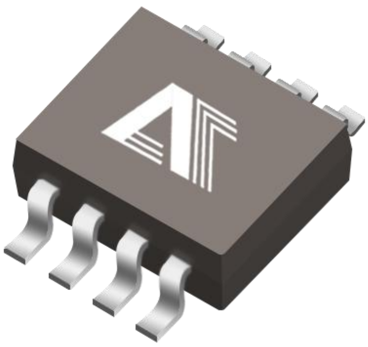
AOTE
SEMICONDUCTOR



Comparator

LM293DR

Product Data Sheet

AOTE DCC
RELEASE

◆ Summary ：

The LM293DR device consists of two independent voltage comparators that can operate with a single power supply over a wide voltage range. Static current is not affected by the power supply voltage.

◆ Product features

- Maximum rated value: up to 36V
- ESD level (HBM): 2kV
- Low input offset voltage: 0.37m
- Low input bias current: 3.5nA
- Low power supply current: 200 μ A per comparator
- The common mode input voltage range includes grounding
- The differential input voltage range is equal to the maximum rated power supply voltage: ± 36V
- Low output saturation voltage
- Output compatible with TTL, MOS, and CMOS

◆ Applications

- Robot Vacuum Cleaner
- Single phase UPS
- Server PSU
- Cordless power tool
- Wireless infrastructure
- Electrical appliances
- Building automation
- Factory Automation and Control
- Motor driver
- Lnformation entertainment system and instrument cluster

◆ Encapsulate information

Product Name	Package	Package size
LM293DR	SOIC-8(SOP8)	4.90mm×3.91mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

◆ Series Comparison Table

Specification	LM293	Unit
power supply voltage	2 to 30	V
Total power supply current (5V to 36V maximum)	1 to 2.5	mA
Temperature range	-25 to 85	℃
ESD (HBM)	2000	V
Offset voltage (The maximum value within the entire temperature range)	±9	mV
Input bias current (Input bias current)	25/250	nA
response time (typical value)	1.3	μsec

◆ Pin definition and function:

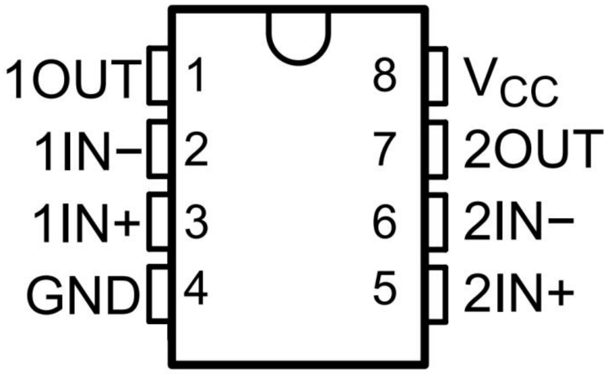


Figure 4-1 D package 8-pin SOIC

Table 4-1 Pin Functions

Name	Pin	I/O(1)	Description
	SOIC-8(SOP8)		
1OUT	1	Output	Output pin of comparator 1
1IN-	2	Input	Negative input pin of comparator 1
1IN+	3	Input	Positive input pin of comparator 1
GND	4		grounding
2IN+	5	Input	Positive input pin of comparator 2
2IN-	6	Input	Negative input pin of comparator 2
2OUT	7	Output	Output pin of comparator 2
V_{CC}	8		Positive power supply
thermal pad			Directly connected to the GND pin

Absolute maximum rating Within the natural ventilation temperature range (unless otherwise specified)

		Min	Max	Unit
V_{CC}	Power supply voltage	-0.3	36	V
V_{ID}	Differential input voltage	-36	36	V
V_I	Input voltage (any input)	-0.3	36	V
I_{IK}	input current	-50		mA
V_O	output voltage	-0.3	36	V
I_O	Output Current		20	mA
I_{SC}	Duration of output ground short circuit	无限		
T_J	Run virtual junction temperature	150		℃
T_{stg}	Storage temperature	-65150		℃

(1) The values listed below for stress exceeding the absolute maximum rated value may cause permanent damage to the device. These listed values are only stress ratings and do not indicate that the device can operate normally under these conditions or any other conditions beyond the recommended operating conditions. Prolonged exposure to absolute maximum rated conditions may affect the reliability of the device. It is not necessary to test all parameters of the product during the production process.
(2) All voltage values, except for differential voltage, are relative to the network ground.
(3) Differential voltage is the value on IN+relative to IN -.
(4) A short circuit from the output to VCC can cause overheating and ultimately result in damage.
(5) The input current flows through the parasitic diode to the ground terminal and turns on the parasitic transistor, which increases the ICC and may result in incorrect output. After removing the input current, normal operation will be restored.

Suggested operating conditions Within the natural ventilation temperature range (unless otherwise specified)

	Min	Max	Unit
power supply voltage, V_S = (V+) - (V-)	2	30	V
Input voltage range, V_{IVR}	0	(V+) - 2.0	V
Ambient temperature, T_A	-25	85	℃

◆ Thermal performance information

Thermal index (1)		LM293 D (SOIC) 8 PINS	Unit
RθJA	Connected to environmental thermal resistance	148.5	℃/W
RθJC(top)	Thermal resistance at the top of the shell	90.2	
RθJB	Connect to the thermal resistance of the circuit board	91.8	
ΨJT	End to top feature parameters	38.5	
ψJB	Based on the characteristic parameters of the circuit board	91.1	
RθJC(bot)	Thermal resistance at the bottom of the shell	-	

◆ ESD Ratings

			Value	Unit
V(ESD)	Electrostatic discharge	Human-body model (HBM),per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22 -C101, all pins(2)	±1000	

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

◆ Electrical characteristics

(At the specified natural ventilation temperature, Vcc=5V (unless otherwise specified)

Parameter		Test conditions		TA [1]	LM293 Min	LM293 Typ	LM293 Max	Unit
V_{IO}	Input offset voltage	VCC=5V to 30V,VIC= VICRmin, VO = 1.4V		25℃		2	5	mV
				Complete scope			9	
I_{IO}	Input offset current	VO = 1.4V		25℃		5	50	nA
				Complete scope			250	
I_{IB}	Input bias current	VO = 1.4V		25℃		-25	-250	nA
				Complete scope			-400	
V_{ICR}	Common mode input voltage range[2]			25℃	0 to VCC- 1.5			V
				Complete scope	0 to VCC- 2			
A_{VD}	Large signal differential voltage amplification	VCC = 15V, VO= 1.4V to 11.4V R_L ≥ 15kΩ to VCC		25℃	50	200		V/mV
I_{OH}	High level output current	VOH= 5V	VID = 1V	25℃		0.1	50	nA
		VOH= 30V	VID= 1V	Complete scope			1	μA
V_{OL}	Low level output voltage	IOL = 4mA, VID = -1V		25℃		130	400	mV
				Complete scope			700	
I_{OL}	Low level output current	VOL = 1.5V, VID = -1V		25℃	6			mA
I_{CC}	power supply current	RL= ∞	VCC = 5V	25℃		0.45	1	mA
			VCC = 30V	Complete scope		0.55	2.5	

(1) The complete range of LM293 is from -25 ℃ to 85 ℃. Unless otherwise specified, all characteristics are measured at zero common mode input voltage.

(2) The voltage at any input terminal should not be lower than negative 0.3V, otherwise the output may be incorrect and excessive input current may be generated.

The upper limit of the common mode voltage range is limited by VCC-2V. However, only one input needs to be within the effective common mode range, while the other input can reach the maximum VCC level, and the comparator will provide an appropriate output state. Either or both inputs can reach the maximum VCC level without causing damage.

◆ Typical characteristics of LM293

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV

(Unless otherwise specified)

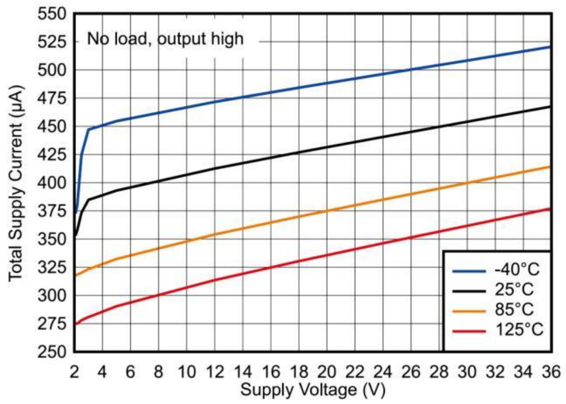


Figure 5-1 The relationship between total power supply current and power supply voltage

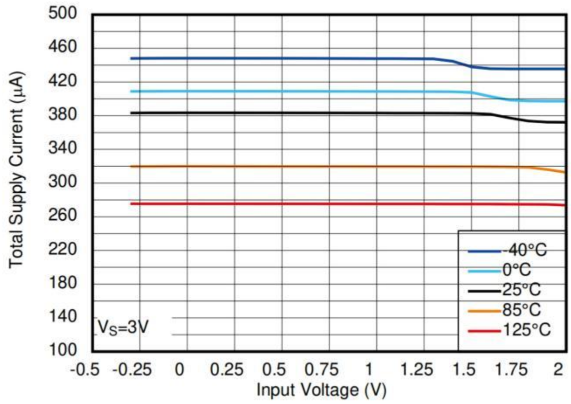


Figure 5-2 The relationship between total power supply current and input voltage at 3V

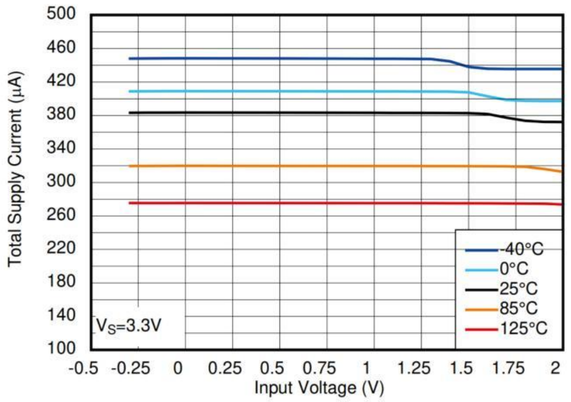


Figure 5-3 The relationship between total power supply current and input voltage at 3.3V

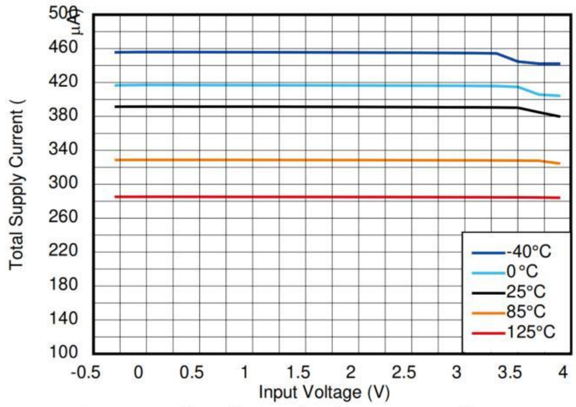


Figure 5-4 The relationship between total power supply current and input voltage at 5V

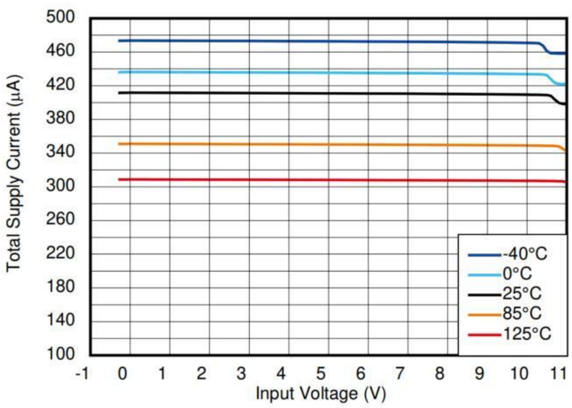


Figure 5-5 The relationship between total power supply current and input voltage at 12V

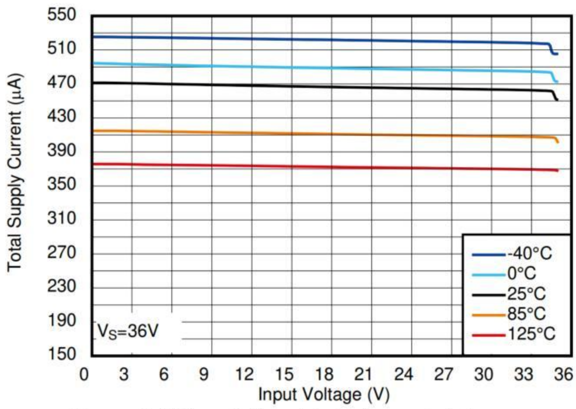


Figure 5-6 The relationship between total power supply current and input voltage at 36V

◆ Typical Characteristics of LM293 (Continued)

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV (Unless otherwise specified)

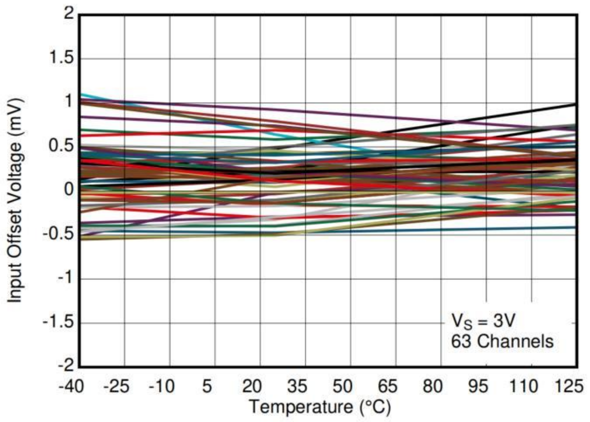


Figure 5-7 The relationship between input offset voltage and temperature at 3V

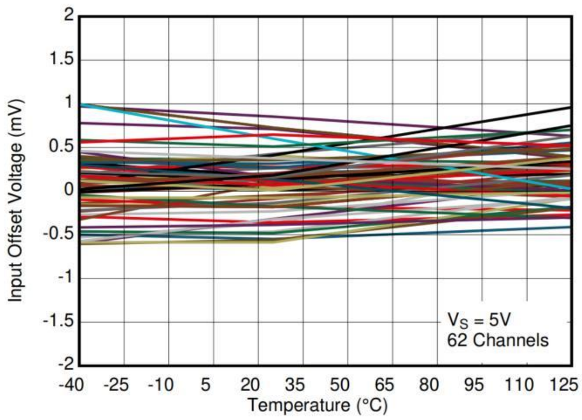


Figure 5-8 The relationship between input offset voltage and temperature at 5V

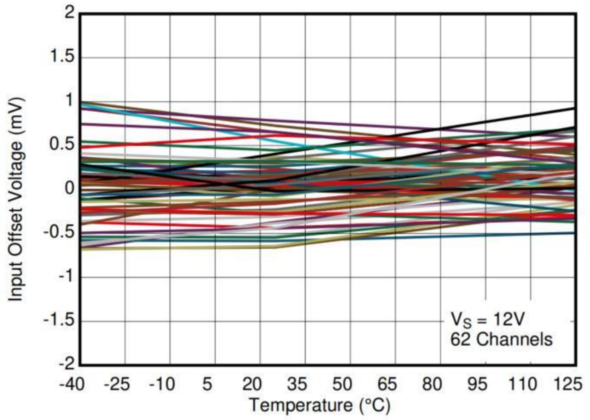


Figure 5-9 The relationship between input offset voltage and temperature at 12V

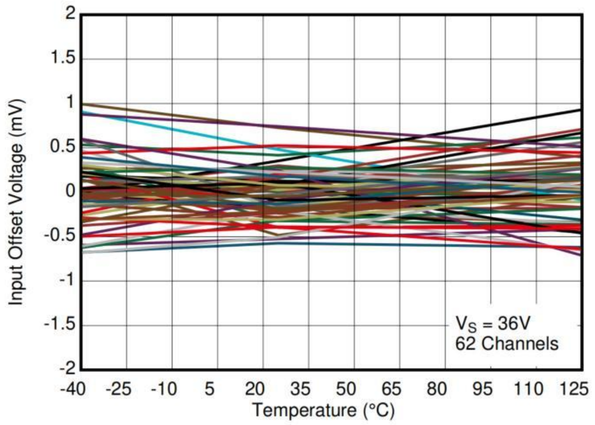


Figure 5-10 The relationship between input offset voltage and temperature at 36V

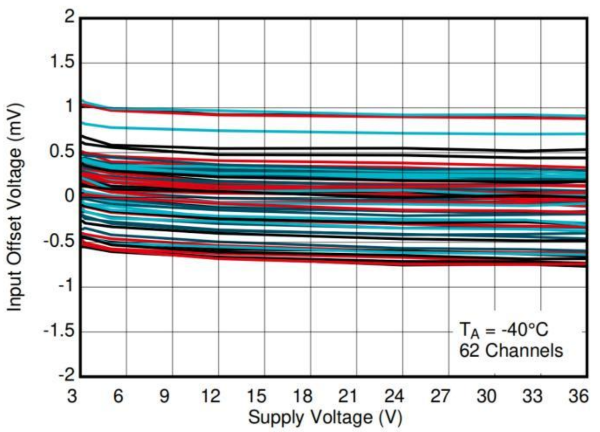


Figure 5-11 -The relationship between input offset voltage and power supply voltage at 40 ° C

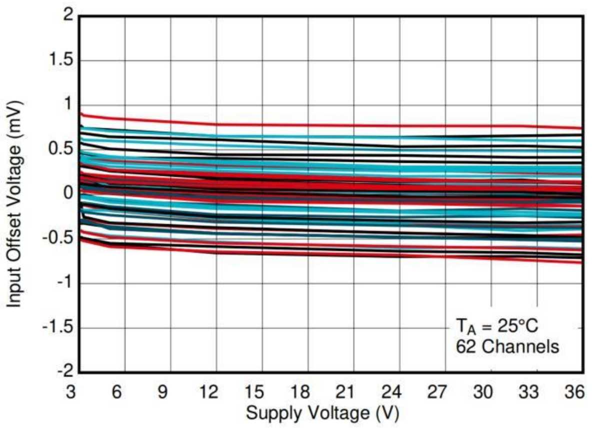


Figure 5-12 The relationship between input offset voltage and power supply voltage at 25 ° C

◆ Typical Characteristics of LM293 (Continued)

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV (Unless otherwise specified)

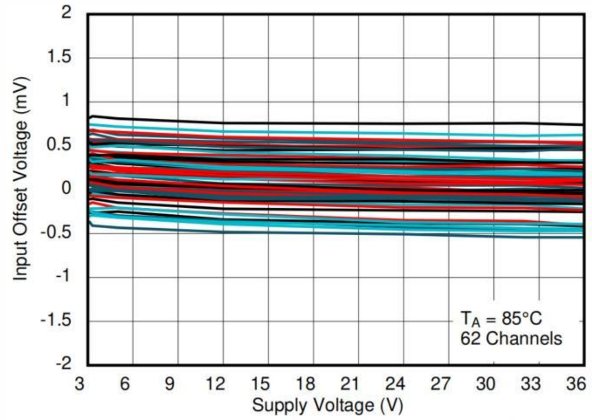


Figure 5-13. Relationship between input offset voltage and supply voltage at 85°C

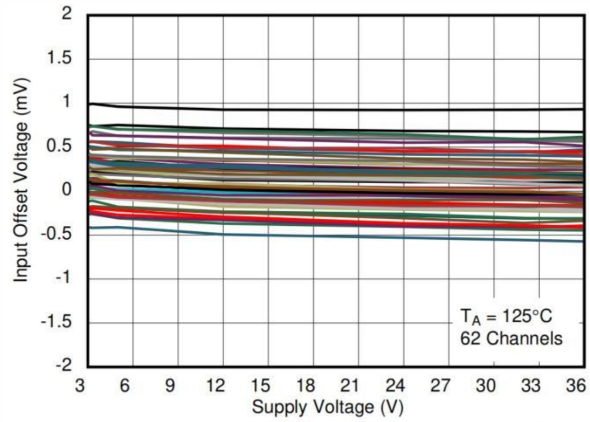


Figure 5-14. Relationship between input offset voltage and power supply voltage at 125°C

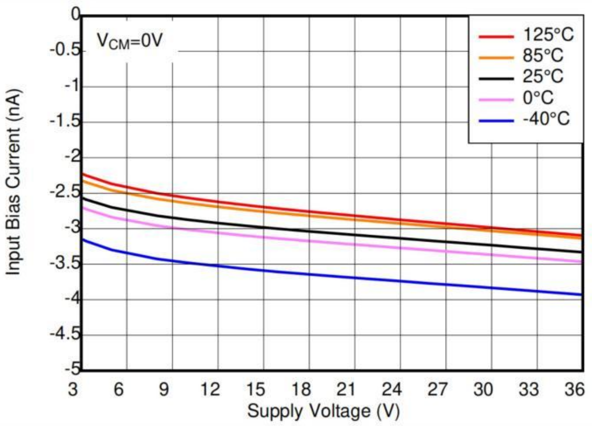


Figure 5-15. Relationship between input bias current and power supply voltage

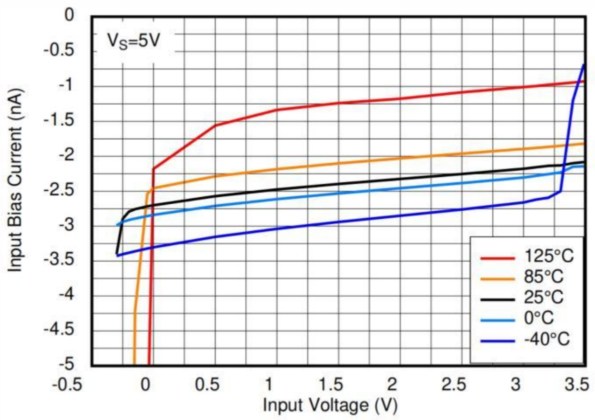


Figure 5-16 The relationship between input bias current and input voltage at 5V

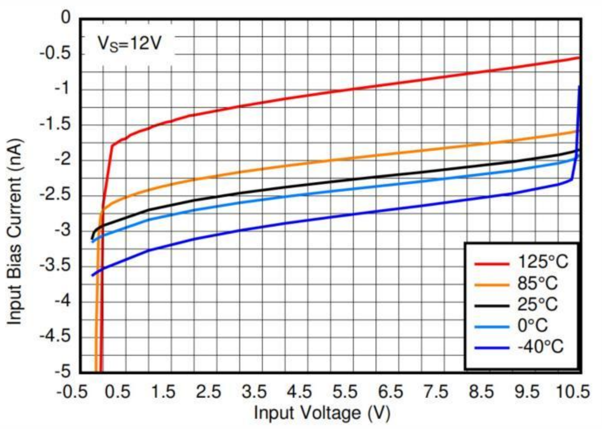


Figure 5-17 The relationship between input bias current and input voltage at 12V

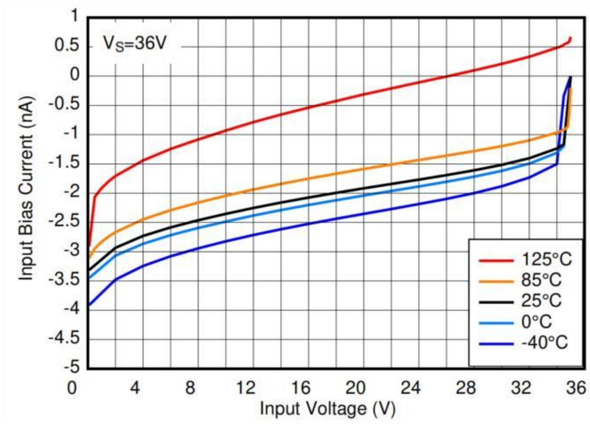


Figure 5-18 The relationship between input bias current and input voltage at 36V

◆ Typical Characteristics of LM293 (Continued)

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV (Unless otherwise specified)

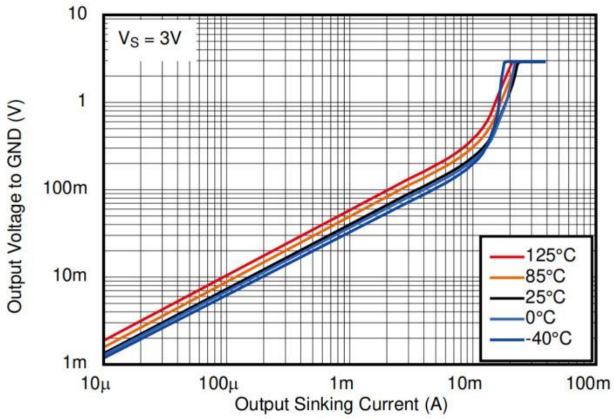


Figure 5-19 The relationship between output low-level voltage and output current at 3V

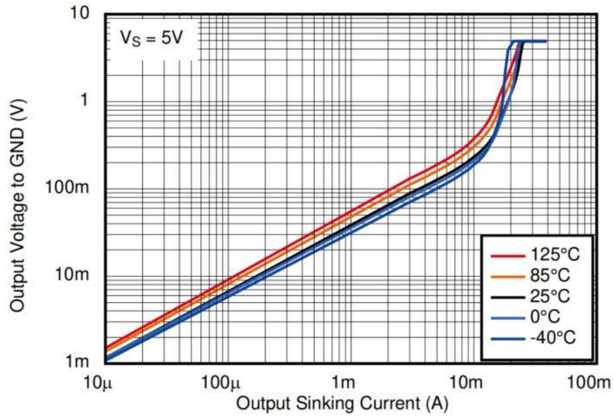


Figure 5-20 The relationship between output low-level voltage and output current at 5V

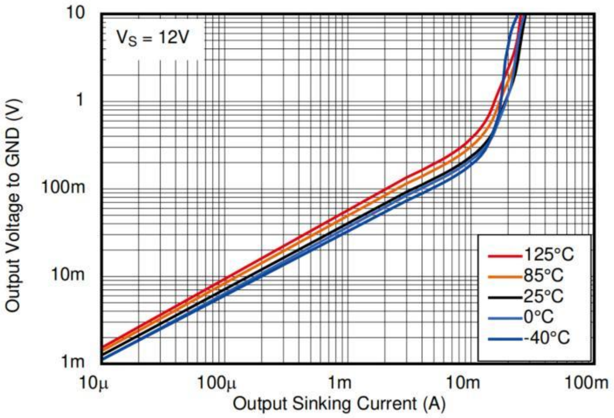


Figure 5-21 The relationship between output low-level voltage and output current at 12V

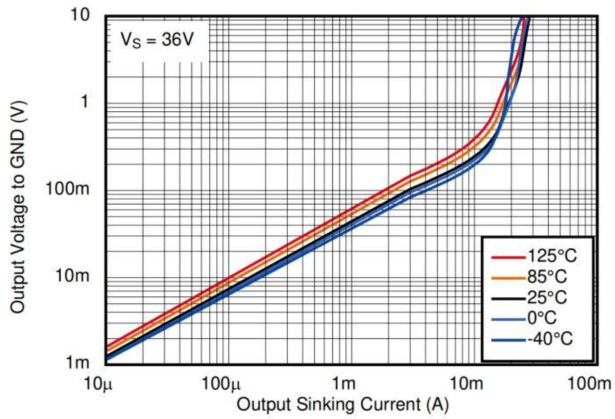


Figure 5-22 The relationship between output low-level voltage and output current at 36V

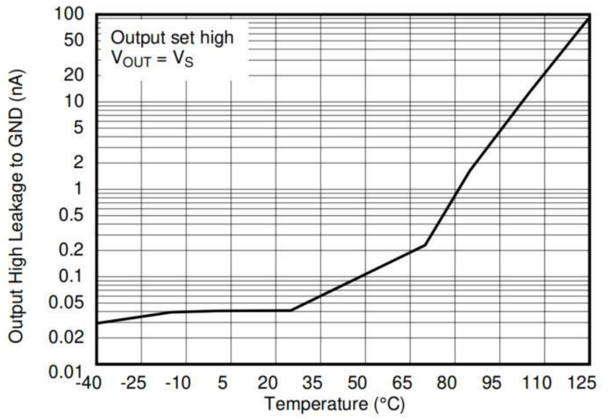


Figure 5-23 The relationship between high-level leakage current and temperature at 5V output

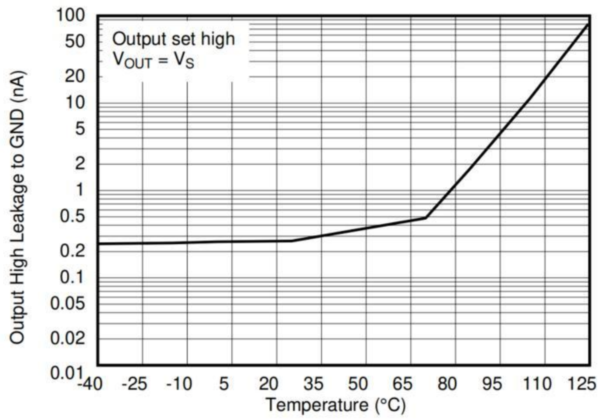


Figure 5-24 The relationship between high-level leakage current output at 36V and temperature

◆ Typical Characteristics of LM293 (Continued)

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV (Unless otherwise specified)

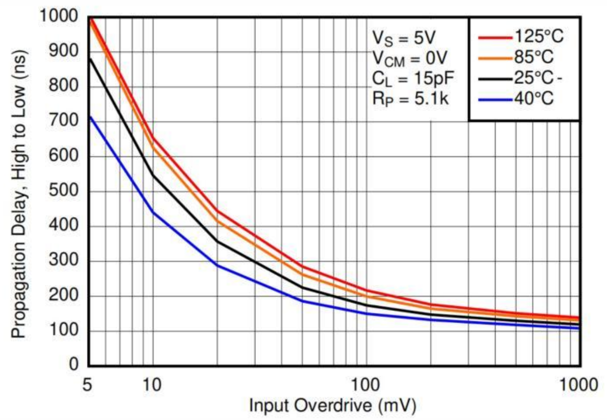


Figure 5-25 The relationship between high-level to low-level propagation delay and input overdrive voltage, 5V

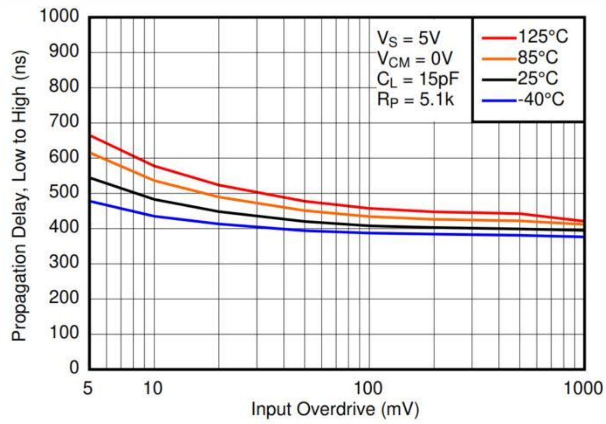


Figure 5-26 The relationship between low-level to high-level propagation delay and input overdrive voltage, 5V

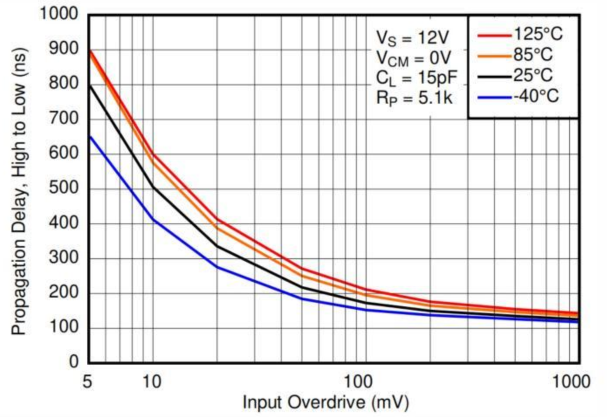


Figure 5-27 The relationship between high-level to low-level propagation delay and input overdrive voltage, 12V

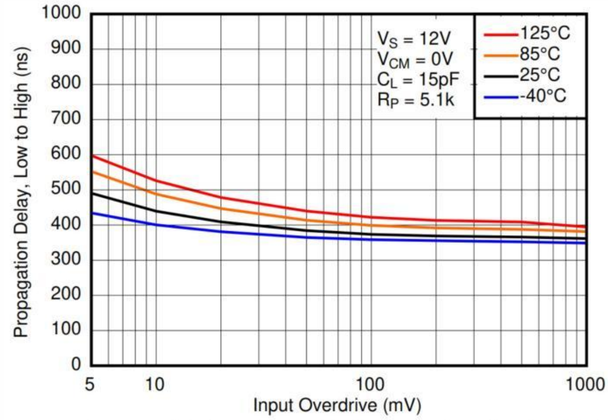


Figure 5-28 The relationship between low-level to high-level propagation delay and input overdrive voltage, 12V

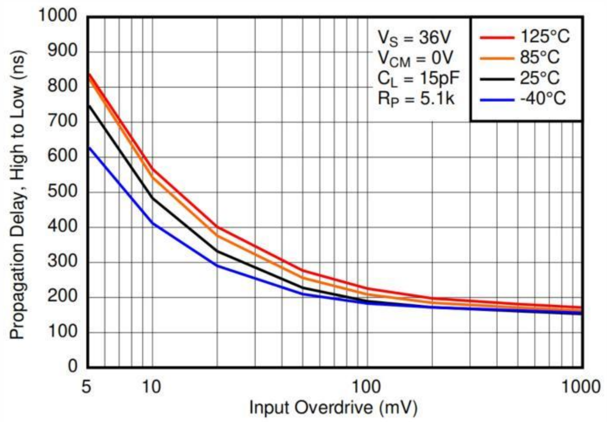


Figure 5-29 The relationship between high-level to low-level propagation delay and input overdrive voltage, 36V

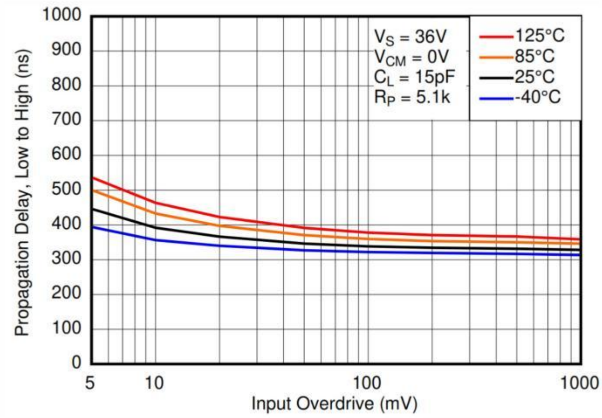


Figure 5-30 The relationship between low-level to high-level propagation delay and input overdrive voltage, 36V

◆ Typical Characteristics of LM293 (Continued)

T_A = 25℃, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, VUNDERDRIVE = 100mV, $V_{OVERDRIVE}$ = 100mV (Unless otherwise specified)

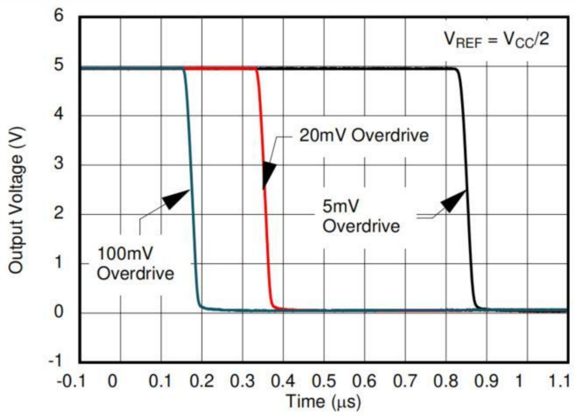


Figure 5-31 Response time of various over drives during high to low level conversion

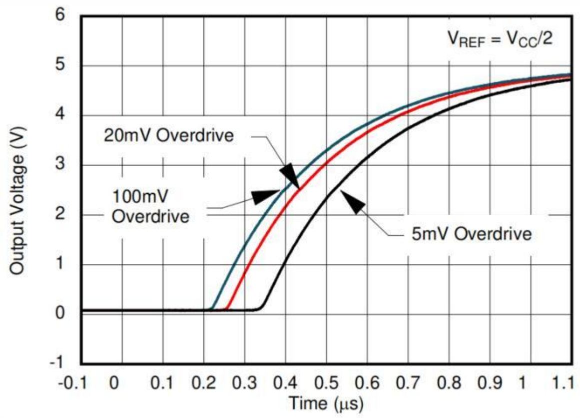


Figure 5-32 Response time of various over drives during low-level to high-level transitions

◆ Detailed Explanation

Overview

These dual comparator circuits are capable of operating at an absolute maximum voltage of up to 36V on the power pin. These devices have been proven to be widely applicable in various applications. This is because these devices have a very wide power supply voltage range, low Iq, and fast response. Open collector output enables users to independently convert the required logic level of VCC, while also enabling AND function when multiple outputs are connected together.

Functional Block Diagram

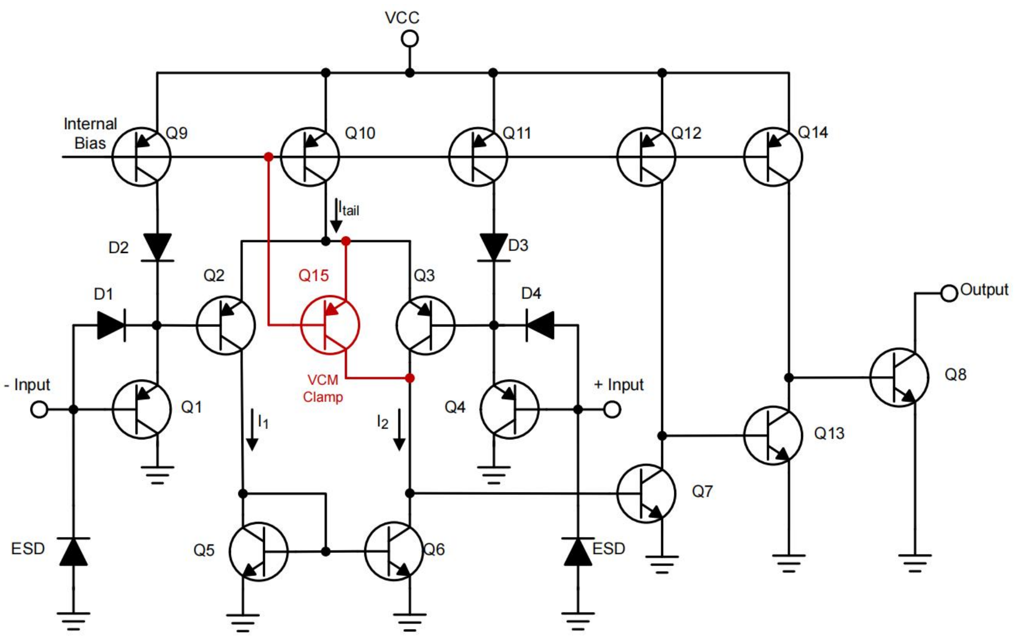


Figure 6-1 Schematic diagram (for each comparator)

Feature Description

This comparator includes a PNP Darlington pair input, allowing the device to achieve very high gain, respond quickly, and operate with minimal input bias current. The input Darlington pair limits the input common mode voltage capability, allowing the comparator to operate accurately under over temperature conditions from ground to VCC -2V. Add a clamp around Q3 to simulate the situation where two inputs exceed the voltage range of the original classic silicon input.

The output contains an open drain NPN (pull-down or low side) transistor. When the negative input voltage is higher than the positive input voltage and offset voltage, the output NPN will inject current. VOL is resistive and proportional to the output current. Please refer to the diagram "Relationship between Output Low Voltage and Output Current" for information on the VOL value of the output current.

Application and Implementation

The information in the following application sections is not within the scope of AOTE device specifications, and AOTE does not guarantee its accuracy and completeness. AOTE customers are responsible for determining whether the device is suitable for their application. Customers should verify and test their design to ensure system functionality.

Application Information

This device is typically used to compare a single signal with a reference signal, or to compare two signals with each other. Many users use open drain output to drive the comparative logic output to the logic voltage level of MCU or logic device. The wide power range and high voltage function make this comparator an ideal choice for level conversion to higher or lower voltages.

Input voltage range

When selecting the input voltage range, the input common mode voltage range (VICR) must be taken into account. If the temperature is below 25 ℃, the VICR range is from 0V to VCC-2.0V. This limits the input voltage range to a maximum of VCC-2.0V and a minimum of 0V.Operations beyond this range may result in comparison errors.

The following is the input voltage situation and its output list:

1、When both IN - and IN+are within the common mode range:

a、 If IN - is higher than IN+and the offset voltage, the output will be at a low level, and the output transistor will be filled with current

b、If IN - is lower than IN+and the offset voltage, the output will be high impedance and the output transistor will not conduct

2、When IN - is higher than the common mode and IN+is within the common mode range, the output is at a low level, and the output transistor is filled with current

3、When IN+is higher than common mode and IN - is within the common mode range, the output is high impedance and the output transistor does not conduct

4、When both IN - and IN+are higher than common mode, please refer to LM339, LM393, TL331 series comparators

Minimum Overdrive Voltage

Overdrive voltage is the differential voltage generated between the positive and negative inputs of a comparator on the offset voltage (VIO). To make accurate comparisons, the over drive voltage (VOD) must be higher than the input offset voltage (VIO). Overdrive voltage can also determine the response time of the comparator, and the response time decreases with the increase of over drive. Figures 7-2 and 7-3 show the positive and negative response times relative to the overdrive voltage.

Output and Drive Current

The output current is determined by the load/pull-up resistor and logic/pull-up voltage. The output current generates an output low voltage (VOL) from the comparator. VOL is directly proportional to the output current. Refer to the relationship diagram between output low level and sink current in the typical characteristics section of LM239, and determine VOL according to the output current. The output current can also affect the transient response.

Response time

The response time is a function of input over drive. Please refer to the application curve for typical response times. The rise and fall times can be determined by the load capacitance (CL), load/pull-up resistance (RPULLUP), and equivalent collector emitter resistance (RCE).

· The rise time (τ R) is approximately $\tau\ R = R_{PULLUP} \times C_L$

· The descent time (τ F) is approximately $\tau\ F = R_{CE} \times C_L$

R_{CE} can be determined by obtaining the slope of the linear region in Figure 5-20 at the desired temperature, or by dividing V_{OL} by I_{out}

Application Curve

The following curves were generated under the conditions of V_{CC} and V_{Logic} at 5V, R_{PULLUP}=5.1kΩ, and 50_{pF} observation instrument probe.

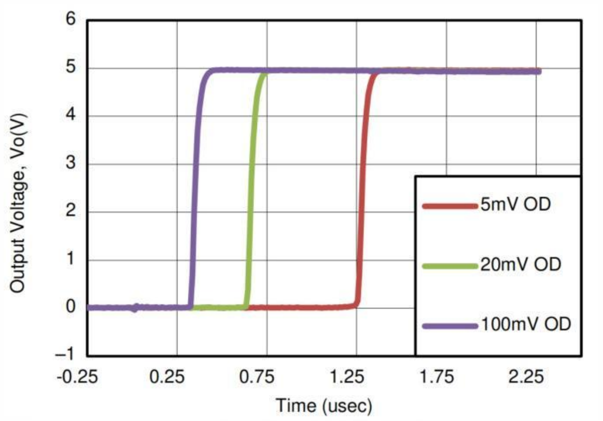


Figure 7-2 Response time of various drives (positive conversion)

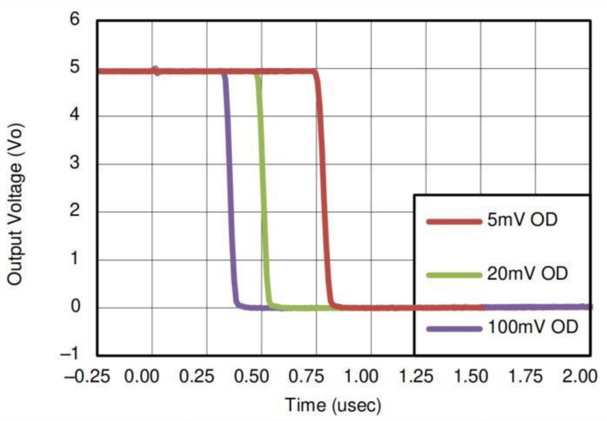


Figure 7-3 Response time of various over drives (negative conversion)

◆ Static discharge warning

Electrostatic discharge (ESD) can damage this integrated circuit. AOTE Semiconductor recommends appropriate pre planning Take preventive measures to handle all integrated circuits. If the correct handling and installation procedures are not followed, it may damage the integrationCircuit.

ESD damage can range from minor performance degradation to overall device failure. Precision integrated circuits may More susceptible to damage, as even very subtle parameter changes can result in the device and its released specifications The grid does not match.

Packaging information

Orderable part number	Status (1)	Material type (2)	Package Pins	Packageqty	RoHS (3)	Lead finish/ Ball material (4)	MSL rating /Peak reflow (5)	Op temp (℃)	Part marking (6)
LM193DR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	LM193
LM193DR.A	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	LM193
LM193DRG4	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	LM193

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance,reliability performance testing , and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the AOTE RoHS Statement for additional information and value definition.

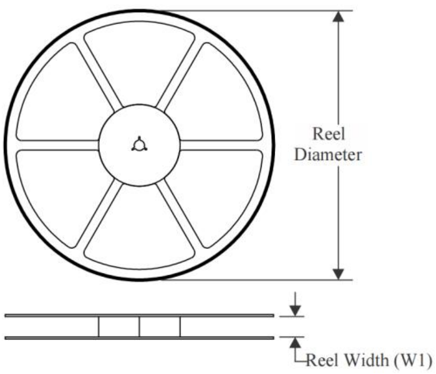
(4) Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown.Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

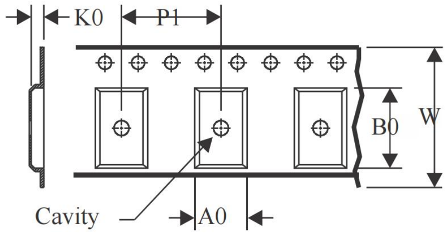
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

◆ Tape and reel information

Reel dimensions

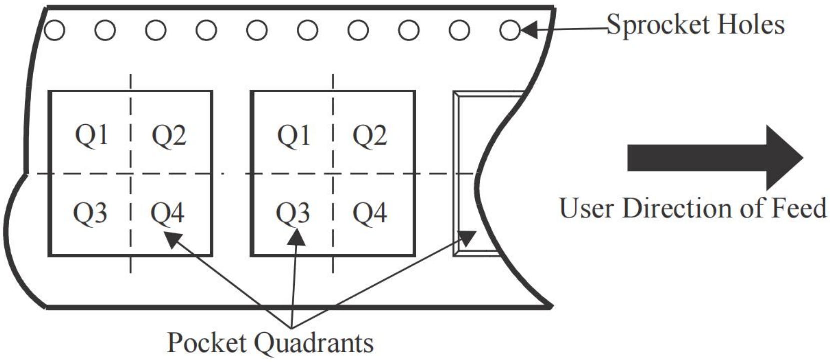


Tape dimensions



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel WidthW1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM293DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1

◆ Attention

- AOTE implements dynamic technical updates. Specifications are subject to change. Refer to the official website for the latest version.
- Users must strictly adhere to specified conditions. Failures caused by misuse (overload, high temperature, incompatible circuits) are excluded from warranty.
- Contact technical support for customized validation in critical applications (medical devices, industrial control).
- This document is valid until December 31, 2026. Updates will be notified on the official website.
- For further clarification on technical specifications or application solutions, please contact us through official channels: