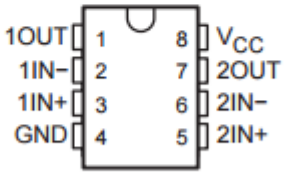
LM193, LM293, LM293A
LM393, LM393A, LM2903, LM2903V
DUAL DIFFERENTIAL COMPARATORS

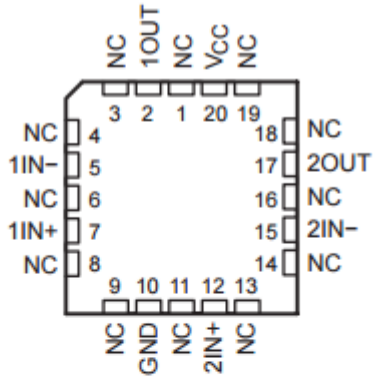
SLCS005S – JUNE 1976 – REVISED OCTOBER 2004

- **Single Supply or Dual Supplies**
- **Wide Range of Supply Voltage**
  - **Max Rating . . . 2 V to 36 V**
  - **Tested to 30 V . . . Non-V Devices**
  - **Tested to 32 V . . . V-Suffix Devices**
- **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**

LM193 . . . D OR JG PACKAGE
LM293 . . . D, DGK, OR P PACKAGE
LM293A . . . D OR DGK PACKAGE
LM393, LM393A . . . D, DGK, P, PS, OR PW PACKAGE
LM2903 . . . D, DGK, P, PS, OR PW 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°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 is characterized for operation from −40°C to 125°C.

description/ordering information (continued)

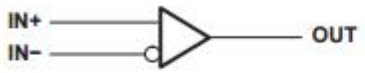
ORDERING INFORMATION

T_A	V_{IOmax} AT 25°C	MAX V_{CC}	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	5 mV	30 V	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	
			MSOP/VSSOP (DGK)	Reel of 2500	LM393DGKR	M9_‡
	2 mV	30 V	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
			MSOP/VSSOP (DGK)	Reel of 2500	LM393ADGKR	M8_‡
−25°C to 85°C	5 mV	30 V	PDIP (P)	Tube of 50	LM293P	LM293P
			SOIC (D)	Tube of 75	LM293D	LM293
				Reel of 2500	LM293DR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM293DGKR	MC_‡
	2 mV	30 V	SOIC (D)	Tube of 75	LM293AD	LM293A
				Reel of 2500	LM293ADR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM293ADGKR	MD_‡
−40°C to 125°C	7 mV	30 V	PDIP (P)	Tube of 50	LM2903P	LM2903P
			SOIC (D)	Tube of 75	LM2903D	LM2903
				Reel of 2500	LM2903DR	
			SOP (PS)	Reel of 2000	LM2903PSR	L2903
			TSSOP (PW)	Reel of 2000	LM2903PWR	L2903
			MSOP/VSSOP (DGK)	Reel of 2500	LM2903DGKR	MA_‡
	7 mV	32 V	SOIC (D)	Reel of 2500	LM2903VQDR	L2903V
			TSSOP (PW)	Reel of 2000	LM2903VQPWR	L2903V
	2 mV	32 V	SOIC (D)	Reel of 2500	LM2903AVQDR	L2903AV
			TSSOP (PW)	Reel of 2000	LM2903AVQPWR	L2903AV
−55°C to 125°C	5 mV	30 V	CDIP (JG)	Tube of 50	LM193JG	LM193JG
			LCCC (FK)	Tube of 55	LM193FK	LM193FK
			SOIC (D)	Reel of 2500	LM193DR	LM193

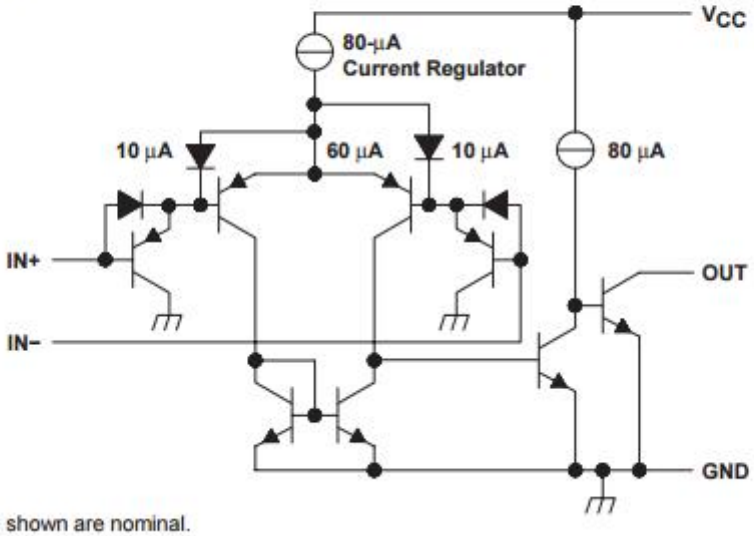
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

‡ The actual top-side marking has one additional character that designates the assembly/test site.

symbol (each comparator)



schematic (each comparator)



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	2
Transistors	30

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) . . . . . ±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, θ_{JA} (see Notes 4 and 5): D package . . . . . 97°C/W
DGK package . . . . . 172°C/W
P package . . . . . 85°C/W
PS package . . . . . 95°C/W
PW package . . . . . 149°C/W
Package thermal impedance, θ_{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 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:
1. All voltage values, except differential voltages, are with respect to GND.
2. Differential voltages are at IN+, with respect to IN−.
3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
4. Maximum power dissipation is a function of $T_J(max)$, θ_{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.
5. The package thermal impedance is calculated in accordance with JESD 51-7.
6. Maximum power dissipation is a function of $T_J(max)$, θ_{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.
7. The package thermal impedance is calculated in accordance with MIL-STD-883.

electrical characteristics at specified free-air temperature, V_{CC} = 5 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 V to 30 V, V_O = 1.4 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 V		25°C		3	25		5	50	nA
				Full range			100			250	
I_{IB}	Input bias current	V_O = 1.4 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 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	50	200		50	200		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V,	V_{ID} = 1 V	25°C		0.1			0.1	50	nA
		V_{OH} = 30 V,	V_{ID} = 1 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = −1 V	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = −1 V	25°C	6			6			mA
I_{CC}	Supply current	R_L = ∞	V_{CC} = 5 V	25°C		0.8	1		0.8	1	mA
			V_{CC} = 30 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 V, but either or both inputs can go to 30 V without damage.

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

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

† Full range (MIN or MAX) for LM293A is 25°C to 85°C, and for LM393A 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 V, but either or both inputs can go to 30 V without damage.

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

PARAMETER		TEST CONDITIONS		T_A†	LM2903			LM2903A			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX‡, V_O = 1.4 V, V_{IC} = $V_{IC(min)}$		25°C		2	7		1	2	mV
				Full range			15			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		5	50		5	50	nA
				Full range			200			200	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		−25	−250		−25	−250	nA
				Full range			−500			−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 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	25	100		25	100		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V,	V_{ID} = 1 V	25°C		0.1	50		0.1	50	nA
		V_{OH} = V_{CC} MAX,	V_{ID} = 1 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = −1 V	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = −1 V	25°C	6			6			mA
I_{CC}	Supply current	R_L = ∞	V_{CC} = 5 V	25°C		0.8	1		0.8	1	mA
			V_{CC} = MAX	Full range			2.5			2.5	

† Full range (MIN or MAX) for LM2903 is −40°C to 125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

‡ V_{CC} MAX = 30 V for non-V devices and 32 V for V-suffix devices.

§ 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 V, but either or both inputs can go to 30 V (32 V for V-suffix devices) without damage.

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

PARAMETER	TEST CONDITIONS		LM193, LM293, LM293A, LM393, LM393A, LM2903	UNIT
			TYP	
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF¶, See Note 8	100-mV input step with 5-mV overdrive	1.3	µs
		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.