

## High performance CMOS quad operational amplifier

### Features

- Output voltage can swing to ground
- Excellent phase margin on capacitive loads
- Gain bandwidth product: 3.5 MHz
- Unity gain stable
- Two input offset voltage selections

### Description

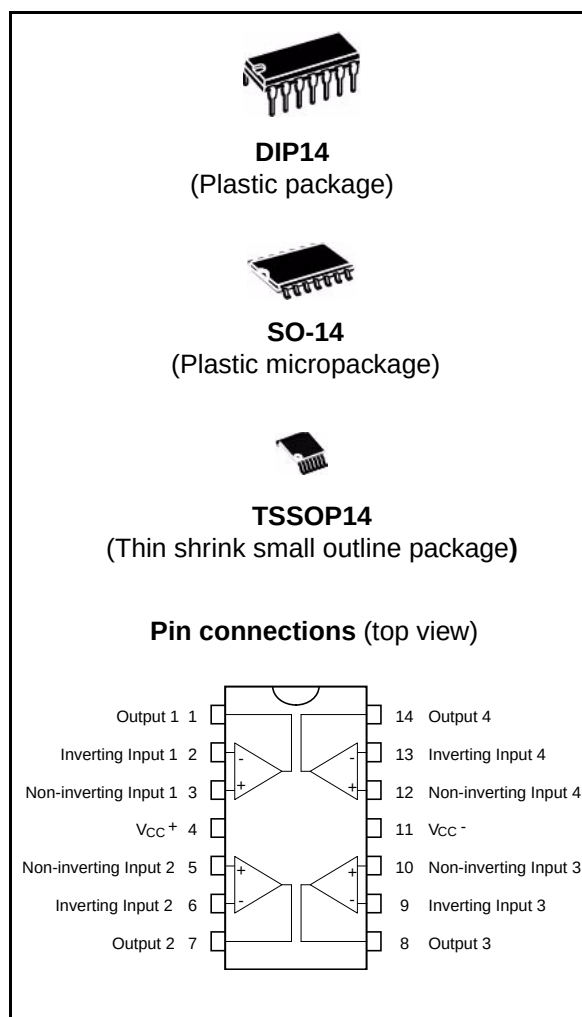
The TS274 devices are low cost, quad operational amplifiers designed to operate with single or dual supplies. These operational amplifiers use the ST silicon gate CMOS process giving an excellent consumption-speed ratio. These series are ideally suited for low consumption applications.

Three power consumptions are available thus offering the best consumption-speed ratio for your application:

- $I_{CC} = 10 \mu\text{A/amp}$ : TS27L4 (very low power)
- $I_{CC} = 150 \mu\text{A/amp}$ : TS27M4 (low power)
- $I_{CC} = 1 \text{ mA/amp}$ : TS274 (standard)

These CMOS amplifiers offer very high input impedance and extremely low input currents. The major advantage versus JFET devices is the very low input currents drift with temperature (see [Figure 5 on page 6](#)).

For enhanced features of TS274, in particular rail-to-rail capability and low offset voltage, two new



families, TSV91x and TSV99x will better suit low voltage applications.

**Table 1. Enhanced related families**

| Part number | V <sub>CC</sub> range (V) | Rail-to-rail I/O | V <sub>io</sub> max (mV) | I <sub>ib</sub> max (pA) | A <sub>vd</sub> min (dB) | I <sub>CC</sub> max (mA) | GBP typ (MHz) | SR typ (V/μs) | Packages       |
|-------------|---------------------------|------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------|---------------|----------------|
| TSV914      | 2.5 - 5.5                 | I/O              | 1.5/4.5                  | 10                       | 80                       | 1.1                      | 8             | 4.5           | SO-14, TSSOP14 |
| TSV994      | 2.5 - 5.5                 | I/O              | 1.5/4.5                  | 10                       | 80                       | 1.1                      | 20 (G ≥ 3)    | 10            | SO-14, TSSOP14 |

# 1 Absolute maximum ratings and operating conditions

**Table 2. Absolute maximum ratings (AMR)**

| Symbol       | Parameter                                                                          | TS274C/AC        | TS274I/AI   | Unit |
|--------------|------------------------------------------------------------------------------------|------------------|-------------|------|
| $V_{CC}^{+}$ | Supply voltage <sup>(1)</sup>                                                      | 18               |             | V    |
| $V_{id}$     | Differential input voltage <sup>(2)</sup>                                          | $\pm 18$         |             | V    |
| $V_{in}$     | Input voltage <sup>(3)</sup>                                                       | -0.3 to 18       |             | V    |
| $I_o$        | Output current for $V_{CC}^{+} \geq 15V$                                           | $\pm 30$         |             | mA   |
| $I_{in}$     | Input current                                                                      | $\pm 5$          |             | mA   |
| $T_{oper}$   | Operating free-air temperature range                                               | 0 to +70         | -40 to +125 | °C   |
| $T_{stg}$    | Storage temperature range                                                          | -65 to +150      |             | °C   |
| $R_{thja}$   | Thermal resistance junction to ambient <sup>(4)</sup><br>SO-14<br>TSSOP14<br>DIP14 | 103<br>100<br>80 |             | °C/W |
| $R_{thjc}$   | Thermal resistance junction to case<br>SO-14<br>TSSOP14<br>DIP14                   | 31<br>32<br>33   |             | °C/W |
| ESD          | HBM: human body model <sup>(5)</sup>                                               | 500              |             | V    |
|              | MM: machine model <sup>(6)</sup>                                                   | 100              |             | V    |
|              | CDM: charged device model <sup>(7)</sup>                                           | 800              |             | V    |

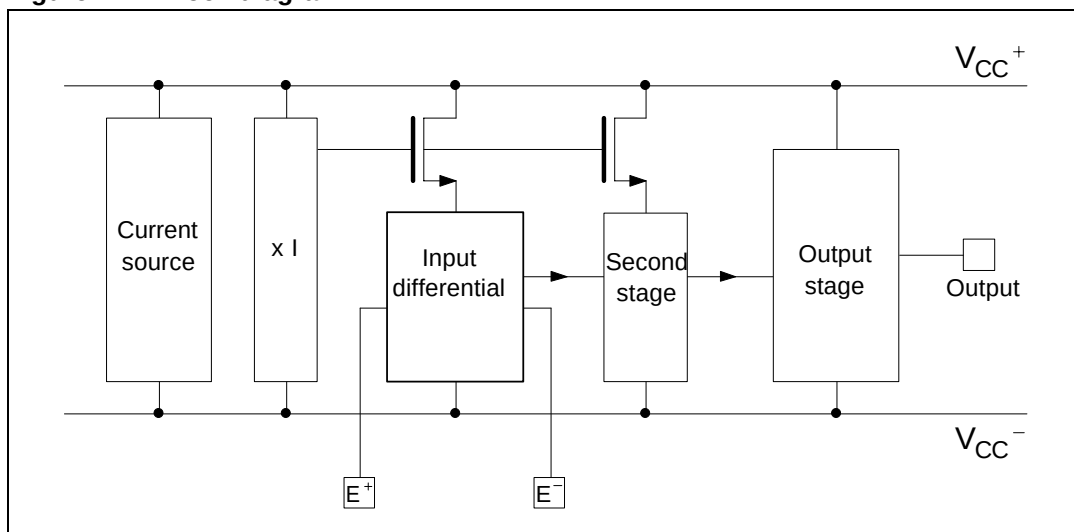
1. All values, except differential voltage are with respect to network ground terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of the input and the output voltages must never exceed the magnitude of the positive supply voltage.
4. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
5. 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.
6. 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.
7. 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 3. Operating conditions**

| Symbol       | Parameter                                                | Value                   | Unit |
|--------------|----------------------------------------------------------|-------------------------|------|
| $V_{CC}^{+}$ | Supply voltage                                           | 3 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>TS274C<br>TS274I | 0 to 70<br>-40 to 125   | °C   |

## 2 Block diagram and circuit schematics

Figure 1. Block diagram



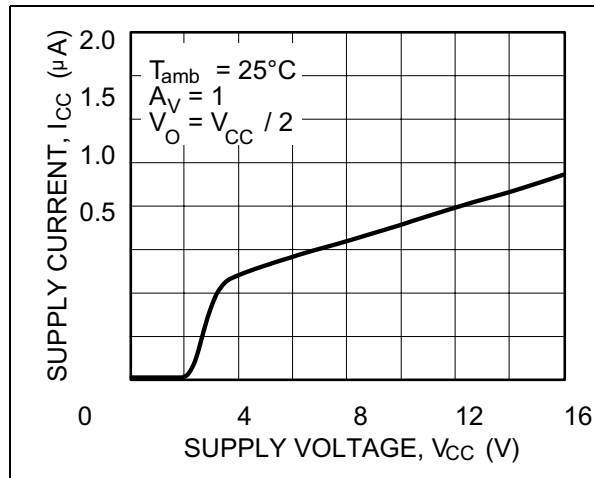
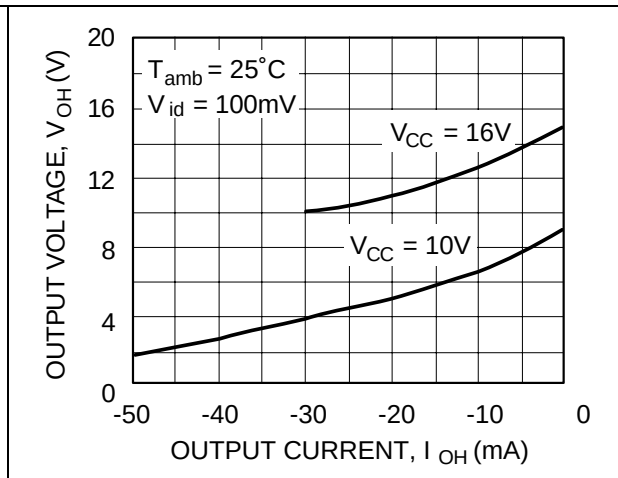
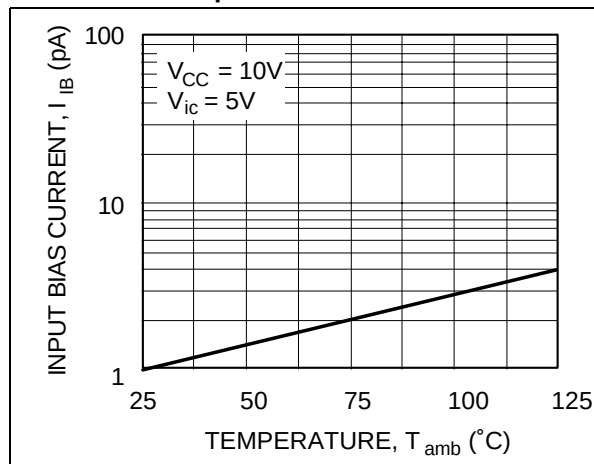
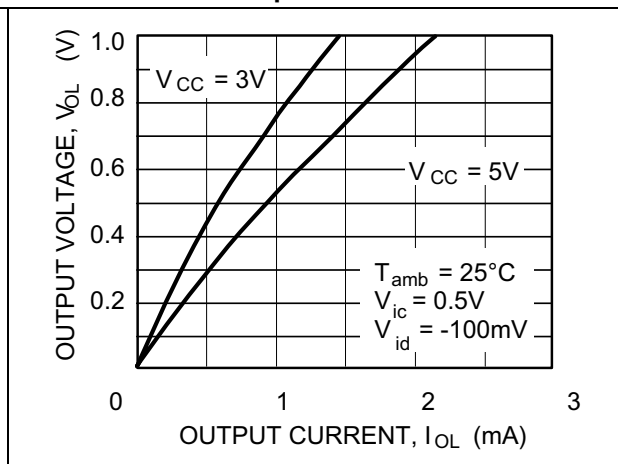
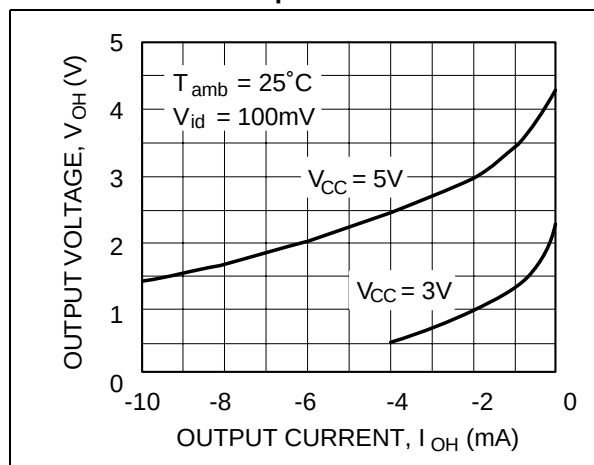
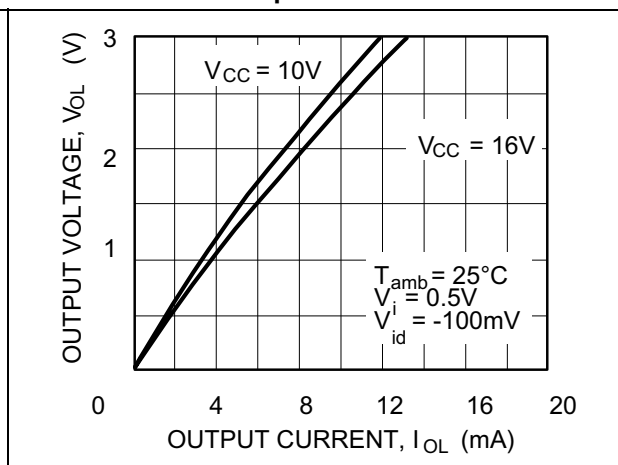
The circuit diagram illustrates a 2N7000-based 10-bit DAC. It consists of a 2N7000 MOSFET (T1) at the input, followed by a network of 27 MOSFETs (T2-T28) and 2 resistors (R1, R2) and 1 capacitor (C1). The output is taken from the drain of T16. The circuit is powered by VCC+ and VCC-.

### 3 Electrical characteristics

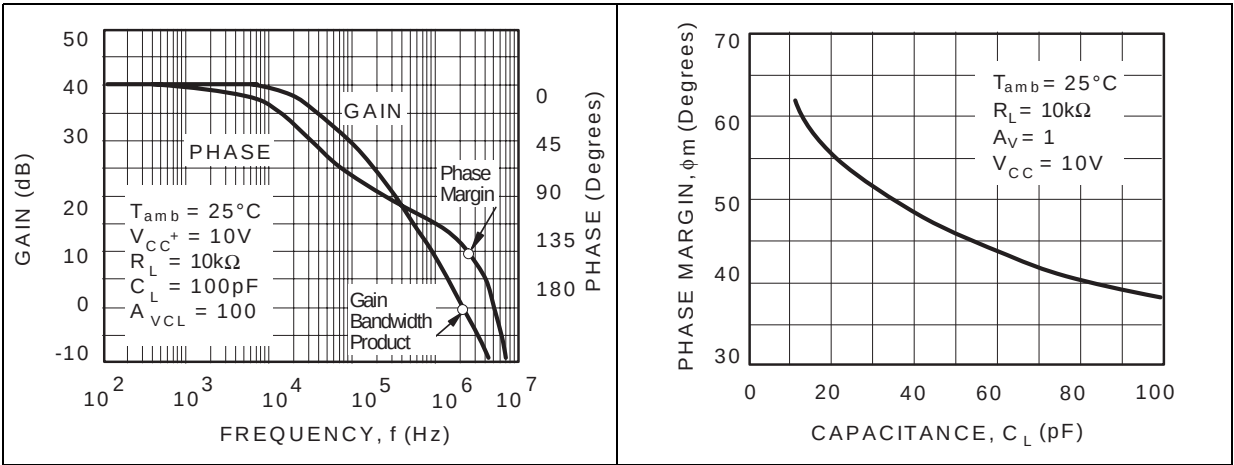
Table 4.  $V_{CC}^+ = +10V$ ,  $V_{CC}^- = 0V$ ,  $T_{amb} = +25^\circ C$  (unless otherwise specified)

| Symbol          | Parameter                           | Conditions                                                                                       | TS274C/AC  |            |              | TS274I/AI |            |              | Unit             |
|-----------------|-------------------------------------|--------------------------------------------------------------------------------------------------|------------|------------|--------------|-----------|------------|--------------|------------------|
|                 |                                     |                                                                                                  | Min        | Typ        | Max          | Min       | Typ        | Max          |                  |
| $V_{io}$        | Input offset voltage                | $V_o = 1.4V$ , $V_{ic} = 0V$<br>TS274C/I<br>TS274AC/AI                                           |            | 1.1<br>0.9 | 10<br>5      |           | 1.1<br>0.9 | 10<br>5      | mV               |
|                 |                                     | $T_{min} \leq T_{amb} \leq T_{max}$<br>TS274C/I<br>TS274AC/AI                                    |            |            | 12<br>6.5    |           |            | 12<br>6.5    | mV               |
| $DV_{io}$       | Input offset voltage drift          |                                                                                                  |            | 2          |              |           | 2          |              | $\mu V/^\circ C$ |
| $I_{io}$        | Input offset current <sup>(1)</sup> | $V_{ic} = 5V$ , $V_o = 5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                |            | 1          | 100          |           | 1          | 200          | pA               |
| $I_{ib}$        | Input bias current <sup>(1)</sup>   | $V_{ic} = 5V$ , $V_o = 5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$                                |            | 1          | 150          |           | 1          | 300          | pA               |
| $V_{OH}$        | High level output voltage           | $V_{id} = 100mV$ , $R_L = 10k\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$                      | 8.2<br>8.1 | 8.4        |              | 8.2<br>8  | 8.4        |              | V                |
| $V_{OL}$        | Low level output voltage            | $V_{id} = -100mV$                                                                                |            |            | 50           |           |            | 50           | mV               |
| $A_{vd}$        | Large signal voltage gain           | $V_{ic} = 5V$ , $R_L = 10k\Omega$ ,<br>$V_o = 1V$ to $6V$<br>$T_{min} \leq T_{amb} \leq T_{max}$ | 10<br>7    | 15         |              | 10<br>6   | 15         |              | V/mV             |
|                 |                                     |                                                                                                  |            |            |              |           |            |              |                  |
| GBP             | Gain bandwidth product              | $A_v = 40dB$ , $R_L = 10k\Omega$ ,<br>$C_L = 100pF$ , $f_{in} = 100kHz$                          |            | 3.5        |              |           | 3.5        |              | MHz              |
| CMR             | Common mode rejection ratio         | $V_{ic} = 1V$ to $7.4V$ , $V_o = 1.4V$                                                           | 65         | 80         |              | 65        | 80         |              | dB               |
| SVR             | Supply voltage rejection ratio      | $V_{CC}^+ = 5V$ to $10V$ , $V_o = 1.4V$                                                          | 60         | 70         |              | 60        | 70         |              | dB               |
| $I_{CC}$        | Supply current (per amplifier)      | $A_v = 1$ , no load, $V_o = 5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$                           |            | 1000       | 1500<br>1600 |           | 1000       | 1500<br>1700 | $\mu A$          |
| $I_o$           | Output short circuit current        | $V_o = 0V$ , $V_{id} = 100mV$                                                                    |            | 60         |              |           | 60         |              | mA               |
| $I_{sink}$      | Output sink current                 | $V_o = V_{CC}$ , $V_{id} = -100mV$                                                               |            | 45         |              |           | 45         |              | mA               |
| SR              | Slew rate at unity gain             | $R_L = 10k\Omega$ , $C_L = 100pF$ ,<br>$V_{in} = 3$ to $7V$                                      |            | 5.5        |              |           | 5.5        |              | V/ $\mu s$       |
| $\phi_m$        | Phase margin at unity gain          | $A_v = 40dB$ , $R_L = 10k\Omega$ ,<br>$C_L = 100pF$                                              |            | 40         |              |           | 40         |              | Degrees          |
| $K_{OV}$        | Overshoot factor                    |                                                                                                  |            | 30         |              |           | 30         |              | %                |
| $e_n$           | Equivalent input noise voltage      | $f = 1kHz$ , $R_s = 100\Omega$                                                                   |            | 30         |              |           | 30         |              | nV/ $\sqrt{Hz}$  |
| $V_{o1}/V_{o2}$ | Channel separation                  |                                                                                                  |            | 120        |              |           | 120        |              | dB               |

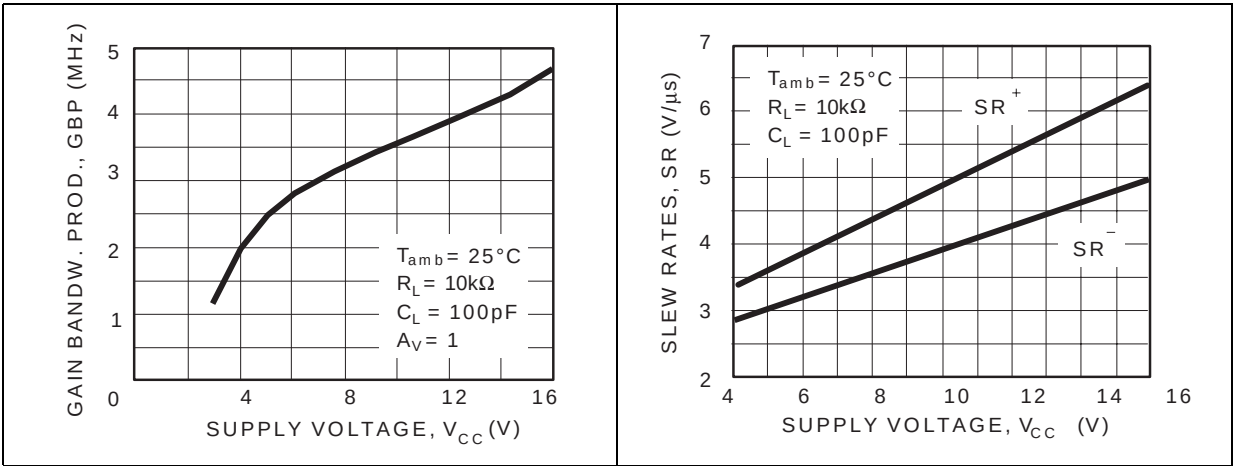
1. Maximum values including unavoidable inaccuracies of the industrial test.

**Figure 3. Supply current (each amplifier) vs. supply voltage****Figure 4. High level output voltage vs. high level output current****Figure 5. Input bias current vs. free-air temperature****Figure 6. Low level output voltage vs. low level output current****Figure 7. High level output voltage vs. high level output current****Figure 8. Low level output voltage vs. low level output current**

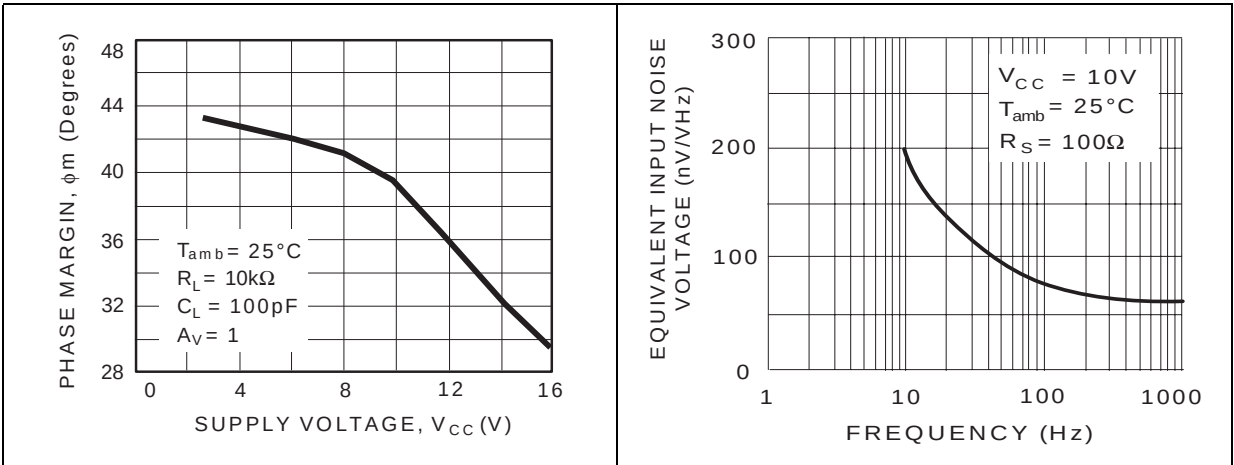
**Figure 9. Open loop frequency response and phase shift** **Figure 10. Phase margin vs. capacitive load**



**Figure 11. Gain bandwidth product vs. supply voltage** **Figure 12. Slew rate vs. supply voltage**



**Figure 13. Phase margin vs. supply voltage** **Figure 14. Input voltage noise vs. frequency**



## 4 Macromodel

### 4.1 Important note concerning this macromodel

Please consider the following remarks before using this macromodel.

- All models are a trade-off between accuracy and complexity (i.e. simulation time).
- Macromodels are not a substitute to breadboarding; rather, they confirm the validity of a design approach and help to select surrounding component values.
- A macromodel emulates the **nominal** performance of a **typical** device within **specified operating conditions** (temperature, supply voltage, for example). Thus the macromodel is often not as exhaustive as the datasheet, its purpose is to illustrate the main parameters of the product.

Data derived from macromodels used outside of the specified conditions ( $V_{CC}$ , temperature, for example) or even worse, outside of the device operating conditions ( $V_{CC}$ ,  $V_{icm}$ , for example), is not reliable in any way.

### 4.2 Macromodel code

```
*****
.SUBCKT TS27X 1 2 3 4 5
*** INP- = 1, INP+ =2, OUT = 3 VDD=4 VSS = 5
*** TYPE = TS271/TS272/TS274
.MODEL MDTH D IS=1E-8 KF=2.664E-16 CJO=10F
***INPUT STAGE
CIP 2 5 1E-12
CIN 1 5 1E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 8
RIN 15 16 8
RIS 11 15 223.84
CPS 11 15 1E-9
DIP 11 120 MDTH 400E-12
DIN 15 140 MDTH 400E-12
RDEG1 12 120 4400
RDEG2 14 140 4400
VOFP 12 13 DC 0
VOFN 13 14 DC 0
IPOL 13 5 38E-6
***ICC
DICC1 4 31 MDTH 400E-12
DICC2 31 32 MDTH 400E-12
DICC3 32 33 MDTH 400E-12
DICC4 33 34 MDTH 400E-12
RICC 34 5 20E3
ICC 4 5 600E-6
***COMMON MODE INPUT LIMITATION
DINN 17 13 MDTH 400E-12
VIN 17 5 DC -0.1
```



```
DINR 15 18 MDTH 400E-12
VIP 4 18 DC 2.2
***GM1 STAGE
FGM1P 119 5 VOFP 1
FGM1N 119 5 VOFN 1
RAP 119 4 1E6
RAN 119 5 1E6
***GM2 STAGE
G2P 19 5 119 5 4E-4
G2N 19 5 119 4 4E-4
R2P 19 4 450E3
R2N 19 5 450E3
***COMPENSATION
CC 19 119 7p
***BUFFER
EBUF 20 5 19 5 1
***SHORT-CIRCUIT LIMITATIONS( ISINK, ISOURCE)
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 910
VIPM 28 4 DC 50
HONM 21 27 VOUT 1222
VINM 5 27 DC 50
VOUT 3 23 DC 0
***VOH, VOL DEFINITIONS
DOP 19 25 MDTH 400E-12
VOP 4 25 2.5
DON 24 19 MDTH 400E-12
VON 24 5 0.92
***OUTPUT RESISTOR
ROUT 23 20 10
.ENDS
```

## 5 Package information

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> 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 ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

### 5.1 DIP14 package information

Figure 15. DIP14 package mechanical drawing

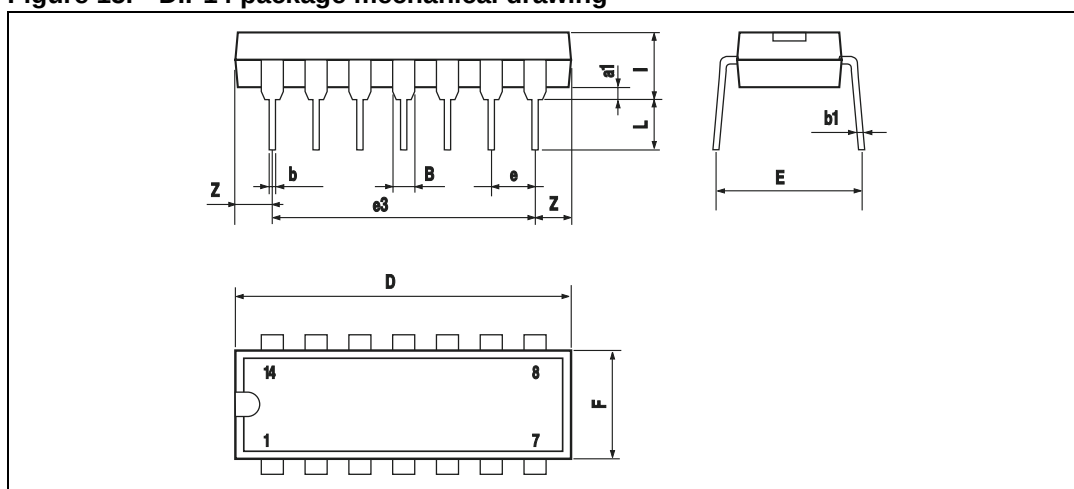


Table 5. DIP14 package mechanical data

| Ref. | 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 |

## 5.2 SO-14 package information

Figure 16. SO-14 package mechanical drawing

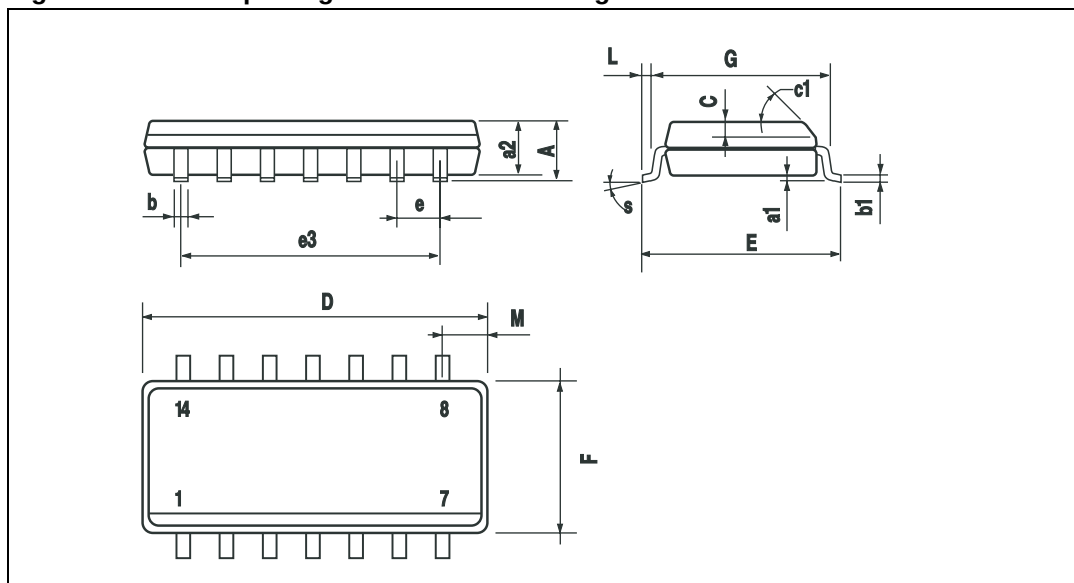


Table 6. SO-14 package mechanical data

| 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.)   |      |      |        |       |       |

### 5.3 TSSOP14 package information

Figure 17. TSSOP14 package mechanical drawing

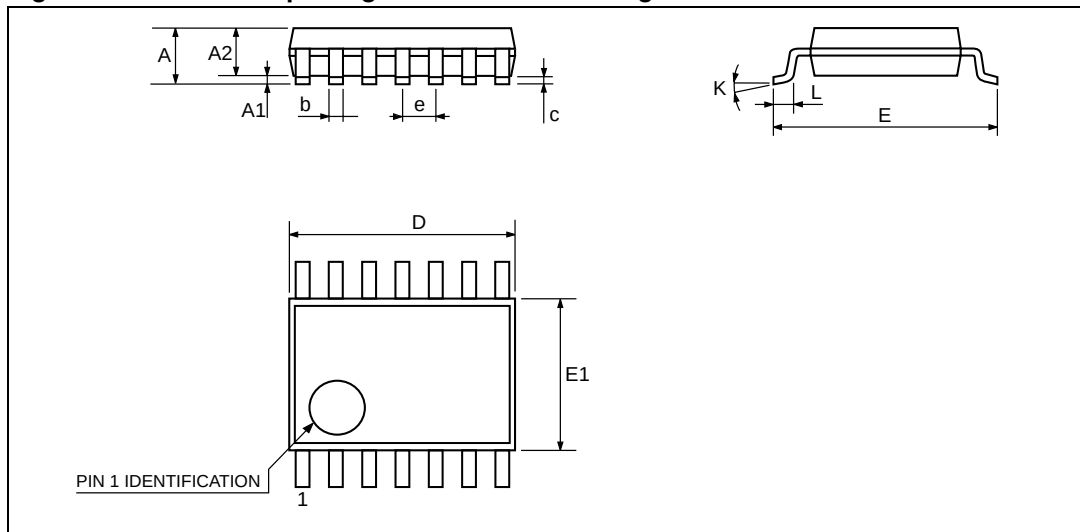


Figure 18. TSSOP14 package mechanical data

| 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°     |
| L1   | 0.45        | 0.60     | 0.75 | 0.018  | 0.024      | 0.030  |

## 6 Ordering information

**Table 7. Order codes**

| Order code            | Temperature range | Package | Packing                | Marking  |
|-----------------------|-------------------|---------|------------------------|----------|
| TS274CD<br>TS274CDT   | 0°C, +70°C        | SO-14   | Tube or<br>Tape & reel | 274C     |
| TS274ACD<br>TS274ACDT |                   |         |                        | 274AC    |
| TS274CN<br>TS274ACN   |                   | DIP14   | Tube                   | TS274CN  |
|                       |                   |         |                        | TS274ACN |
| TS274CPT<br>TS274ACPT |                   | TSSOP14 | Tape & reel            | 274C     |
|                       |                   |         |                        | 274AC    |
| TS274ID<br>TS274IDT   | -40°C, +125°C     | SO-14   | Tube or<br>Tape & reel | 274I     |
| TS274AID<br>TS274AIDT |                   |         |                        | 274AI    |
| TS274IN<br>TS274AIN   |                   | DIP14   | Tube                   | TS274IN  |
|                       |                   |         |                        | TS274AIN |
| TS274IPT<br>TS274AIPT |                   | TSSOP14 | Tape & reel            | 274I     |
|                       |                   |         |                        | 274AI    |

## 7 Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                         |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19-Nov-2001 | 1        | Initial release.                                                                                                                                                                                                                |
| 07-Apr-2006 | 2        | ESD protection inserted in <a href="#">Table 2. on page 2.</a><br>Thermal resistance junction to case information added see <a href="#">Table 2. on page 2.</a><br>Macromodel insertion in <a href="#">Section 4 on page 8.</a> |
| 01-Feb-2008 | 3        | Added information on enhanced related families of devices on cover page.<br>Removed TS274B version in AMR table and in order codes table.                                                                                       |

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Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели,  
кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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