

Features

- AEC-Q100 Qualified for Automotive Applications
 - Grade 1: -40°C to 125°C T_A
- Wide Single-supply Voltage Range or Dual Supplies: $+2\text{ V}$ to $+40\text{ V}$ or $\pm 1\text{ V}$ to $\pm 20\text{ V}$
- Low Supply Current: $460\text{ }\mu\text{A}$ per Channel (Typ)
- Propagation Delay: $1\text{ }\mu\text{s}$
- Low Offset Voltage: $\pm 4\text{ mV}$ (Max, -40°C to 125°C)
- Low Input Bias Current: 60 nA (Typ)
- Input Common-mode Voltage Range Includes Ground
- Internal Differential Input Voltage Range Equal to The Supply Voltage
- Open-Drain Output for Maximum Flexibility
- Low Output Saturation

Applications

- Peak and Zero-Crossing Detectors
- Threshold Detectors/Discriminators
- Sensing at the Ground or Supply Line
- Logic Level Shifting or Translation
- Window Comparators
- IR Receivers

Description

The devices in this series consist of single, dual, or quad independent comparators on a single monolithic substrate. The common mode input voltage range includes ground even when operated from a single supply, and the low power supply current drain makes these comparators suitable for battery operation. These types are designed to directly interface with TTL and CMOS. The current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

The operating temperature range of the devices is from -40°C to $+125^{\circ}\text{C}$.

Typical Application Circuit

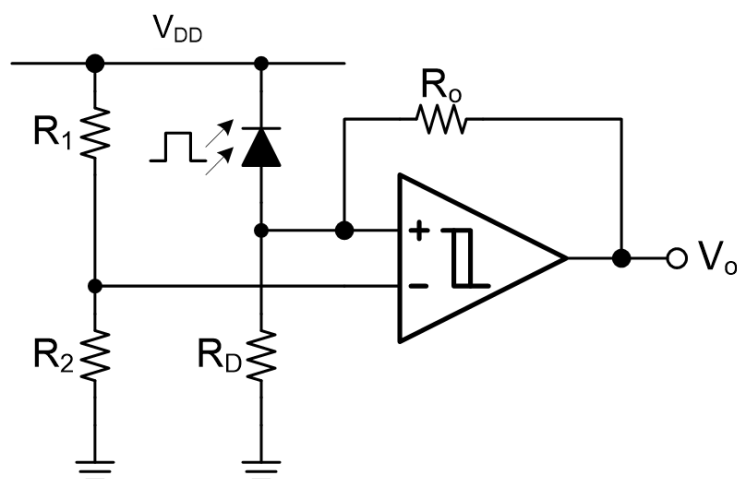


Table of Contents

Features	1
Applications	1
Description	1
Typical Application Circuit	1
Revision History	3
Pin Configuration and Functions	4
Specifications	7
Absolute Maximum Ratings ⁽¹⁾	7
ESD, Electrostatic Discharge Protection.....	7
Recommended Operating Conditions.....	7
Thermal Information.....	8
Electrical Characteristics.....	9
Typical Performance Characteristics.....	11
Detailed Description	13
Overview.....	13
Functional Block Diagram.....	13
Application and Implementation	14
Application Information	14
Typical Application.....	15
Tape and Reel Information	16
Package Outline Dimensions	18
SOP8.....	18
SOT23-5.....	19
MSOP8.....	20
TSSOP8.....	21
SOP14.....	22
TSSOP14.....	23
DFN2X2-8.....	24
Order Information	25
IMPORTANT NOTICE AND DISCLAIMER	26

Revision History

Date	Revision	Notes
2025-08-27	Rev.A.0	Initial version.

Pin Configuration and Functions

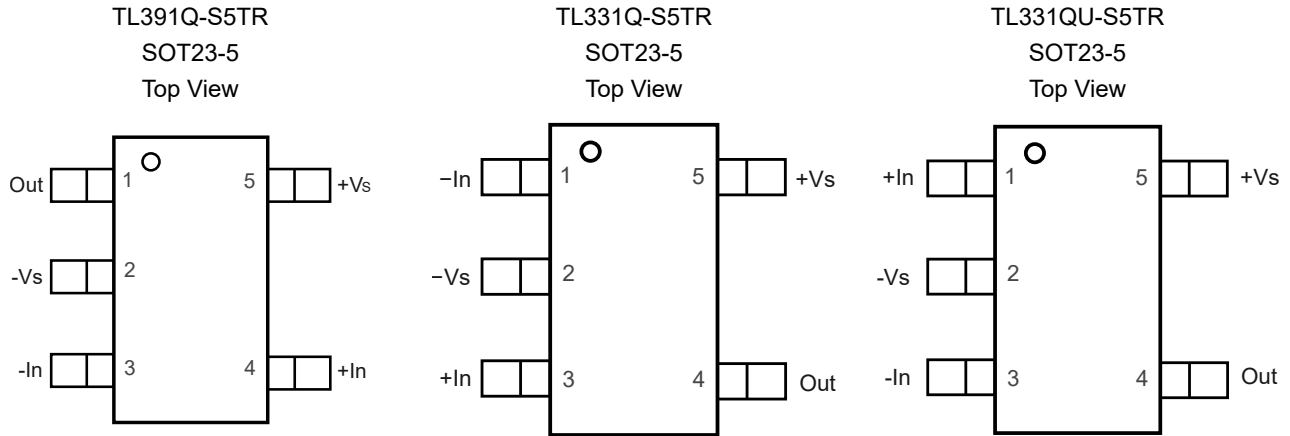
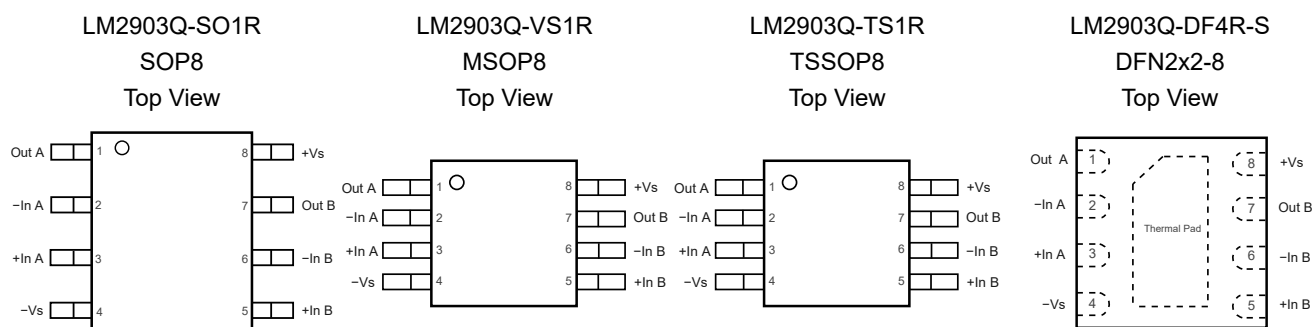
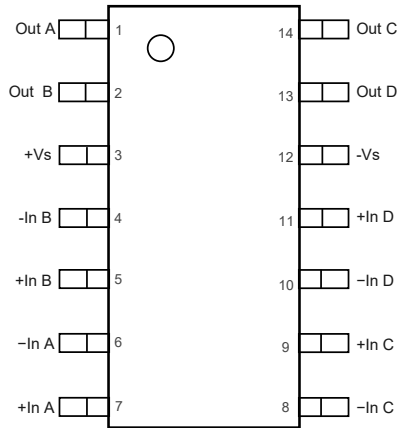
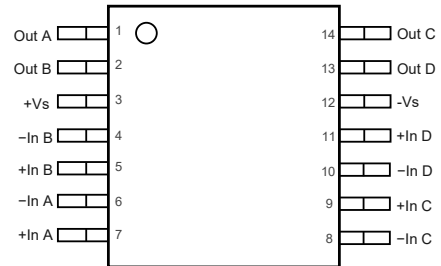


Table 1. Pin Functions: TL391Q-S5TR/TL331Q-S5TR/TL331QU-S5TR

Pin No.			Name	I/O	Description
TL391Q-S5TR	TL331Q-S5TR	TL331QU-S5TR			
3	1	3	-In	I	Inverting input
2	2	2	-Vs		Negative power supply
4	3	1	+In	I	Non-inverting input
1	4	4	Out	O	Output
5	5	5	+Vs		Positive power supply

Automotive 40-V High-Power Comparators with Open-Drain Output

Table 2. Pin Functions: LM2903Q-SO1R/LM2903Q-VS1R/LM2903Q-TS1R/LM2903Q-DF4R-S

Pin No.				Name	I/O	Description
LM2903Q-SO1R	LM2903Q-VS1R	LM2903Q-TS1R	LM2903Q-DF4R-S			
1	1	1	1	Out A	O	Output.
2	2	2	2	-In A	I	Inverting input.
3	3	3	3	+In A	I	Non-inverting input.
4	4	4	4	-Vs	-	Negative power supply.
5	5	5	5	+In B	I	Non-inverting input.
6	6	6	6	-In B	I	Inverting input.
7	7	7	7	Out B	O	Output.
8	8	8	8	+Vs	-	Positive power supply.
-	-	-	Thermal Pad	Thermal Pad	-	Exposed Thermal Pad. The exposed pad is tied to the -Vs.

LM2901Q-SO2R
SOP14 Package
Top View

LM2901Q-TS2R
TSSOP14 Package
Top View

Table 3. Pin Functions: LM2901Q-SO2R/LM2901Q-TS2R

Pin No.		Name	I/O	Description
LM2901Q-SO2R	LM2901Q-TS2R			
1	1	Out A	O	Output
2	2	Out B	O	Output
3	3	+Vs		Positive power supply
4	4	-In B	I	Inverting input
5	5	+In B	I	Non-inverting input
6	6	-In A	I	Inverting input
7	7	+In A	I	Non-inverting input
8	8	-In C	I	Inverting input
9	9	+In C	I	Non-inverting input
10	10	-In D	I	Inverting input
11	11	+In D	I	Noninverting input
12	12	-Vs		Negative power supply
13	13	Out D	O	Output
14	14	Out C	O	Output

Specifications

Absolute Maximum Ratings ⁽¹⁾

Parameter		Min	Max	Unit
	Supply Voltage, (+V _S) – (–V _S)	–0.3	42	V
	Input Voltage	(–V _S) – 0.3	42	V
	Input Current: +IN, –IN ⁽²⁾	–10	10	mA
	Output Current: OUT	–10	10	mA
	Output Short-Circuit Duration ⁽³⁾		Infinite	
T _J	Maximum Junction Temperature		150	°C
T _A	Operating Temperature Range	–40	125	°C
T _{STG}	Storage Temperature Range	–65	150	°C
T _L	Lead Temperature (Soldering 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

(2) The inputs are protected by ESD protection diodes to negative power supply. If the input extends more than 500 mV beyond the negative power supply, the input current should be limited to less than 10 mA.

(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many comparators are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Level	Unit
HBM	Human Body Model ESD	AEC Q100-002	3	kV
CDM	Charged Device Model ESD	AEC Q100-011	1.5	kV

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _S	Supply Voltage, (+V _S) – (–V _S)	2		40	V

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
TSSOP8	191	44	°C/W
DFN2X2-8	100	60	°C/W
SOP14	97	47	°C/W
TSSOP14	108	43	°C/W

Automotive 40-V High-Power Comparators with Open-Drain Output
Electrical Characteristics

All test conditions: $V_S = 5\text{ V}$, $R_{\text{PULL-UP}} = 5.1\text{ k}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
I _Q	Quiescent Current	V _S = 5 V, No Load, Output High, V _{INP} = 1 V, V _{INN} = 0 V, TL391Q / TL331Q / LM2903Q		0.74	1	mA
		V _S = 5 V, No Load, Output Low, V _{INP} = 0 V, V _{INN} = 1 V, T _A = -40°C to 125°C, TL391Q / TL331Q / LM2903Q			1.1	mA
		V _S = 40 V, No Load, Output High, V _{INP} = 1 V, V _{INN} = 0 V, TL391Q / TL331Q / LM2903Q		0.92	1.3	mA
		V _S = 40 V, No Load, Output High, V _{INP} = 1 V, V _{INN} = 0 V, T _A = -40°C to 125°C, TL391Q / TL331Q / LM2903Q			1.45	mA
Input Characteristics						
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 5 V, V _{CM} = 0 V	-2		2	mV
		V _S = 5 V, V _{CM} = 0 V, T _A = -40°C to 125°C	-3		3	mV
V _{OS} TC	Input Offset Voltage Drift ⁽²⁾	V _S = 5 V, V _{CM} = 0 V, T _A = -40°C to 125°C		2		μV/°C
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 5 V, V _{CM} = 3 V	-2		2	mV
		V _S = 5 V, V _{CM} = 3 V, T _A = -40°C to 125°C	-3		3	mV
V _{OS} TC	Input Offset Voltage Drift ⁽²⁾	V _S = 5 V, V _{CM} = 3 V, T _A = -40°C to 125°C		2		μV/°C
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 5 V, V _{CM} = 3.5 V	-3		3	mV
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 40 V, V _{CM} = 0 V	-3		3	mV
		V _S = 40 V, V _{CM} = 0 V, T _A = -40°C to 125°C	-3.5		3.5	mV
V _{OS} TC	Input Offset Voltage Drift ⁽²⁾	V _S = 40 V, V _{CM} = 0 V, T _A = -40°C to 125°C		2		μV/°C
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 40 V, V _{CM} = 38 V	-3		3	mV
		V _S = 40 V, V _{CM} = 38 V, T _A = -40°C to 125°C	-4		4	mV
V _{OS} TC	Input Offset Voltage Drift ⁽²⁾	V _S = 40 V, V _{CM} = 38 V, T _A = -40°C to 125°C		2		μV/°C
V _{OS}	Input Offset Voltage ⁽¹⁾	V _S = 40 V, V _{CM} = 38.5 V	-4		4	mV
I _B	Input Bias Current	V _S = 40 V, V _{CM} = 0 V	-100	-60	0	nA

Automotive 40-V High-Power Comparators with Open-Drain Output

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		V _S = 40 V, V _{CM} = 0 V, T _A = −40°C to 125°C	−150			nA
I _{OS}	Input Offset Current	V _S = 40 V, V _{CM} = 0 V	−30	0	30	nA
I _{OS} TC	Input Offset Current Drift ⁽²⁾	V _S = 40 V, V _{CM} = 0 V, T _A = −40°C to 125°C		10		pA/°C
I _B	Input Bias Current	V _S = 40V, V _{CM} = 38V	−100	-30	0	nA
		V _S = 40V, V _{CM} = 38V, T _A = −40°C to 125°C	−150			nA
I _{OS}	Input Offset Current	V _S = 40 V, V _{CM} = 38 V	−30	0	30	nA
I _{OS} TC	Input Offset Current Drift ⁽²⁾	V _S = 40 V, V _{CM} = 38 V, T _A = −40°C to 125°C		10		pA/°C
A _V	Large-signal Differential-voltage Amplification ⁽⁴⁾	V _S = 15 V, V _O = 1.4 V to 11.4 V, R _L ≥ 15 kΩ to V _{CC}	50	500		V/mV
		V _S = 15 V, V _O = 1.4 V to 11.4 V, R _L ≥ 15 kΩ to V _{CC} , T _A = −40°C to 125°C	5			V/mV
V _{CM}	Common-mode Input Voltage Range	V _S = 40 V	0		38.5	V
		V _S = 40 V, T _A = −40°C to 125°C	0		38	V
Output						
I _{OH}	High-level Output Current	V _S = 5 V, V _{OH} = 5 V, V _{ID} = 1 V		8	25	nA
		V _S = 5 V, V _{OH} = 5 V, V _{ID} = 1 V, T _A = −40°C to 125°C			2000	nA
		V _S = 5 V, V _{OH} = 40 V, V _{ID} = 1 V		35	100	nA
		V _S = 5 V, V _{OH} = 40 V, V _{ID} = 1 V, T _A = −40°C to 125°C			4000	nA
I _{OL}	Low-level Output Current	V _S = 5 V, V _{OL} = 1.5 V, V _{ID} = −1 V	10	17		mA
		V _S = 5 V, V _{OL} = 1.5 V, V _{ID} = −1 V, T _A = −40°C to 125°C	9			mA
V _{OL}	Output Voltage Low	V _S = 5 V, I _{OL} = 4 mA, V _{ID} = −1 V		40	100	mV
		V _S = 5 V, I _{OL} = 4 mA, V _{ID} = −1 V, T _A = −40°C to 125°C ⁽²⁾			150	mV
Switching Characteristics ⁽³⁾						
t _{RT}	Response Time	V _S = 5 V, R _L connected to 5 V through 5.1 kΩ, C _L = 15 pF, 100-mV input step with 5-mV overdrive ⁽²⁾		1		μs
		V _S = 5 V, R _L connected to 5 V through 5.1 kΩ, C _L = 15 pF, TTL-level input step ⁽²⁾		0.3		μs

(1) The input offset voltage is the average of the input-referred trip points.

(2) Provided by bench tests and design simulation.

(3) Delay time is measured from the mid-point of the input to the mid-point of the output.

(4) Provided by design simulation.

Typical Performance Characteristics

All test conditions: $V_S = 5\text{ V}$, $V_{CM} = 2.5\text{ V}$, $R_{PULL-UP} = 5.1\text{ k}$, unless otherwise noted.

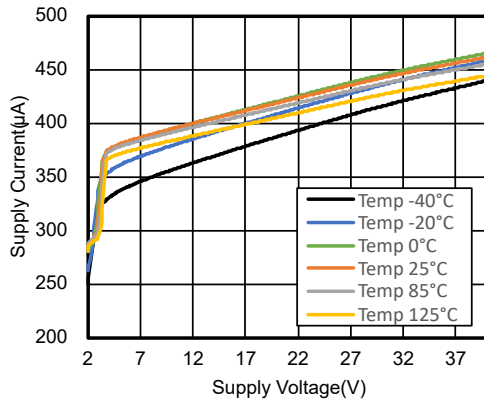


Figure 1. Supply Current vs. Supply Voltage, Output High, per Comparator for LM2903Q

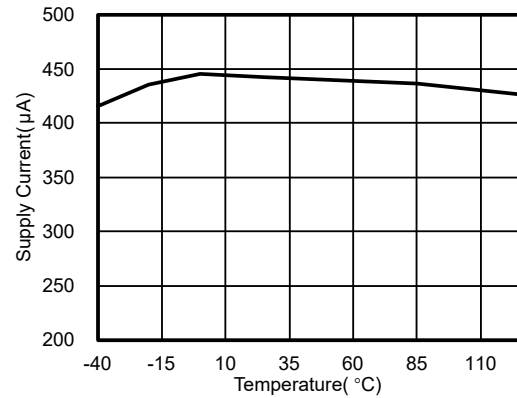


Figure 2. Supply Current vs. Temperature, per Comparator for LM2903Q

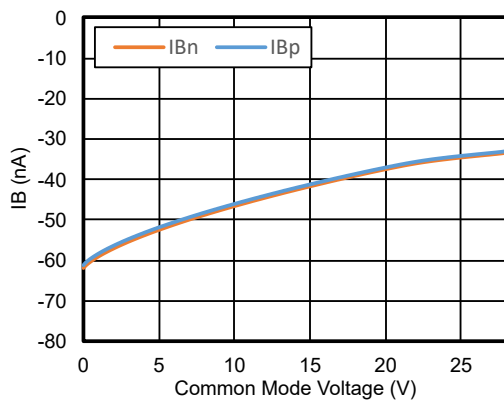


Figure 3. IB vs. Common-Mode Voltage

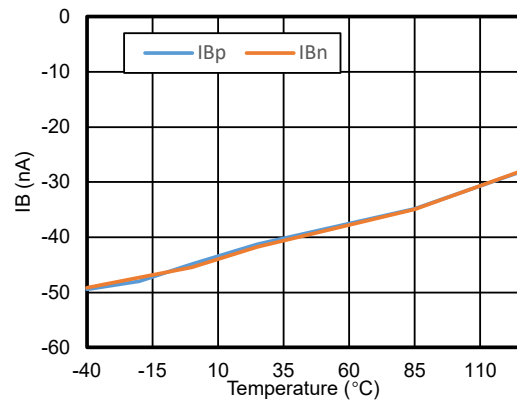


Figure 4. IB vs. Temperature

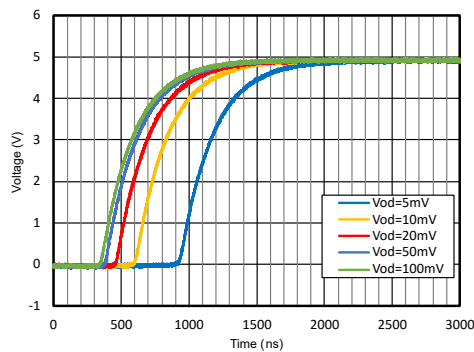


Figure 5. Propagation Delay, Low to High, 5 V

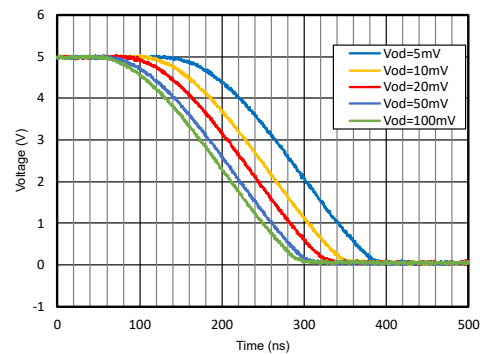


Figure 6. Propagation Delay, High to Low, 5 V

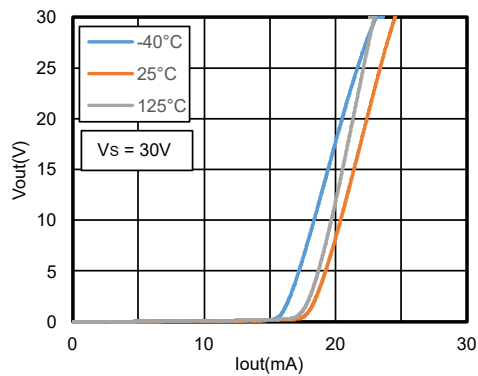


Figure 7. Output Voltage vs. Output Sinking Current, 5 V

Detailed Description

Overview

The devices in this series consist of single/dual/quad independent single- or dual-supply voltage comparators on a single monolithic substrate. The common-mode input voltage range includes ground even when operated from a single supply, and the low power supply current drain makes these comparators suitable for battery operation. These types were designed to directly interface with TTL and CMOS. The current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

Functional Block Diagram

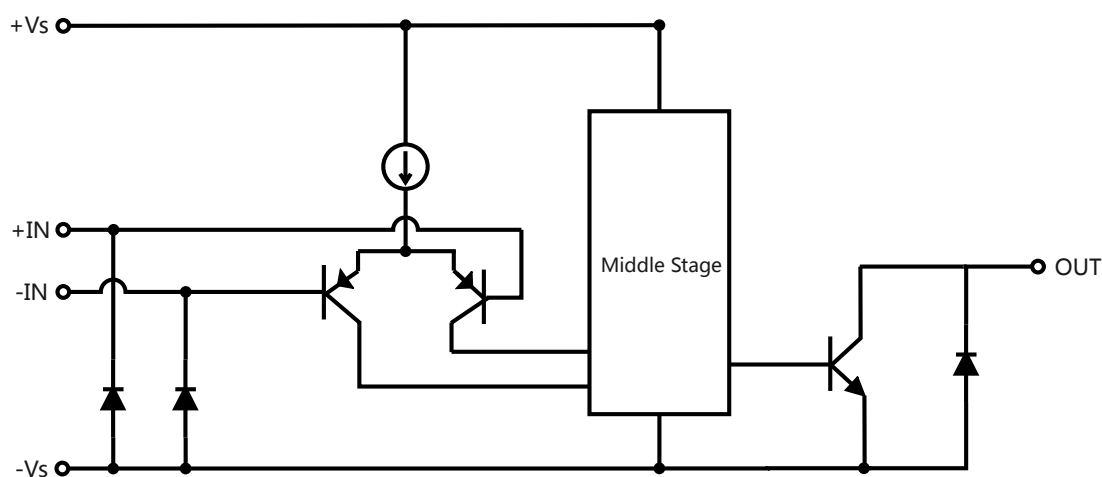


Figure 8. Functional Block Diagram

Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

Power Supply Layout and Bypass

The power supply pins of TL331Q, TL391Q, LM2903Q, and LM2901Q families should have local bypass capacitors (i.e., 0.01 μF to 0.1 μF) within 2 mm for high-frequency performance. They can also use a bulk capacitor (i.e., 1 μF or larger) within 100 mm to provide large and slow currents. This bulk capacitor can be shared with other analog parts.

A good ground layout improves performance by decreasing the amount of stray capacitance and noise at the inputs and outputs of the comparator. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components to the pins of the comparator as close as possible.

Operation Outside of the Common Input Voltage Range

A list of input voltage situations and the corresponding outcomes are as follows:

1. When both $-IN$ and $+IN$ are within the common-mode range:
 - a. If the voltage at the $-IN$ pin is higher than the voltage at the $+IN$ pin and the offset voltage, the output is low, and the output MOSFET is sinking current.
 - b. If the voltage at the $-IN$ pin is lower than the voltage at the $+IN$ pin and the offset voltage, the output is high impedance.
2. When the voltage at the $-IN$ pin is higher than the common-mode voltage range and the voltage at the $+IN$ pin is within the common-mode voltage range, the output is low, and the output MOSFET is sinking current.
3. When the voltage at the $+IN$ pin is higher than the common-mode voltage range and the voltage at the $-IN$ pin is within the common-mode voltage range, the output is high impedance.
4. When the voltages at the $-IN$ and $+IN$ pins are both higher than the common-mode voltage range, the output is in an uncertain state.

Typical Application

IR Receiver

The device is an ideal candidate to be used as an infrared receiver shown in [Figure 9](#). The infrared photo diode creates a current relative to the amount of infrared light present. The current creates a voltage across R_D . When this voltage level crosses the voltage applied by the voltage divider to the inverting input, the output transitions. Optional R_O provides additional hysteresis for noise immunity.

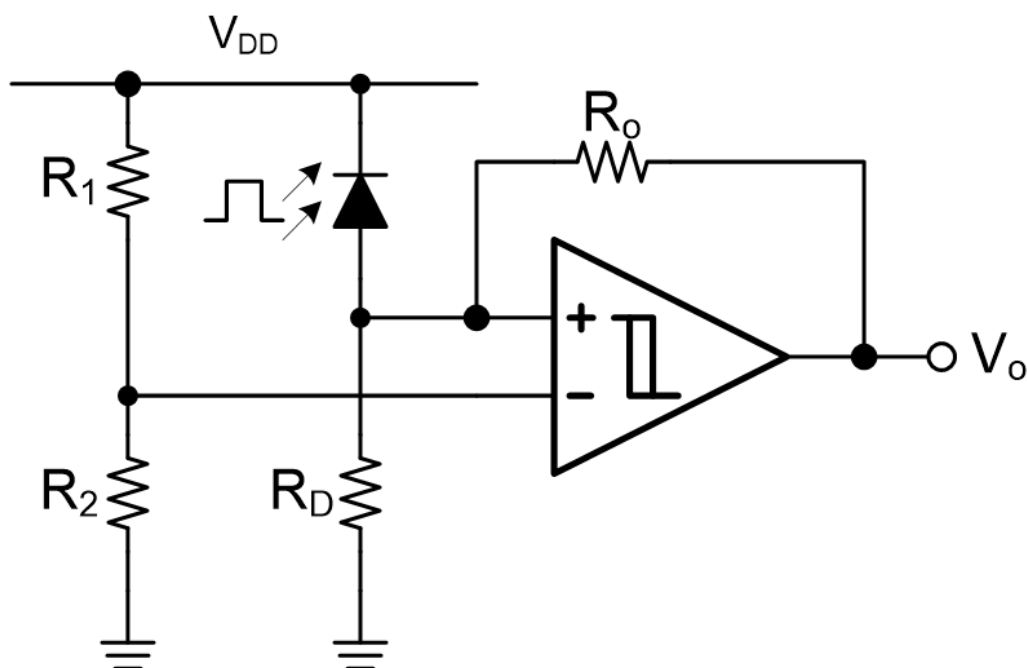
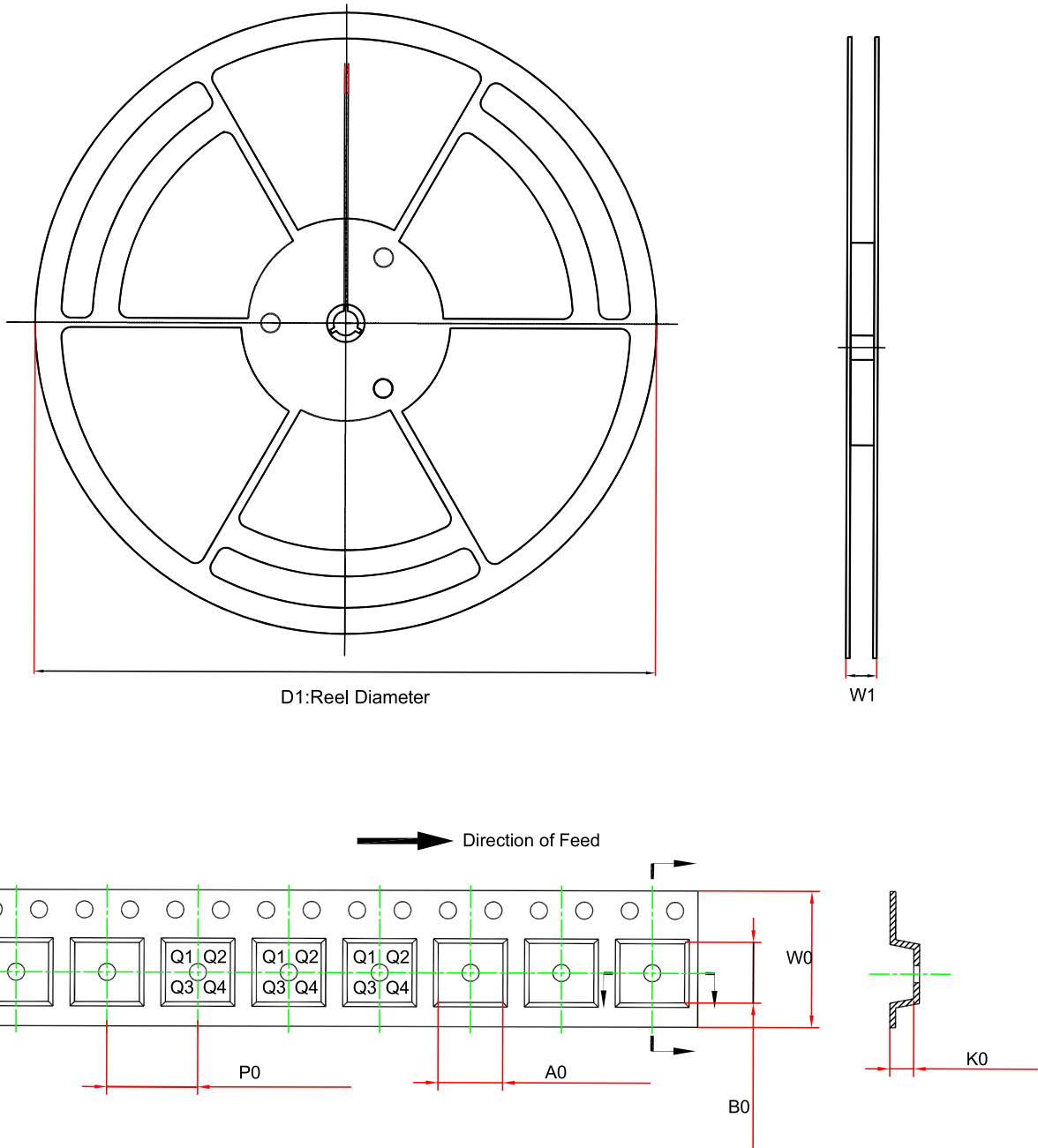


Figure 9. Typical Application Circuit

Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) ⁽¹⁾	B0 (mm) ⁽¹⁾	K0 (mm) ⁽¹⁾	P0 (mm)	W0 (mm)	Pin1 Quadrant
TL391Q-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
TL331Q-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
TL331QU-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
LM2903Q-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
LM2903Q-VS1R	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1

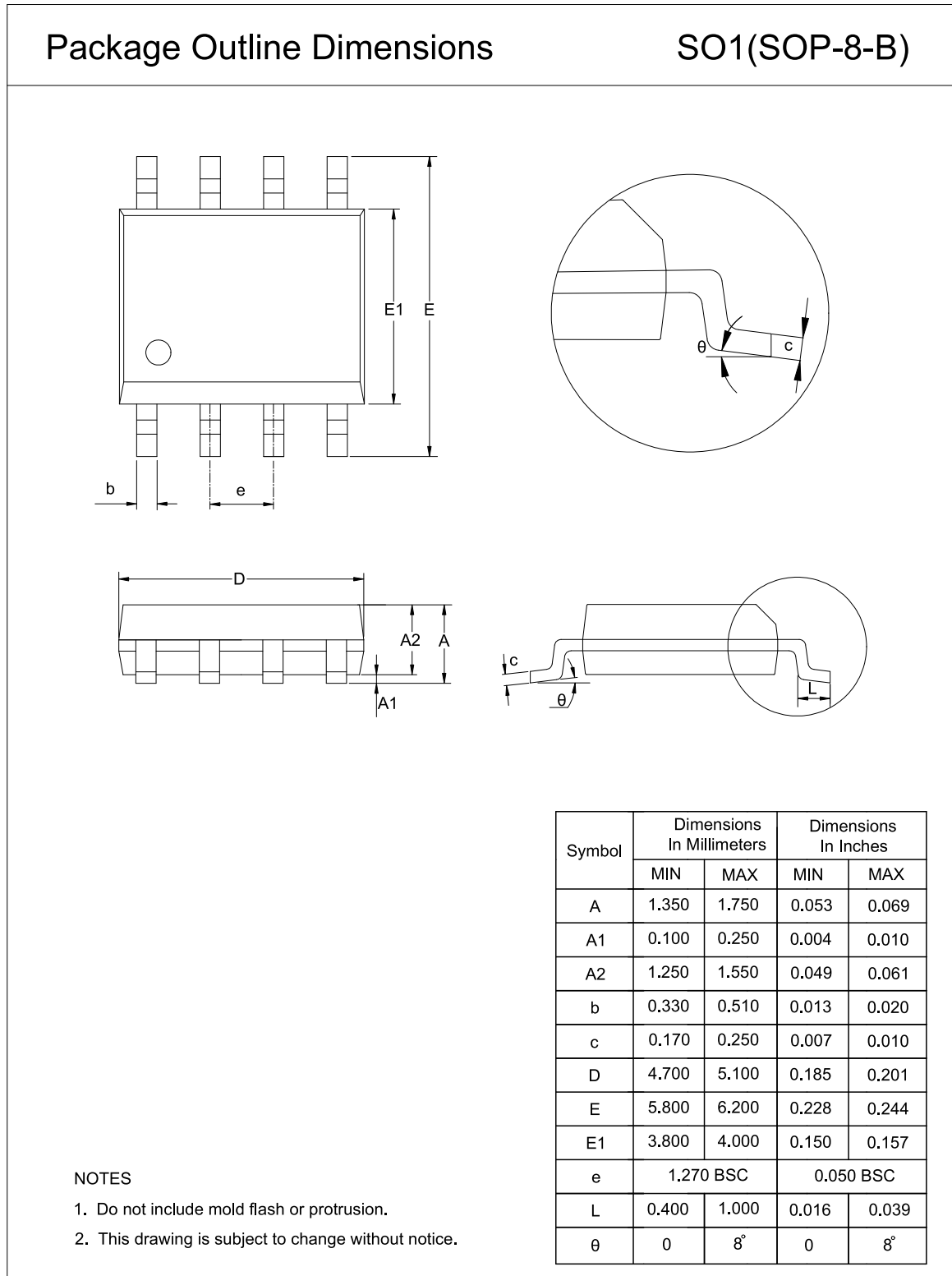
Automotive 40-V High-Power Comparators with Open-Drain Output

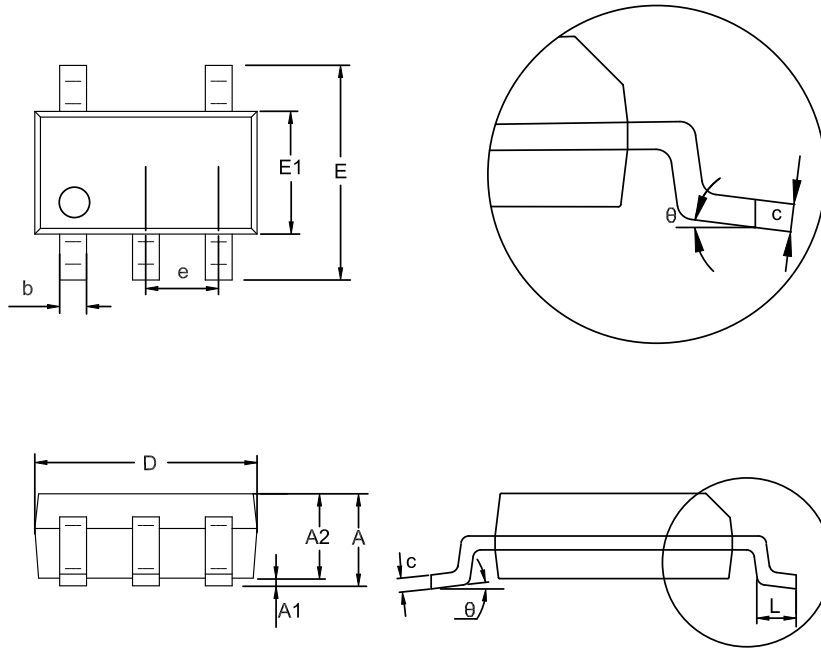
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) ⁽¹⁾	B0 (mm) ⁽¹⁾	K0 (mm) ⁽¹⁾	P0 (mm)	W0 (mm)	Pin1 Quadrant
LM2903Q-TS1R-S	TSSOP8	330	17.6	6.8	3.4	1.8	8	12	Q1
LM2903Q-DF4R-S	DFN2x2-8	180	12.5	2.3	2.3	1.1	4	8	Q2
LM2901Q-SO2R-S	SOP14	330	21.6	6.5	9.3	2.1	8	16	Q1
LM2901Q-TS2R-S	TSSOP14	330	17.6	6.8	5.5	1.5	8	12	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

Package Outline Dimensions

SOP8

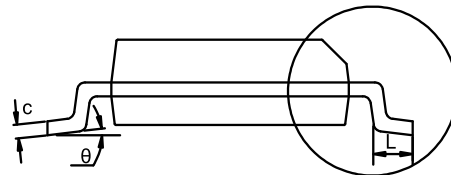
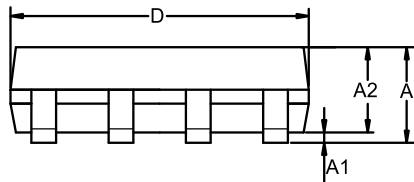
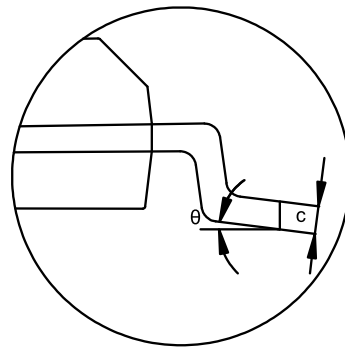
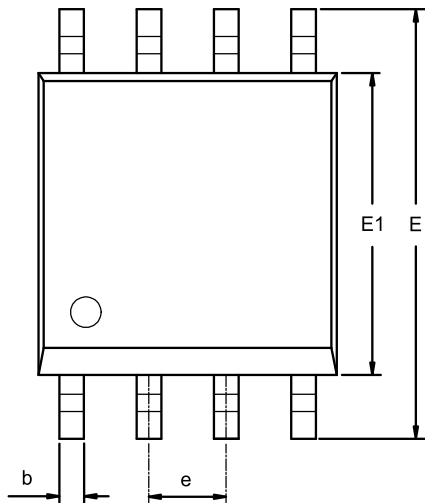


SOT23-5
Package Outline Dimensions
S5T(SOT23-5-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

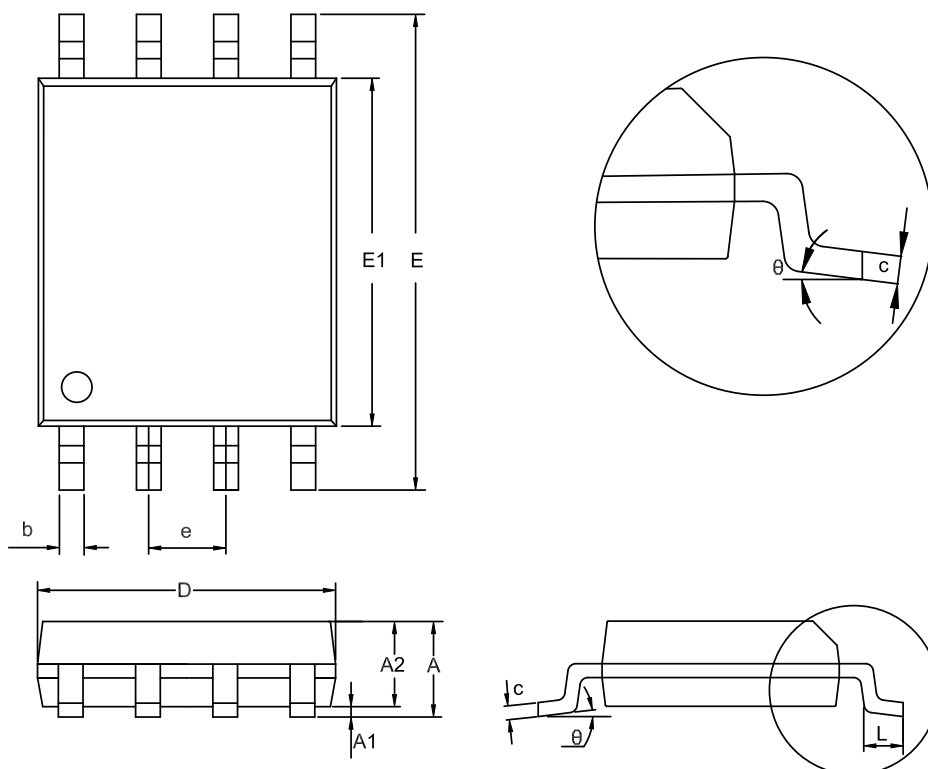
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

MSOP8
Package Outline Dimensions
VS1(MSOP-8-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

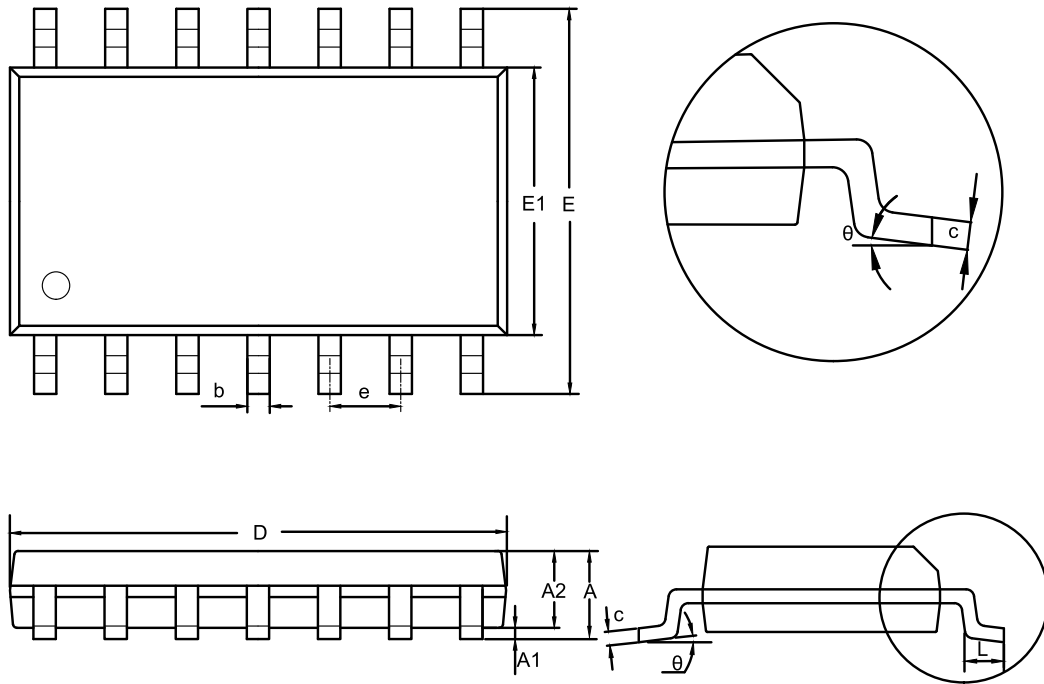
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP8
Package Outline Dimensions
TS1(TSSOP-8-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

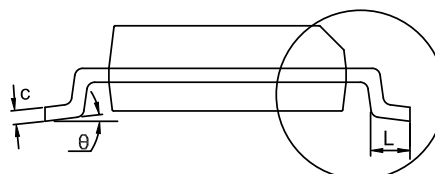
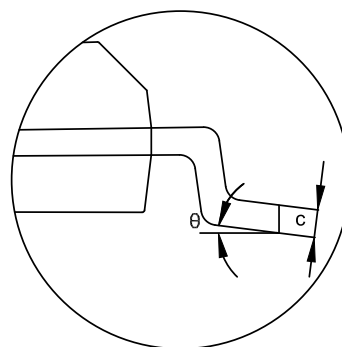
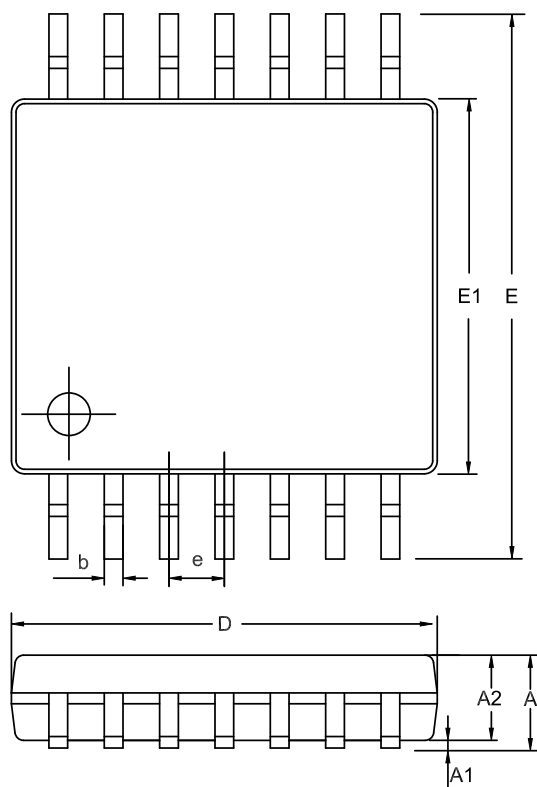
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP14
Package Outline Dimensions
SO2(SOP-14-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0	8°	0	8°

NOTES

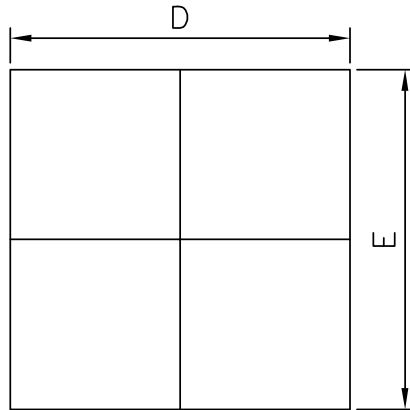
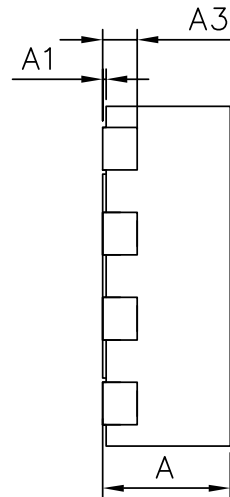
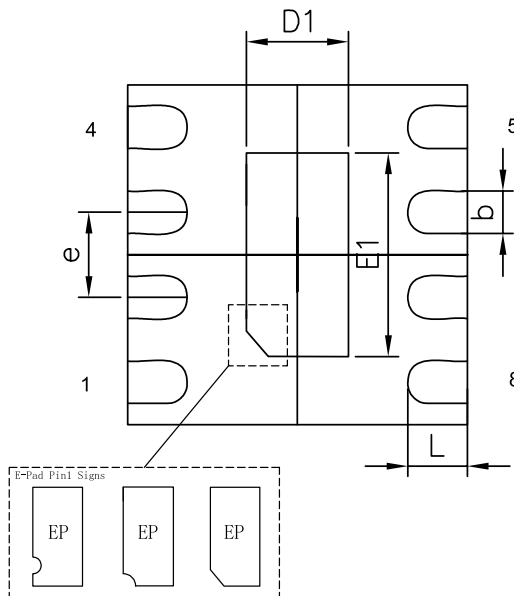
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP14
Package Outline Dimensions
TS2(TSSOP-14-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

DFN2X2-8
Package Outline Dimensions
DF4(DFN2X2-8-D)

Top View

Side View

Bottom View
NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.180	0.300	0.007	0.012
A3	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D1	0.800	1.000	0.031	0.039
E	1.900	2.100	0.075	0.083
E1	1.500	1.700	0.059	0.067
e	0.500 BSC		0.020BSC	
L	0.250	0.350	0.010	0.014

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TL391Q-S5TR-S ⁽¹⁾	-40 to 125°C	SOT23-5	A9F	1	Tape and Reel, 3000	Green
TL331Q-S5TR-S	-40 to 125°C	SOT23-5	A9E	1	Tape and Reel, 3000	Green
TL331QU-S5TR-S ⁽¹⁾	-40 to 125°C	SOT23-5	ACu	1	Tape and Reel, 3000	Green
LM2903Q-SO1R-S ⁽¹⁾	-40 to 125°C	SOP8	L903Q	1	Tape and Reel, 4000	Green
LM2903Q-VS1R-S	-40 to 125°C	MSOP8	L903Q	1	Tape and Reel, 3000	Green
LM2903Q-TS1R-S ⁽¹⁾	-40 to 125°C	TSSOP8	L903Q	1	Tape and Reel, 3000	Green
LM2903Q-DF4R-S ⁽¹⁾	-40 to 125°C	DFN2x2-8	ACt	1	Tape and Reel, 3000	Green
LM2901Q-SO2R-S ⁽¹⁾	-40 to 125°C	SOP14	L901Q	1	Tape and Reel, 2500	Green
LM2901Q-TS2R-S ⁽¹⁾	-40 to 125°C	TSSOP14	L901Q	1	Tape and Reel, 3000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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