

## SIGNATURE SERIES

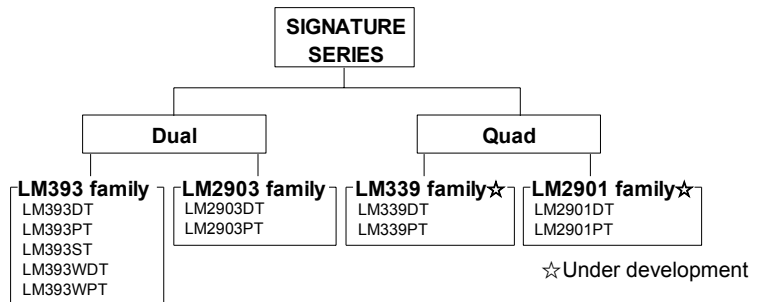


# Universal Standard Ground sense Comparator

## LM393 family, LM339 family, LM2903 family, LM2901 family

### Description

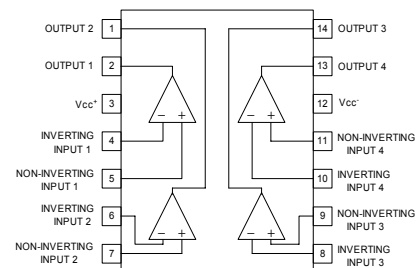
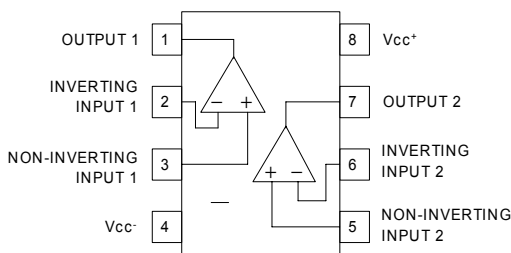
The Universal Standard LM393/LM339/LM2903/LM2901 family monolithic ICs integrate two/four independent comparator circuits on a single chip and feature high gain, low power consumption, and an operating voltage range between 2[V] and 36[V] (single power supply).



### Characteristics

- 1) Operating temperature range  
Commercial Grade  
LM339/393 family: 0[°C] to +70[°C]  
Extended Industrial Grade  
LM2903/2901 family: -40[°C] to +125[°C]
- 2) Open collector output stage
- 3) Single / dual power supply compatible
- 4) Low supply current  
0.4[mA] typ. (LM2903/393 family)  
1.1[mA] typ. (LM2901/339 family)
- 5) Low supply current: 25[nA] typ
- 6) Low input offset current: 5[nA] typ
- 7) Common-mode input voltage range includes ground
- 8) Differential input voltage is possible to apply the absolute maximum ratings  $\pm 36[V]$ .
- 9) Low output saturation voltage
- 10) TTL, MOS, CMOS compatible output

### Pin Assignment



☆Under development

#### SO package8

LM393DT  
LM393WDT  
LM2903DT

#### TSSOP8

LM393PT  
LM393WPT  
LM2903PT

#### Mini SO8

LM393ST

#### SO package 14

LM339DT  
LM2901DT

#### TSSOP14

LM339PT  
LM2901PT

## ● Absolute Maximum Ratings (Ta=25°C)

| Parameter                       | Symbol                             | Rating       |               |               |                | Unit |
|---------------------------------|------------------------------------|--------------|---------------|---------------|----------------|------|
|                                 |                                    | LM393 family | LM339 family☆ | LM2903 family | LM2901 family☆ |      |
| Supply Voltage                  | Vcc <sup>+</sup> -Vcc <sup>-</sup> | +36          |               |               |                | V    |
| Differential Input Voltage      | Vid                                | ±36          |               |               |                | V    |
| Common-mode Input Voltage Range | Vicm                               | -0.3 to +36  |               |               |                | V    |
| Operating Temperature Range     | Topr                               | 0 to +70     |               | -40 to +125   |                | °C   |
| Storage Temperature Range       | Tstg                               | -65 to +150  |               |               |                | °C   |
| Maximum Junction Temperature    | Tjmax                              | +150         |               |               |                | °C   |

☆Under development

## ● Electric Characteristics

○ LM393/339 family (Unless otherwise specified, Vcc<sup>+</sup>=+5[V])

| Parameter                        | Symbol | Temperature range | Limit        |      |                       |               |      |                       | Unit | Condition  | Fig.No. |
|----------------------------------|--------|-------------------|--------------|------|-----------------------|---------------|------|-----------------------|------|--|---------|
|                                  |        |                   | LM393 family |      |                       | LM339 family☆ |      |                       |      |  |         |
|                                  |        |                   | Min.         | Typ. | Max.                  | Min.          | Typ. | Max.                  |      |  |         |
| Input Offset Voltage (*1)        | VIO    | 25°C              | —            | 1    | 7                     | —             | 1    | 7                     | mV   | Vcc <sup>+</sup> =5 to 30[V],<br>VO=1.4[V],<br>Vicm=0 to -1.5[V]         | 2       |
|                                  |        | full range        | —            | —    | 9                     | —             | —    | 9                     |      |  |         |
| Input Offset Current (*1)        | IIO    | 25°C              | —            | 5    | 50                    | —             | 5    | 50                    | nA   | VO=1.4[V]  | 2       |
|                                  |        | full range        | —            | —    | 150                   | —             | —    | 150                   |      |  |         |
| Input Bias Current (*1)          | IIB    | 25°C              | —            | 25   | 250                   | —             | 25   | 250                   | nA   | VO=1.4[V]  | 2       |
|                                  |        | full range        | —            | —    | 400                   | —             | —    | 400                   |      |  |         |
| Large Signal Voltage Gain        | AVD    | 25°C              | 25           | 200  | —                     | 25            | 200  | —                     | V/mV | Vcc <sup>+</sup> =15[V], VO=1 to 11[V],<br>RL=15[kΩ]                     | 2       |
| Supply Current (All Comparators) | ICC    | 25°C              | —            | 0.4  | 1                     | —             | 1.1  | 2                     | mA   | Vcc <sup>+</sup> =5V, no load  | 3       |
|                                  |        | full range        | —            | 1    | 2.5                   | —             | 1.3  | 2.5                   |      | Vcc <sup>+</sup> =30[V], no load   |         |
| Input Common-mode Voltage Range  | VICM   | 25°C              | —            | —    | Vcc <sup>+</sup> -1.5 | —             | —    | Vcc <sup>+</sup> -1.5 | V    | —  | 2       |
|                                  |        | full range        | —            | —    | Vcc <sup>+</sup> -2.0 | —             | —    | Vcc <sup>+</sup> -2.0 |      |  |         |
| Differential Input Voltage       | VID    | 25°C              | —            | —    | Vcc <sup>+</sup>      | —             | —    | Vcc <sup>+</sup>      | V    | —  | —       |
| Low level Output Voltage         | VOL    | 25°C              | —            | 250  | 400                   | —             | 250  | 400                   | mV   | VID=-1[V], Isink=4[mA]   | 3       |
|                                  |        | full range        | —            | —    | 700                   | —             | —    | 700                   |      |  |         |
| High level Output Current        | IOH    | 25°C              | —            | 0.1  | —                     | —             | 0.1  | —                     | nA   | Vcc <sup>+</sup> =30[V], VID=1[V]<br>VO=30[V]                            | 3       |
|                                  |        | full range        | —            | —    | 1                     | —             | —    | 1                     | μA   |  |         |
| Output Sink Current              | Isink  | 25°C              | 6            | 16   | —                     | 6             | 16   | —                     | mA   | VID=-1[V], VO=1.5[V]   | 3       |
| Small Single Response Time       | tRE    | 25°C              | —            | 1.3  | —                     | —             | 1.3  | —                     | μs   | RL=5.1[kΩ], Vcc <sup>+</sup> =5[V]<br>VIN=100[mVp-p],<br>Overdrive=5[mV] | 3       |
| Large Single Response Time       | tREL   |                   | —            | 300  | —                     | —             | 300  | —                     | ns   | RL=5.1[kΩ], Vcc <sup>+</sup> =5[V]<br>VIN=TTL input, Vref=1.4[V]         | 3       |

(\*1) Absolute value

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○LM2903/2901 family(Unless otherwise specified,  $V_{CC}^+=+5[V]$ )

| Parameter                        | Symbol | Temperature range | Limit         |      |                |                |      |                | Unit    | Condition  | Fig.No. |
|----------------------------------|--------|-------------------|---------------|------|----------------|----------------|------|----------------|---------|--|---------|
|                                  |        |                   | LM2903 family |      |                | LM2901 family☆ |      |                |         |  |         |
|                                  |        |                   | Min.          | Typ. | Max.           | Min.           | Typ. | Max.           |         |  |         |
| Input Offset Voltage (*2)        | VIO    | 25°C              | —             | 2    | 7              | —              | 1    | 7              | mV      | $V_{CC}^+=5$ to $30[V]$ , $V_O=1.4[V]$<br>$V_{ICM}=0$ to $-1.5[V]$               | 2       |
|                                  |        | full range        | —             | —    | 15             | —              | —    | 15             |         |  |         |
| Input Offset Current (*2)        | IIO    | 25°C              | —             | 5    | 50             | —              | 5    | 50             | nA      | $V_O=1.4[V]$   | 2       |
|                                  |        | full range        | —             | —    | 150            | —              | —    | 150            |         |  |         |
| Input Bias Current (*2)          | IIB    | 25°C              | —             | 25   | 250            | —              | 25   | 250            | nA      | $V_O=1.4[V]$   | 2       |
|                                  |        | full range        | —             | —    | 400            | —              | —    | 400            |         |  |         |
| Large Signal Voltage Gain        | AVD    | 25°C              | 25            | 200  | —              | 25             | 200  | —              | V/mV    | $V_{CC}^+=15[V]$ , $V_O=1$ to $11[V]$ ,<br>$R_L=15[k\Omega]$                     | 2       |
| Supply Current (All Comparators) | ICC    | 25°C              | —             | 0.4  | 1              | —              | 1.1  | 2              | mA      | $V_{CC}^+=5V$ , no load  | 3       |
|                                  |        | full range        | —             | 1    | 2.5            | —              | 1.3  | 2.5            |         | $V_{CC}^+=30[V]$ , no load   |         |
| Input Common-mode Voltage Range  | VICM   | 25°C              | —             | —    | $V_{CC}^+-1.5$ | —              | —    | $V_{CC}^+-1.5$ | V       | —  | 2       |
|                                  |        | full range        | —             | —    | $V_{CC}^+-2.0$ | —              | —    | $V_{CC}^+-2.0$ |         |  |         |
| Differential Input Voltage       | VID    | 25°C              | —             | —    | $V_{CC}^+$     | —              | —    | $V_{CC}^+$     | V       | —  | —       |
| Low level Output Voltage         | VOL    | 25°C              | —             | 250  | 400            | —              | 250  | 400            | mV      | $V_{ID}=-1[V]$ , $I_{sink}=4[mA]$  | 3       |
|                                  |        | full range        | —             | —    | 700            | —              | —    | 700            |         |  |         |
| High level Output Current        | Isink  | 25°C              | —             | 0.1  | —              | —              | 0.1  | —              | nA      | $V_{CC}^+=30[V]$ , $V_{ID}=1[V]$<br>$V_O=30[V]$                                  | 3       |
|                                  |        | full range        | —             | —    | 1              | —              | —    | 1              | $\mu A$ |  |         |
| Output Sink Current              | IOL    | 25°C              | 6             | 16   | —              | 6              | 16   | —              | mA      | $V_{ID}=-1[V]$ , $V_O=1.5[V]$  | 3       |
| Small Single Response Time       | tRE    | 25°C              | —             | 1.3  | —              | —              | 1.3  | —              | $\mu s$ | $R_L=5.1[k\Omega]$ , $V_{CC}^+=5[V]$<br>$V_{IN}=100[mVp-p]$ ,<br>Overdrive=5[mV] | 3       |
| Large Single Response Time       | tREL   | 25°C              | —             | —    | 1.0            | —              | —    | 1.0            | $\mu s$ | TTL input $V_{ref}=1.4[V]$<br>$R_L=5.1[k\Omega]$<br>Output voltage at 95%        | 3       |

(\*2) Absolute value

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●Circuit Diagram

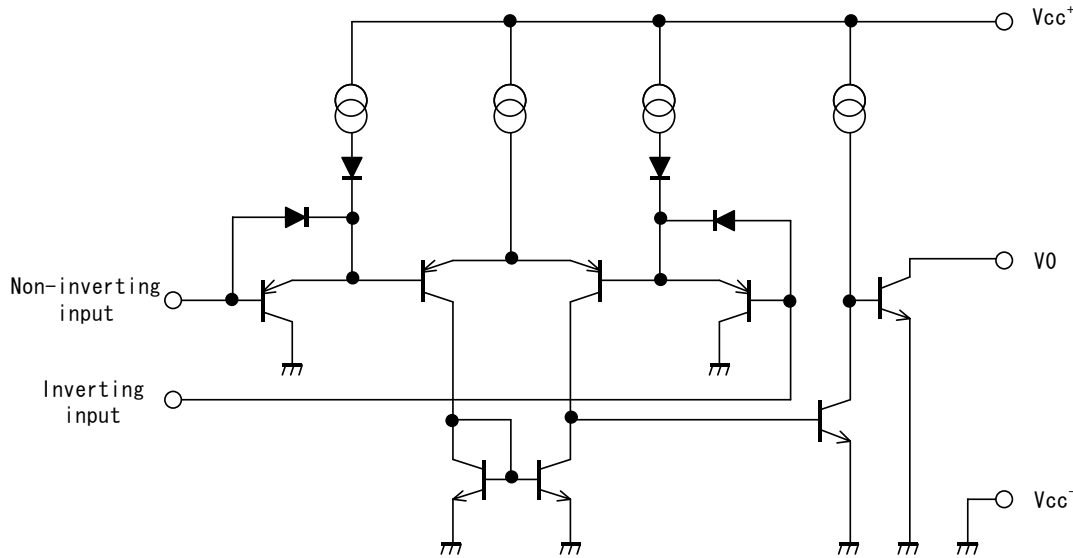


Fig.1 Circuit Diagram (each Comparator)

●Measurement circuit 1 NULL Method measurement condition

Vcc+, Vcc-, EK, Vicm unit : [V]

| Parameter                 | VF  | S1  | S2  | S3 | LM393/LM339 family |      |       |      | LM2903/LM2901 family |      |       |      | Calculation |
|---------------------------|-----|-----|-----|----|--------------------|------|-------|------|----------------------|------|-------|------|-------------|
|                           |     |     |     |    | Vcc+               | Vcc- | EK    | Vicm | Vcc+                 | Vcc- | EK    | Vicm |             |
| Input Offset Voltage      | VF1 | ON  | ON  | ON | 5 to 30            | 0    | -1.4  | 0    | 5 to 30              | 0    | -1.4  | 0    | 1           |
| Input Offset Current      | VF2 | OFF | OFF | ON | 5                  | 0    | -1.4  | 0    | 5                    | 0    | -1.4  | 0    | 2           |
| Input Bias Current        | VF3 | OFF | ON  | ON | 5                  | 0    | -1.4  | 0    | 5                    | 0    | -1.4  | 0    | 3           |
|                           | VF4 | ON  | OFF |    | 5                  | 0    | -1.4  | 0    | 5                    | 0    | -1.4  | 0    |             |
| Large Signal Voltage Gain | VF5 | ON  | ON  | ON | 15                 | 0    | -1.4  | 0    | 15                   | 0    | -1.4  | 0    | 4           |
|                           | VF6 |     |     |    | 15                 | 0    | -11.4 | 0    | 15                   | 0    | -11.4 | 0    |             |

— Calculation —

1. Input offset voltage (Vio)

$$V_{io} = \frac{|VF1|}{1 + R_f/R_s} \text{ [V]}$$

2. Input offset current (Iio)

$$I_{io} = \frac{|VF2 - VF1|}{R_i(1 + R_f/R_s)} \text{ [A]}$$

3. Input bias current (Ib)

$$I_b = \frac{|VF4 - VF3|}{2 \times R_i(1 + R_f/R_s)} \text{ [A]}$$

4. Large signal voltage gain (Av)

$$A_v = 20 \times \text{Log} \frac{10 \times (1 + R_f/R_s)}{|VF6 - VF5|} \text{ [dB]}$$

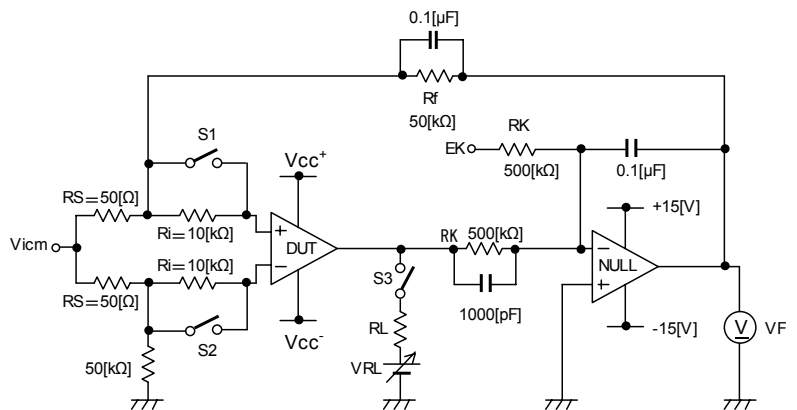


Fig.2 Measurement Circuit 1 (each Comparator)

## ● Measurement Circuit 2: Switch Condition

| SW No.                 |                        | SW<br>1 | SW<br>2 | SW<br>3 | SW<br>4 | SW<br>5 | SW<br>6 | SW<br>7 |
|------------------------|------------------------|---------|---------|---------|---------|---------|---------|---------|
| Supply Current         | —                      | OFF     | OFF     | OFF     | OFF     | OFF     | OFF     | OFF     |
| Output Sink Current    | VOL=1.5[V]             | OFF     | ON      | ON      | OFF     | ON      | ON      | OFF     |
| Saturation Voltage     | IOL=4[mA]              | OFF     | ON      | ON      | OFF     | OFF     | OFF     | ON      |
| Output Leakage Current | VOH=36[V]              | OFF     | ON      | ON      | OFF     | OFF     | OFF     | ON      |
| Response Time          | RL=5.1[kΩ]<br>VRL=5[V] | ON      | OFF     | ON      | ON      | OFF     | ON      | OFF     |

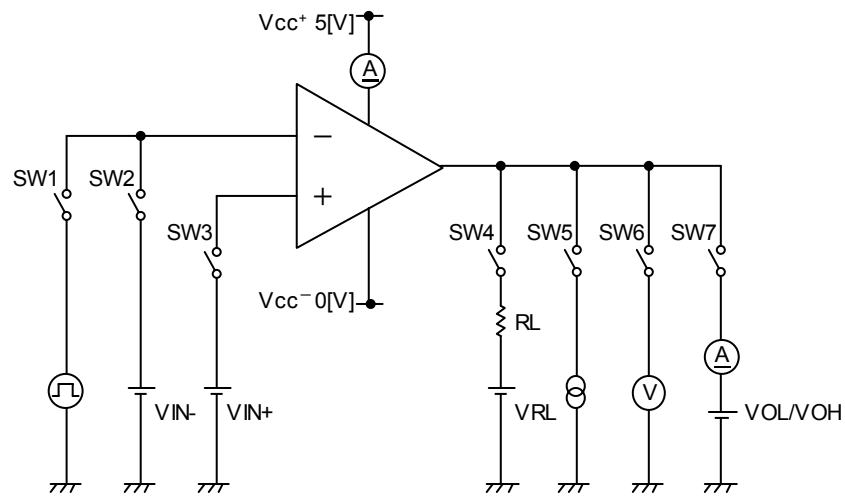


Fig.3 Measurement Circuit 2 (each Comparator)

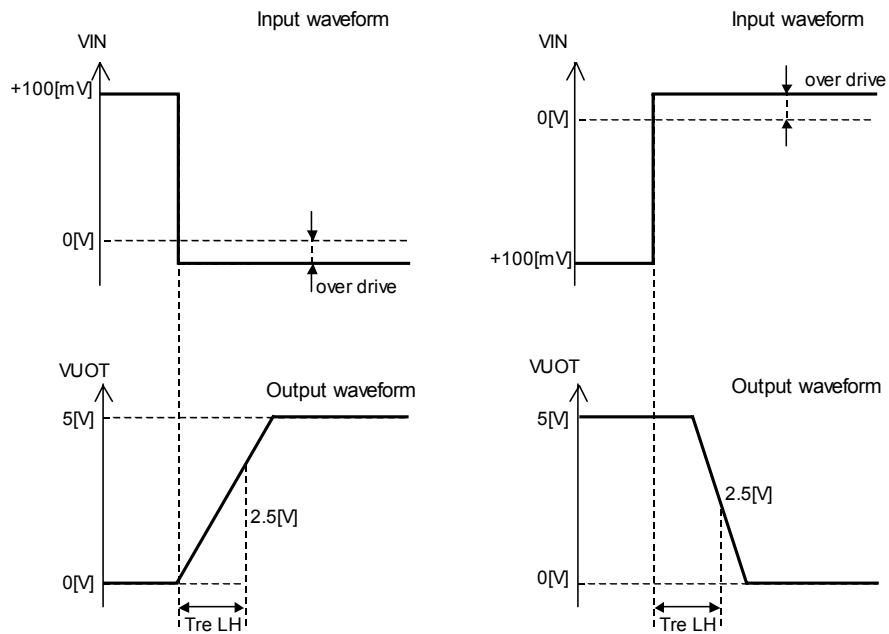


Fig.4 Response Time

## ● Description of Electrical Characteristics

Described below are descriptions of the relevant electrical terms.

Please note that item names, symbols, and their meanings may differ from those on another manufacturer's documents.

### 1. Absolute maximum ratings

The absolute maximum ratings are values that should never be exceeded, since doing so may result in deterioration of electrical characteristics or damage to the part itself as well as peripheral components.

#### 1.1 Power supply voltage ( $V_{cc}^+/V_{cc}$ )

Expresses the maximum voltage that can be supplied between the positive and negative power supply terminals without causing deterioration of the electrical characteristics or destruction of the internal circuitry.

#### 1.2 Differential input voltage (VID)

Indicates the maximum voltage that can be supplied between the non-inverting and inverting terminals without damaging the IC.

#### 1.3 Input common-mode voltage range (VICM)

Signifies the maximum voltage that can be supplied to non-inverting and inverting terminals without causing deterioration of the electrical characteristics or damage to the IC itself. Normal operation is not guaranteed within the input common-mode voltage range of the maximum ratings – use within the input common-mode voltage range of the electric characteristics instead.

#### 1.4 Operating temperature range and storage temperature range ( $T_{opr}, T_{stg}$ )

The operating temperature range indicates the temperature range within which the IC can operate. The higher the ambient temperature, the lower the power consumption of the IC. The storage temperature range denotes the range of temperatures the IC can be stored under without causing excessive deterioration of the electrical characteristics.

#### 1.5 Power dissipation ( $P_d$ )

Indicates the power that can be consumed by a particular mounted board at ambient temperature ( $25^\circ\text{C}$ ). For packaged products,  $P_d$  is determined by the maximum junction temperature and the thermal resistance.

### 2. Electric characteristics

#### 2.1 Input offset voltage (VIO)

Signifies the voltage difference between the non-inverting and inverting terminals. It can be thought of as the input voltage difference required for setting the output voltage to 0V.

#### 2.2 Input offset current (IIO)

Indicates the difference of the input bias current between the non-inverting and inverting terminals.

#### 2.3 Input bias current (IIB)

Denotes the current that flows into or out of the input terminal, it is defined by the average of the input bias current at the non-inverting terminal and the input bias current at the inverting terminal.

#### 2.4 Input common-mode voltage range (VICM)

Indicates the input voltage range under which the IC operates normally.

#### 2.5 Large signal differential voltage gain (AVD)

The amplifying rate (gain) of the output voltage against the voltage difference between the non-inverting and inverting terminals, it is (normally) the amplifying rate (gain) with respect to DC voltage.

$AVD = (\text{output voltage fluctuation}) / (\text{input offset fluctuation})$

#### 2.6 Supply current (ICC)

Indicates the current of the IC itself that flows under specific conditions and during no-load steady state.

#### 2.7 Low level output current (IOL)

Denotes the maximum current that can be output under specific output conditions.

#### 2.8 Low level output voltage (VOL)

Signifies the voltage range that can be output under specific output conditions.

#### 2.9 High level output current (IOH)

Indicates the current that flows into the IC under specific input and output conditions.

#### 2.10 Response time ( $T_{re}$ )

The interval between the application of input and output conditions.

#### 2.11 Common-mode rejection ratio (CMRR)

Denotes the ratio of fluctuation of the input offset voltage when the in-phase input voltage is changed (DC fluctuation).

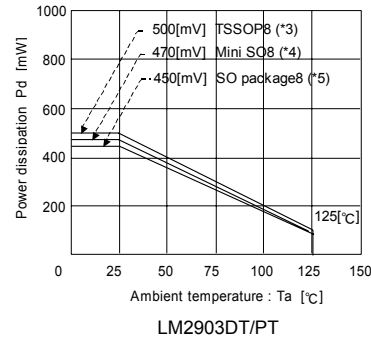
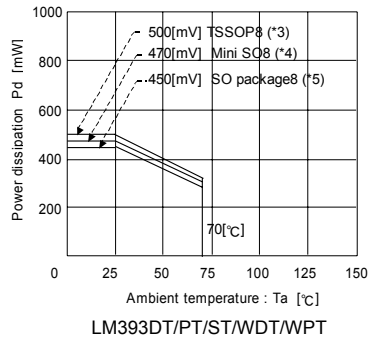
$CMRR = (\text{change in input common-mode voltage}) / (\text{input offset fluctuation})$

#### 2.12 Power supply rejection ratio (PSRR)

Signifies the ratio of fluctuation of the input offset voltage when the supply voltage is changed (DC fluctuation).

$PSRR = (\text{change in power supply voltage}) / (\text{input offset fluctuation})$

## Derating Curve



Power Dissipation

| Package          | Pd[W] | $\theta_{ja}$ [°C/W] |
|------------------|-------|----------------------|
| SO Package8 (*5) | 450   | 3.6                  |
| TSSOP8 (*3)      | 500   | 4.0                  |
| Mini SO8 (*4)    | 470   | 3.76                 |

$$\theta_{ja} = (T_j - T_a) / P_d [^{\circ}\text{C}/\text{W}]$$

Fig.5 Derating Curve

## Precautions

### 1) Unused circuits

When there are unused circuits it is recommended that they be connected as in Fig. 6, setting the non-inverting input terminal to a potential within the in-phase input voltage range (VICM).

### 2) Input terminal voltage

Applying  $V_{cc} + 36[\text{V}]$  to the input terminal is possible without causing deterioration of the electrical characteristics or destruction, irrespective of the supply voltage. However, this does not ensure normal circuit operation. Please note that the circuit operates normally only when the input voltage is within the common mode input voltage range of the electric characteristics.

### 3) Power supply (single / dual)

The op-amp operates when the specified voltage supplied is between  $V_{cc}^+$  and  $V_{cc}^-$ . Therefore, the single supply op-amp can be used as a dual supply op-amp as well.

### 4) Power dissipation Pd

Using the unit in excess of the rated power dissipation may cause deterioration in the electrical characteristics due to a rise in chip temperature, including reduced current capability. Therefore, please take into consideration the power dissipation (Pd) under actual operating conditions and apply a sufficient margin in thermal design. Refer to the thermal derating curves for more information.

### 5) Short-circuit between pins and erroneous mounting

Incorrect mounting may damage the IC. In addition, the presence of foreign particles between the outputs, the output and the power supply, or the output and  $V_{cc}^-$  may result in IC destruction.

### 6) Terminal short-circuits

When output and  $V_{cc}^+$  terminals are shorted, excessive output current may flow, resulting in undue heat generation and, subsequently, destruction.

### 7) Operation in a strong electromagnetic field

Operation in a strong electromagnetic field may cause malfunctions.

### 8) Radiation

This IC is not designed to withstand radiation.

### 9) IC handling

Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations in the electrical characteristics due to piezoelectric (piezo) effects.

### 10) Board inspection

Connecting a capacitor to a pin with low impedance may stress the IC. Therefore, discharging the capacitor after every process is recommended. In addition, when attaching and detaching the jig during the inspection phase, ensure that the power is turned OFF before inspection and removal. Furthermore, please take measures against ESD in the assembly process as well as during transportation and storage.

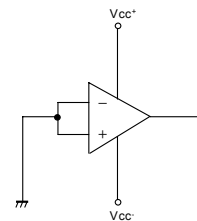
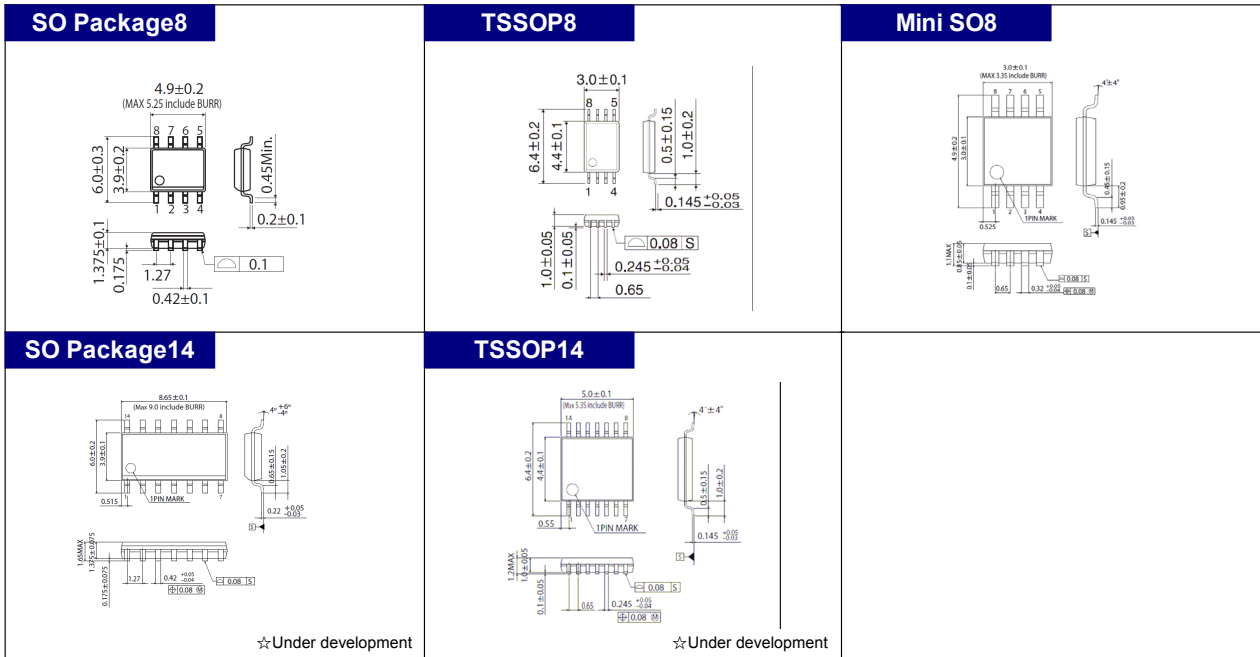


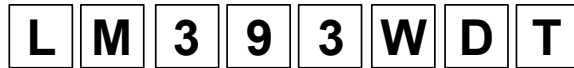
Fig.6 Disable circuit example

● Dimensions



● Part number explanation

- Specify the product by the part number when placing orders.
- Verify that the entire part number is correct.
- Start with the leftmost space without leaving any empty space between characters.



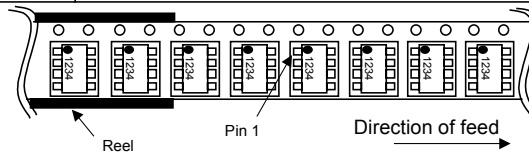
family name    ESD tolerance applicable    Package type    T : Reel

- LM393
- LM339
- LM2903
- LM2901

- W : 2kV
- None : Normal

- D : SO Package
- P : TSSOP
- S : Mini SO

|                   |  |
|-------------------|--|
| Tape              | Embossed carrier tape  |
| Quantity          | 2500pcs  |
| Direction of feed | Pin 1 is at the upper left holding the reel with the left hand while pulling the tape out with the right |



※Please order in multiples of the minimum package quantity.