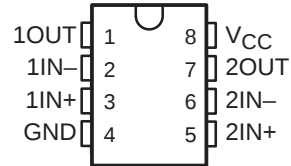


# LM193, LM293, LM293A, LM393 LM393A, LM393Y, LM2903, LM2903Q DUAL DIFFERENTIAL COMPARATORS

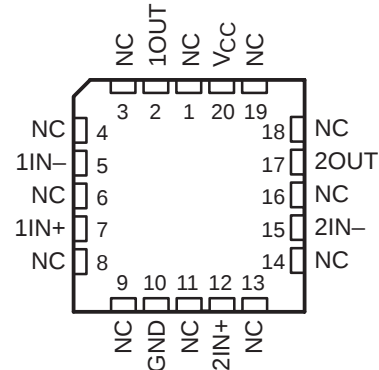
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- Single Supply or Dual Supplies
- Wide Range of Supply Voltage . . . 2 V to 36 V
- Low Supply-Current Drain Independent of Supply Voltage . . . 0.4 mA Typ Per Comparator
- Low Input Bias Current . . . 25 nA Typ
- Low Input Offset Current . . . 3 nA 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

D, JG, P, OR PW PACKAGE  
(TOP VIEW)



FK PACKAGE  
(TOP VIEW)



NC – No internal connection

## 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 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 and LM2903Q are characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  and are manufactured to demanding automotive requirements.

## logic diagram (each comparator)



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

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AVAILABLE OPTIONS

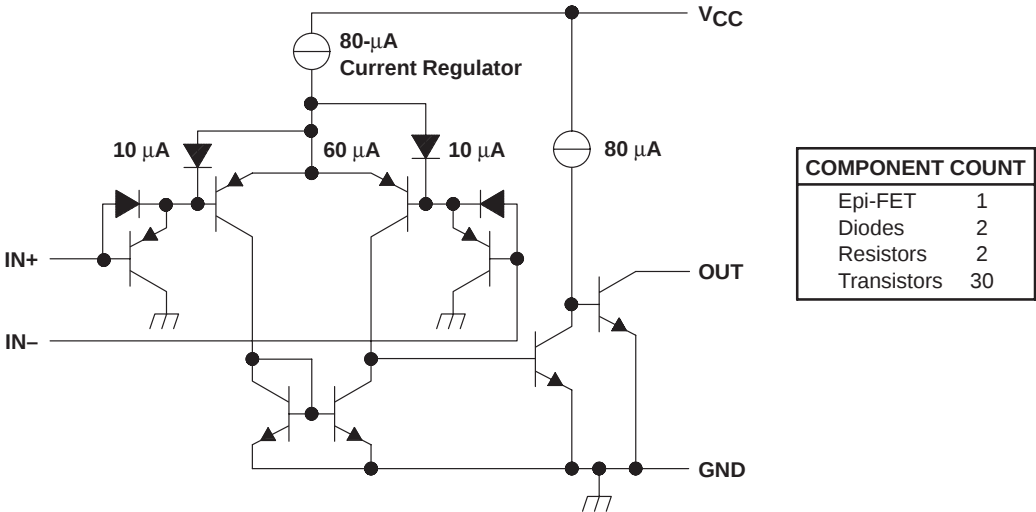
| T <sub>A</sub> | V <sub>IO(max)</sub><br>AT 25°C | PACKAGED DEVICES                     |                         |                        |                       |                            | CHIP<br>FORM<br>(Y) <sup>§</sup> |
|----------------|---------------------------------|--------------------------------------|-------------------------|------------------------|-----------------------|----------------------------|----------------------------------|
|                |                                 | SMALL<br>OUTLINE<br>(D) <sup>†</sup> | CHIP<br>CARRIER<br>(FK) | CERAMIC<br>DIP<br>(JG) | PLASTIC<br>DIP<br>(P) | TSSOP<br>(PW) <sup>‡</sup> |                                  |
| 0°C to 70°C    | 5 mV                            | LM393D                               | —                       | —                      | LM393P                | LM393PW                    | LM393Y                           |
|                | 2 mV                            | LM393AD                              | —                       | —                      | LM393AP               | —                          | —                                |
| –25°C to 85°C  | 5 mV                            | LM293D                               | —                       | —                      | LM293P                | —                          | —                                |
|                | 2 mV                            | LM293AD                              | —                       | —                      | LM293AP               | —                          | —                                |
| –40°C to 125°C | 7 mV                            | LM2903D                              | —                       | —                      | LM2903P               | LM2903PW                   | —                                |
|                |                                 | 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).

<sup>‡</sup> The PW package is only available left-end taped and reeled (e.g., LM393PWR).

<sup>§</sup> Chips are tested at 25°C (see LM393Y for electrical characteristics).

schematic (each comparator)



Current values shown are nominal.

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

|                                                                                   |                              |
|-----------------------------------------------------------------------------------|------------------------------|
| 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                    |
| Continuous total power dissipation                                                | See Dissipation Rating Table |
| Package thermal impedance, $\theta_{JA}$ (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 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               |

<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  $V_{CC}$  can cause excessive heating and eventual destruction.
  4. The package thermal impedance is calculated in accordance with JESD 51.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING<br>FACTOR | DERATE<br>ABOVE $T_A$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>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**

SLCS005F – JUNE 1976 – REVISED JUNE 2000

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

| PARAMETER        |                                                 | TEST CONDITIONS                                                                                           |                        | T <sub>A</sub> <sup>†</sup> | LM193                     |     |      | LM293<br>LM393            |           |      | UNIT |    |
|------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------|-----------------------------|---------------------------|-----|------|---------------------------|-----------|------|------|----|
|                  |                                                 |                                                                                                           |                        |                             | MIN                       | TYP | MAX  | MIN                       | TYP       | MAX  |      |    |
| V <sub>IO</sub>  | Input offset voltage                            | V <sub>CC</sub> = 5 V to 30 V,<br>V <sub>O</sub> = 1.4 V,<br>V <sub>IC</sub> = V <sub>IC(min)</sub>       |                        | 25°C                        |                           | 2   | 5    |                           | 2         | 5    | mV   |    |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | 9    |                           |           | 9    |      |    |
| I <sub>IO</sub>  | Input offset current                            | V <sub>O</sub> = 1.4 V                                                                                    |                        | 25°C                        |                           | 3   | 25   |                           | 5         | 50   | nA   |    |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | 100  |                           |           | 250  |      |    |
| I <sub>IB</sub>  | Input bias current                              | V <sub>O</sub> = 1.4 V                                                                                    |                        | 25°C                        |                           | –25 | –100 |                           | –25       | –250 | nA   |    |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | –300 |                           |           | –400 |      |    |
| V <sub>ICR</sub> | Common-mode input voltage range <sup>‡</sup>    |                                                                                                           |                        | 25°C                        | 0 to V <sub>CC</sub> –1.5 |     |      | 0 to V <sub>CC</sub> –1.5 |           |      | V    |    |
|                  |                                                 |                                                                                                           |                        | 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 <sub>CC</sub> = 15 V,<br>V <sub>O</sub> = 1.4 V to 11.4 V,<br>R <sub>L</sub> ≥ 15 kΩ to V <sub>CC</sub> |                        | 25°C                        |                           | 50  | 200  |                           | 50        | 200  | V/mV |    |
| I <sub>OH</sub>  | High-level output current                       | V <sub>OH</sub> = 5 V,    V <sub>ID</sub> = 1 V                                                           |                        | 25°C                        |                           | 0.1 |      |                           | 0.1    50 |      |      | nA |
|                  |                                                 | V <sub>OH</sub> = 30 V,    V <sub>ID</sub> = 1 V                                                          |                        | Full range                  |                           | 1   |      |                           | 1         |      |      | μA |
| V <sub>OL</sub>  | Low-level output voltage                        | I <sub>OL</sub> = 4 mA,    V <sub>ID</sub> = –1 V                                                         |                        | 25°C                        |                           | 150 | 400  |                           | 150       | 400  | mV   |    |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           | 700 |      | 700                       |           |      |      |    |
| I <sub>OL</sub>  | Low-level output current                        | V <sub>OL</sub> = 1.5 V,    V <sub>ID</sub> = 1 V                                                         |                        | 25°C                        |                           | 6   |      |                           | 6         |      | mA   |    |
| I <sub>CC</sub>  | Supply current                                  | R <sub>L</sub> = ∞                                                                                        | V <sub>CC</sub> = 5 V  | 25°C                        |                           | 0.8 | 1    |                           | 0.8       | 1    | mA   |    |
|                  |                                                 |                                                                                                           | V <sub>CC</sub> = 30 V | Full range                  |                           | 2.5 |      | 2.5                       |           |      |      |    |

$^\dagger$  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.

$^\ddagger$  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 <sub>A</sub> <sup>†</sup> | LM293A<br>LM393A          |     |      | LM2903<br>LM2903Q         |     |      | UNIT |
|------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------|-----------------------------|---------------------------|-----|------|---------------------------|-----|------|------|
|                  |                                                 |                                                                                                           |                        |                             | MIN                       | TYP | MAX  | MIN                       | TYP | MAX  |      |
| V <sub>IO</sub>  | Input offset voltage                            | V <sub>CC</sub> = 5 V to 30 V,<br>V <sub>O</sub> = 1.4 V,<br>V <sub>IC</sub> = V <sub>IC(min)</sub>       |                        | 25°C                        | 1                         |     | 2    | 2                         |     | 7    | mV   |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | 4    |                           |     | 15   |      |
| I <sub>IO</sub>  | Input offset current                            | V <sub>O</sub> = 1.4 V                                                                                    |                        | 25°C                        | 5                         |     | 50   | 5                         |     | 50   | nA   |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | 150  |                           |     | 200  |      |
| I <sub>IB</sub>  | Input bias current                              | V <sub>O</sub> = 1.4 V                                                                                    |                        | 25°C                        | –25                       |     | –250 | –25                       |     | –250 | nA   |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | –400 |                           |     | –500 |      |
| V <sub>ICR</sub> | Common-mode input voltage range‡                |                                                                                                           |                        | 25°C                        | 0 to V <sub>CC</sub> –1.5 |     |      | 0 to V <sub>CC</sub> –1.5 |     |      | V    |
|                  |                                                 |                                                                                                           |                        | 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 <sub>CC</sub> = 15 V,<br>V <sub>O</sub> = 1.4 V to 11.4 V,<br>R <sub>L</sub> ≥ 15 kΩ to V <sub>CC</sub> |                        | 25°C                        | 50                        |     | 200  | 25                        |     | 100  | V/mV |
| I <sub>OH</sub>  | High-level output current                       | V <sub>OH</sub> = 5 V,    V <sub>ID</sub> = 1 V                                                           |                        | 25°C                        | 0.1                       |     | 50   | 0.1                       |     | 50   | nA   |
|                  |                                                 | V <sub>OH</sub> = 30 V,    V <sub>ID</sub> = 1 V                                                          |                        | Full range                  |                           |     | 1    |                           |     | 1    | μA   |
| V <sub>OL</sub>  | Low-level output voltage                        | I <sub>OL</sub> = 4 mA,    V <sub>ID</sub> = –1 V                                                         |                        | 25°C                        | 150                       |     | 400  | 150                       |     | 400  | mV   |
|                  |                                                 |                                                                                                           |                        | Full range                  |                           |     | 700  |                           |     | 700  |      |
| I <sub>OL</sub>  | Low-level output current                        | V <sub>OL</sub> = 1.5 V,    V <sub>ID</sub> = 1 V                                                         |                        | 25°C                        | 6                         |     |      | 6                         |     |      | mA   |
| I <sub>CC</sub>  | Supply current                                  | R <sub>L</sub> = ∞                                                                                        | V <sub>CC</sub> = 5 V  | 25°C                        | 0.8                       |     | 1    | 0.8                       |     | 1    | mA   |
|                  |                                                 |                                                                                                           | V <sub>CC</sub> = 30 V | Full range                  |                           |     | 2.5  |                           |     | 2.5  |      |

<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.

<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  $V_{CC} + 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.

**electrical characteristics at  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

| PARAMETER                                                        | TEST CONDITIONS                                                                          | LM393Y            |                  |      | UNIT |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------|-------------------|------------------|------|------|
|                                                                  |                                                                                          | MIN               | TYP <sup>§</sup> | MAX  |      |
| $V_{IO}$ Input offset voltage                                    | $V_{CC} = 5\text{ V to }30\text{ V}$ , $V_{IC} = V_{ICR(min)}$ ,<br>$V_O = 1.4\text{ V}$ |                   | 2                | 5    | mV   |
| $I_{IO}$ Input offset current                                    |                                                                                          |                   | 5                | 50   | nA   |
| $I_{IB}$ Input bias current                                      |                                                                                          |                   | –25              | –250 | nA   |
| $V_{ICR}$ Common-mode input voltage range                        | $V_{CC} = 5\text{ V to }30\text{ V}$                                                     | 0 to $V_{CC}-1.5$ |                  |      | V    |
| $A_{VD}$ Large-signal differential voltage amplification         | $V_{CC} = 15\text{ V}$ ,<br>$R_L \geq 15\text{ k}\Omega$ to $V_{CC}$                     |                   | 25               | 200  | V/mV |
| $V_O = 1.4\text{ V to }11.4\text{ V}$ ,<br>$V_{ID} = 1\text{ V}$ |                                                                                          |                   |                  |      |      |
| $I_{OH}$ High-level output current                               | $V_{OH} = 5\text{ V}$ , $V_{ID} = 1\text{ V}$                                            |                   | 0.1              | 50   | nA   |
| $V_{OL}$ Low-level output voltage                                | $I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$                                          |                   | 150              | 400  | mV   |
| $I_{OL}$ Low-level output current                                | $V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$                                         | 6                 |                  |      | mA   |
| $I_{CC}$ Supply current                                          | $R_L = \infty$ , $V_{CC} = 5\text{ V}$                                                   |                   | 0.8              | 1    | mA   |

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

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

SLCS005F – JUNE 1976 – REVISED JUNE 2000

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

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

$^\dagger C_L$  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.



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