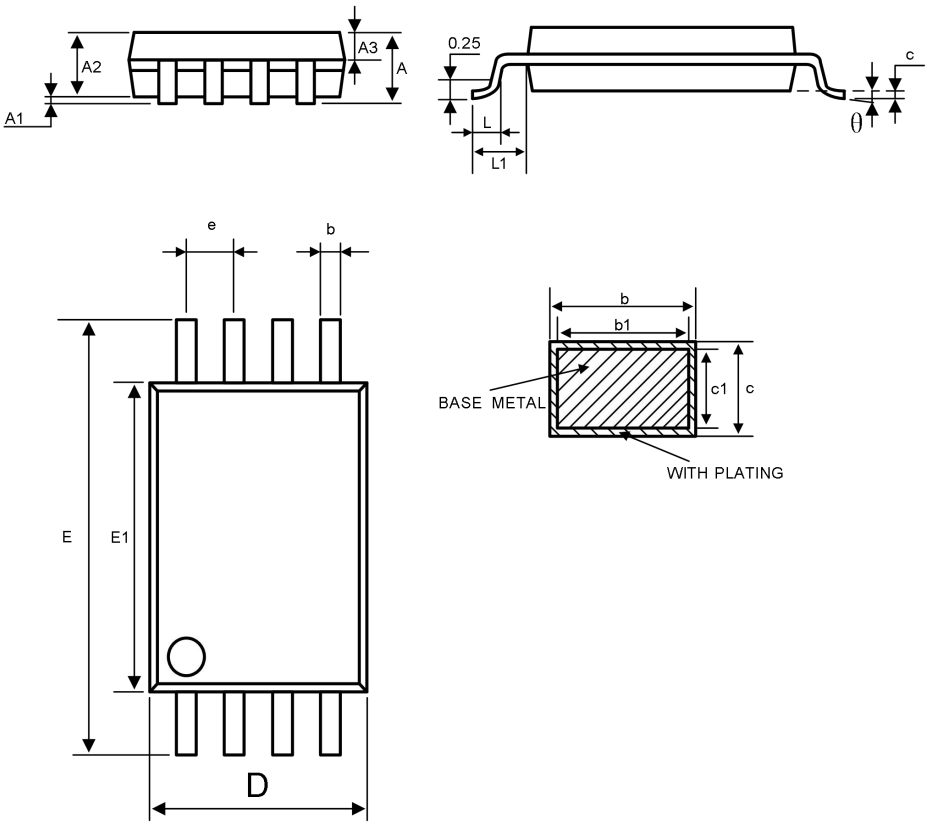
SOP8



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	1.75	—	—	0.069
A1	0.10	—	0.225	0.004	—	0.009
A2	1.30	1.40	1.50	0.051	0.055	0.059
A3	0.60	0.65	0.70	0.024	0.026	0.028
b	0.39	—	0.47	0.015	—	0.019
b1	0.38	0.41	0.44	0.015	0.016	0.017
c	0.20	—	0.24	0.008	—	0.009
c1	0.19	0.20	0.21	0.007	0.008	0.008
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e	1.27BSC			0.05BSC		
h	0.25	—	0.50	0.010	—	0.020
L	0.50	—	0.80	0.020	—	0.031
L1	1.05REF			0.041REF		
θ	0	—	8°	0	—	8°

10 Package Outline Dimension(Continued)

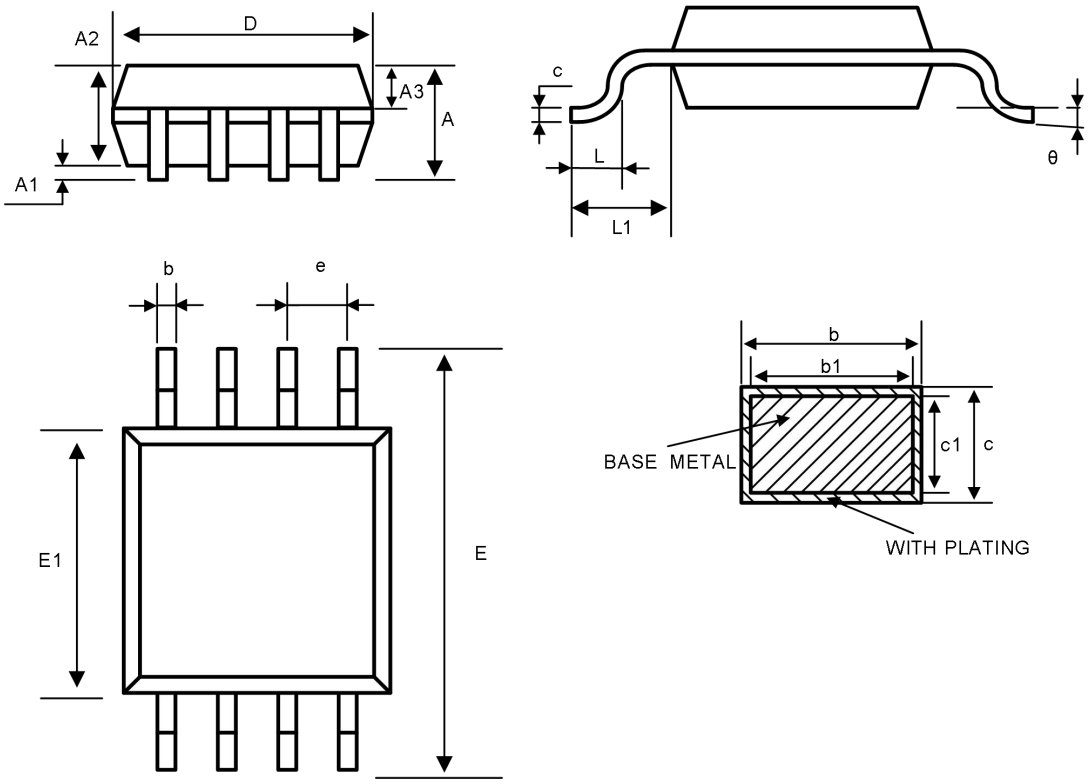
TSSOP8



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	1.20	—	—	0.047
A1	0.05	—	0.15	0.002	—	0.006
A2	0.90	1.00	1.05	0.035	0.039	0.041
A3	0.39	0.44	0.49	0.015	0.017	0.019
b	0.20	—	0.28	0.008	—	0.011
b1	0.19	0.22	0.25	0.007	0.009	0.010
c	0.13	—	0.17	0.005	—	0.007
c1	0.12	0.13	0.14	0.005	0.005	0.006
D	2.90	3.00	3.10	0.114	0.118	0.122
E1	4.30	4.40	4.50	0.169	0.173	0.177
E	6.20	6.40	6.60	0.244	0.251	0.260
e	0.65BSC			0.026BSC		
L	0.45	—	0.75	0.018	—	0.030
L1	1.00REF			0.039REF		
θ	0	—	8°	0	—	8°

10 Package Outline Dimension(Continued)

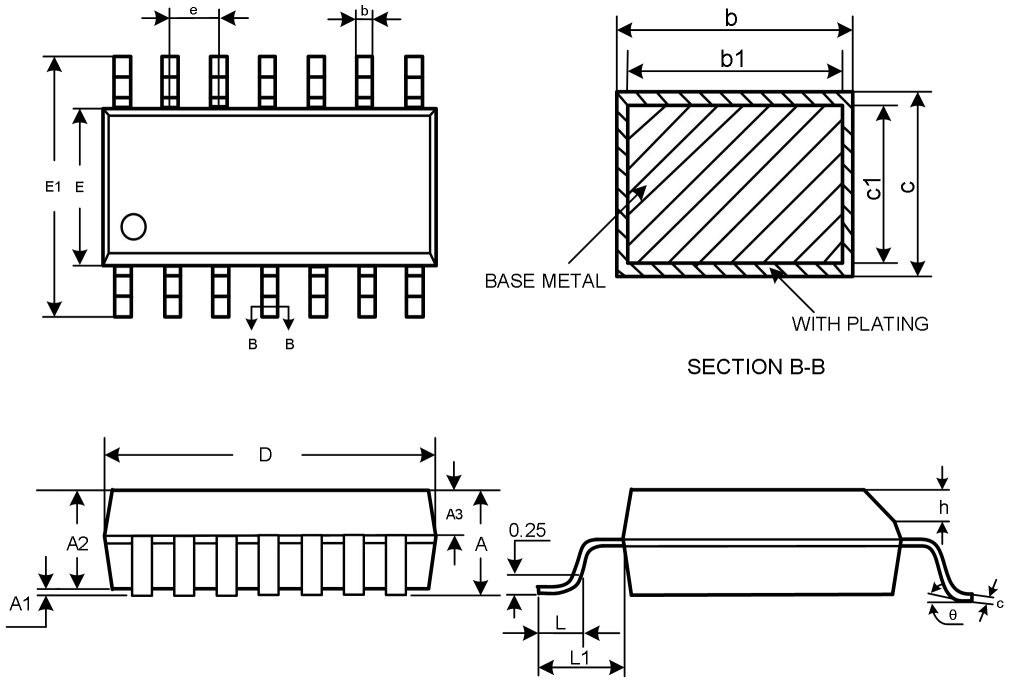
MSOP8



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	—	—	1.10	—	—	0.043
A1	0.05	—	0.15	0.002	—	0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
A3	0.30	0.35	0.40	0.012	0.014	0.016
b	0.28	—	0.36	0.011	—	0.014
b1	0.27	0.30	0.33	0.011	0.012	0.013
c	0.15	—	0.19	0.006	—	0.007
c1	0.14	0.15	0.16	0.006	0.006	0.006
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.70	4.90	5.10	0.185	0.193	0.201
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65BSC			0.026BSC		
L	0.40	—	0.70	0.016	—	0.028
L1	0.95REF			0.037REF		
θ	0	—	8°	0	—	8°

10 Package Outline Dimension(Continued)

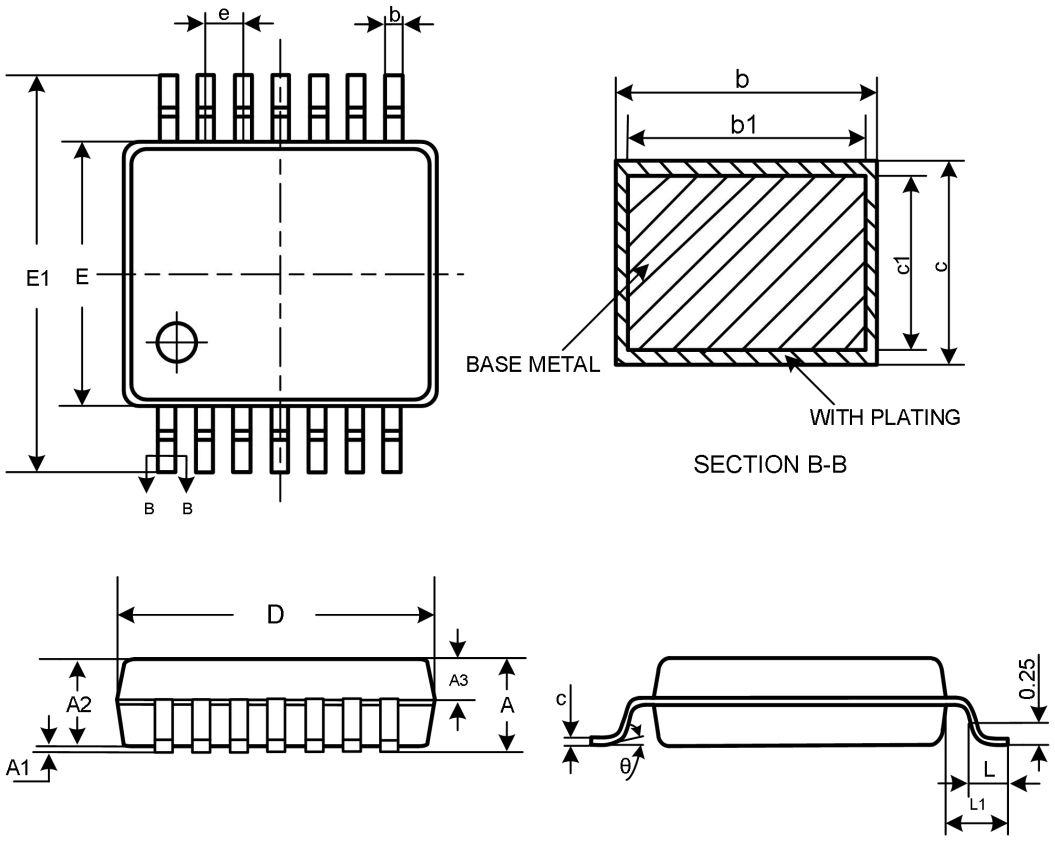
SOP14



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min	Nom	Max	Min	Nom	Max
A	——	——	1.75	——	——	0.069
A1	0.10	——	0.225	0.004	——	0.009
A2	1.30	1.40	1.50	0.051	0.055	0.059
A3	0.60	0.65	0.70	0.024	0.026	0.028
b	0.39	——	0.47	0.015	——	0.019
b1	0.38	0.41	0.44	0.015	0.016	0.017
c	0.20	——	0.24	0.008	——	0.009
c1	0.19	0.20	0.21	0.007	0.008	0.008
D	8.55	8.65	8.75	0.337	0.341	0.344
E1	5.80	6.00	6.20	0.228	0.236	0.244
E	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27BSC			0.05BSC	
h	0.25	——	0.50	0.010	——	0.020
L	0.50	——	0.80	0.020	——	0.031
L1		1.05REF			0.041REF	
θ	0	——	8°	0	——	8°

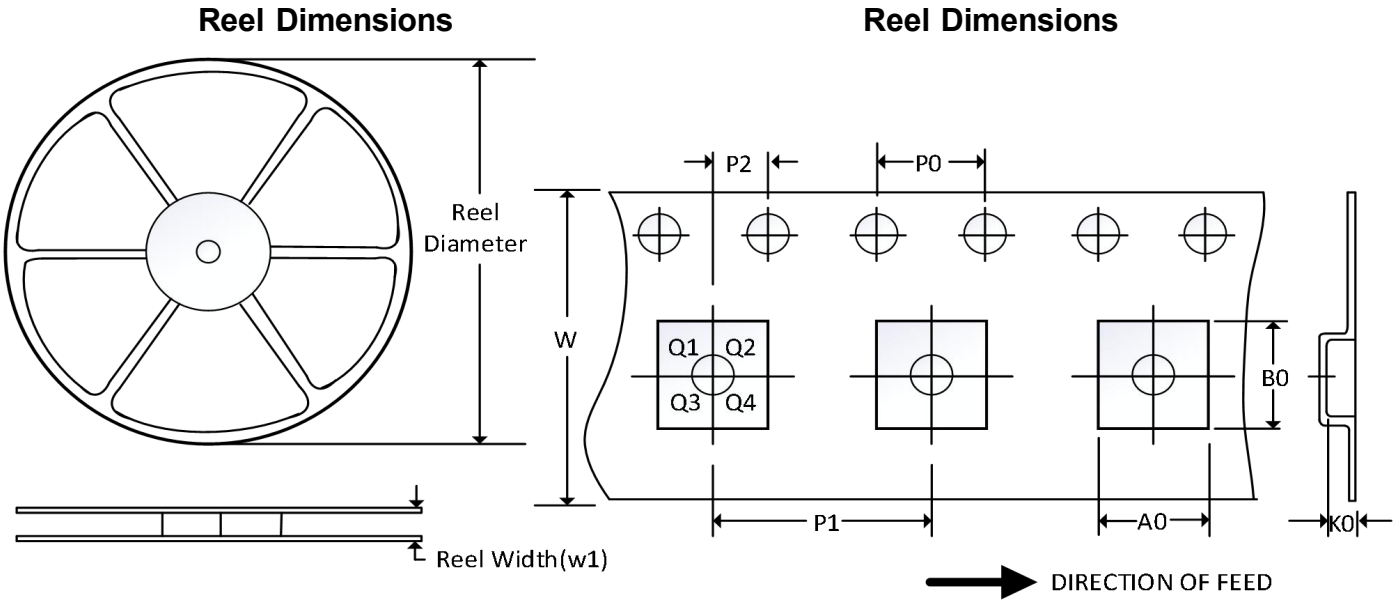
10 Package Outline Dimension(Continued)

TSSOP14



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min	Nom	Max	Min	Nom	Max
A	——	——	1.20	——	——	0.047
A1	0.05	——	0.15	0.002	——	0.006
A2	0.90	1.00	1.05	0.035	0.039	0.041
A3	0.39	0.44	0.49	0.015	0.017	0.019
b	0.20	——	0.28	0.008	——	0.011
b1	0.19	0.22	0.25	0.007	0.009	0.010
c	0.13	——	0.17	0.005	——	0.007
c1	0.12	0.13	0.14	0.005	0.005	0.006
D	4.90	5.00	5.10	0.193	0.197	0.201
E	4.30	4.40	4.50	0.169	0.173	0.177
E1	6.20	6.40	6.60	0.244	0.252	0.260
e	0.65BSC			0.026BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	1.00BCS			0.039BSC		
θ	0	——	8°	0	——	8°

11 Tape and Reel Information



NOTE: The picture is only for reference. Please make the object as the standard.

Key Parameter List of Tape and Reel

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-5	7''	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOP8	13''	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
TSSOP8	13''	12.4	6.90	3.45	1.65	4.0	8.0	2.0	12.0	Q1
MSOP8	13''	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOP14	13''	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1
TSSOP14	13''	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.