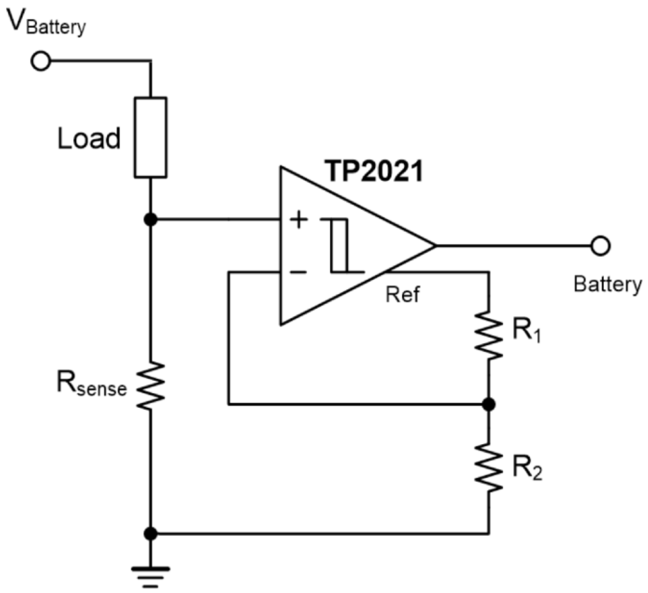
1.8V, Nano-power Comparators with Voltage Reference

Features

- **Ultra-Low Supply Current:**
  390 nA Comparator with Reference
- **Internal 1.3V Reference @ VDD =5V**
- **Fast Response Time: 13 μs Propagation Delay, with 100 mV Overdrive**
- **Internal Hysteresis for Clean Switching**
- **Input Bias Current: 6 pA Typical**
- **Push-Pull Output with ±25 mA Drive Capability**
- **No Phase Reversal for Overdriven Inputs**
- **Low Supply Voltage: 1.8V to 5.5V**
- **Green, Space-Saving SOT23 Package**

Applications

- **Battery Monitoring / Management**
- **Alarm and Monitoring Circuits**
- **Threshold Detectors/Discriminators**
- **Sensing at Ground or Supply Line**
- **Ultra-Low-Power Systems**

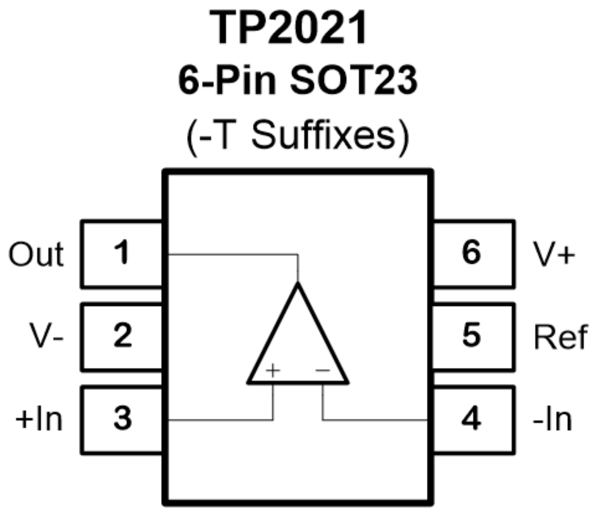


TP2021 in Low-Side Current Sensing

Description

The device has a push-pull output stage with loads up to 25mA. The device features an on-chip 1.3-V reference and draw an ultra-low supply current of only 390nA. The device incorporates 3PEAK's proprietary and patented design techniques to achieve the best world-class performance among all nano-power comparators. The internal input hysteresis eliminates output switching due to internal input noise voltage, reducing current draw. These features make the device ideal for low power application.

Pin Configuration (Top View)



Order Information

Order Number	Operating Temperature Range	Package	Transport Media, Quantity	Marking Information
TP2021-TR	0°C to 70°C	6-Pin SOT23	Tape and Reel, 3000	C2T
TP2021A-TR	–40°C to 125°C	6-Pin SOT23	Tape and Reel, 3000	C2T

Absolute Maximum Ratings Note 1

Supply Voltage: $V^+ - V^-$....................................6.0V
Input Voltage............................ $V^- - 0.3$ to $V^+ + 0.3$
Input Current: +IN, –IN, Note 2..........................±10mA
Output Current: OUT.................................... ±25mA
Output Short-Circuit Duration Note 3............ Indefinite

Maximum Junction Temperature................... 150°C
Storage Temperature Range......... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 260°C

Note 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.

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

Note 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 amplifiers 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

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	1	kV

Electrical Characteristics

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 27°C. V_{DD} = 5.5 V, C_L = 15 pF.

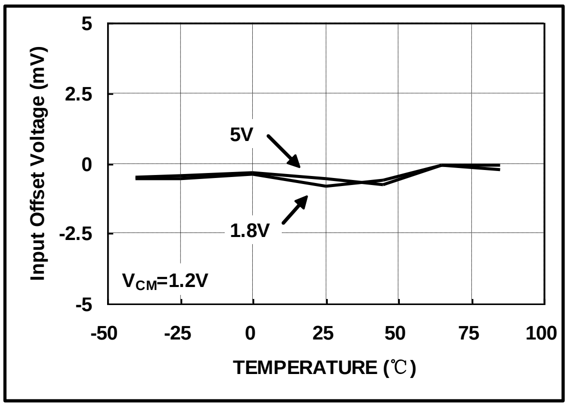
SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{DD}	Supply Voltage		●	1.8		5.5	V
V_{OS}	Input Offset Voltage Note 1	V_{CM} = 1.2 V		-12.0	0.5	+12.0	mV
		V_{DD} = 5.5 V, V_{CM} = 1.2 V		-12.0	0.5	+12.0	mV
V_{OS} TC	Input Offset Voltage Drift Note 1	V_{CM} = 1.2 V			0.3		µV/°C
V_{HYST}	Input Hysteresis Voltage Note 1	V_{CM} = 1.2 V			4		mV
V_{HYST} TC	Input Hysteresis Voltage Drift Note 1	V_{CM} = 1.2 V			20		µV/°C
I_B	Input Bias Current	V_{CM} = 1.2 V			6		pA
I_{OS}	Input Offset Current	V_{CM} = 1.2 V			4		pA
R_{IN}	Input Resistance				> 100		GΩ
C_{IN}	Input Capacitance	Differential Common Mode			2 4		pF
CMRR	Common-mode Rejection Ratio	TP2021, V_{CM} = 0 V to V^+ – 1.2 V			82		dB
		TP2021A, V_{CM} = 0V to V^+			82		dB
V_{CM}	Common-mode Input Voltage Range	TP2021		V^-		V^+ – 1.2	V
		TP2021A		V^-		V^+	V
PSRR	Power Supply Rejection Ratio	V_{DD} = 1.8 V to 5.5 V, V_{CM} = 1.2 V		60	90		dB
V_{OH}	High-Level Output Voltage	I_{OUT} = –1mA	●	V_{DD} – 0.3			V
V_{OL}	Low-Level Output Voltage	I_{OUT} = 1mA	●			0.3	V
I_{SC}	Output Short-Circuit Current	Sink or source current			25		mA
I_Q	Quiescent Current per Comparator				390	550	nA
V_{OUT}	Reference Voltage	V_{DD} = 5 V		1.14	1.3	1.46	V
		V_{DD} = 3 V		1.13	1.29	1.45	V
V_{OUT} TC	Reference Voltage Drift				150		µV/°C
V_{OUT} LC	Reference Voltage Load Regulation	0µA ≤ I_{source} ≤ 400 µA			1.45		µV/µA
		0µA ≤ I_{sink} ≤ 400µA			0.13		µV/µA
t_R	Rising Time				5		ns
t_F	Falling Time				5		ns
t_{PD+}	Propagation Delay (Low-to-High)	Overdrive = 100 mV, V_{IN-} = 1.2 V			13		µs
t_{PD-}	Propagation Delay (High-to-Low)	Overdrive = 100mV, V_{IN-} = 1.2 V			14		µs
$T_{PD-SKEW}$	Propagation Delay Skew Note 2	Overdrive = 100mV, V_{IN-} = 1.2 V			3		µs

Note 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.

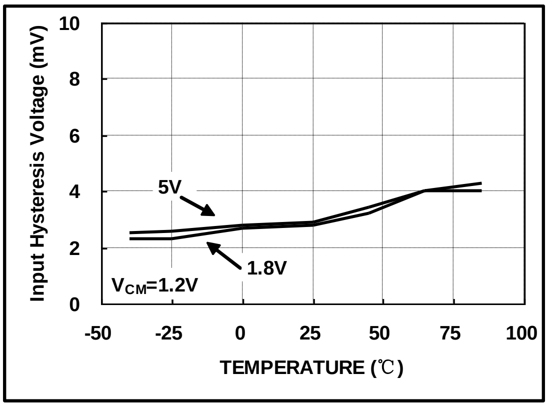
Note 2: Propagation Delay Skew is defined as: $t_{PD-SKEW} = t_{PD+} - t_{PD-}$.

Typical Performance Characteristics

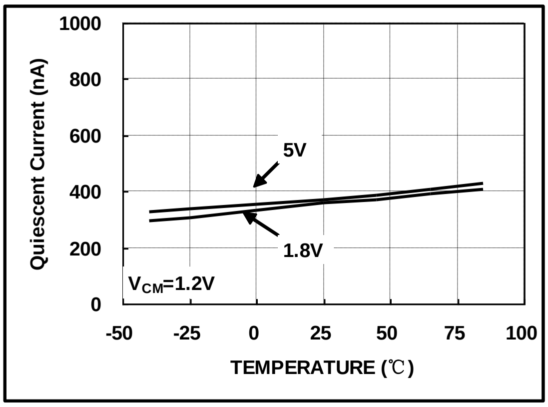
Input Offset Voltage vs. Temperature



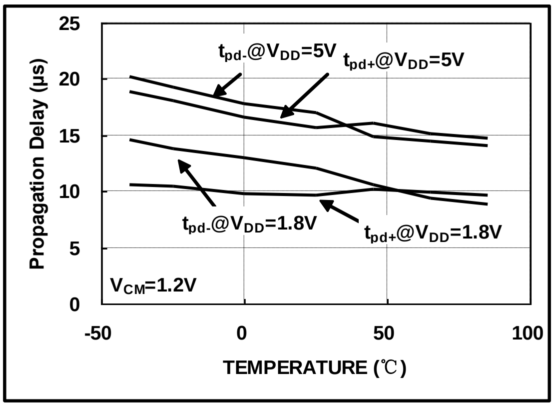
Input Hysteresis Voltage vs. Temperature



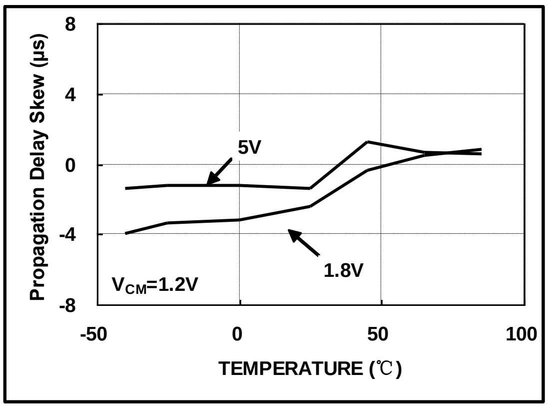
Quiescent Current vs. Temperature



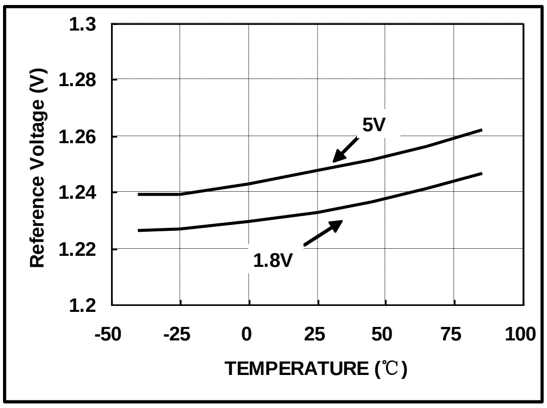
Propagation Delay vs. Temperature



Propagation Delay Skew vs. Temperature

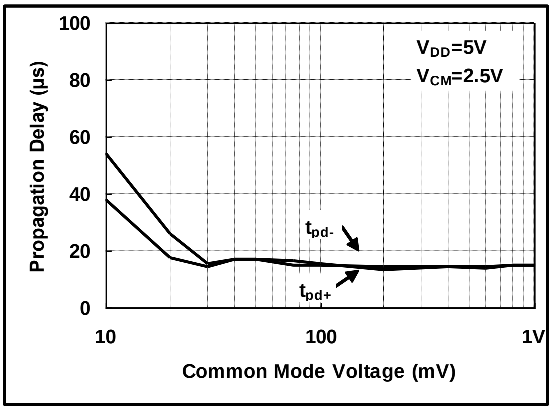


Reference Voltage vs. Temperature

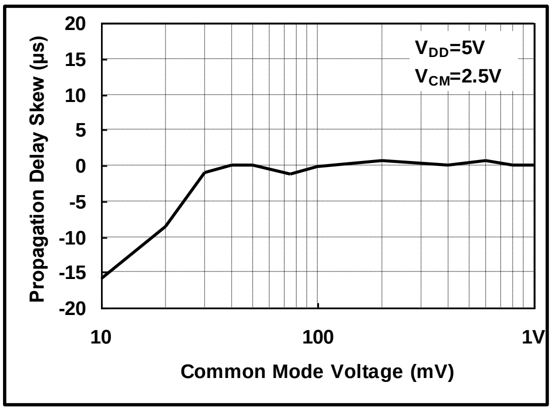


Typical Performance Characteristics

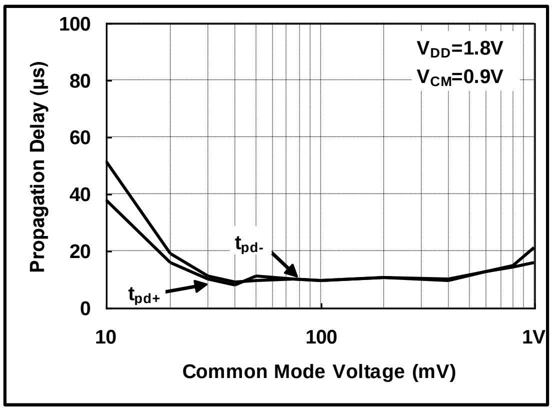
Propagation Delay vs. Overdrive Voltage



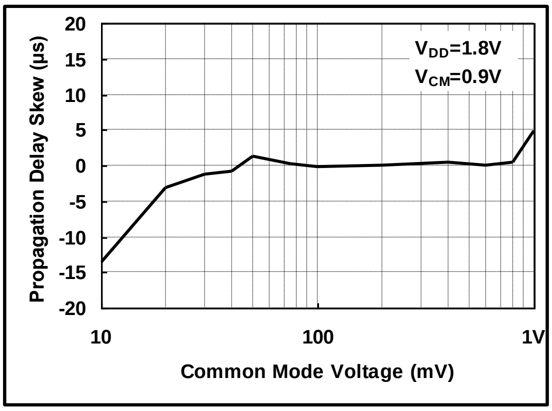
Propagation Delay Skew vs. Overdrive Voltage



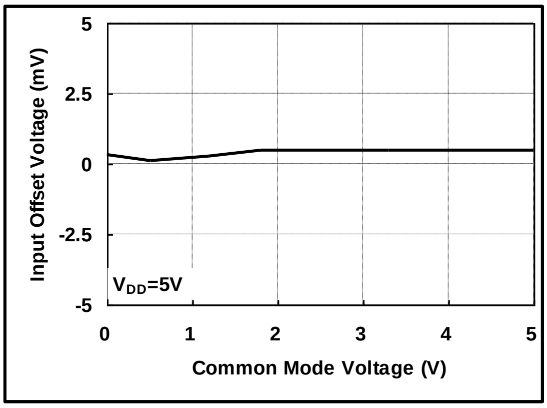
Propagation Delay vs. Overdrive Voltage



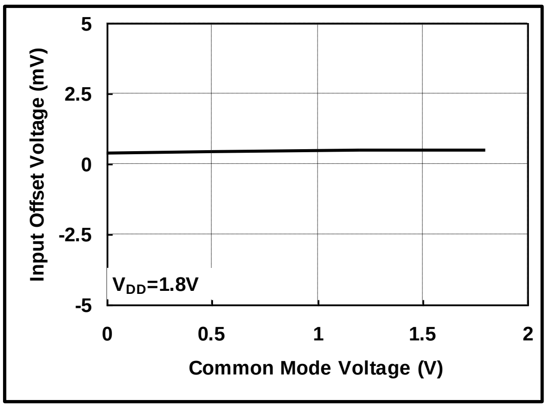
Propagation Delay Skew vs. Overdrive Voltage



Input Offset Voltage vs. Common Mode Voltage

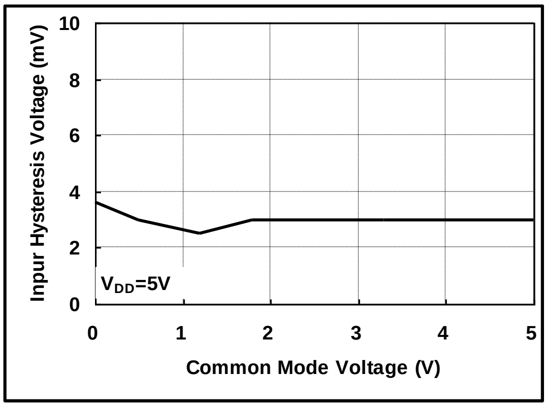


Input Offset Voltage vs. Common Mode Voltage

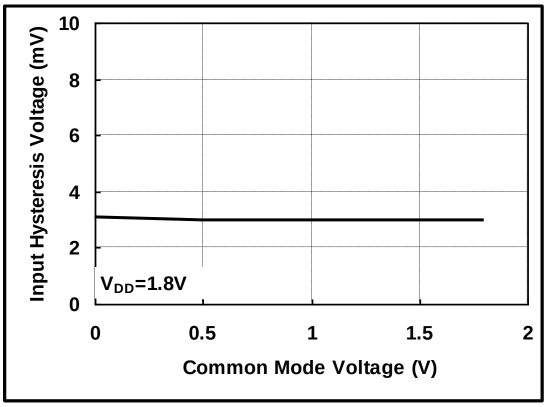


Typical Performance Characteristics

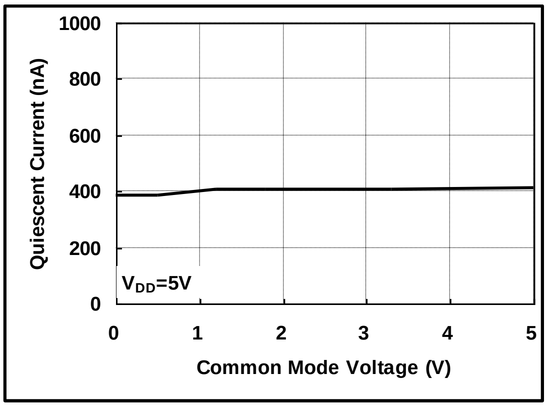
Input Hysteresis Voltage vs. Common Mode Voltage



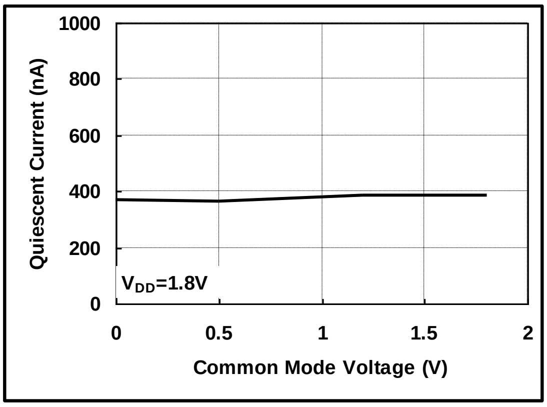
Input Hysteresis Voltage vs. Common Mode Voltage



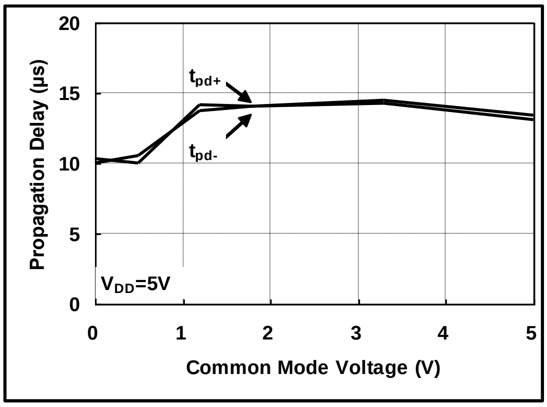
Quiescent Current vs. Common Mode Voltage



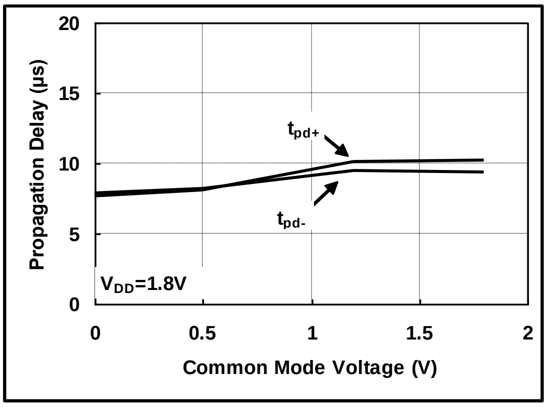
Quiescent Current vs. Common Mode Voltage



Propagation Delay vs. Common Mode Voltage

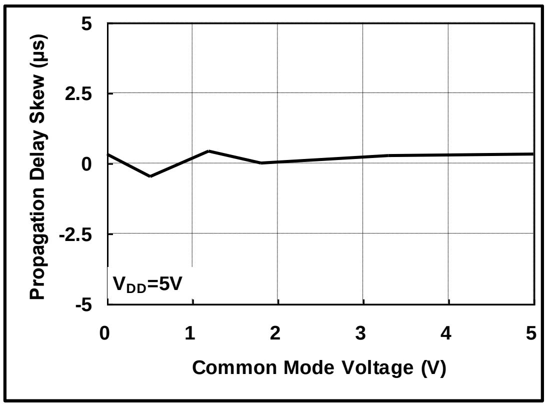


Propagation Delay vs. Common Mode Voltage

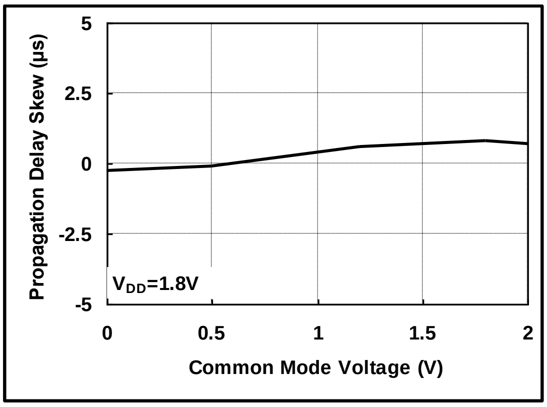


Typical Performance Characteristics

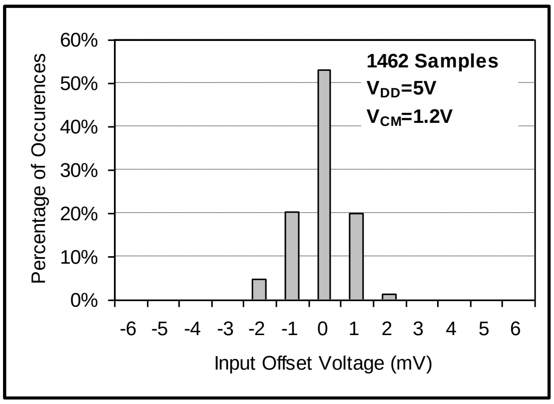
Propagation Delay Skew vs. Common Mode Voltage



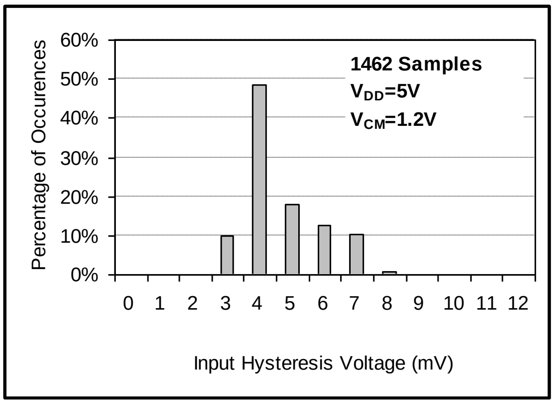
Propagation Delay Skew vs. Common Mode Voltage



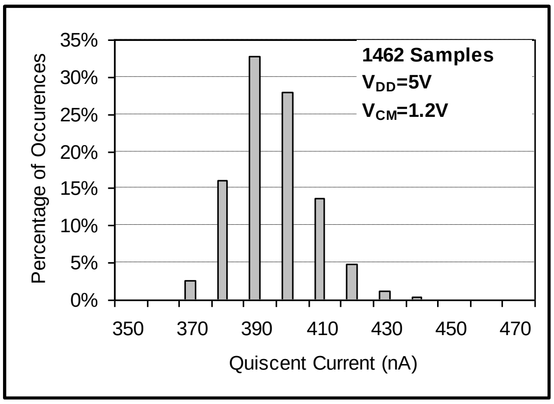
Input Offset Voltage Distribution



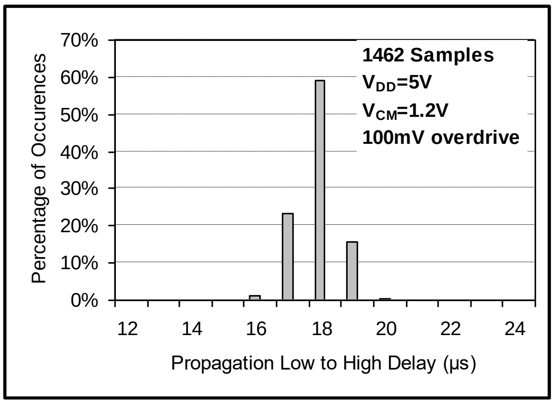
Input Hysteresis Voltage Distribution



Quiescent Current Distribution

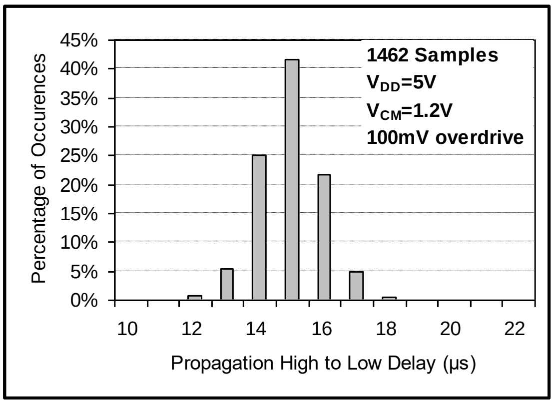


Low to High Propagation Delay Distribution

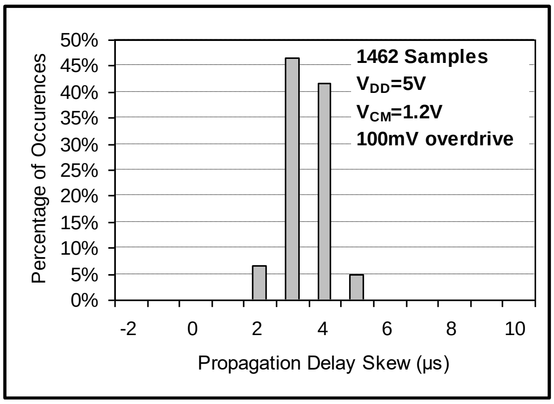


Typical Performance Characteristics

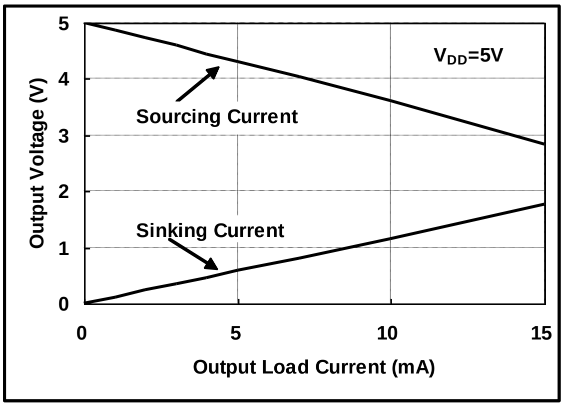
High to Low Propagation Delay Distribution



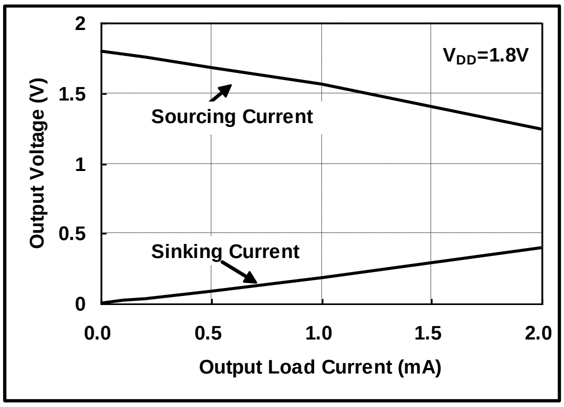
Propagation Delay Skew Distribution



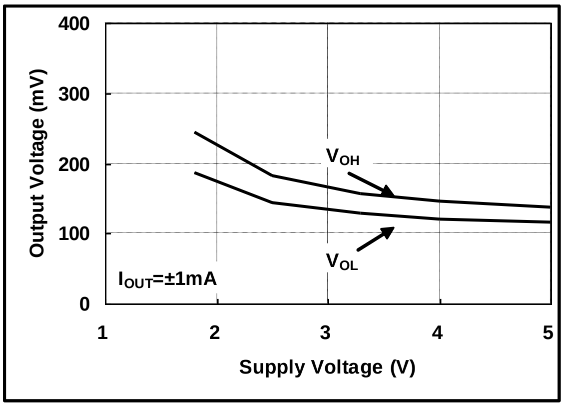
Output Voltage Headroom vs. Output Load Current



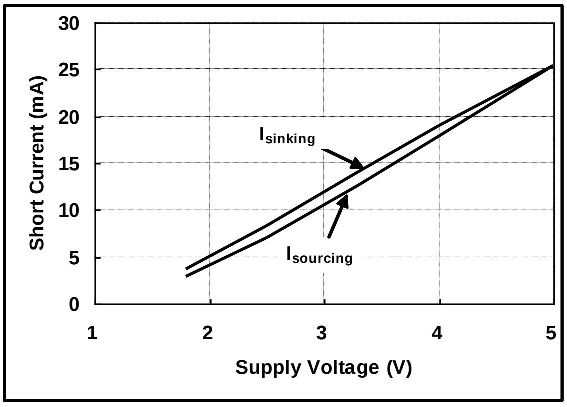
Output Voltage Headroom vs. Output Load Current



Output Voltage Headroom vs. Supply Voltage



Output Short Current vs. Supply Voltage



Pin Functions

–IN: Inverting Input of the Comparator. Voltage range of this pin can go from V^- – 0.3V to V^+ + 0.3V.

+IN: Non-Inverting Input of Comparator. This pin has the same voltage range as –IN.

V+: Positive Power Supply. Typically the voltage is from 1.8V to 5.5V. Split supplies are possible as long as the voltage between V+ and V– is between 1.8V and 5.5V. A bypass capacitor of 0.1μF as close to the part as possible should be used between power supply pins or between supply pins and ground.

V^-: Negative Power Supply. It is normally tied to ground. It can also be tied to a voltage other than ground as long as the voltage between V^+ and V^- is from 1.8V to 5.5V. If it is not connected to ground, bypass it with a capacitor of 0.1μF as close to the part as possible.

OUT: Comparator Output. The voltage range extends to within millivolts of each supply rail.

Ref: Reference voltage output.

Operation

The TP202x family single-supply comparators feature internal hysteresis, internal reference, high speed, and ultra-low power. Input signal range extends beyond the negative and positive power supplies. The output can even extend all the way to the negative supply. The input stage is comprised of two CMOS differential amplifiers, a PMOS stage and NMOS stage that are active over different ranges of common mode input voltage. Rail-to-rail input voltage range and low-voltage single-supply operation make these devices ideal for portable equipment.

Applications Information

Internal Hysteresis

Most high-speed comparators oscillate in the linear region because of noise or undesired parasitic feedback. This tends to occur when the voltage on one input is at or equal to the voltage on the other input. To counter the parasitic effects and noise, the TP2021 implements internal hysteresis.

The hysteresis in a comparator creates two trip points: one for the rising input voltage and one for the falling input voltage. The difference between the trip points is the hysteresis. When the comparator's input voltages are equal, the hysteresis effectively causes one comparator input voltage to move quickly past the other, thus taking the input out of the region where oscillation occurs. Figure 1 illustrates the case where IN- is fixed and IN+ is varied. If the inputs were reversed, the figure would look the same, except the output would be inverted.

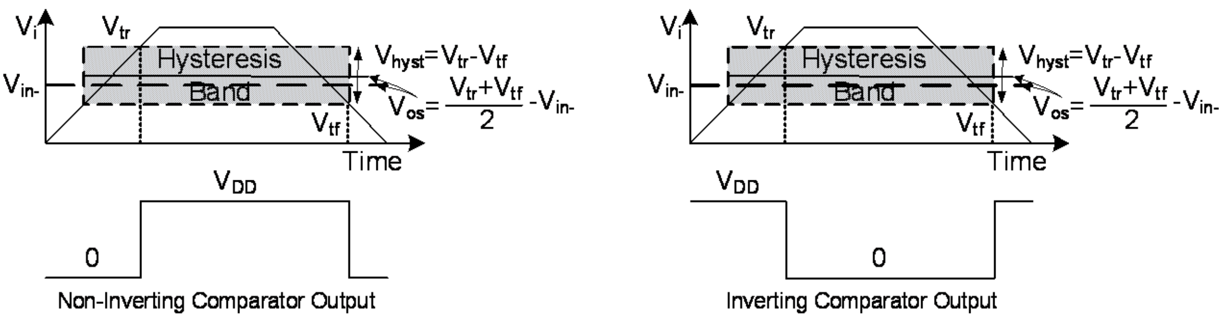


Figure 1. Comparator's hysteresis and offset

Low Input Bias Current

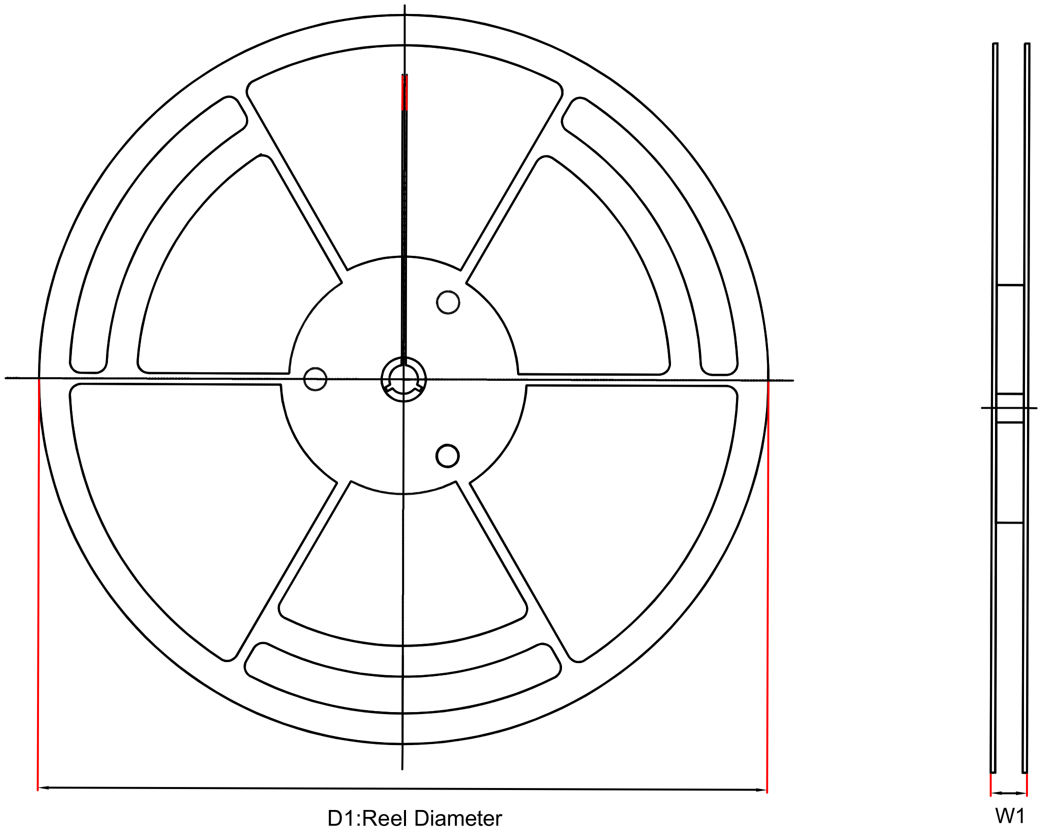
The TP202x family is a CMOS comparator family and features very low input bias current in pA range. The low input bias current allows the comparators to be used in applications with high resistance sources. Care must be taken to minimize PCB Surface Leakage. See below section on "PCB Surface Leakage" for more details.

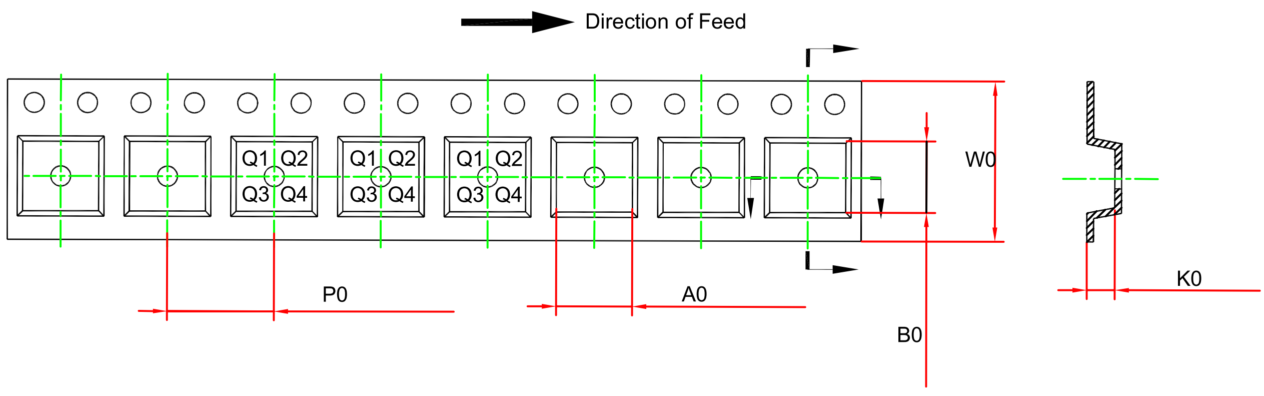
Power Supply Layout and Bypass

The TP202x family's power supply pin should have a local bypass capacitor (i.e., 0.01μF to 0.1μF) within 2mm for good high frequency performance. It can also use a bulk capacitor (i.e., 1μF or larger) within 100mm 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 comparator's inputs and outputs. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components as close to the comparator' pins as possible.

Tape and Reel Information



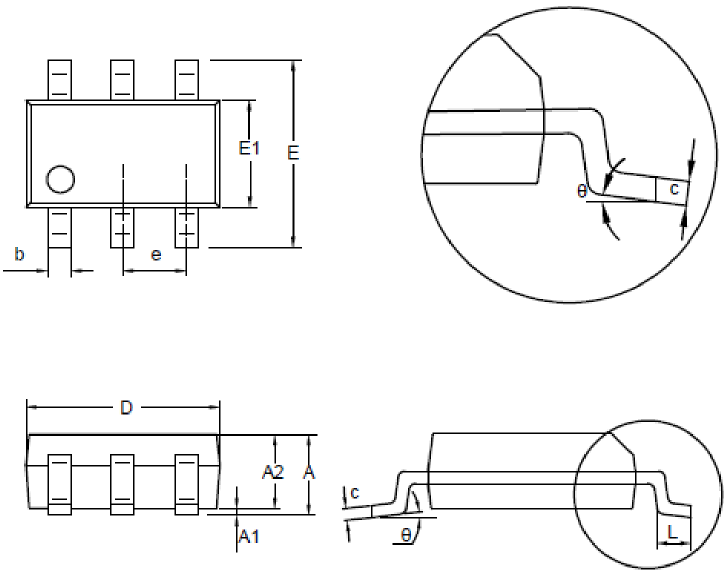


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TP2021-TR	SOT23-6	180.0	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TP2021A-TR	SOT23-6	180.0	12.0	3.3	3.2	1.4	4.0	8.0	Q3

Package Outline Dimensions

SOT23-6

Package Outline Dimensions S6T(SOT23-6-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.

Revision History

Table 1.

Date	Revision	Notes
2022/4/29	1.6	Update order information
2024/1/25	1.7	Added part number: TP2021A-TR. Updated EC table: 1) Adjusted the condition of EC table: from "VDD = +1.8V to +5.5V, VIN+ = VDD, VIN- = 1.2V, RPU=10kΩ, CL =15pF." to "V_{DD} = 5.5V, CL =15pF." 2) Added specification of V_{OS} at V_{DD} = 1.8V 3) Added condition of PSRR 4) Adjusted MIN/TYP/MAX of VOUT(Reference Voltage) at VDD = 5V: MIN: from 1.225 to 1.14; TYP: from 1.248 to 1.3; MAX: from 1.285 to 1.46 5) Adjusted MIN/TYP/MAX of VOUT(Reference Voltage) at VDD = 3V: MIN: from 1.20 to 1.13; TYP: from 1.23 to 1.29; MAX: from 1.26 to 1.45 The following updates are all about the new datasheet formats or typo, the actual product remains unchanged. Updated figures and application information. Removed description about TP2025 and other part number which are not in production. Updated to new format of package dimensions. Added tape and reel information.

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