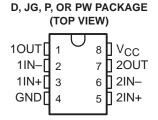
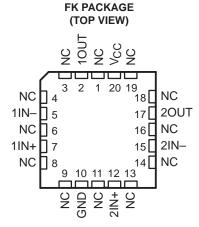
SLCS005E - JUNE 1976 - REVISED NOVEMBER 1999

- 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 . . . ±36 V
- Low Output Saturation Voltage
- Output Compatible With TTL, MOS, and CMOS

#### description

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





NC - No internal connection

long as the difference between the two supplies is 2 V to 36 V, and V<sub>CC</sub> 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°C to 125°C. The LM293 and LM293A are characterized for operation from –25°C to 85°C. The LM393 and LM393A are characterized for operation from 0°C to 70°C. The LM2903 and LM2903Q are characterized for operation from –40°C to 125°C and are manufactured to demanding automotive requirements.

#### logic diagram (each comparator)





Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



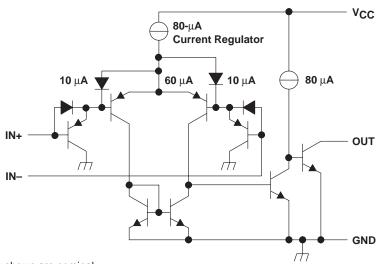
SLCS005E – JUNE 1976 – REVISED NOVEMBER 1999

#### **AVAILABLE OPTIONS**

			PACKAGED DEVICES						
TA	V <sub>IO(max</sub> ) AT 25°C	SMALL OUTLINE (D)†	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW) <sup>‡</sup>	CHIP FORM (Y)§		
0°C to 70°C	5 mV	LM393D	_	_	LM393P	LM393PW	LM393Y		
0.01070.0	2 mV	LM393AD	_	_	LM393AP	_	_		
-25°C to 85°C	5 mV	LM293D	_	_	LM293P	_	_		
-25 C 10 65 C	2 mV	LM293AD	_	_	LM293AP	_	_		
-40°C to 125°C	7 mV	LM2903D	_	_	LM2903P	LM2903PW	_		
-40°C to 125°C	7 1110	LM2903QD	_	_	LM2903QP	_	_		
–55°C to 125°C	5 mV	LM193D	LM193FK	LM193JG	LM193P	_	_		

<sup>†</sup>The D package is available taped and reeled. Add the suffix R (e.g., LM393DR).

#### schematic (each comparator)



COUNT
1
2
2
30

Current values shown are nominal.



<sup>†</sup> The PW package is only available left-end taped and reeled (e.g., LM393PWR). § Chips are tested at 25°C (see LM393Y for electrical characteristics).

### LM193, LM293, LM293A, LM393 LM393A, LM393Y, LM2903, LM2903Q DUAL DIFFERENTIAL COMPARATORS

SLCS005E – JUNE 1976 – REVISED NOVEMBER 1999

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

Supply voltage, V <sub>CC</sub> (see Note 1)	36 V
Differential input voltage, V <sub>ID</sub> (see Note 2)	
Input voltage range, V <sub>I</sub> (either input)	
Output voltage, VO	36 V
Output current, IO	20 mA
Duration of output short-circuit to ground (see Note 3)	Unlimited
Continuous total power dissipation	See Dissipation Rating Table
Package thermal impedance, θ <sub>JA</sub> (see Note 4): D package	97°C/W
P package	85°C/W
PW package	149°C/W
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, P, or PW p	
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C
Storage temperature range, T <sub>stq</sub>	–65°C to 150°C

<sup>†</sup> 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: 1. All voltage values, except differential voltages, are with respect to the network ground.
  - 2. Differential voltages are at IN+ with respect to IN-.
  - 3. Short circuits from outputs to V<sub>CC</sub> can cause excessive heating and eventual destruction.
  - 4. The package thermal impedance is calculated in accordance with JESD 51.

#### **DISSIPATION RATING TABLE**

PACKAGE	$\begin{aligned} & \textbf{T}_{\pmb{A}} \leq \textbf{25}^{\circ}\textbf{C} \\ & \textbf{POWER RATING} \end{aligned}$	DERATING FACTOR	DERATE ABOVE T <sub>A</sub>	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 125°C POWER RATING
FK	900 mW	11.0 mW/°C	68°C	880 mW	715 mW	275 mW
JG	900 mW	8.4 mW/°C	43°C	672 mW	546 mW	210 mW



## LM193, LM293, LM293A, LM393 LM393A, LM393Y, LM2903, LM2903Q DUAL DIFFERENTIAL COMPARATORS

SLCS005E – JUNE 1976 – REVISED NOVEMBER 1999

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

PARAMETER		TEST CO	NDITIONS	T <sub>A</sub> †	L	M193		l	M293 M393		UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
\/.a	Input offset voltage	$V_{CC} = 5 \text{ V to } 30$	0 V,	25°C		2	5		2	5	mV
VIO	input onset voltage	$V_O = 1.4 \text{ V},$ $V_{IC} = V_{IC}(\text{min})$		Full range			9			9	IIIV
lio.	Input offset current	V <sub>O</sub> = 1.4 V		25°C		3	25		5	50	nA
lio	input onset current	VO = 1.4 V		Full range			100			250	IIA
1	Input bigg gurrent	V= -1.4.V		25°C		-25	-100		-25	-250	nA
IB	Input bias current	V <sub>O</sub> = 1.4 V		Full range			-300			-400	nA
V	Common-mode			25°C	0 to V <sub>CC</sub> -1.5			0 to V <sub>CC</sub> -1.5			V
VICR	input voltage range‡				0 to V <sub>CC</sub> -2			0 to V <sub>CC</sub> -2			v
AVD	Large-signal differential voltage amplification	$V_{CC}$ = 15 V, $V_{O}$ = 1.4 V to 1 $R_{L} \ge$ 15 kΩ to \		25°C	50	200		50	200		V/mV
la	High-level	V <sub>OH</sub> = 5 V,	V <sub>ID</sub> = 1 V	25°C		0.1			0.1	50	nA
ЮН	output current	V <sub>OH</sub> = 30 V,	V <sub>ID</sub> = 1 V	Full range			1			1	μΑ
V	Low-level	1a. 1 mA	\/ 1\/	25°C		150	400		150	400	\/
VOL	VOL output voltage	$I_{OL} = 4 \text{ mA},$	$V_{ID} = -1 V$	Full range			700			700	m∨
loL	Low-level output current	V <sub>OL</sub> = 1.5 V,	V <sub>ID</sub> = 1 V	25°C	6			6			mA
laa	Cupply ourrant	D	V <sub>CC</sub> = 5 V	25°C		0.8	1		0.8	1	mA
ICC	Supply current	R <sub>L</sub> = ∞	V <sub>CC</sub> = 30 V	Full range			2.5			2.5	IIIA

<sup>†</sup> 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.



<sup>&</sup>lt;sup>‡</sup> 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<sub>CC+</sub> -1.5 V, but either or both inputs can go to 30 V without damage.

SLCS005E – JUNE 1976 – REVISED NOVEMBER 1999

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

	PARAMETER	TEST CO	NDITIONS	T <sub>A</sub> †		M293A M393A			M2903 I2903Q		UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
\/10	Input offset voltage	$V_{CC} = 5 \text{ V to } 3$ $V_{C} = 1.4 \text{ V},$	0 V,	25°C		1	3		2	7	mV
VIO	input onset voltage	$V_{IC} = V_{IC(min)}$		Full range			4			15	IIIV
110	Input offset current	V <sub>O</sub> = 1.4 V		25°C		5	50		5	50	nA
lio	input onset current	VO = 1.4 V		Full range			150			200	ш
1.5	Input bias current	V <sub>O</sub> = 1.4 V		25°C		-25	-250		-25	-250	nA
IB	input bias current	VO = 1.4 V		Full range			-400			-500	IIA
V	Common-mode	nge‡		25°C	0 to V <sub>CC</sub> -1.5			0 to V <sub>CC</sub> -1.5			V
VICR	input voltage range‡			Full range	0 to V <sub>CC</sub> -2			0 to V <sub>CC</sub> -2			
A <sub>VD</sub>	Large-signal differential voltage amplification	$V_{CC}$ = 15 V, $V_{O}$ = 1.4 V to 1 $R_{L} \ge$ 15 kΩ to \		25°C	50	200		25	100		V/mV
lou	High-level	V <sub>OH</sub> = 5 V,	V <sub>ID</sub> = 1 V	25°C		0.1	50		0.1	50	nA
ЮН	output current	V <sub>OH</sub> = 30 V,	V <sub>ID</sub> = 1 V	Full range			1			1	μΑ
1/2:	Low-level	1 - 1 - 1		25°C		150	400		150	400	mV
VOL	output voltage	$I_{OL} = 4 \text{ mA},$	$V_{ID} = -1 V$	Full range			700			700	IIIV
lOL	Low-level output current	V <sub>OL</sub> = 1.5 V,	V <sub>ID</sub> = 1 V	25°C	6			6			mA
loo	Cupply ourrent	D	V <sub>CC</sub> = 5 V	25°C		0.8	1		0.8	1	m /\
Icc	Supply current	R <sub>L</sub> = ∞	V <sub>CC</sub> = 30 V	Full range			2.5			2.5	mA

<sup>†</sup> 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.

## electrical characteristics at $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

	DADAMETED	TEST OF	NUDITIONS	LM393Y MIN TYP§ MA			UNIT
	PARAMETER	TEST CC	ONDITIONS				UNIT
VIO	Input offset voltage	5,77, 00,77	., .,		2	5	mV
I <sub>IO</sub>	Input offset current	$V_{CC} = 5 \text{ V to } 30 \text{ V},$ $V_{O} = 1.4 \text{ V}$	VIC = VICR(min)		5	50	nA
I <sub>IB</sub>	Input bias current	VO = 1.4 V			-25	-250	nA
VICR	Common-mode input voltage range	V <sub>CC</sub> = 5 V to 30 V		0 to V <sub>CC</sub> -1.5	5		V
AVD	Large-signal differential voltage amplification	$V_{CC} = 15 \text{ V},$ $R_L \ge 15 \text{ k}\Omega \text{ to } V_{CC}$	$V_0 = 1.4 \text{ V to } 11.4 \text{ V},$	25	200		V/mV
ІОН	High-level output current	V <sub>OH</sub> = 5 V,	V <sub>ID</sub> = 1 V		0.1	50	nA
VOL	Low-level output voltage	$I_{OL} = 4 \text{ mA},$	$V_{ID} = -1 V$		150	400	mV
loL	Low-level output current	V <sub>OL</sub> = 1.5 V,	V <sub>ID</sub> = −1 V	6			mA
ICC	Supply current	R <sub>L</sub> = ∞,	V <sub>CC</sub> = 5 V		0.8	1	mA

<sup>§</sup> All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified.



<sup>&</sup>lt;sup>‡</sup> 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<sub>CC+</sub> -1.5 V, but either or both inputs can go to 30 V without damage.

# LM193, LM293, LM293A, LM393 LM393A, LM393Y, LM2903, LM2903Q **DUAL DIFFERENTIAL COMPARATORS**

SLCS005E – JUNE 1976 – REVISED NOVEMBER 1999

## switching characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

PARAMETER TEST CONDI	ONDITIONS	LM193 LM293, LM293A LM393, LM393A LM2903, LM2903Q			UNIT	
			MIN	TYP	MAX	
Response time	R <sub>L</sub> connected to 5 V through 5.1 k $\Omega$ ,	100-mV input step with 5-mV overdrive		1.3		
Response time	C <sub>L</sub> = 15 pF <sup>†</sup> , See Note 5	TTL-level input step		0.3		μs

† C<sub>L</sub> includes probe and jig capacitance.

NOTE 5: The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.



#### **IMPORTANT NOTICE**

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.

Copyright © 1999, Texas Instruments Incorporated