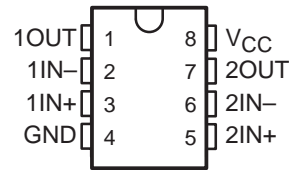


# LM193, LM293, LM293A, LM393 LM393A, LM2903, LM2903Q DUAL DIFFERENTIAL COMPARATORS

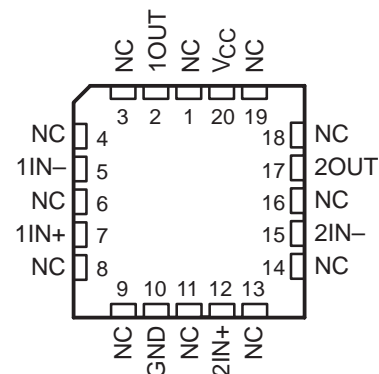
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- Single Supply or Dual Supplies
- Wide Range of Supply Voltage . . . 2 V to 36 V
- Low Supply-Current Drain Independent of Supply Voltage . . . 0.4 mA Typ Per Comparator
- Low Input Bias Current . . . 25 nA Typ
- Low Input Offset Current . . . 3 nA Typ (LM193)
- Low Input Offset Voltage . . . 2 mV Typ
- Common-Mode Input Voltage Range Includes Ground
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . .  $\pm 36$  V
- Low Output Saturation Voltage
- Output Compatible With TTL, MOS, and CMOS
- LM2903Q Available in Q-Temp Automotive
  - High-Reliability Automotive Applications
  - Configuration Control/Print Support
  - Qualification to Automotive Standards
- For Single Version in SOT23-5, See TL331 Data Sheet

LM193 . . . D OR JG PACKAGE  
LM293 . . . D OR P PACKAGE  
LM293A . . . D PACKAGE  
LM393, LM393A . . . D, P, PS, OR PW PACKAGE  
LM2903 . . . D, P, PS, OR PW PACKAGE  
LM2903Q . . . D PACKAGE  
(TOP VIEW)



LM193 . . . FK PACKAGE  
(TOP VIEW)



NC – No internal connection

## description/ordering information

These devices consist of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Operation from dual supplies also is possible as long as the difference between the two supplies is 2 V to 36 V, and  $V_{CC}$  is at least 1.5 V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

The LM193 is characterized for operation from  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The LM293 and LM293A are characterized for operation from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The LM393 and LM393A are characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM2903 is characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The LM2903Q is tested from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  and is manufactured to demanding automotive requirements.



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

**LM193, LM293, LM293A, LM393  
LM393A, LM2903, LM2903Q  
DUAL DIFFERENTIAL COMPARATORS**

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**description/ordering information (continued)**

**ORDERING INFORMATION**

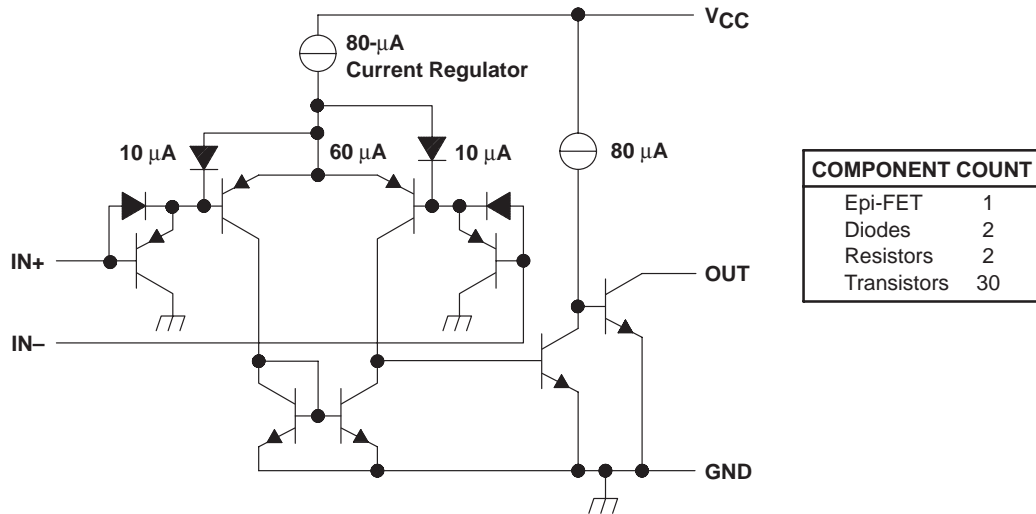
TA	V <sub>IO(max)</sub> AT 25°C	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	5 mV	PDIP (P)	Tube of 50	LM393P	LM393P
		SOIC (D)	Tube of 75	LM393D	LM393
			Reel of 2500	LM393DR	
		SOP (PS)	Reel of 2000	LM393PSR	L393
	TSSOP (PW)	Tube of 150	LM393PW	L393	
		Reel of 2000	LM393PWR		
	2 mV	PDIP (P)	Tube of 50	LM393AP	LM393AP
		SOIC (D)	Tube of 75	LM393AD	LM393A
Reel of 2500			LM393ADR		
SOP (PS)		Reel of 2000	LM393APSR	L393A	
TSSOP (PW)	Reel of 2000	LM393APWR	L393A		
-25°C to 85°C	5 mV	PDIP (P)	Tube of 50	LM293P	LM293P
		SOIC (D)	Tube of 75	LM293D	LM293
	Reel of 2500		LM293DR		
	2 mV	SOIC (D)	Tube of 75	LM293AD	LM293A
Reel of 2500			LM293ADR		
-40°C to 125°C	7 mV	PDIP (P)	Tube of 50	LM2903P	LM2903P
		SOIC (D)	Tube of 75	LM2903D	LM2903
			Reel of 2500	LM2903DR	
			LM2903QD	Tube of 75	LM2903QD
				Reel of 2500	LM2903QDR
		SOP (PS)	Reel of 2000	LM2903PSR	L2903
TSSOP (PW)	Reel of 2000	LM2903PWR	L2903		
-55°C to 125°C	5 mV	CDIP (JG)	Tube of 50	LM193JG	LM193JG
		LCCC (FK)	Tube of 55	LM193FK	LM193FK
		SOIC (D)	Tube of 75	LM193D	LM193D

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

**symbol (each comparator)**



**schematic (each comparator)**



Current values shown are nominal.

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{CC}$ (see Note 1)	36 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 36$ V
Input voltage range, $V_I$ (either input)	-0.3 V to 36 V
Output voltage, $V_O$	36 V
Output current, $I_O$	20 mA
Duration of output short-circuit to ground (see Note 3)	Unlimited
Package thermal impedance, $\theta_{JA}$ (see Notes 4 and 5):	
D package	97°C/W
P package	85°C/W
PS package	95°C/W
PW package	149°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 6 and 7):	
FK package	5.61°C/W
JG package	14.5°C/W
Operating virtual junction temperature, $T_J$	150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, P, PS, or PW package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C
Storage temperature range, $T_{Stg}$	-65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
- All voltage values, except differential voltages, are with respect to GND.
  - Differential voltages are at IN+ with respect to IN-.
  - Short circuits from outputs to  $V_{CC}$  can cause excessive heating and eventual destruction.
  - Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  - The package thermal impedance is calculated in accordance with JESD 51-7.
  - Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JC}$ , and  $T_C$ . The maximum allowable power dissipation at any allowable case temperature is  $P_D = (T_J(\max) - T_C)/\theta_{JC}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  - The package thermal impedance is calculated in accordance with MIL-STD-883.

**LM193, LM293, LM293A, LM393  
LM393A, LM2903, LM2903Q  
DUAL DIFFERENTIAL COMPARATORS**

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**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	LM193			LM293 LM393			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$ , $V_O = 1.4\text{ V}$ , $V_{IC} = V_{IC(min)}$	25°C		2	5		2	5	mV
		Full range			9		9		
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C		3	25		5	50	nA
		Full range			100		250		
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C		-25	-100		-25	-250	nA
		Full range			-300		-400		
$V_{ICR}$ Common-mode input voltage range‡		25°C	0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			V
		Full range	0 to $V_{CC}-2$			0 to $V_{CC}-2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V to }11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega$ to $V_{CC}$	25°C	50	200		50	200	V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C	0.1			0.1	50	nA	
	$V_{OH} = 30\text{ V}$ , $V_{ID} = 1\text{ V}$	Full range				1	1	$\mu\text{A}$	
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C	150	400		150	400	mV	
		Full range				700	700		
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	6			6		mA	
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8	1	0.8	1	mA	
		$V_{CC} = 30\text{ V}$	Full range				2.5		2.5

† Full range (MIN or MAX) for LM193 is -55°C to 125°C, for LM293 is 25°C to 85°C, and for LM393 is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

‡ The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC+} - 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.



**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	$T_A$ †	LM293A LM393A			LM2903 LM2903Q			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$ , $V_O = 1.4\text{ V}$ , $V_{IC} = V_{IC(min)}$	25°C		1	2		2	7	mV	
		Full range			4			15		
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C		5	50		5	50	nA	
		Full range			150			200		
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C		-25	-250		-25	-250	nA	
		Full range			-400			-500		
$V_{ICR}$ Common-mode input voltage range‡		25°C		0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$		V	
		Full range		0 to $V_{CC}-2$			0 to $V_{CC}-2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V to }11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega\text{ to }V_{CC}$	25°C		50	200		25	100	V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C		0.1	50		0.1	50	nA	
	$V_{OH} = 30\text{ V}$ , $V_{ID} = 1\text{ V}$	Full range			1			1	$\mu\text{A}$	
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C		150	400		150	400	mV	
		Full range			700			700		
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C		6			6		mA	
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C		0.8	1		0.8	1	mA
		$V_{CC} = 30\text{ V}$	Full range			2.5			2.5	

† Full range (MIN or MAX) for LM293A is 25°C to 85°C, for LM393A is 0°C to 70°C, and for LM2903 and LM2903Q is -40°C to 125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

‡ The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC+} - 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.

**switching characteristics,  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS		LM193 LM293, LM293A LM393, LM393A LM2903, LM2903Q	UNIT
			TYP	
Response time	$R_L$ connected to 5 V through 5.1 k $\Omega$ , $C_L = 15\text{ pF}$ §, See Note 8	100-mV input step with 5-mV overdrive	1.3	$\mu\text{s}$
		TTL-level input step	0.3	

§  $C_L$  includes probe and jig capacitance.

NOTE 8: The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification.  
 E. Falls within MIL STD 1835 GDIP1-T8

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals are gold plated.
  - E. Falls within JEDEC MS-004

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



4040082/D 05/98

- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)



D (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN



4040047/E 09/01

- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MS-012

## MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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