5-V, 50-ns Low-Power Comparators with Push-Pull Output

Features

- Power Supply Voltage: 2.7 V to 5.5 V
- Low Supply Current: 400 µA per Channel
- Propagation Delay: 50 ns
- Offset Voltage: ±3.5 mV
- Input Common-Mode Range Extends 200 mV
- Push-Pull Output

Applications

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

Description

The devices are low-power, high-speed comparators. The common-mode input voltage range extends 200 mV beyond the power rail. The devices have 50-ns propagation delay with only 400-µA quiescent current, which makes the devices suitable for low-power applications. The devices have push-pull output to support rail-to-rail output swing.

The operating temperature range of the devices is from −40°C to +125°C.

Typical Application Circuit

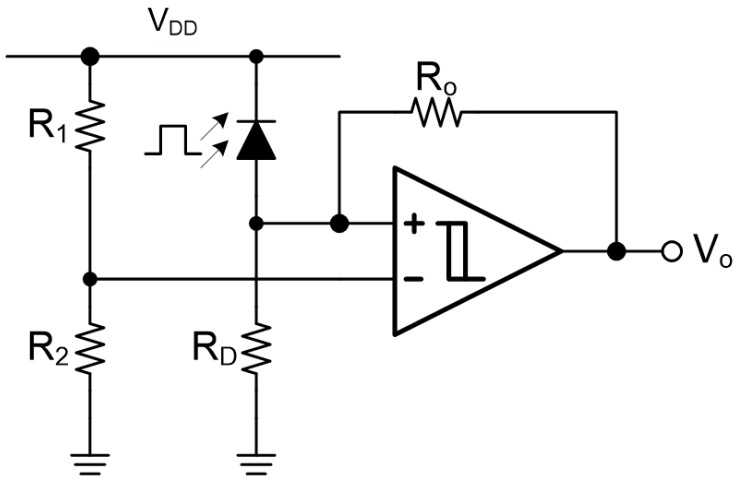


Table of Contents

Revision History

Date	Revision	Notes
2024-03-26	Rev.A.0	Initial version.
2024-06-20	Rev.A.1	Updated the specification. Added the part number: TPCMP231A-S5TR.
2024-12-18	Rev.A.2	Corrected handwriting errors. The physical object has not changed.

Pin Configuration and Functions

TPCMP231
SOT23-5
Top View

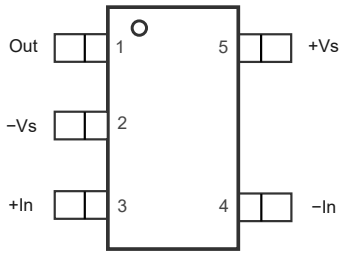
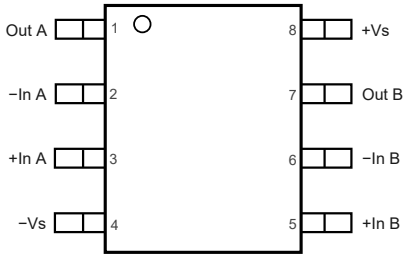


Table 1. Pin Functions: TPCMP231

Pin No.	Name	I/O	Description
1	Out	O	Output
2	$-V_S$	-	Negative power supply
3	+In	I	Non-inverting input
4	−In	I	Inverting input
5	$+V_S$	-	Positive power supply

TPCMP232
SOP8
Top View



TPCMP232
MSOP8
Top View

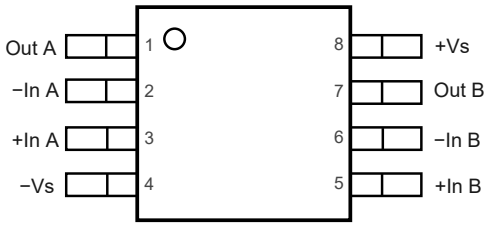


Table 2. Pin Functions: TPCMP232

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Non-inverting input
4	$-V_S$	-	Negative power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$	-	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	Single Supply	2.7		5.5	V
		Dual Supply	±1.35		±2.75	V
T_A	Operating Temperature Range		−40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	180	81	°C/W
SOP8	158	43	°C/W
MSOP8	150	45	°C/W

Electrical Characteristics

All test conditions: V_S = 5 V, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
I_Q	Quiescent Current per Comparator	V_{CM} = 0 V, output low		450	500	μA
		V_{CM} = 0 V, output low, T_A = −40°C to 125°C			550	μA
		V_{CM} = 0 V, output high		470	550	μA
		V_{CM} = 0 V, output high, T_A = −40°C to 125°C			650	μA
PSRR	Power Supply Rejection Ratio	V_S = 2.7 V to 5.5 V, V_{CM} = 0 V	65	90		dB
		V_S = 2.7 V to 5.5 V, V_{CM} = 0 V, T_A = −40°C to 125°C	60			dB
Input Characteristics						
V_{OS}	Input Offset Voltage (1)	V_{CM} = 0 V to 5 V	−3.5	±0.6	3.5	mV
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C	−5		5	mV
		V_{CM} = 0 V to 5 V, TPCMP231A-S5TR	−2	±0.6	2	mV
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C, TPCMP231A-S5TR	−4		4	mV
	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C		2		μV/°C
I_B	Input Bias Current (2)	V_{CM} = 2.5 V	−50	±0.05	50	nA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	−200		200	nA
I_{OS}	Input Offset Current (2)	V_{CM} = 2.5 V	−50	±0.05	50	nA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C	−100		100	nA
V_{CM}	Common-Mode Input Voltage Range	T_A = −40°C to 125°C	($-V_S$) − 0.2		($+V_S$) + 0.2	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0 V to 5 V	90	120		dB
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C	80			dB
Output Characteristics						
I_{SC}	Output Short-Circuit Current (2)	Sink current	55	60		mA
		Sink current, T_A = −40°C to 125°C	45			mA
		Source current	60	65		mA
		Source current, T_A = −40°C to 125°C	50			mA
V_{OH}	Output Voltage Swing from Positive Rail	I_{OL} = 4 mA, V_{ID} = −1 V		100	160	mV
		I_{OL} = 4 mA, V_{ID} = −1 V, T_A = −40°C to 125°C			200	mV
V_{OL}	Output Voltage Swing from Negative Rail	I_{OL} = 4 mA, V_{ID} = −1 V		80	110	mV
		I_{OL} = 4 mA, V_{ID} = −1 V, T_A = −40°C to 125°C			160	mV

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
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, 100-mV overdrive		40	75	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20-mV overdrive (2)		60	105	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 10-mV overdrive (2)		80		ns
T_{PHL}	Propagation Delay Time, High to Low	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100-mV overdrive		40	75	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20-mV overdrive (2)		60	95	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 10-mV overdrive (2)		80		ns
T_R	Rise Time	(2)(4)		4		ns
T_F	Fall Time	(2)(4)		4		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 tests and design simulation.
(3) Delay time is measured from the mid-point of the input to the mid-point of the output.
(4) Measured between 10% of V_S and 90% of V_S.

Electrical Characteristics (Continued)

All test conditions: V_S = 3.3 V, T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
I_Q	Quiescent Current per Comparator	V_{CM} = 0 V, output low		370	410	µA
		V_{CM} = 0 V, output low, T_A = −40°C to 125°C			500	µA
		V_{CM} = 0 V, output high		400	450	µA
		V_{CM} = 0 V, output high, T_A = −40°C to 125°C			550	µA
Input Characteristics						
V_{OS}	Input Offset Voltage (1)	V_{CM} = 0 V to 3.3 V	−3.5	±0.6	3.5	mV
		V_{CM} = 0 V to 3.3 V, T_A = −40°C to 125°C	−5		5	mV
		V_{CM} = 0 V to 3.3 V, TPCMP231A-S5TR	−2	±0.6	2	mV
		V_{CM} = 0 V to 3.3 V, T_A = −40°C to 125°C, TPCMP231A-S5TR	−4		4	mV
	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C		2		µV/°C
I_B	Input Bias Current (2)	V_{CM} = 1.75 V	−50	±0.05	50	nA
		V_{CM} = 1.75 V, T_A = −40°C to 125°C	−200		200	nA
I_{OS}	Input Offset Current (2)	V_{CM} = 1.75 V	−50	±0.05	50	nA
		V_{CM} = 1.75 V, T_A = −40°C to 125°C	−100		100	nA
V_{CM}	Common-Mode Input Voltage Range	T_A = −40°C to 125°C	($-V_S$) − 0.2		($+V_S$) + 0.2	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0 V to 3.3 V	75	95		dB
		V_{CM} = 0 V to 3.3 V, T_A = −40°C to 125°C	65			dB
Output Characteristics						
I_{SC}	Output Short-Circuit Current (2)	Sink current	30	33		mA
		Sink current, T_A = −40°C to 125°C	23			mA
		Source current	25	33		mA
		Source current , T_A = −40°C to 125°C	20			mA
V_{OH}	Output Voltage Swing from Positive Rail	I_{OL} = 4 mA, V_{ID} = −1 V		35	80	mV
		I_{OL} = 4 mA, V_{ID} = −1 V, T_A = −40°C to 125°C			150	mV
V_{OL}	Output Voltage Swing from Negative Rail	I_{OL} = 4 mA, V_{ID} = −1 V		25	50	mV
		I_{OL} = 4 mA, V_{ID} = −1 V, T_A = −40°C to 125°C			100	mV
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, 100-mV overdrive		50	65	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20-mV overdrive (2)		65	75	ns

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 10-mV overdrive (2)		80		ns
T_{PHL}	Propagation Delay Time, High to Low	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100-mV overdrive		40	65	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20-mV overdrive (2)		60	75	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 10-mV overdrive (2)		80		ns
T_R	Rise Time	(2)(4)		6.1		ns
T_F	Fall Time	(2)(4)		5.5		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 tests and design simulation.
(3) Delay time is measured from the mid-point of the input to the mid-point of the output.
(4) Measured between 10% of V_S and 90% of V_S.

Typical Performance Characteristics

All test conditions: V_S = 5 V, V_{CM} = 0 V, R_L = open, unless otherwise noted.

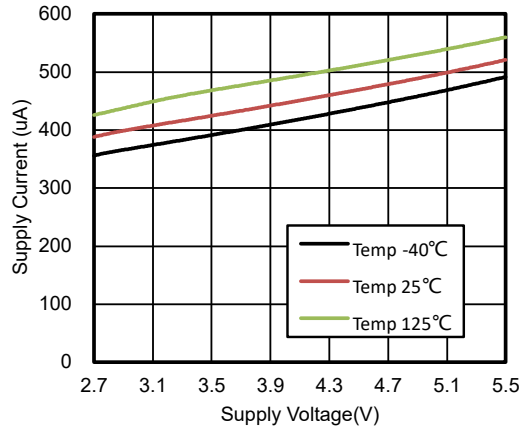


Figure 1. Supply Current vs. Supply Voltage, Output High

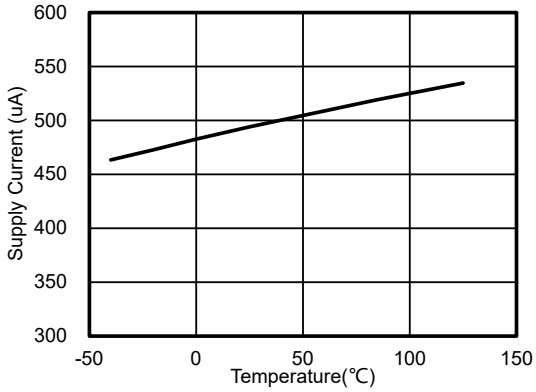


Figure 2. Supply Current vs. Temperature, Output High

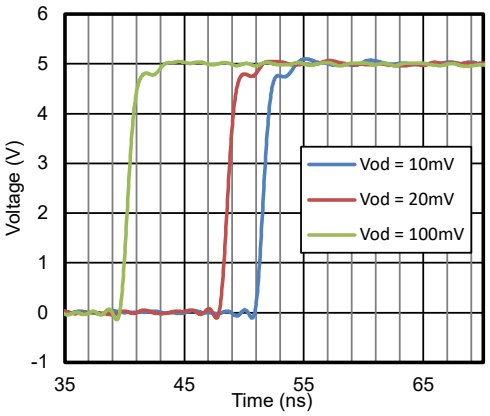


Figure 3. Propagation Delay, Low to High

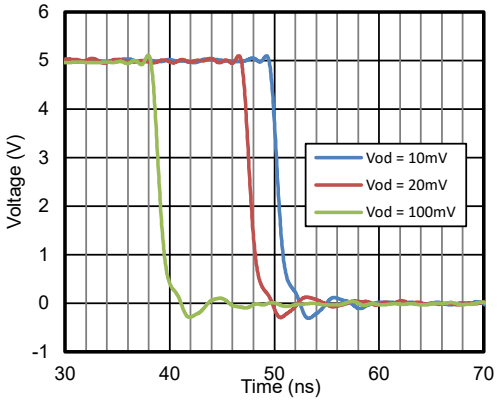


Figure 4. Propagation Delay, High to Low

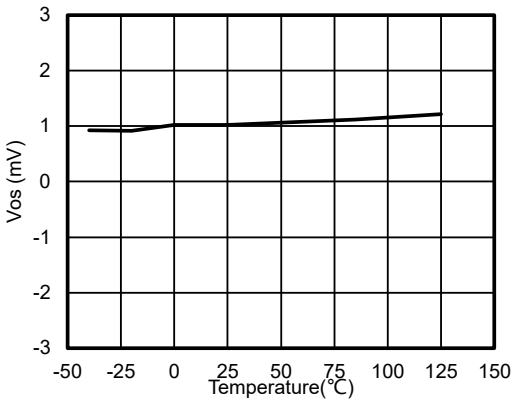


Figure 5. Offset Voltage vs. Temperature

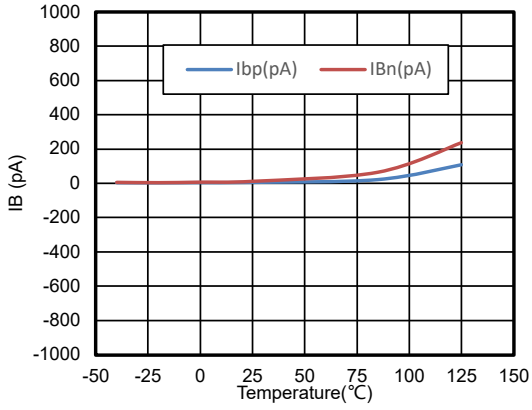


Figure 6. Input Bias Current vs. Temperature

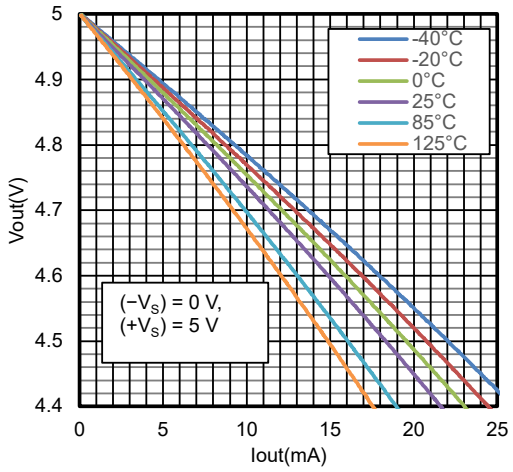


Figure 7. V_{OUT} vs. I_{OUT}, Source

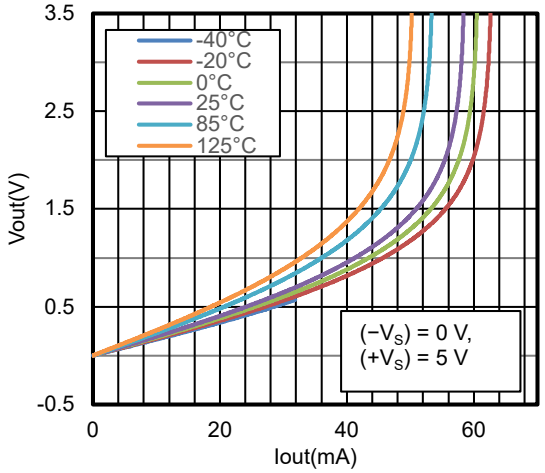


Figure 8. V_{OUT} vs. I_{OUT}, Sink

Detailed Description

Overview

The TPCMP23x devices are micropower comparators with low input offset voltage and the ability to operate at low voltages. The TPCMP23x family features rail-to-rail input stages capable of operating up to 200 mV beyond the supply rails. The comparators can achieve the 100-ns propagation with only 10-mV overdrive voltage, which benefits the high-precise protection applications.

Functional Block Diagram

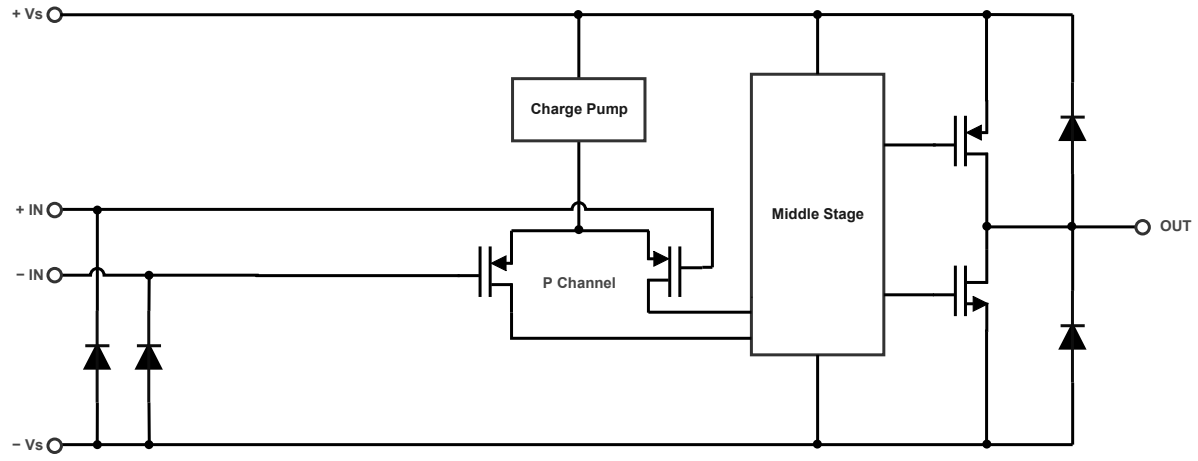


Figure 9. Functional Block Diagram

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 pin of the TPCMP23x family has a local bypass capacitor (i.e., 0.01 μF to 0.1 μF) within 2 mm for high-frequency performance. It can also use a bulk capacitor (i.e., 1 μF or larger) within 100 mm to provide large, 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 comparator pins as close as possible.

Operation Outside of the Common Input Voltage Range

The following is a list of input voltage situation and their 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, and output MOSFET is sourcing current.
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.

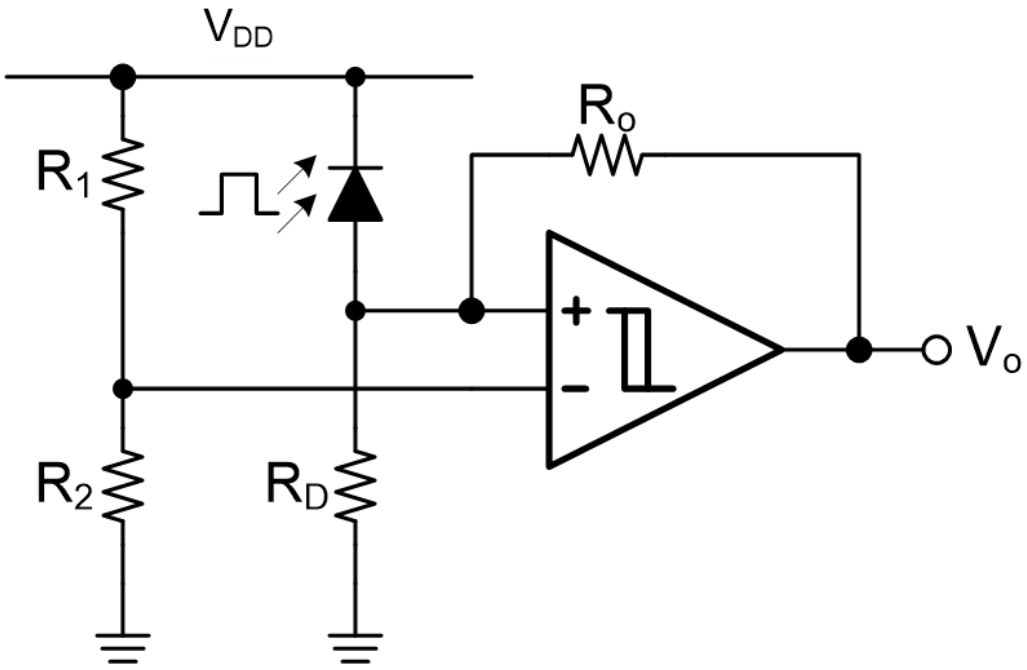
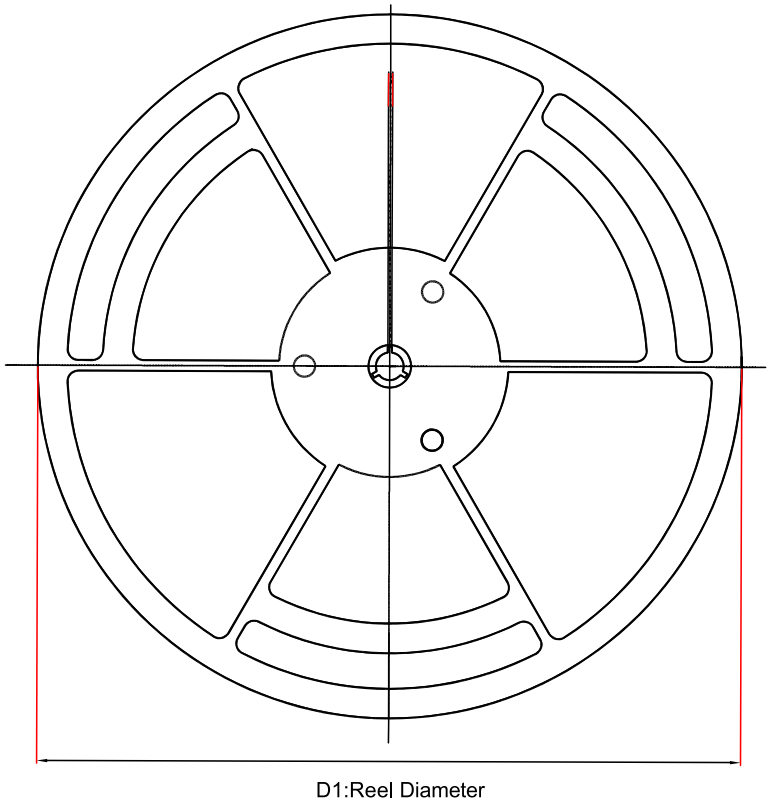
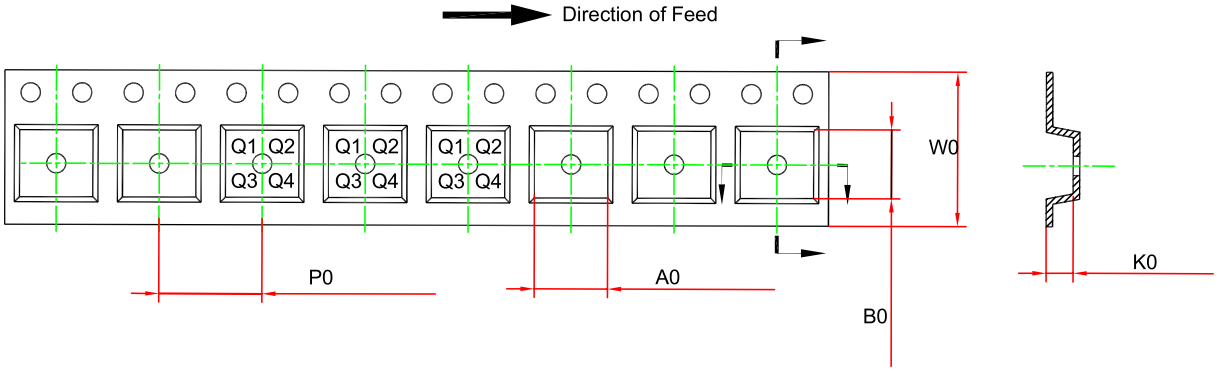


Figure 10. Typical Application Circuit

Tape and Reel Information





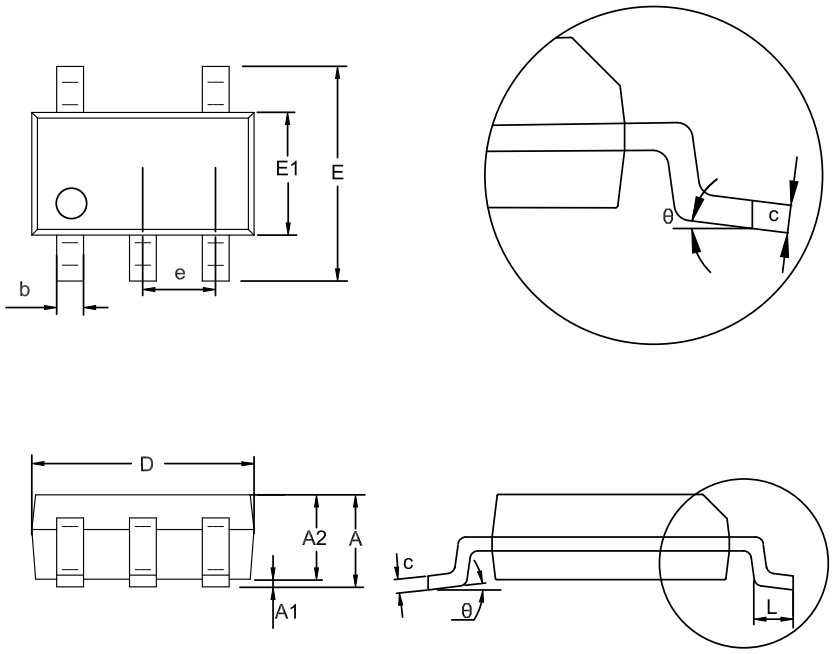
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPCMP232-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPCMP232-VS1R	MSOP8	330	17.6	5.3	3.4	1.3	8	12	Q1
TPCMP231-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3
TPCMP231A-S5TR	SOT23-5	180	12	3.3	3.25	1.4	4	8	Q3

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

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



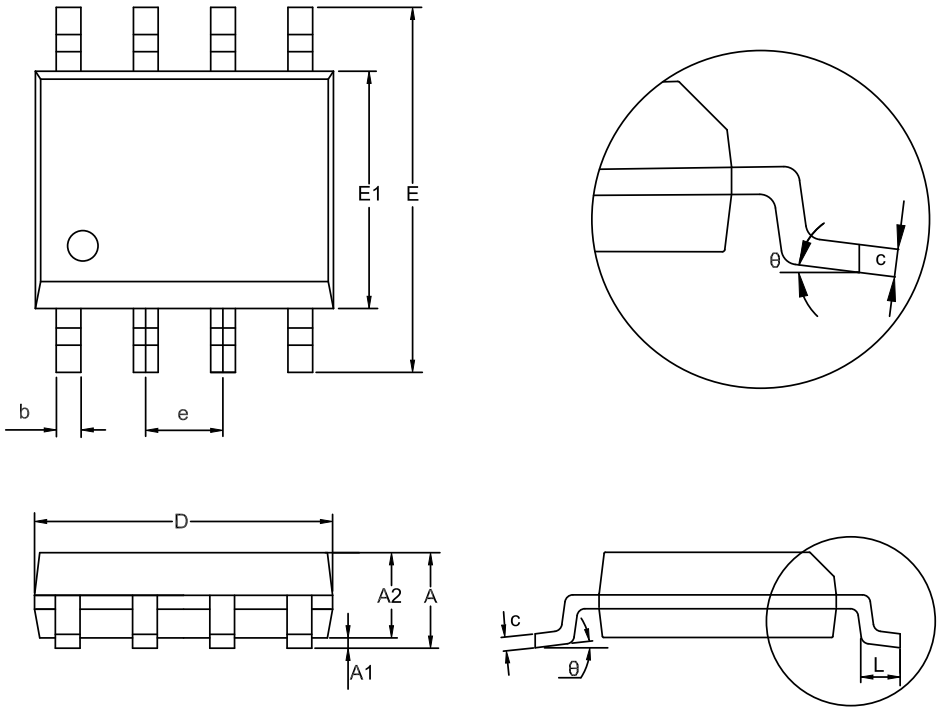
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037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

SOP8

Package Outline Dimensions SO1(SOP-8-A)



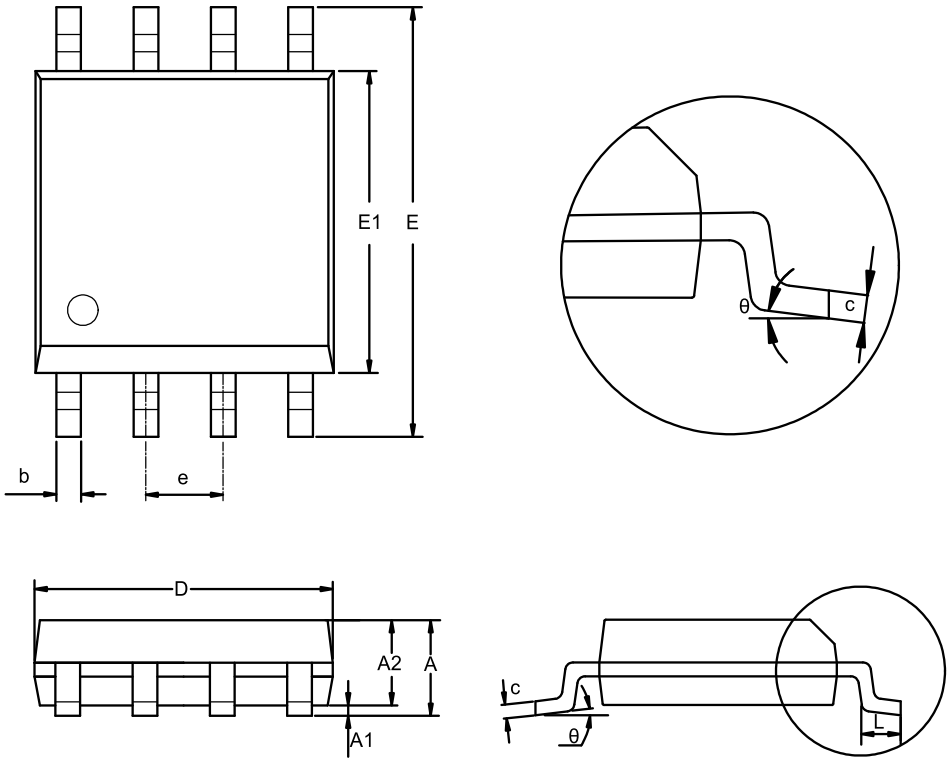
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 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
TPCMP231-S5TR (1)	−40 to 125°C	SOT23-5	A45	1	Tape and Reel, 3000	Green
TPCMP231A-S5TR (1)	−40 to 125°C	SOT23-5	A45	1	Tape and Reel, 3000	Green
TPCMP232-SO1R (1)	−40 to 125°C	SOP8	CM232	1	Tape and Reel, 4000	Green
TPCMP232-VS1R (1)	−40 to 125°C	MSOP8	CM232	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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Performance Information. Performance tests or performance range contained in this document/material are either results of design simulation or actual tests conducted under designated testing environment. Any variation in testing environment or simulation environment, including but not limited to testing method, testing process or testing temperature, may affect actual performance of the product.

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