

## Micropower quad CMOS voltage comparators

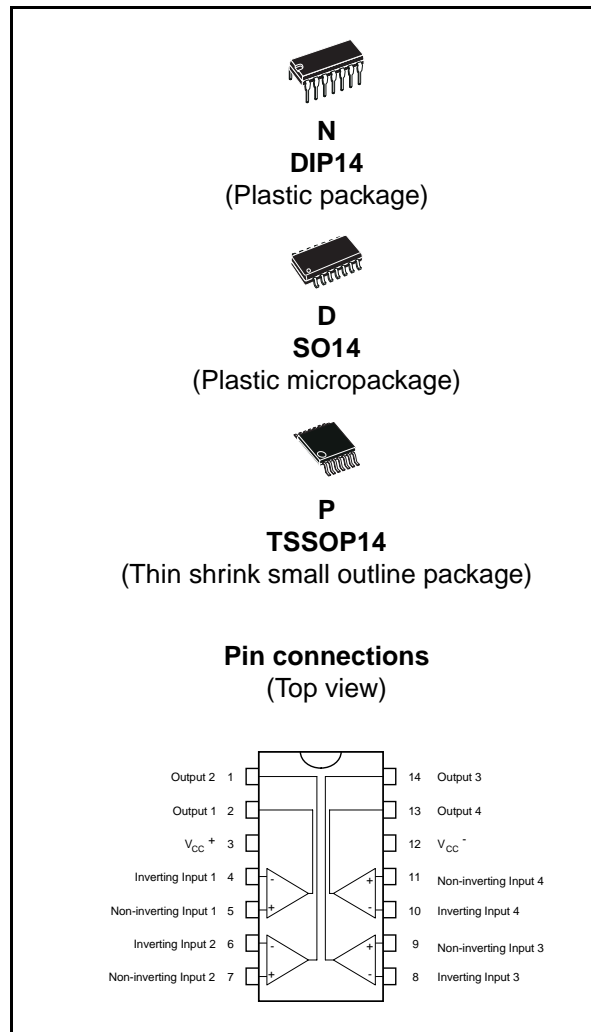
### Features

- Push-pull CMOS output (no external pull-up resistor required)
- Extremely low supply current: 9µA typ per comparator
- Wide single supply range 2.7V to 16V or dual supplies (±1.35V to ±8V)
- Extremely low input bias current: 1pA typ
- Extremely low input offset current: 1pA typ
- Input common-mode voltage range includes GND
- High input impedance:  $10^{12}\Omega$  typ
- Last response time: 2µs typ. for 5mV overdrive
- Pin-to-pin and functionally compatible with bipolar LM339

### Description

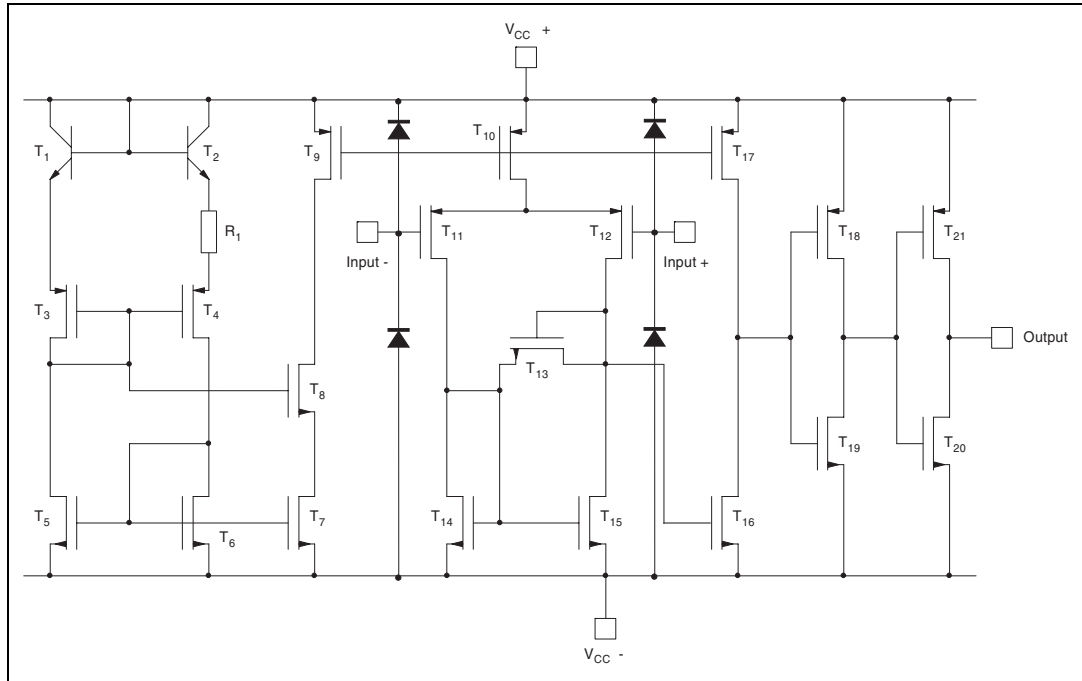
The TS3704 is a micropower CMOS quad voltage comparator with extremely low consumption of 9µA typ / comparator (20 times less than bipolar LM339). The push-pull CMOS output stage allows power and space saving by eliminating the external pull-up resistor required by usual open-collector output comparators.

Thus response times remain similar to the LM339.



# 1 Schematic diagram

Figure 1. Schematic diagram (for 1/4 TS3704)



## 2 Absolute maximum ratings

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter  | Value       | Unit |
|------------|--|-------------|------|
| $V_{CC}^+$ | Supply voltage <sup>(1)</sup>                                    | 18          | V    |
| $V_{id}$   | Differential input voltage <sup>(2)</sup>                        | $\pm 18$    | V    |
| $V_i$      | Input voltage <sup>(3)</sup>                                     | 18          | V    |
| $V_o$      | Output voltage   | 18          | V    |
| $I_o$      | Output current   | 20          | mA   |
| $I_F$      | Forward current in ESD protection diodes on input <sup>(4)</sup> | 50          | mA   |
| $P_d$      | Power dissipation <sup>(5)</sup>                                 |             |      |
|            | DIP14  | 1500        | mW   |
|            | SO14   | 830         |      |
| TSSOP14    | 710  |             |      |
| $T_{stg}$  | Storage temperature range  | -65 to +150 | °C   |
| ESD        | HBM: human body model <sup>(6)</sup>                             | 500         | V    |
|            | MM: machine model <sup>(7)</sup>                                 | 50          | V    |
|            | CDM: charged device model <sup>(8)</sup>                         | 1.5         | kV   |

- All voltage values, except differential voltage, are with respect to network ground terminal.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- The magnitude of the input and the output voltages must never exceed the magnitude of the positive and negative supply voltages.
- Guaranteed by design.
- $P_d$  is calculated with  $T_{amb} = +25^\circ\text{C}$ ,  $T_j = +150^\circ\text{C}$  and  
 $R_{thja} = 80^\circ\text{C/W}$  for DIP14 package  
 $R_{thja} = 150^\circ\text{C/W}$  for SO14 package  
 $R_{thja} = 175^\circ\text{C/W}$  for TSSOP14 package
- Human body model: A 100pF capacitor is charged to the specified voltage, then discharged through a 1.5k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- Machine model: A 200pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
- Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

**Table 2. Operating conditions**

| Symbol     | Parameter   | Value                                  | Unit |
|------------|---|--|------|
| $V_{CC}^+$ | Supply voltage<br>TS3704C, TS3704I<br>TS3704M                         | 2.7 to 16<br>4 to 16                   | V    |
| $V_{icm}$  | Common mode input voltage range                                       | 0 to $V_{CC}^+ - 1.5$                  | V    |
| $T_{oper}$ | Operating free-air temperature range<br>TS3704C<br>TS3704I<br>TS3704M | 0 to +70<br>-40 to +125<br>-55 to +125 | °C   |

### 3 Electrical characteristics

**Table 3.**  $V_{CC}^+ = 3V$ ,  $V_{CC}^- = 0V$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

| Symbol    | Parameter  | Min.     | Typ.       | Max.                                 | Unit    |
|-----------|--|----------|------------|--------------------------------------|---------|
| $V_{io}$  | Input offset voltage <sup>(1)</sup><br>$V_{ic} = 1.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$          |          |            | 5<br>6.5                             | mV      |
| $I_{io}$  | Input offset current <sup>(2)</sup><br>$V_{ic} = 1.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$          |          | 1          | 300                                  | pA      |
| $I_{ib}$  | Input bias current <sup>(2)</sup><br>$V_{ic} = 1.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$            |          | 1          | 600                                  | pA      |
| $V_{icm}$ | Input common mode voltage range<br>$T_{min} \leq T_{amb} \leq T_{max}$                                 | 0<br>0   |            | $V_{CC}^+ - 1.2$<br>$V_{CC}^+ - 1.5$ | V       |
| CMR       | Common-mode rejection ratio<br>$V_{ic} = V_{icm\ min}$   |          | 80         |                                      | dB      |
| SVR       | Supply voltage rejection ratio<br>$V_{CC}^+ = 3V$ to $5V$  |          | 75         |                                      | dB      |
| $V_{OH}$  | High level output voltage<br>$V_{id} = 1V$ , $I_{OH} = -4mA$<br>$T_{min} \leq T_{amb} \leq T_{max}$    | 2<br>1.8 | 2.4        |                                      | V       |
| $V_{OL}$  | Low level output voltage<br>$V_{id} = -1V$ , $I_{OL} = 4mA$<br>$T_{min} \leq T_{amb} \leq T_{max}$     |          | 300        | 400<br>575                           | mV      |
| $I_{CC}$  | Supply current (each comparator)<br>No load - Outputs low<br>$T_{min} \leq T_{amb} \leq T_{max}$       |          | 7          | 20<br>25                             | $\mu A$ |
| $t_{PLH}$ | Response time low to high<br>$V_{ic} = 0V$ , $f = 10kHz$ , $C_L = 50pF$ , overdrive = 5mV<br>TTL input |          | 1.2<br>0.7 |                                      | $\mu s$ |
| $t_{PHL}$ | Response time high to low<br>$V_{ic} = 0V$ , $f = 10kHz$ , $C_L = 50pF$ , overdrive = 5mV<br>TTL input |          | 2<br>0.15  |                                      | $\mu s$ |

1. The specified offset voltage is the maximum value required to drive the output up to 2.5V or down to 0.3V.
2. Maximum values include unavoidable inaccuracies of the industrial tests.

Table 4.  $V_{CC}^+ = 5V$ ,  $V_{CC}^- = 0V$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

| Symbol    | Parameter  | Min.       | Typ.                           | Max.                                 | Unit    |
|-----------|--|------------|--------------------------------|--------------------------------------|---------|
| $V_{io}$  | Input offset voltage <sup>(1)</sup><br>$V_{ic} = 2.5V$ , $V_{CC}^+ = 5V$ to $10V$<br>$T_{min} \leq T_{amb} \leq T_{max}$   |            | 1.2                            | 5<br>6.5                             | mV      |
| $I_{io}$  | Input offset current <sup>(2)</sup><br>$V_{ic} = 2.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |            | 1                              | 300                                  | pA      |
| $I_{ib}$  | Input bias current <sup>(2)</sup><br>$V_{ic} = 2.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |            | 1                              | 600                                  | pA      |
| $V_{icm}$ | Input common mode voltage range<br>$T_{min} \leq T_{amb} \leq T_{max}$   | 0<br>0     |                                | $V_{CC}^+ - 1.2$<br>$V_{CC}^+ - 1.5$ | V       |
| CMR       | Common-mode rejection ratio<br>$V_{ic} = V_{icm \text{ min}}$  |            | 80                             |                                      | dB      |
| SVR       | Supply voltage rejection ratio<br>$V_{CC}^+ = +5V$ to $+10V$   |            | 92                             |                                      | dB      |
| $V_{OH}$  | High level output voltage<br>$V_{id} = 1V$ , $I_{OH} = -4mA$<br>$T_{min} \leq T_{amb} \leq T_{max}$  | 4.5<br>4.3 | 4.7                            |                                      | V       |
| $V_{OL}$  | Low level output voltage<br>$V_{id} = -1V$ , $I_{OL} = 4mA$<br>$T_{min} \leq T_{amb} \leq T_{max}$   |            | 200                            | 300<br>375                           | mV      |
| $I_{CC}$  | Supply current (each comparator)<br>No load - Outputs low  |            | 9                              | 20<br>25                             | $\mu A$ |
| $t_{PLH}$ | Response time low to high<br>$V_{ic} = 0V$ , $f = 10kHz$ , $C_L = 50pF$ , overdrive = $5mV$<br>Overdrive = $10mV$<br>Overdrive = $20mV$<br>Overdrive = $40mV$<br>TTL input |            | 1.2<br>1<br>0.9<br>0.8<br>0.7  |                                      | $\mu s$ |
| $t_{PHL}$ | Response time high to low<br>$V_{ic} = 0V$ , $f = 10kHz$ , $C_L = 50pF$ , overdrive = $5mV$<br>Overdrive = $10mV$<br>Overdrive = $20mV$<br>Overdrive = $40mV$<br>TTL input |            | 2<br>1.5<br>0.9<br>0.7<br>0.15 |                                      | $\mu s$ |
| $t_f$     | Fall time<br>$f = 10kHz$ , $C_L = 50pF$ , overdrive $50mV$   |            | 30                             |                                      | ns      |

1. The specified offset voltage is the maximum value required to drive the output up to  $4.5V$  or down to  $0.3V$ .
2. Maximum values include unavoidable inaccuracies of the industrial tests.

## 4 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

### 4.1 DIP14 package mechanical data

| Ref. | Dimensions  |       |      |        |       |       |
|------|-------------|-------|------|--------|-------|-------|
|      | Millimeters |       |      | Inches |       |       |
|      | Min.        | Typ.  | Max. | Min.   | Typ.  | Max.  |
| a1   | 0.51        |       |      | 0.020  |       |       |
| B    | 1.39        |       | 1.65 | 0.055  |       | 0.065 |
| b    |             | 0.5   |      |        | 0.020 |       |
| b1   |             | 0.25  |      |        | 0.010 |       |
| D    |             |       | 20   |        |       | 0.787 |
| E    |             | 8.5   |      |        | 0.335 |       |
| e    |             | 2.54  |      |        | 0.100 |       |
| e3   |             | 15.24 |      |        | 0.600 |       |
| F    |             |       | 7.1  |        |       | 0.280 |
| l    |             |       | 5.1  |        |       | 0.201 |
| L    |             | 3.3   |      |        | 0.130 |       |
| Z    | 1.27        |       | 2.54 | 0.050  |       | 0.100 |

### 4.2 SO14 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.068 |
| a1   | 0.1         |      | 0.2  | 0.003  |       | 0.007 |
| a2   |             |      | 1.65 |        |       | 0.064 |
| b    | 0.35        |      | 0.46 | 0.013  |       | 0.018 |
| b1   | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C    |             | 0.5  |      |        | 0.019 |       |
| c1   | 45° (typ.)  |      |      |        |       |       |
| D    | 8.55        |      | 8.75 | 0.336  |       | 0.344 |
| E    | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e    |             | 1.27 |      |        | 0.050 |       |
| e3   |             | 7.62 |      |        | 0.300 |       |
| F    | 3.8         |      | 4.0  | 0.149  |       | 0.157 |
| G    | 4.6         |      | 5.3  | 0.181  |       | 0.208 |
| L    | 0.5         |      | 1.27 | 0.019  |       | 0.050 |
| M    |             |      | 0.68 |        |       | 0.026 |
| S    | 8° (max.)   |      |      |        |       |       |

The figure contains three mechanical drawings of the SO14 package:

- Top View:** Shows the package footprint with dimensions D (total length), M (lead length), and F (width). Pin positions are labeled 1, 7, 8, and 14.
- Side View:** Shows the package height with dimensions A (total height), a2 (lead height), b (lead width), e (pitch), and e3 (total width).
- Perspective View:** Shows the package with dimensions L (lead length), G (lead width), C (lead thickness), c1 (lead angle), a1 (lead width), b1 (lead width), and S (lead angle).



### 4.3 TSSOP14 package mechanical data

Figure 2. TSSOP14 package

| Ref. | Dimensions  |          |      |        |            |        |
|------|-------------|----------|------|--------|------------|--------|
|      | Millimeters |          |      | Inches |            |        |
|      | Min.        | Typ.     | Max. | Min.   | Typ.       | Max.   |
| A    |             |          | 1.2  |        |            | 0.047  |
| A1   | 0.05        |          | 0.15 | 0.002  | 0.004      | 0.006  |
| A2   | 0.8         | 1        | 1.05 | 0.031  | 0.039      | 0.041  |
| b    | 0.19        |          | 0.30 | 0.007  |            | 0.012  |
| c    | 0.09        |          | 0.20 | 0.004  |            | 0.0089 |
| D    | 4.9         | 5        | 5.1  | 0.193  | 0.197      | 0.201  |
| E    | 6.2         | 6.4      | 6.6  | 0.244  | 0.252      | 0.260  |
| E1   | 4.3         | 4.4      | 4.48 | 0.169  | 0.173      | 0.176  |
| e    |             | 0.65 BSC |      |        | 0.0256 BSC |        |
| K    | 0°          |          | 8°   | 0°     |            | 8°     |
| L    | 0.45        | 0.60     | 0.75 | 0.018  | 0.024      | 0.030  |

The figure includes three mechanical drawings of the TSSOP14 package. The top-left drawing is a side view showing dimensions A (total height), A1 (lead height), A2 (lead thickness), b (lead width), e (pitch), and c (lead length). The top-right drawing is a cross-sectional view showing dimensions K (lead thickness), L (lead length), and E (package width). The bottom drawing is a top-down view showing dimensions D (package length), E1 (package width), and a PIN 1 IDENTIFICATION circle with the number 1.

## 5 Ordering information

**Table 5. Order codes**

| Part number  | Temperature range | Package | Packaging           | Marking  |
|--------------|-------------------|---------|---------------------|----------|
| TS3704CN     | 0°C, +70°C        | DIP14   | Tube                | TS3704CN |
| TS3704CD/CDT |                   | SO14    | Tube or tape & reel | 3704C    |
| TS3704IN     | -40°C, +125°C     | DIP14   | Tube                | TS3704IN |
| TS3704ID/IDT |                   | SO14    | Tube or tape & reel | 3704I    |
| TS3704IPT    |                   | TSSOP14 | Tape & reel         | 3704I    |
| TS3704MN     | -55°C, +125°C     | DIP14   | Tube                | TS3704MN |
| TS3704MD/MDT |                   | SO14    | Tube or tape & reel | 3704M    |
| TS3704MPT    |                   | TSSOP14 | Tape & reel         | 3704M    |

## 6 Revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 1-Oct-2004  | 1        | Initial release.  |
| 1-Aug-2005  | 2        | 1 - PPAP references inserted in the datasheet.<br>2 - ESD protection inserted in <a href="#">Table 1 on page 3</a> .  |
| 26-Feb-2007 | 3        | PPAP references removed.<br>Updated footnotes related to ESD in <a href="#">Table 1 on page 3</a> .<br>Added <a href="#">Table 2 on page 3</a> .<br>Order codes added to <a href="#">Table 5 on page 10</a> . |

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