

5-V Low-Power Comparators with Open Drain Output**Features**

- Power Supply Voltage: 2.5 V to 5.5 V
- Low Supply Current: 50 μ A per Channel
- High-to-Low Propagation Delay: 120 ns
- Internal Hysteresis Ensures Clean Switching
- Offset Voltage: ± 4 mV
- Input Bias Current: 30 pA Typical
- Input Common-Mode Range Extends 100 mV
- No ESD Diode at both Input Pin to +Vs and Output Pin to +Vs
- Open-Drain Output for Maximum Flexibility

Description

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

The devices are specified for the temperature range from -40°C to $+125^{\circ}\text{C}$.

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

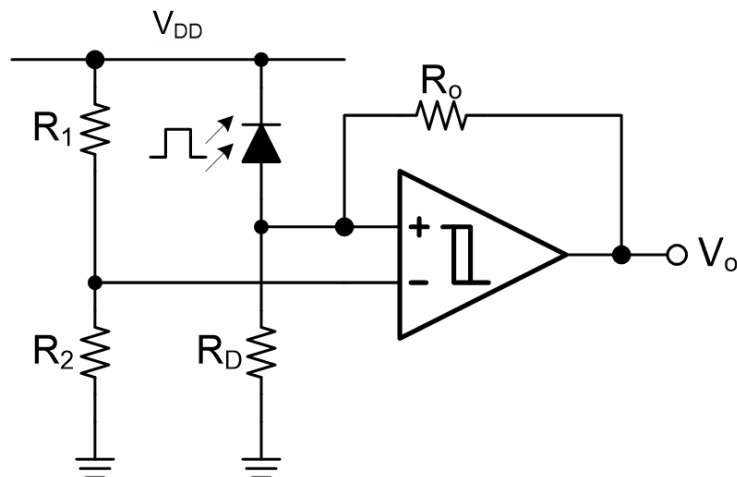
Typical Application Circuit

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Revision History

Date	Revision	Notes
2023-09-03	Rev.A.0	Initial version.
2024-01-22	Rev.A.1	Added the chapter: Detailed Description, including some performance description and block diagram. Added the ESD diode description in the "Features".
2024-02-15	Rev.A.2	Modified the pin configuration of SOP8. The physical object has not changed, just a correction of hand writing errors.

Pin Configuration and Functions

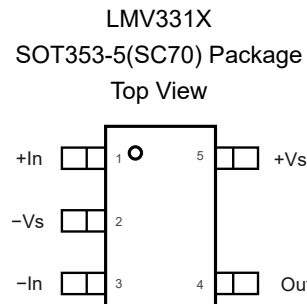
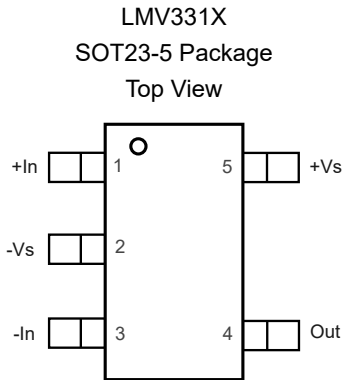
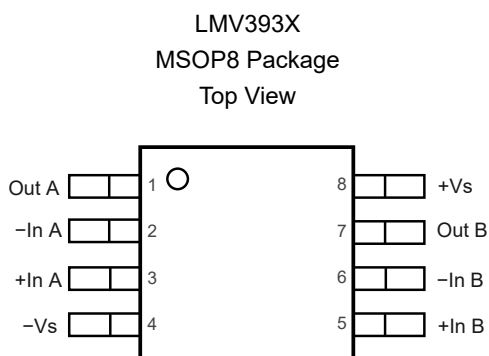
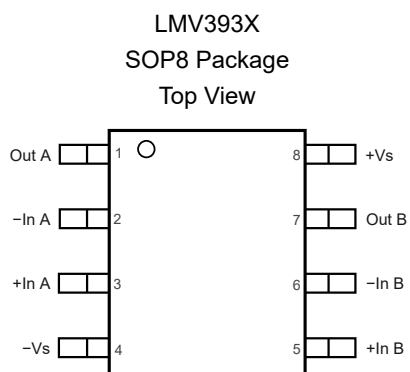


Table 1. Pin Functions: LMV331X

Pin No.	Name	I/O	Description
4	Out	O	Output
2	-V _S	-	Negative power supply
1	+In	I	Noninverting input
3	-In	I	Inverting input
5	+V _S	-	Positive power supply

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Table 2. Pin Functions: LMV393X

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	-In A	I	Inverting input
3	+In A	I	Noninverting input
4	-Vs	-	Negative power supply
5	+In B	I	Noninverting input
6	-In B	I	Inverting input
7	Out B	O	Output
8	+Vs		Positive power supply

Specifications

Absolute Maximum Ratings ⁽¹⁾

Parameter		Min	Max	Unit
	Supply Voltage, (+V _S) – (–V _S)		6.5	V
	Input Voltage	(–V _S) – 0.3	6.5	V
	Input Current: +IN, –IN ⁽²⁾	–10	+10	mA
	Output Current: OUT	–10	+10	mA
	Output Short-Circuit Duration ⁽³⁾		Thermal protection	
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 each 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	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 ⁽²⁾	1.5	kV

(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.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _S	Supply Voltage, (+V _S) – (–V _S)	2.5		5.5	V

Thermal Information

Package Type	θ _{JA}	θ _{JC}	Unit
SOT353 (SC70-5)	400	150	°C/W
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W

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

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Electrical Characteristics

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

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
I _Q	Quiescent Current per Comparator	V _{CM} = 5 V		50	75	μA
		V _{CM} = 5 V, T _A = −40°C to 125°C			80	μA
PSRR	Power Supply Rejection Ratio	V _S = 2.5 V to 5 V, V _{CM} = 0 V	60	80		dB
		V _S = 2.5 V to 5 V, V _{CM} = 0 V, T _A = −40°C to 125°C	50			dB
Input Characteristics						
V _{OS}	Input Offset Voltage ⁽¹⁾	V _{CM} = 0 V to 5 V	−4	−0.5	4	mV
		V _{CM} = 0 V to 5 V, T _A = −40°C to 125°C	−5		5	mV
	Input Offset Voltage Drift ⁽²⁾	T _A = −40°C to 125°C		2		μV/°C
V _{HYST}	Input Hysteresis Voltage ⁽¹⁾	V _{CM} = 0 V to 5 V	1	4.5	10	mV
		V _{CM} = 0 V to 5 V, T _A = −40°C to 125°C			15	mV
	Input Hysteresis Voltage Drift ⁽²⁾	T _A = −40°C to 125°C		10		μV/°C
I _B	Input Bias Current ⁽²⁾	V _{CM} = 2.5 V		30		pA
		V _{CM} = 2.5 V, T _A = −40°C to 125°C			240	nA
I _{OS}	Input Offset Current ⁽²⁾	V _{CM} = 2.5 V		30		pA
		V _{CM} = 2.5 V, T _A = −40°C to 125°C			240	nA
C _{IN}	Input Capacitance ⁽⁴⁾	T _A = 25°C	Differential	3.5		pF
			Common Mode	6		
V _{CM}	Common-mode Input Voltage Range	T _A = −40°C to 125°C	(−V _S) − 0.1		(+V _S)+ 0.1	V
CMRR	Common Mode Rejection Ratio	V _{CM} = 0 V to 5 V	60	80		dB
		V _{CM} = 0 V to 5 V, T _A = −40°C to 125°C	50			dB
Output Characteristics						
I _{OH}	High-level Output Current ⁽²⁾	V _{OH} = 5 V, V _{ID} = 1 V		1		nA
		V _{OH} = 5 V, V _{ID} = 1 V, T _A = −40°C to 125°C		100		nA
V _{OL}	Low-Level Output Voltage	I _{OL} = 1 mA, V _{ID} = −1 V		10	20	mV
		I _{OL} = 1 mA, V _{ID} = −1 V, T _A = −40°C to 125°C			50	mV
I _{OL}	Low-Level Output Current	V _{OL} = 1.5 V, V _{ID} = −1 V	80	120		mA
		V _{OL} = 1.5 V, V _{ID} = −1 V, T _A = −40°C to 125°C	50			mA
I _{SC}	Output Short-Circuit Current	Sink current,	85	125		mA
		Sink current, T _A = −40°C to 125°C	70			mA
Switching Characteristics, T _A = −40°C to 125°C ⁽³⁾						

5-V Low-Power Comparators with Open Drain Output

Parameter		Conditions	Min	Typ	Max	Unit
T _{PLH}	Propagation Delay Time, Low-to High	$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 100mV overdrive, $C_L = 15\text{pF}$ ⁽²⁾		120	180	ns
		$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 20mV overdrive, $C_L = 15\text{pF}$ ⁽²⁾		220		ns
T _{PHL}	Propagation Delay Time, High-to Low	$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 100mV overdrive, $C_L = 15\text{pF}$ ⁽²⁾		110	170	ns
		$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 20mV overdrive, $C_L = 15\text{pF}$ ⁽²⁾		222		ns
T _R	Rise Time	$C_L = 15\text{pF}$ ^{(2) (5)}		181		ns
T _F	Fall Time	^{(2) (5)}		0.81		ns

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

(2) Provided by bench test and design simulation.

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

(4) Provided by design simulation.

(5) Measured between 10% of V_S and 90% of V_S .

5-V Low-Power Comparators with Open Drain Output
Electrical Characteristics (continued)

All test condition is $V_S = 2.5\text{ V}$, $R_{PULL-UP} = 5.1\text{ k}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

Parameter		Conditions		Min	Typ	Max	Unit	
Power Supply								
I _Q	Quiescent Current per Comparator	V _{CM} = 2.5 V			53	90	μA	
		V _{CM} = 2.5 V, T _A = −40°C to 125°C				100	μA	
Input Characteristics								
V _{OS}	Input Offset Voltage ⁽¹⁾	V _{CM} = 0 V to 2.5 V		−4	−0.5	4	mV	
		V _{CM} = 0 V to 2.5 V, T _A = −40°C to 125°C		−5		5	mV	
	Input Offset Voltage Drift ⁽²⁾	T _A = −40°C to 125°C			2		μV/°C	
V _{HYST}	Input Hysteresis Voltage ⁽¹⁾	V _{CM} = 0 V to 2.5 V		1	4.5	10	mV	
		V _{CM} = 0 V to 2.5 V, T _A = −40°C to 125°C				15	mV	
	Input Hysteresis Voltage Drift ⁽²⁾	T _A = −40°C to 125°C			10		μV/°C	
I _B	Input Bias Current ⁽²⁾	V _{CM} = 1.25 V			30		pA	
		V _{CM} = 1.25 V, T _A = −40°C to 125°C				240000	pA	
I _{OS}	Input Offset Current ⁽²⁾	V _{CM} = 1.25 V			2		pA	
		V _{CM} = 1.25 V, T _A = −40°C to 125°C				10	pA	
C _{IN}	Input Capacitance ⁽⁴⁾	T _A = 25°C	Differential		3.5		pF	
			Common Mode		6			
V _{CM}	Common-mode Input Voltage Range	T _A = −40°C to 125°C		(−V _S) − 0.1		(+V _S)+ 0.1	V	
CMRR	Common Mode Rejection Ratio	V _{CM} = 0 V to 2.5 V		60	75		dB	
		V _{CM} = 0 V to 2.5 V, T _A = −40°C to 125°C		50			dB	
Output Characteristics								
I _{OH}	High-level Output Current ⁽⁴⁾	V _{OH} = 2.5 V, V _{ID} = 1 V			10		nA	
		V _{OH} = 2.5 V, V _{ID} = 1 V, T _A = −40°C to 125°C					nA	
V _{OL}	Low-Level Output Voltage	I _{OL} = 1 mA, V _{ID} = −1 V			15	20	mV	
		I _{OL} = 1 mA, V _{ID} = −1 V, T _A = −40°C to 125°C				50	mV	
I _{OL}	Low-Level Output Current ⁽⁴⁾	V _{OL} = 1.5 V, V _{ID} = 1 V			45		mA	
		V _{OL} = 1.5 V, V _{ID} = 1 V, T _A = −40°C to 125°C					mA	
I _{SC}	Output Short-Circuit Current	Sink current		42	50		mA	
		Sink current, T _A = −40°C to 125°C		35			mA	
Switching Characteristics, T _A = −40°C to 125°C ⁽³⁾								
T _{PLH}	Propagation delay time, low-to high	ΔV _{IN} = 1 V, V _{CM} = 0 V, 100mV overdrive, C _L = 15pF ⁽⁴⁾				158	230	ns

5-V Low-Power Comparators with Open Drain Output

Parameter		Conditions	Min	Typ	Max	Unit
		$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 20mV overdrive, $C_L = 15\text{pF}$ ⁽⁴⁾		280		ns
T_{PHL}	Propagation delay time, high-to-low	$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 100mV overdrive, $C_L = 15\text{pF}$ ⁽⁴⁾		120	230	ns
		$\Delta V_{IN} = 1\text{ V}$, $V_{CM} = 0\text{ V}$, 20mV overdrive, $C_L = 15\text{pF}$ ⁽⁴⁾		223		ns
T_R	Rise time	$C_L = 15\text{pF}$ ⁽⁴⁾ ⁽⁵⁾		181		ns
T_F	Fall time	⁽²⁾ ⁽⁵⁾		1.5		ns

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

(2) Provided by bench test and design simulation.

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

(4) Provided by design simulation.

(5) Measured between 10% of V_S and 90% of V_S .

Typical Performance Characteristics

All test conditions: $V_S = 5\text{ V}$, $V_{CM} = 0\text{ V}$, $R_{pull-up} = 5.1\text{ K}$, unless otherwise noted.

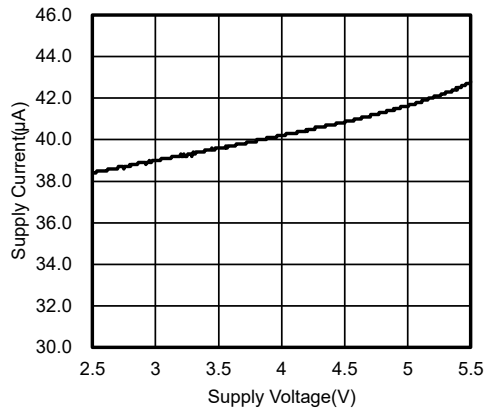


Figure 1. Supply Current vs. Supply Voltage, Output High (Single channel)

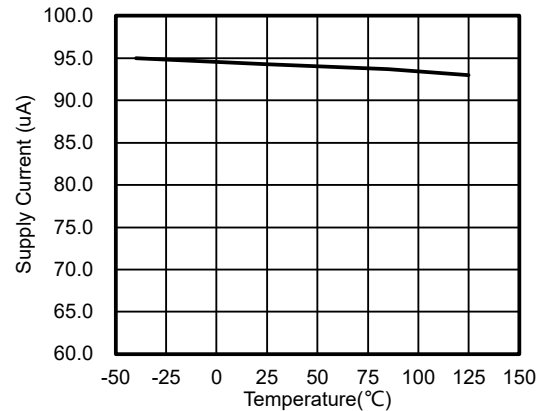


Figure 2. Supply Current vs Temperature (Dual channel)

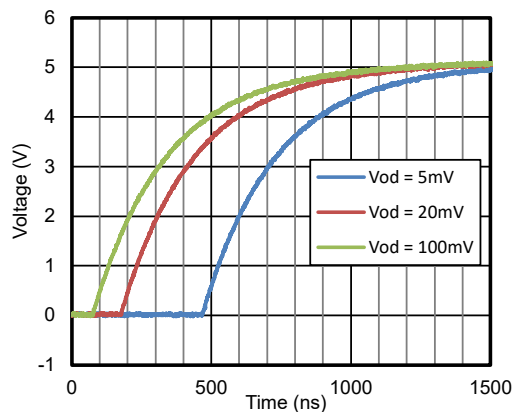


Figure 3. Propagation Delay, Low to High

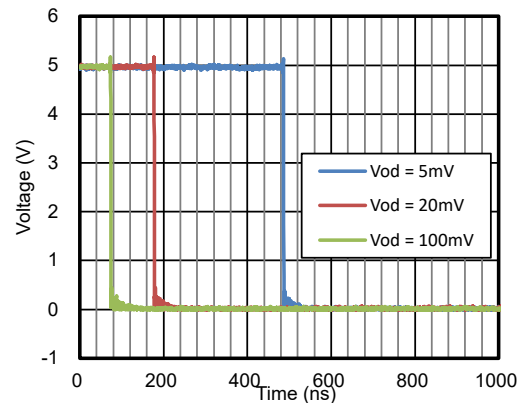


Figure 4. Propagation Delay, High to Low

Detailed Description

Overview

The LMV331X and LMV393X devices feature 158-ns response time and include 4.5 mV of internal hysteresis for improved noise immunity with an input common-mode range that extends 0.1 V beyond the power supply rails, having the ability to operate from 2.5 V to 5.5 V on the supply pin.

The open-drain output allows the output's logic high voltage (V_{OH}) can be configured, or be used in AND functionality. Without the ESD diode between the output pin and the +Vs pin, the output pull-up resistor can be connected to the voltage level independent from the positive supply voltage for level-shifting applications.

Functional Block Diagram

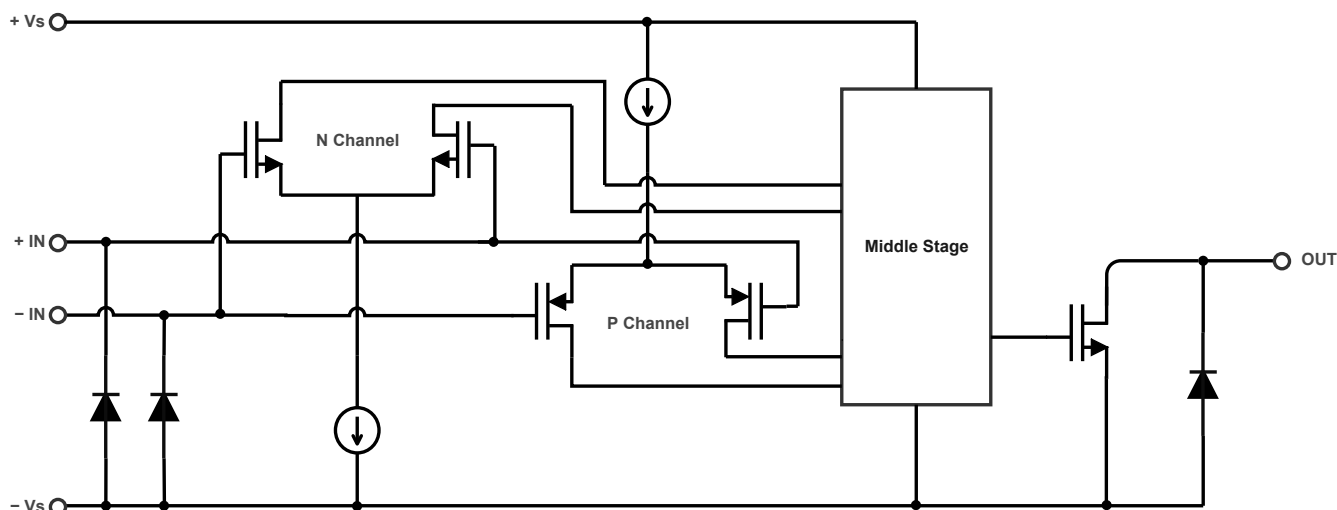


Figure 5. Functional Block Diagram

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 LMV331X and LMV393X families are supposed to have local bypass capacitors (i.e., 0.01 μF to 0.1 μF) within 2 mm for good high-frequency performance. It 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 comparator's inputs and outputs. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components as close to the pins of comparators as possible.

Operation Outside of the Common Input Voltage Range

The following is a list of input voltage situations and the corresponding outcomes:

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 voltage 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 4. 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.

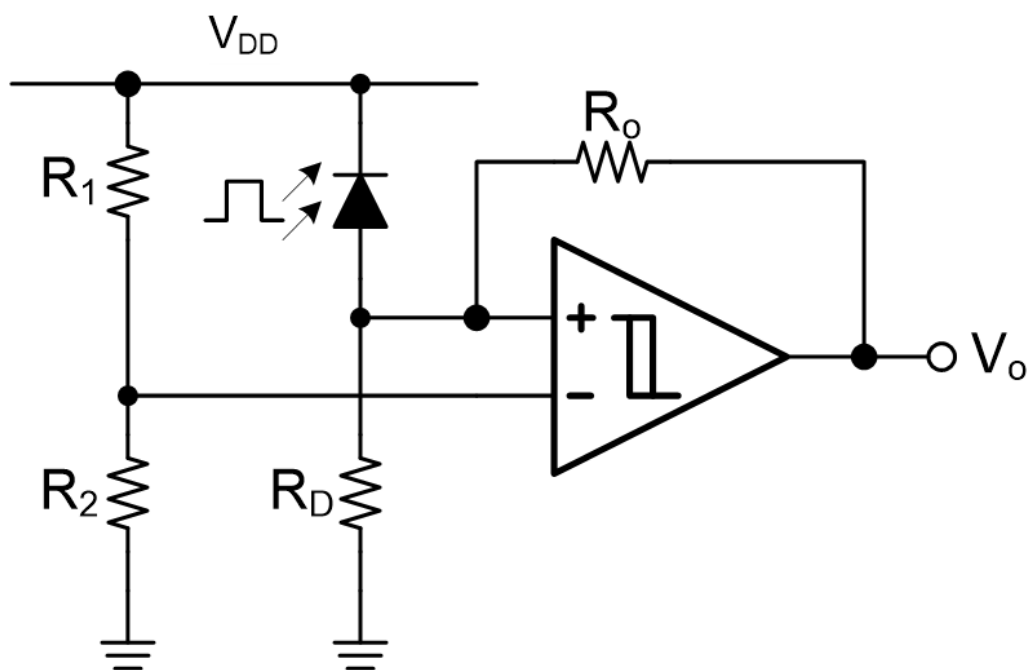
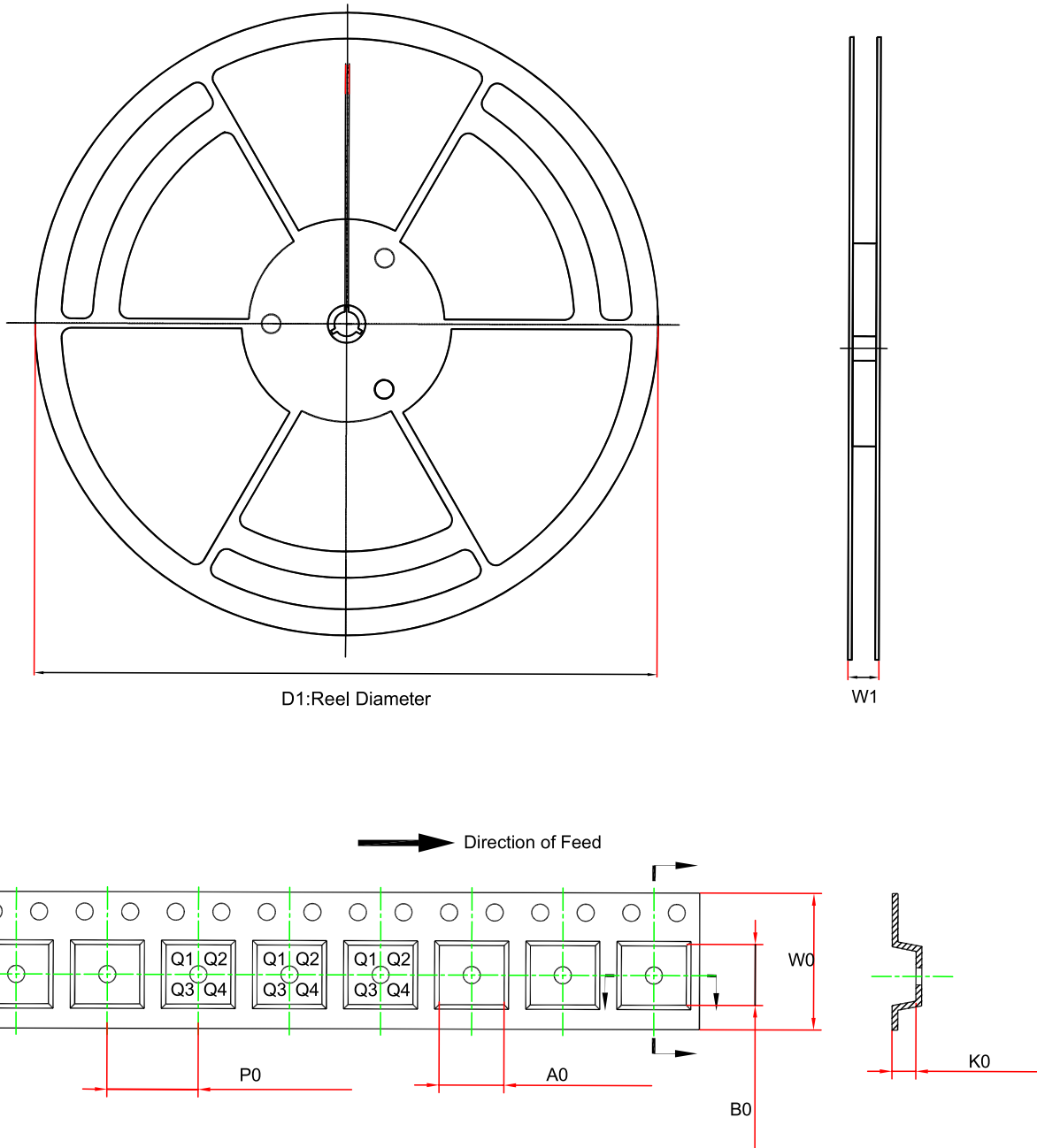


Figure 6. Typical Application Circuit

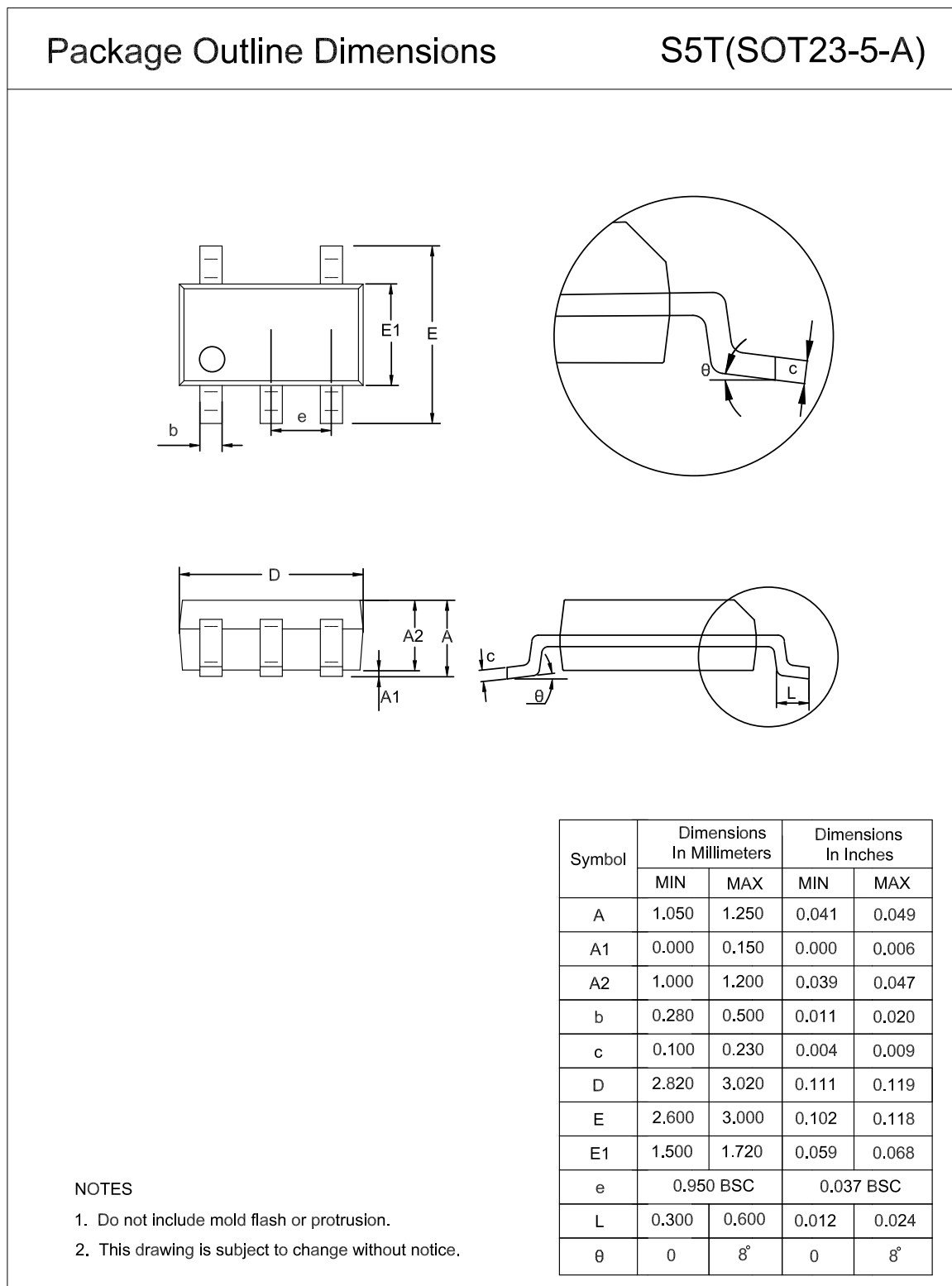
Tape and Reel Information

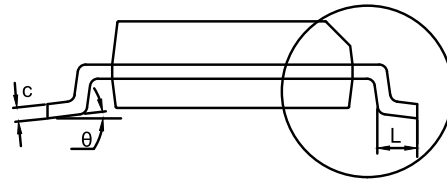
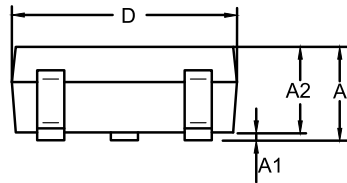
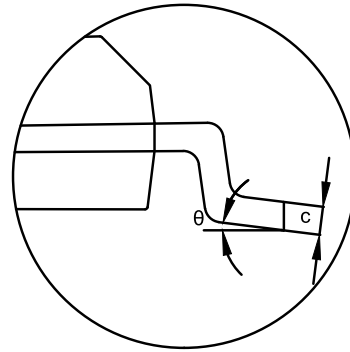
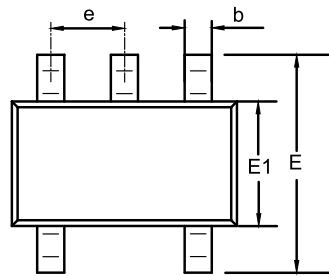


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
LMV331X-SC5R	SOT353 (SC70-5)	178	12.1	2.4	2.5	1.2	4	8	Q3
LMV393X-VS1R	MSOP8	330	17.6	5.2	3.3	1.3	8	12	Q1
LMV393X-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
LMV331X-S5TR	SOT23-5	179	12	3.3	3.25	1.4	4	8	Q3

Package Outline Dimensions

SOT23-5

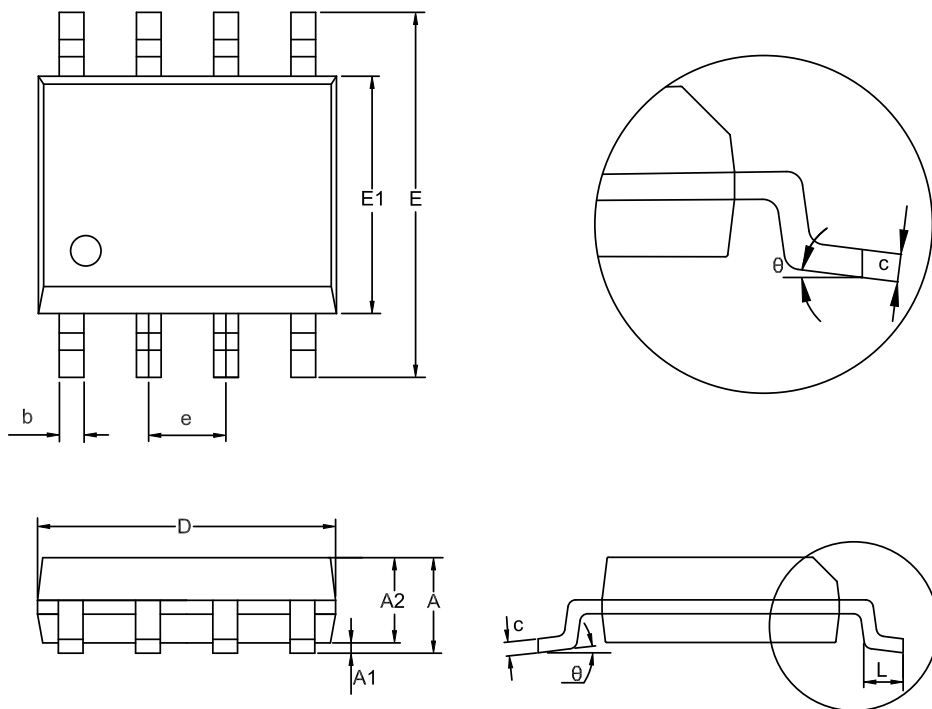


SOT353-5
Package Outline Dimensions
SC5(SOT353-5-A)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.850	1.100	0.033	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.110	0.230	0.004	0.009
D	2.000	2.200	0.079	0.087
E	2.150	2.450	0.085	0.096
E1	1.150	1.350	0.045	0.053
e	0.650 BSC		0.026 BSC	
L	0.260	0.460	0.010	0.018
θ	0	8°	0	8°

NOTES

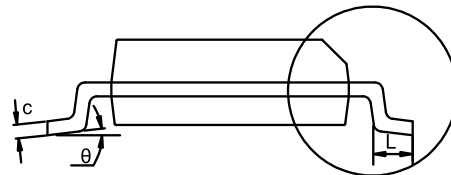
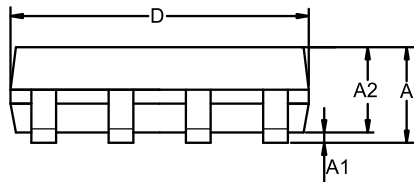
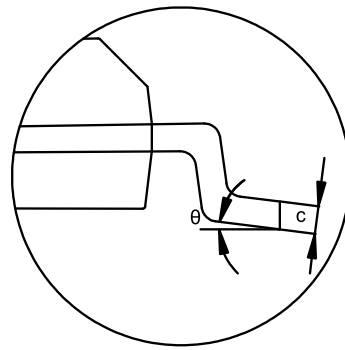
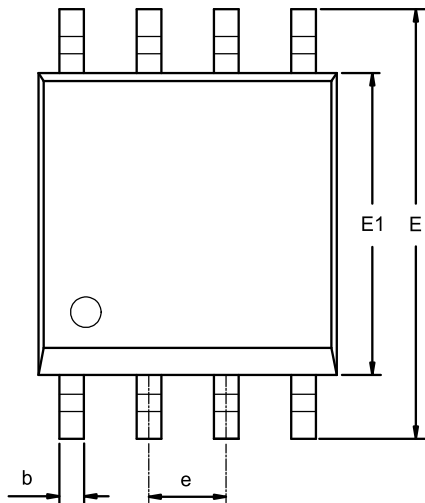
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP8
Package Outline Dimensions
SO1(SOP-8-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	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
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	1.000	0.016	0.039
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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
LMV331X-SC5R	-40 to 125°C	SOT353 (SC70-5)	A16	MSL1	Tape and Reel,3000	Green
LMV393X-VS1R	-40 to 125°C	MSOP8	V393X	MSL2	Tape and Reel,3000	Green
LMV393X-SO1R	-40 to 125°C	SOP8	V393X	MSL2	Tape and Reel,4000	Green
LMV331X-S5TR	-40 to 125°C	SOT23-5	A16	MSL2	Tape and Reel,3000	Green

(1) The sample will be ready in 1 month.

(2) The sample will be ready in 2 months after manufacture starts.

(3) 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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