5-V, 55-ns Comparators with Push-Pull Output

Features

- Power Supply Voltage: 1.8 V to 5.5 V
- Low Supply Current: 350 μA per channel
- Propagation Delay: 55 ns
- Offset Voltage: ±6 mV
- Input Common-Mode Range Extends 100 mV
- Push-Pull Output
- Qualified for Automotive Applications with AEC-Q100 Reliability Test

Applications

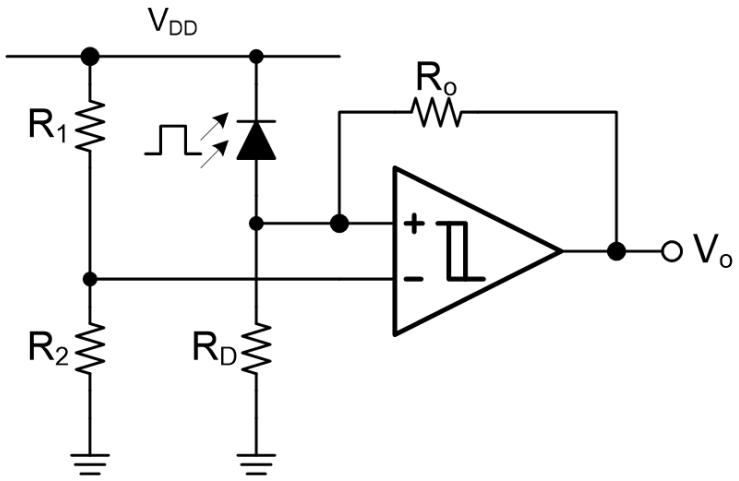
- On-Board Charger
- Motor Control
- Precision Signal Condition
- Battery Management System

Description

The TPA2031Q-S5TR-S is the newest comparator with 55-ns propagation delay. The device is optimized for single +3-V or +5-V operation. The input common-mode range extends 100 mV beyond the rail, and the outputs is push-pull and can sink or source 1 mA to within 200 mV of the power supply rail.

The devices are specified for the aotomotive temperature range from −40°C to +125°C.

Typical Application Circuit



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Revision History

Date	Revision	Notes
2023-09-06	Rev.A.0	Initial version.

Pin Configuration and Functions

TPA2031Q
SOT23-5 Package
Top View

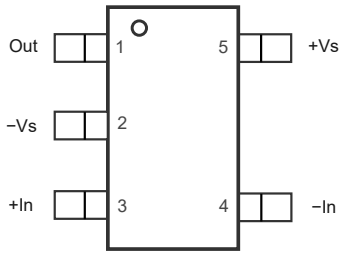


Table 1. Pin Functions: TPA2031Q

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

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) – (-V_S)$		6.5	V
	Input Voltage	$(-V_S) – 0.3$	$(V_S) + 0.3$	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 comparator 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	4	kV
CDM	Charged Device Model ESD	AEC Q100-011	1.5	kV

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_S	Supply Voltage, (+VS) – (−VS)	1.8		5.5	V

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W

Electrical Characteristics

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

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
I_Q	Quiescent Current per Comparator	V_{CM} = 0 V		350	500	μA
		V_{CM} = 0 V,T_A= −40°C to 125°C			600	μA
PSRR	Power Supply Rejection Ratio	V_S = 2.7 V to 5.5 V, V_{CM} = 0 V	60	75		dB
		V_S = 2.7 V to 5.5 V, V_{CM} = 0 V, T_A = −40°C to 125°C	55			dB
Input Characteristics						
V_{OS}	Input Offset Voltage (1)	V_{CM} = 2.5 V,	−6		6	mV
		V_{CM} = 2.5 V,T_A = −40°C to 125°C	−7		7	mV
V_{OS}TC	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C		4		μV/°C
I_B	Input Bias Current	V_{CM} = 2.5 V,		1	20	nA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C			25	nA
I_{OS}	Input Offset Current	V_{CM} = 2.5 V		0.5	8	nA
		V_{CM} = 2.5 V,T_A = −40°C to 125°C			10	nA
V_{DIFF}	Differential Mode Input Voltage Range(4)	T_A = −40°C to 125°C	–5		5	V
V_{CMR}	Common-mode Input Voltage Range	T_A = −40°C to 125°C	(V-) – 0.1		(V+) + 0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 5 V	70	95		dB
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C	65			dB
Output Characteristics						
V_{OH}	Output Voltage High	I_{LOAD} = 4 mA	4.8	4.84		V
		I_{LOAD} = 4 mA, T_A = −40°C to 125°C	4.7			V
V_{OL}	Output Voltage Low	I_{LOAD} = 4 mA		130	180	mV
		I_{LOAD} = 4 mA, T_A = −40°C to 125°C			250	mV
I_{SC}	Short-circuit current			40		mA
Switching Characteristics (3)						
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		42	75	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			100	ns
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF		55	95	ns

Parameter		Conditions	Min	Typ	Max	Unit
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			125	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		45	75	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			100	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF		55	95	ns
		V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			125	ns
T_{RISE}	Rising Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		5.5		ns
T_{FALL}	Falling Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		5.5		ns
T_{PDSKEW}	Propagation Delay Skew (2)	V_{CM}= 0, Overdrive = 100mV, T_{PDSKEW} = | T_{PHL}− T_{PLH}|		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.

Electrical Characteristics (continued)

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

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
I_Q	Quiescent Current per Amplifier	V_{CM} = 0 V,		350	500	µA
		V_{CM} = 0 V,T_A = −40°C to 125°C			600	µA
Input Characteristics						
V_{OS}	Input Offset Voltage (1)	V_{CM} = 1.65 V,	−6		6	mV
		V_{CM} = 1.65 V,T_A = −40°C to 125°C	−7		7	mV
V_{OS}TC	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C		4		µV/°C
I_B	Input Bias Current	V_{CM} = 1.65 V,		1	20	nA
		V_{CM} = 1.65 V, T_A = −40°C to 125°C			25	nA
I_{OS}	Input Offset Current	V_{CM} = 1.65 V,		0.5	8	nA
		V_{CM} = 1.65 V, T_A = −40°C to 125°C			10	nA
V_{DIFF}	Differential Mode Input Voltage Range (4)	T_A = −40°C to 125°C	–3.3		3.3	V
V_{CMR}	Common-mode Input Voltage Range	T_A = −40°C to 125°C	(V-) – 0.1		(V+) + 0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 3.3 V	61	80		dB
		V_{CM} = 0 V to 3.3 V, T_A = −40°C to 125°C	60			dB
Output Characteristics						
V_{OH}	Output Voltage High	I_{LOAD} = 1 mA	3.1	3.2		V
		I_{LOAD} = 1 mA, T_A = −40°C to 125°C	3			V
V_{OL}	Output Voltage Low	I_{LOAD} = 1 mA		40	150	mV
		I_{LOAD} = 1 mA, T_A = −40°C to 125°C			200	mV
I_{SC}	Short-circuit current			25		mA
Switching Characteristics(3)						
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		40	65	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			85	ns
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 20 mV,		50	80	ns

Parameter		Conditions	Min	Typ	Max	Unit
		C_{LOAD} = 50 pF				
		V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			115	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		40	65	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			85	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF		50	80	ns
		V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			115	ns
T_{RISE}	Rising Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		8		ns
T_{FALL}	Falling Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		5		ns
T_{PDSKEW}	Propagation Delay Skew (2)	V_{CM} = 0, Overdrive = 100mV, T_{PDSKEW} = $\lvert T_{PHL} - T_{PLH} \rvert$		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.

Electrical Characteristics (continued)

All test conditions: V_S = 1.8 V, T_A = 25°C, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
I_Q	Quiescent Current per Amplifier	V_{CM} = 0 V,		300	340	µA
		V_{CM} = 0 V, T_A = −40°C to 125°C			370	µA
Input Characteristics						
V_{OS}	Input Offset Voltage (1)	V_{CM} = 0.9 V,	−6		6	mV
		V_{CM} = 0.9 V, T_A = −40°C to 125°C	−7		7	mV
$V_{OS}TC$	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C		4		µV/°C
I_B	Input Bias Current	V_{CM} = 0.9 V,		1	20	nA
		V_{CM} = 0.9 V, T_A = −40°C to 125°C			25	nA
I_{OS}	Input Offset Current	V_{CM} = 0.9 V,		0.5	8	nA
		V_{CM} = 0.9 V, T_A = −40°C to 125°C			10	nA
V_{DIFF}	Differential Mode Input Voltage Range (4)	T_A = −40°C to 125°C	–1.8		1.8	V
V_{CMR}	Common-mode Input Voltage Range	T_A = −40°C to 125°C	(V-) – 0.1		(V+) + 0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 1.8 V	61	80		dB
		V_{CM} = 0 V to 1.8 V, T_A = −40°C to 125°C	60			dB
Output Characteristics						
V_{OH}	Output Voltage High	I_{LOAD} = 1 mA	1.6	1.7		V
		I_{LOAD} = 1 mA, T_A = −40°C to 125°C	1.5			V
V_{OL}	Output Voltage Low	I_{LOAD} = 1 mA		100	150	mV
		I_{LOAD} = 1 mA, T_A = −40°C to 125°C			200	mV
I_{SC}	Short-circuit current			5		mA
Switching Characteristics(3)						
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		50	80	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			100	ns
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF		60	110	ns

Parameter		Conditions	Min	Typ	Max	Unit
T_{PLH}	Propagation Delay (Low-to-High)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			150	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF		50	80	ns
		V_{CM} = 0 V, Overdrive = 100 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			100	ns
T_{PHL}	Propagation Delay (High -to-Low)	V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF		60	110	ns
		V_{CM} = 0 V, Overdrive = 20 mV, C_{LOAD} = 50 pF, T_A = −40°C to 125°C			150	ns
T_{RISE}	Rising Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		19		ns
T_{FALL}	Falling Time (2) (5)	f = 10 kHz, C_{LOAD} = 50 pF, R_{LOAD} = 10 kΩ, Overdrive = 100 mV		15		ns
T_{PDSKEW}	Propagation Delay Skew (2)	V_{CM} = 0, Overdrive = 100mV, T_{PDSKEW} = $\lvert T_{PHL} - T_{PLH} \rvert$		10		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 V, V_{CM} = 0 V, $V_{overdrive}$ = 100 mV, R_L = Open, unless otherwise noted.

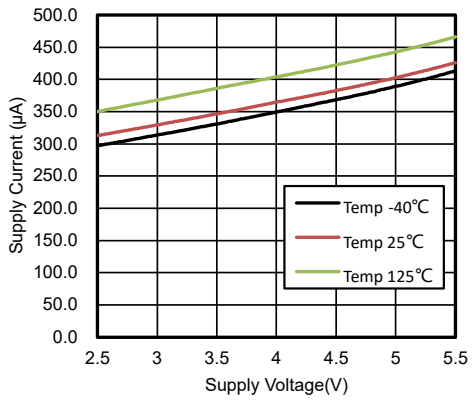


Figure 1. Supply Current vs. Supply Voltage, Output High

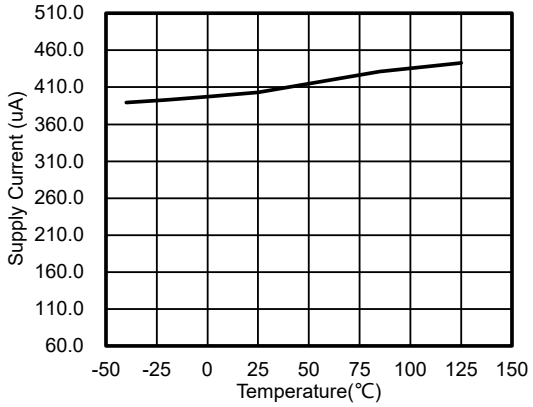


Figure 2. Supply Current vs. Temperature

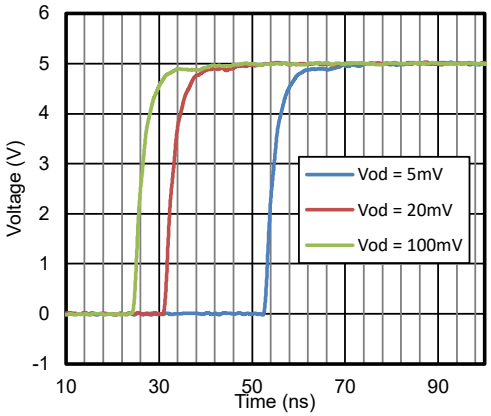


Figure 3. Propagation Delay, Low to High

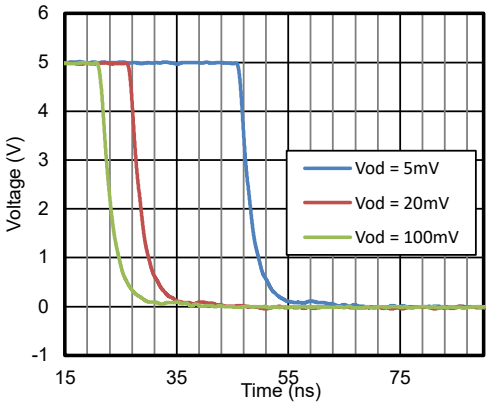


Figure 4. Propagation Delay, High to Low

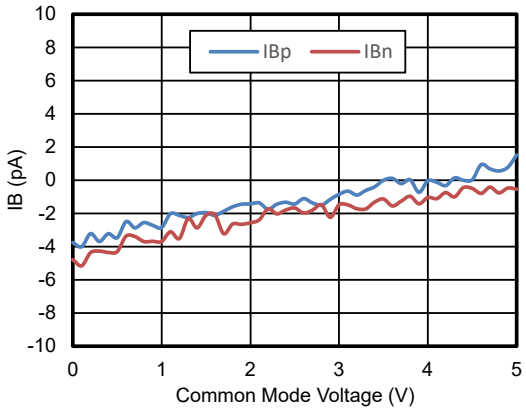


Figure 5. I_B vs Common-Mode Voltage

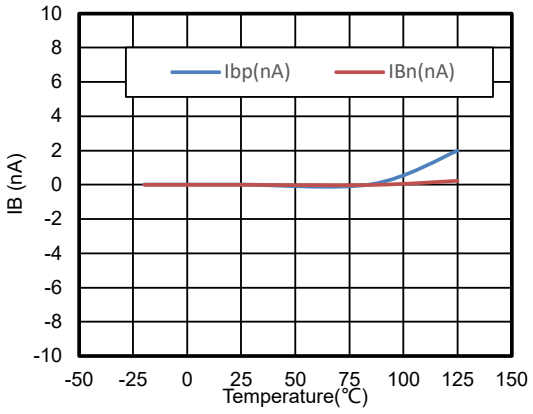


Figure 6. I_B vs Temperature

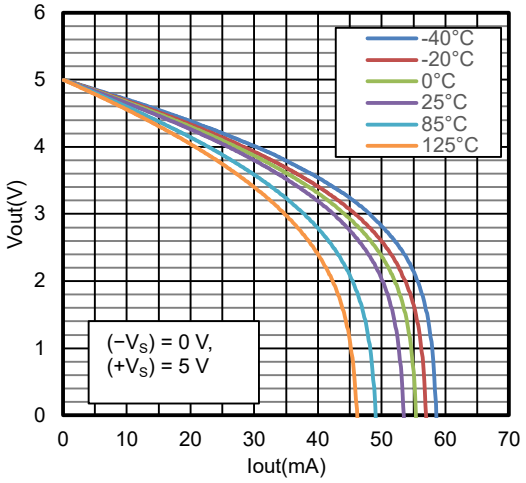


Figure 7. Output Voltage vs. Output Sourcing Current, 5 V

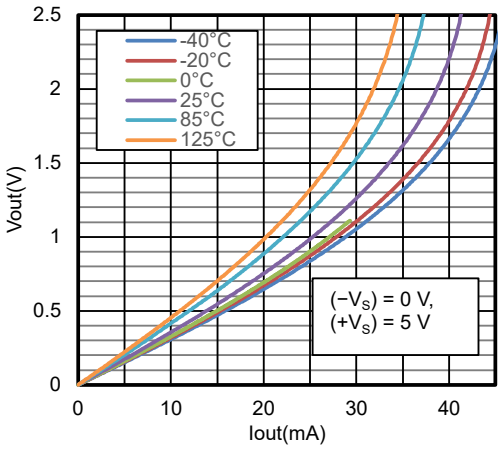


Figure 8. Output Voltage vs. Output Sinking Current, 5 V

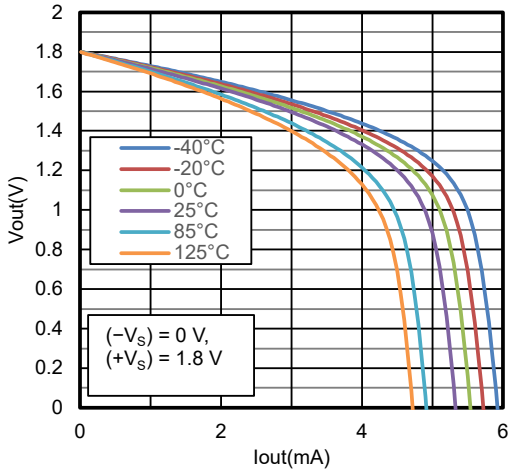


Figure 9. Output Voltage vs. Output Sourcing Current, 1.8 V

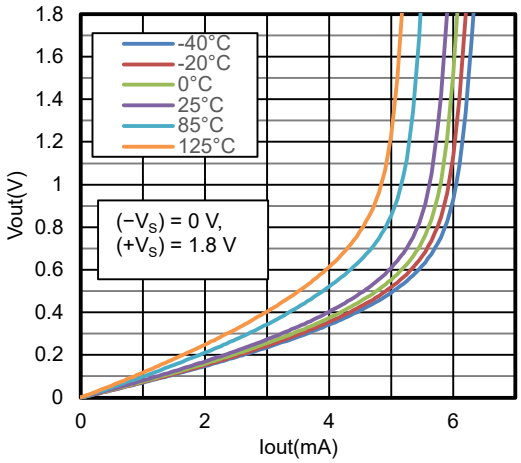


Figure 10. Output Voltage vs. Output Sinking Current, 1.8 V

Detailed Description

Overview

The TPA2031Q device is a micro-power comparator with push-pull output and low input offset voltage. Operating down to 1.8 V while only consuming only 350 μA per channel. The design of the TPA2031Q comparator includes an internal charge-pump that powers the input stage with an internal supply rail which is above the external supply (V+). This internal supply rail allows the single differential input pair to operate and remain linear over a very wide input common-mode range. The TPA2031Q is ideally suited for portable, automotive, and industrial applications.

Functional Block Diagram

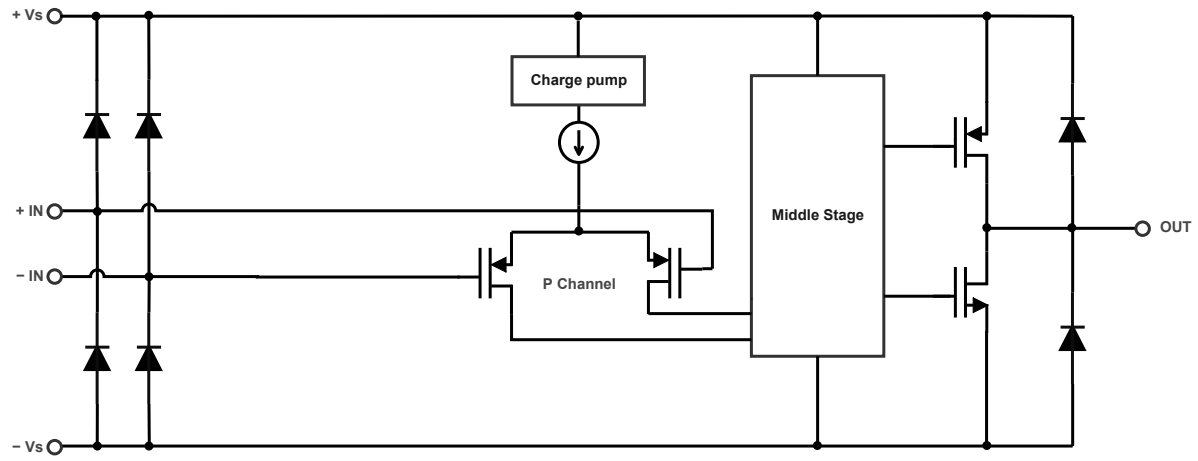


Figure 11. Functional Block Diagram

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 TPA2031 is supposed to have a local bypass capacitor (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, slow currents. This bulk capacitor can be shared with other analog parts.

Good ground layout improves performance by decreasing the amount of stray capacitance and noise at the inputs and outputs of comparator. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components as close to the comparator pins 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 ouput 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 RD. When this voltage level crosses the voltage applied by the voltage divider to the inverting input, the output transitions. Optional Ro provides additional hysteresis for noise immunity.

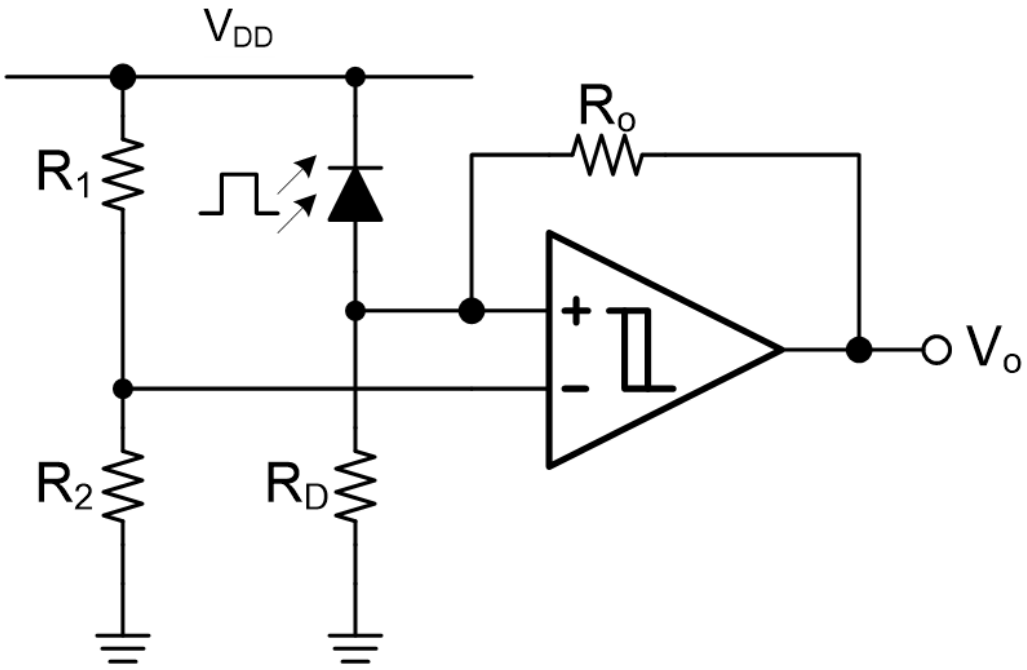
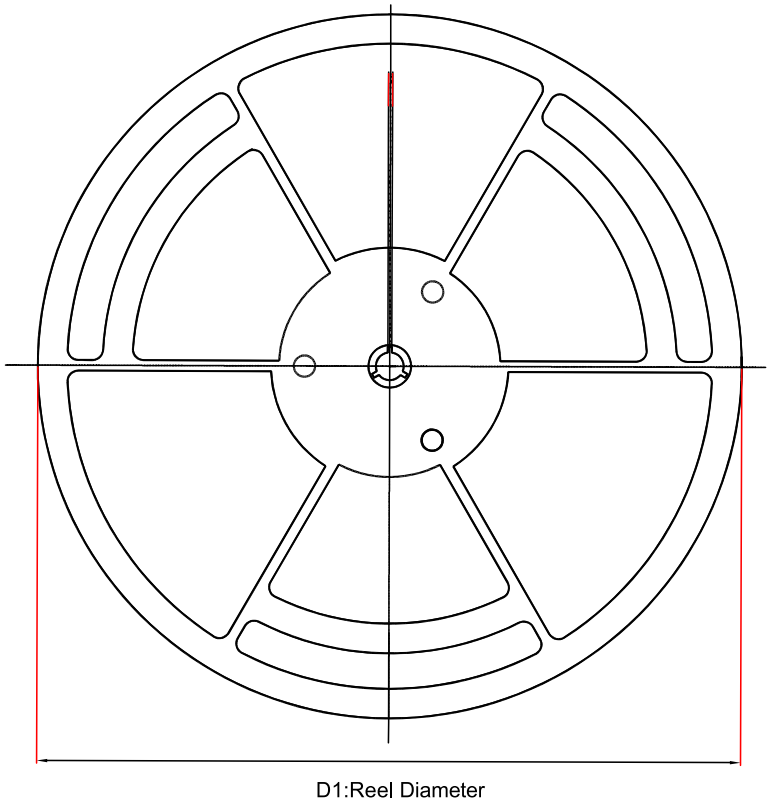
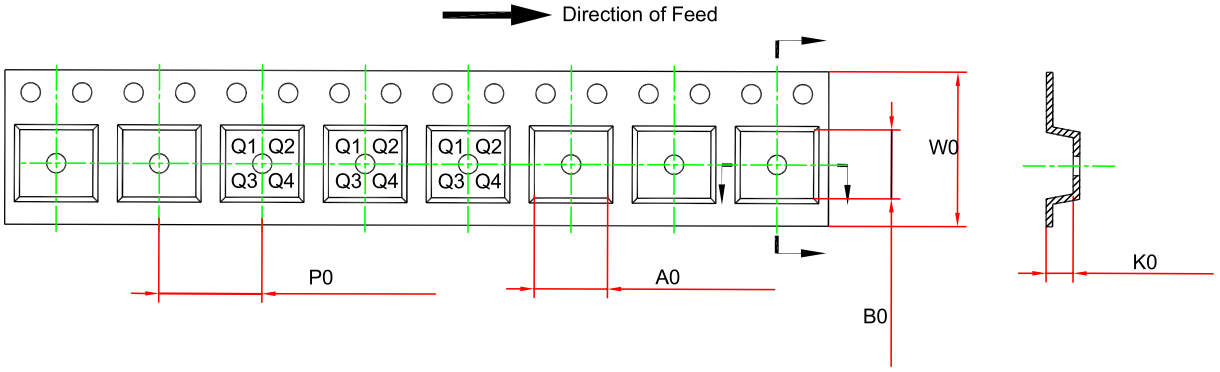


Figure 12. Typical Application Circuit

Tape and Reel Information



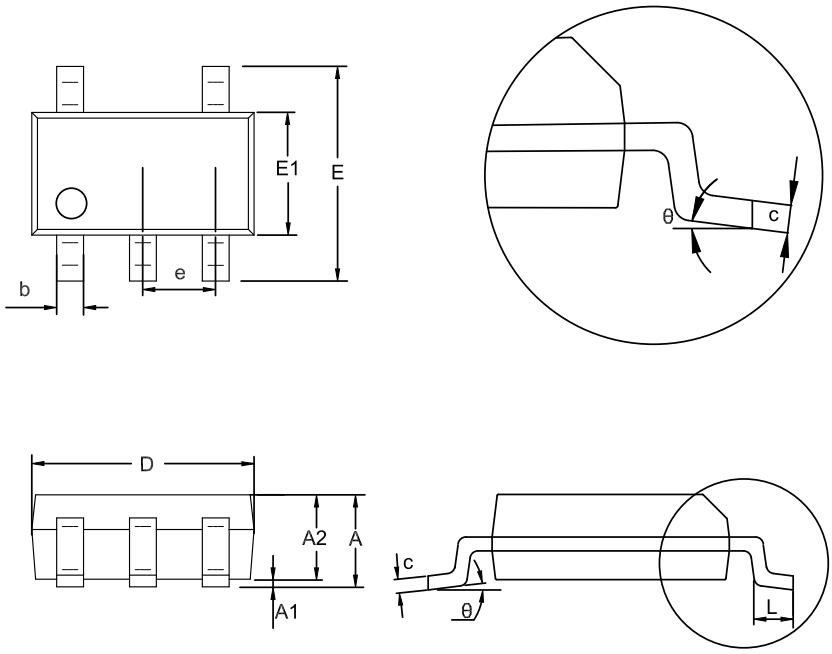


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA2031Q-S5TR-S	SOT23-5	179	12	3.3	3.25	1.4	4	8	Q3

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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA2031Q-S5TR-S	−40 to 125°C	SOT23-5	31Q	MSL3	Tape and Reel,3000	Green

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

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