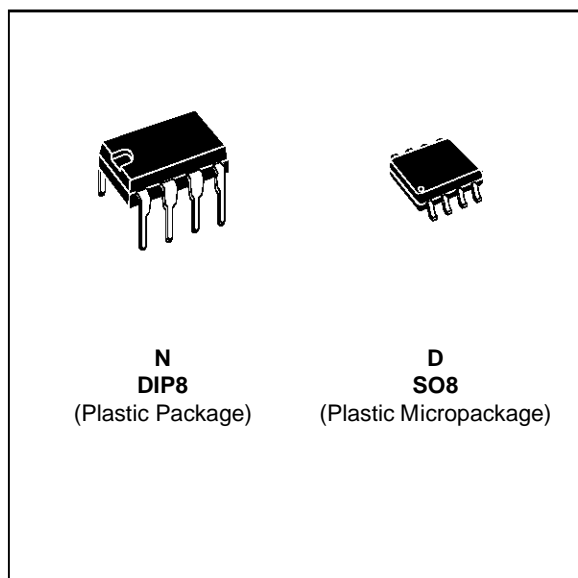


## INPUT/OUTPUT RAIL TO RAIL DUAL CMOS OPERATIONAL AMPLIFIER

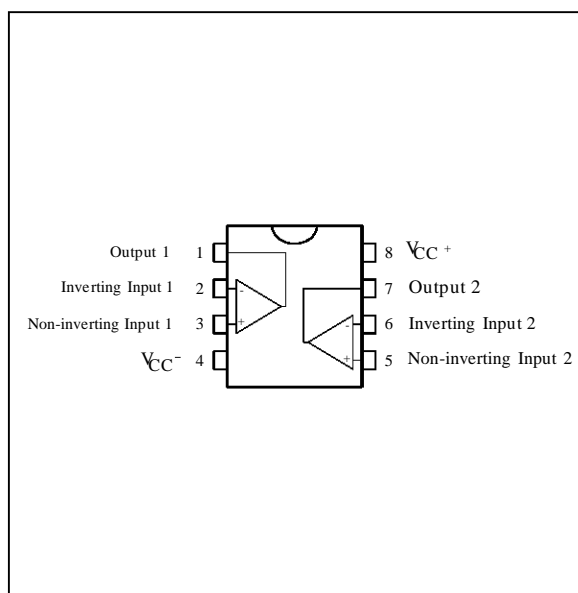
- **RAIL TO RAIL** INPUT AND OUTPUT VOLTAGE RANGES
- SINGLE (OR DUAL) SUPPLY OPERATION FROM **2.7V TO 16V** ( $\pm 1.35V$  to  $\pm 8V$ )
- EXTREMELY LOW INPUT BIAS CURRENT : **1pA TYP**
- LOW INPUT OFFSET VOLTAGE : **2mV max.**
- SPECIFIED FOR **600Ω** AND **100Ω** LOADS
- LOW SUPPLY CURRENT : 400μA/Ampli
- SPEED : 1.4MHz - 1.3V/μs
- ESD TOLERANCE : 3KV
- LATCH-UP IMMUNITY
- **SPICE MACROMODEL** INCLUDED IN THIS SPECIFICATION



### ORDER CODES

| Part Number  | Temperature Range | Package |   |
|--------------|-------------------|---------|---|
|              |                   | N       | D |
| TS912I/AI/BI | -40, +125°C       | •       | • |

### PIN CONNECTIONS (top view)



### DESCRIPTION

The TS912 is a RAIL TO RAIL dual CMOS operational amplifier designed to operate with single or dual supply voltage.

The input voltage range  $V_{icm}$  includes the two supply rails  $V_{CC}^+$  and  $V_{CC}^-$ .

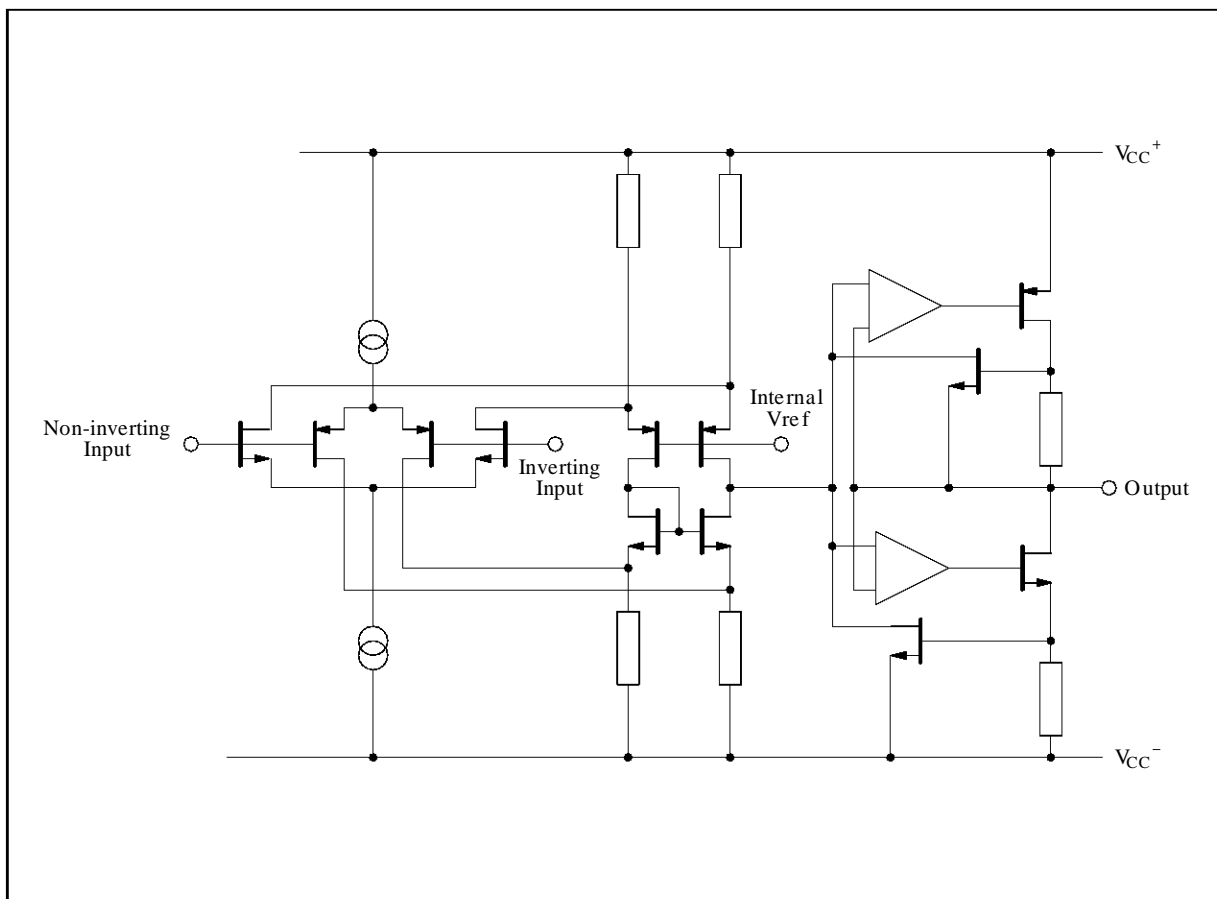
The output reaches :

- $V_{CC}^- + 50mV$      $V_{CC}^+ - 50mV$     with  $R_L = 10k\Omega$
- $V_{CC}^- + 650mV$      $V_{CC}^+ - 650mV$     with  $R_L = 600\Omega$

This product offers a broad supply voltage operating range from 2.7V to 16V, a supply current of only 400μA/amp ( $V_{CC} = 10V$ ) and a high output current capability fixed by an internal limitation circuit :

$$I_{source} = 65mA - I_{sink} = 75mA$$

**SCHEMATIC DIAGRAM (1/2 TS912)**



**ABSOLUTE MAXIMUM RATINGS**

| Symbol     | Parameter  | Value       | Unit        |
|------------|--|-------------|-------------|
| $V_{CC}$   | Supply Voltage - (note 1)                            | 18          | V           |
| $V_{id}$   | Differential Input Voltage - (note 2)                | $\pm 18$    | V           |
| $V_i$      | Input Voltage - (note 3)                             | -0.3 to 18  | V           |
| $I_{in}$   | Current on Inputs                                    | $\pm 50$    | mA          |
| $I_o$      | Current on Outputs                                   | $\pm 130$   | mA          |
| $T_{oper}$ | Operating Free Air Temperature Range<br>TS912I/AI/BI | -40 to +125 | $^{\circ}C$ |
| $T_{stg}$  | Storage Temperature                                  | -65 to +150 | $^{\circ}C$ |

- Notes :**
1. All voltage 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 input and output voltages must never exceed  $V_{CC}^{+} + 0.3V$ .

**OPERATING CONDITIONS**

| Symbol    | Parameter                       | Value                                    | Unit |
|-----------|---------------------------------|--|------|
| $V_{CC}$  | Supply Voltage                  | 2.7 to 16                                | V    |
| $V_{icm}$ | Common Mode Input Voltage Range | $V_{CC}^{-} - 0.2$ to $V_{CC}^{+} + 0.2$ | V    |

**ELECTRICAL CHARACTERISTICS**
 $V_{CC}^+ = 10V$ ,  $V_{CC}^- = 0V$ ,  $R_L, C_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

| Symbol          | Parameter  | TS912I/AI/BI  |                                     |  | Unit                   |
|-----------------|--|---|-------------------------------------|--|------------------------|
|                 |  | Min.  | Typ.                                | Max.                                       |                        |
| $V_{io}$        | Input Offset Voltage ( $V_{ic} = V_o = V_{CC}/2$ )<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                | TS912<br>TS912A<br>TS912B<br>TS912<br>TS912A<br>TS912B  |                                     | 10<br>5<br>2<br>12<br>7<br>3               | mV                     |
| $DV_{io}$       | Input Offset Voltage Drift   |   | 5                                   |  | $\mu V/^\circ C$       |
| $I_{io}$        | Input Offset Current - (note 1)<br>$T_{min.} \leq T_{amb} \leq T_{max.}$   |   | 1                                   | 100<br>200                                 | pA                     |
| $I_{ib}$        | Input Bias Current - (note 1)<br>$T_{min.} \leq T_{amb} \leq T_{max.}$   |   | 1                                   | 150<br>300                                 | pA                     |
| $I_{CC}$        | Supply Current (per amplifier, $A_{VCL} = 1$ , no load)<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                           |   | 400                                 | 600<br>700                                 | $\mu A$                |
| CMR             | Common Mode Rejection Ratio<br>$V_{ic} = 3$ to $7V$ , $V_o = 5V$<br>$V_{ic} = 0$ to $10V$ , $V_o = 5V$                     |   | 60<br>50                            | 90<br>75                                   | dB                     |
| SVR             | Supply Voltage Rejection Ratio ( $V_{CC}^+ = 5$ to $10V$ , $V_o = V_{CC}/2$ )  |   | 60                                  | 90   | dB                     |
| $A_{vd}$        | Large Signal Voltage Gain ( $R_L = 10k\Omega$ , $V_o = 2.5V$ to $7.5V$ )<br>$T_{min.} \leq T_{amb} \leq T_{max.}$          |   | 20<br>15                            | 60   | V/mV                   |
| $V_{OH}$        | High Level Output Voltage ( $V_{id} = 1V$ )<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                       | $R_L = 100k\Omega$<br>$R_L = 10k\Omega$<br>$R_L = 600\Omega$<br>$R_L = 100\Omega$<br><br>$R_L = 10k\Omega$<br>$R_L = 600\Omega$ | 9.95<br>9.85<br>9<br><br>9.8<br>8.8 | 9.95<br>9.35<br>7.8                        | V                      |
| $V_{OL}$        | Low Level Output Voltage ( $V_{id} = -1V$ )<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                       | $R_L = 100k\Omega$<br>$R_L = 10k\Omega$<br>$R_L = 600\Omega$<br>$R_L = 100\Omega$<br><br>$R_L = 10k\Omega$<br>$R_L = 600\Omega$ |                                     | 50<br>150<br>800<br>2300<br><br>150<br>900 | mV                     |
| $I_o$           | Output Short Circuit Current ( $V_{id} = \pm 1V$ )   | Source ( $V_o = V_{CC}^-$ )<br>Sink ( $V_o = V_{CC}^+$ )  | 45<br>50                            | 65<br>75                                   | mA                     |
| GBP             | Gain Bandwidth Product<br>( $A_{VCL} = 100$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$ )                           |   |                                     | 1.4  | MHz                    |
| $SR^+$          | Slew Rate ( $A_{VCL} = 1$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $V_i = 2.5V$ to $7.5V$ )                                   |   |                                     | 1.3  | V/ $\mu s$             |
| $SR^-$          | Slew Rate ( $A_{VCL} = 1$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $V_i = 2.5V$ to $7.5V$ )                                   |   |                                     | 0.8  | V/ $\mu s$             |
| $\phi_m$        | Phase Margin   |   |                                     | 40   | Degrees                |
| $e_n$           | Equivalent Input Noise Voltage ( $R_s = 100\Omega$ , $f = 1kHz$ )  |   |                                     | 30   | $\frac{nV}{\sqrt{Hz}}$ |
| THD             | Total Harmonic Distortion<br>( $A_{VCL} = 1$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $V_o = 4.75V$ to $5.25V$ , $f = 1kHz$ ) |   |                                     | 0.024                                      | %                      |
| $C_{in}$        | Input Capacitance  |   |                                     | 1.5  | pF                     |
| $V_{O1}/V_{O2}$ | Channel Separation ( $f = 1kHz$ )  |   |                                     | 120  | dB                     |

**Note 1** : Maximum values including unavoidable inaccuracies of the industrial test.

TYPICAL CHARACTERISTICS

Figure 1 : Supply Current (each amplifier) versus Supply Voltage

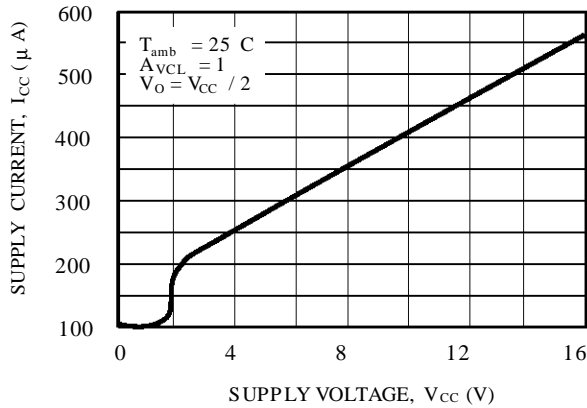


Figure 2 : Input Bias Current versus Temperature

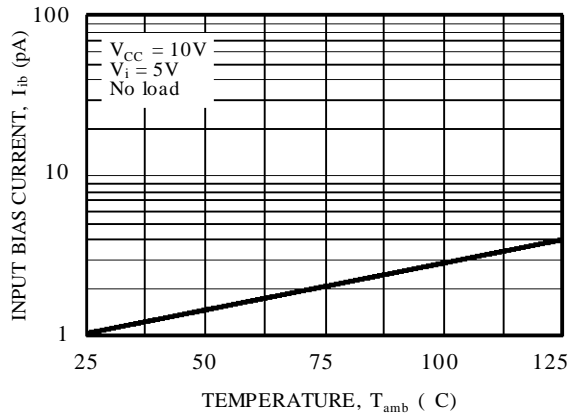


Figure 3a : High Level Output Voltage versus High Level Output Current

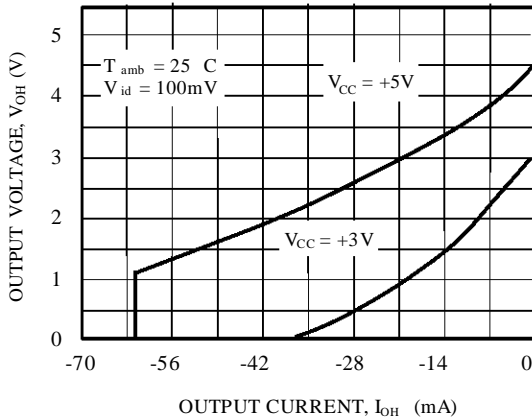


Figure 3b : High Level Output Voltage versus High Level Output Current

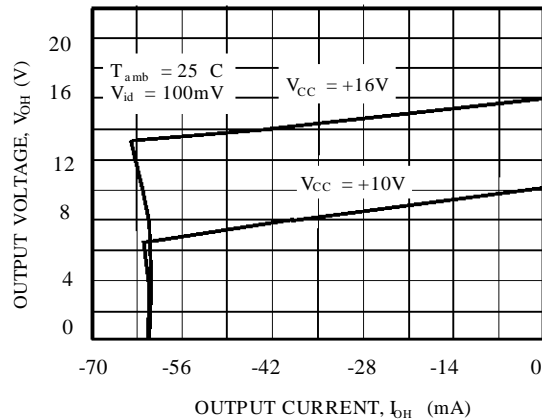


Figure 4a : Low Level Output Voltage versus Low Level Output Current

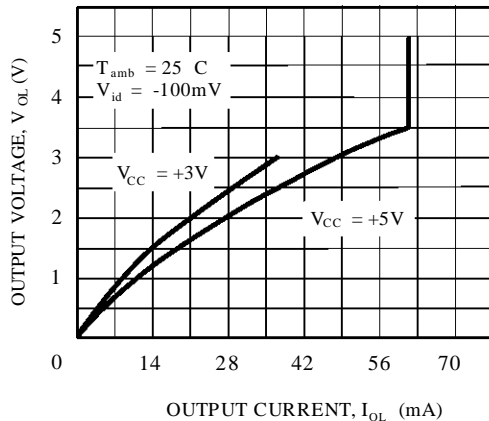
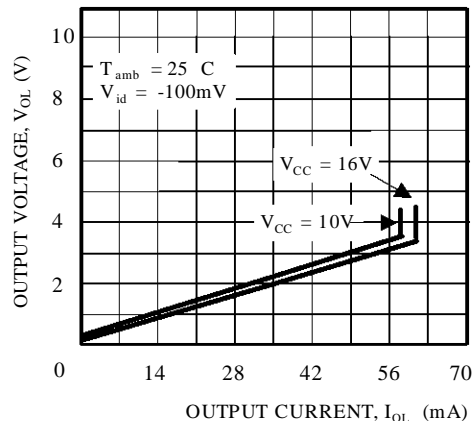
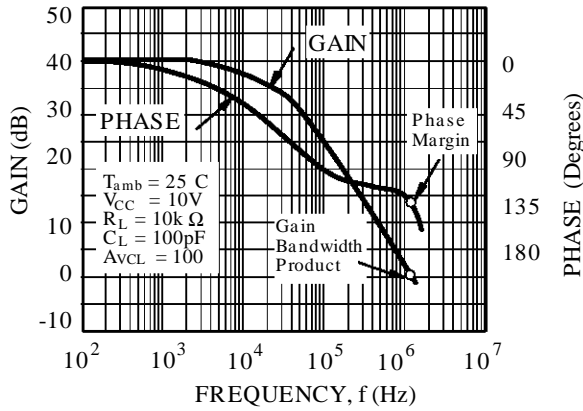


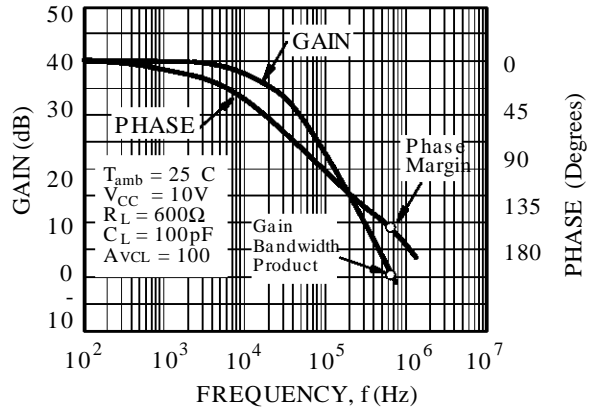
Figure 4b : Low Level Output Voltage versus Low Level Output Current



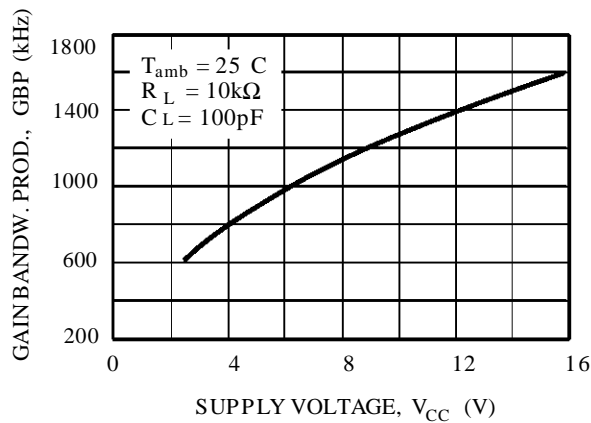
**Figure 5a** : Open Loop Frequency Response and Phase Shift



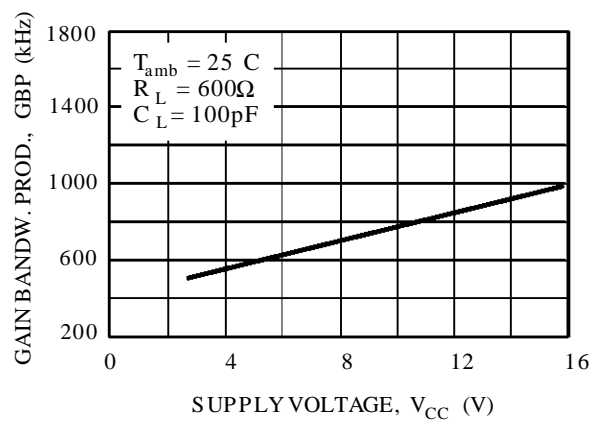
**Figure 5b** : Open Loop Frequency Response and Phase Shift



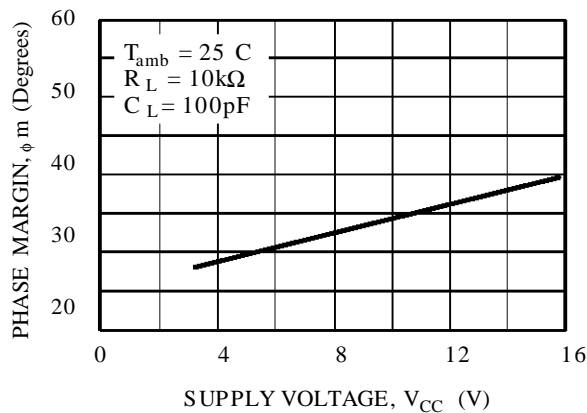
**Figure 6a** : Gain Bandwidth Product versus Supply Voltage



**Figure 6b** : Gain bandwidth Product versus Supply Voltage



**Figure 7a** : Phase Margin versus Supply Voltage



**Figure 7b** : Phase Margin versus Supply Voltage

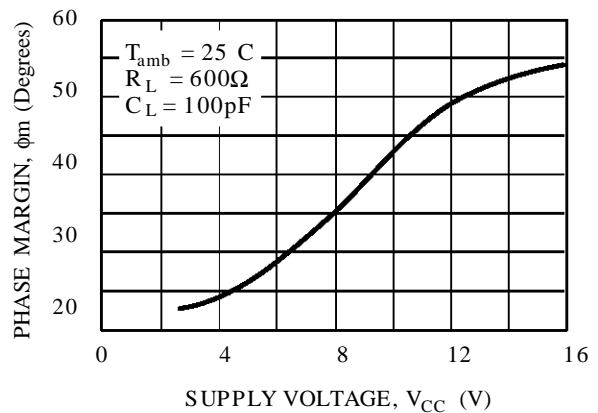
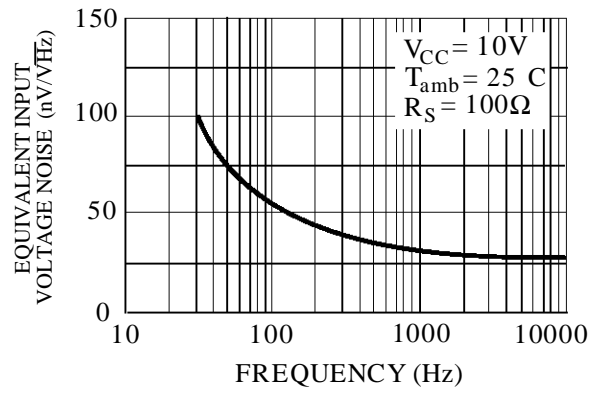
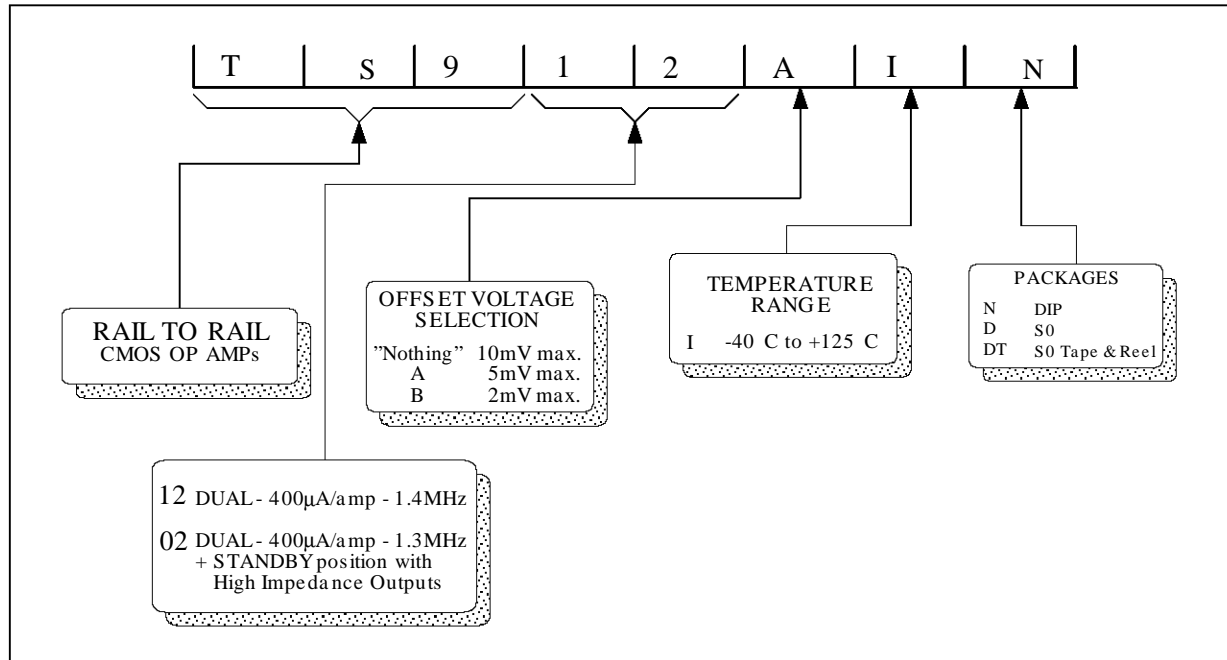


Figure 8 : Input Voltage Noise versus Frequency



ORDERING INFORMATION



**MACROMODEL**

- RAIL TO RAIL INPUT AND OUTPUT VOLTAGE RANGES
- SINGLE (OR DUAL) SUPPLY OPERATION FROM **2.7V TO 16V** ( $\pm 1.35V$  to  $\pm 8V$ )
- EXTREMELY LOW INPUT BIAS CURRENT : **1pA typ.**
- LOW INPUT OFFSET VOLTAGE : **2mV max.**
- SPECIFIED FOR **600Ω** AND **100Ω** LOADS
- LOW SUPPLY CURRENT : 400μA/Ampli
- SPEED : 1.4MHz - 1.3V/μs

**Applies to : TS912I,AI**

\*\* Standard Linear Ics Macromodels, 1993.

\*\* CONNECTIONS :

\* 1 INVERTING INPUT

\* 2 NON-INVERTING INPUT

\* 3 OUTPUT

\* 4 POSITIVE POWER SUPPLY

\* 5 NEGATIVE POWER SUPPLY

.SUBCKT TS912 1 3 2 4 5 (analog)

\*\*\*\*\*

.MODEL MDTH D IS=1E-8 KF=6.563355E-14 CJO=10F

\* INPUT STAGE

CIP 2 5 1.500000E-12

CIN 1 5 1.500000E-12

EIP 10 5 2 5 1

EIN 16 5 1 5 1

RIP 10 11 6.500000E+00

RIN 15 16 6.500000E+00

RIS 11 15 7.655100E+00

DIP 11 12 MDTH 400E-12

DIN 15 14 MDTH 400E-12

VOFP 12 13 DC 0.000000E+00

VOFN 13 14 DC 0

IPOL 13 5 4.000000E-05

CPS 11 15 3.82E-08

DINN 17 13 MDTH 400E-12

VIN 17 5 -0.5000000e+00

DINR 15 18 MDTH 400E-12

VIP 4 18 -0.5000000E+00

FCP 4 5 VOFP 7.750000E+00

FCN 5 4 VOFN 7.750000E+00

\* AMPLIFYING STAGE

FIP 5 19 VOFP 5.500000E+02

FIN 5 19 VOFN 5.500000E+02

RG1 19 5 5.087344E+05

RG2 19 4 5.087344E+05

CC 19 29 2.200000E-08

HZTP 30 29 VOFP 12.33E+02

HZTN 5 30 VOFN 12.33E+02

DOPM 19 22 MDTH 400E-12

DONM 21 19 MDTH 400E-12

HOPM 22 28 VOUT 3135

VIPM 28 4 150

HONM 21 27 VOUT 3135

VINM 5 27 150

EOUT 26 23 19 5 1

VOUT 23 5 0

ROUT 26 3 65

COUT 3 5 1.000000E-12

DOP 19 68 MDTH 400E-12

VOP 4 25 1.924

HSCP 68 25 VSCP1 1E8

DON 69 19 MDTH 400E-12

VON 24 5 2.4419107

HSCN 24 69 VSCN1 1.5E8

VSCTHP 60 61 0.1375

DSCP1 61 63 MDTH 400E-12

VSCP1 63 64 0

ISCP 64 0 1.000000E-8

DSCP2 0 64 MDTH 400E-12

DSCN2 0 74 MDTH 400E-12

ISCN 74 0 1.000000E-8

VSCN1 73 74 0

DSCN1 71 73 MDTH 400E-12

VSCTHN 71 70 -0.75

ESCP 60 0 2 1 500

ESCN 70 0 2 1 -2000

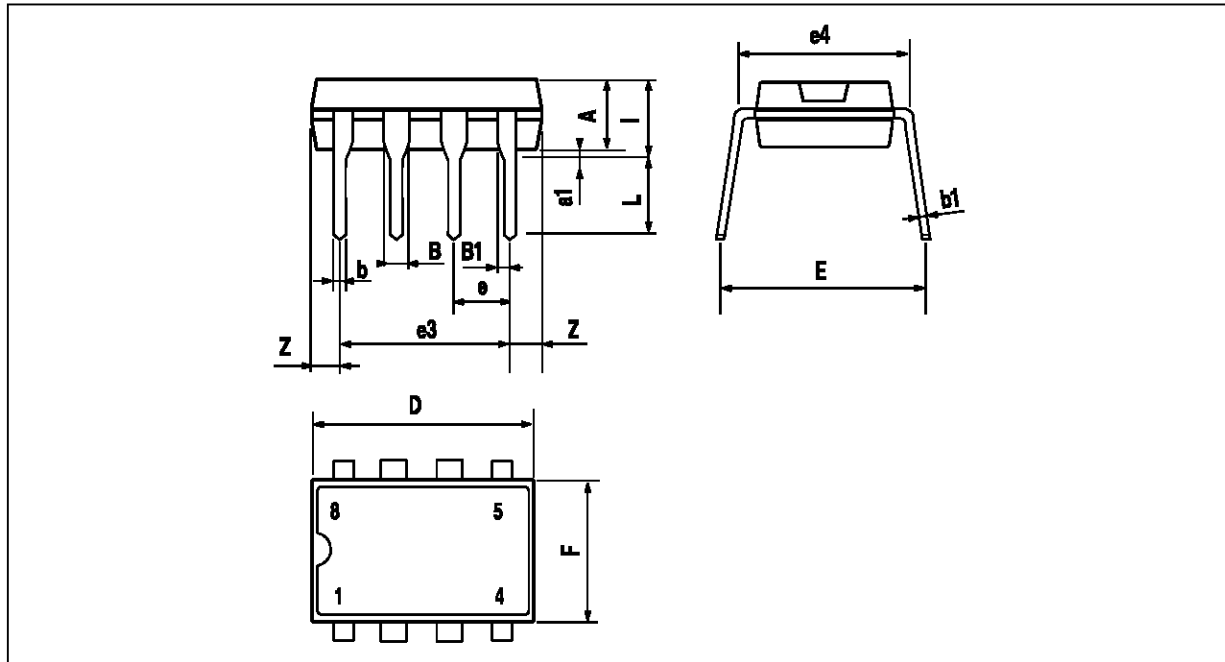
.ENDS

**ELECTRICAL CHARACTERISTICS**

$V_{CC^+} = 10V$ ,  $V_{CC^-} = 0V$ ,  $R_L, C_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25^{\circ}C$   
(unless otherwise specified)

| Symbol       | Conditions                        | Value        | Unit       |
|--------------|-----------------------------------|--------------|------------|
| $V_{io}$     |                                   | 0            | mV         |
| $A_{vd}$     | $R_L = 10k\Omega$                 | 20           | V/mV       |
| $I_{CC}$     | No load, per operator             | 350          | $\mu A$    |
| $V_{icm}$    |                                   | -0.2 to 10.2 | V          |
| $V_{OH}$     | $R_L = 10k\Omega$                 | 9.95         | V          |
| $V_{OL}$     | $R_L = 10k\Omega$                 | 50           | mV         |
| $I_{sink}$   | $V_O = 10V$                       | 50           | mA         |
| $I_{source}$ | $V_O = 0V$                        | 50           | mA         |
| GBP          | $R_L = 10k\Omega$ , $C_L = 100pF$ | 1            | MHz        |
| SR           | $R_L = 10k\Omega$ , $C_L = 100pF$ | 1            | V/ $\mu s$ |
| $\phi_m$     | $R_L = 10k\Omega$ , $C_L = 100pF$ | 40           | Degrees    |

**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC DIP

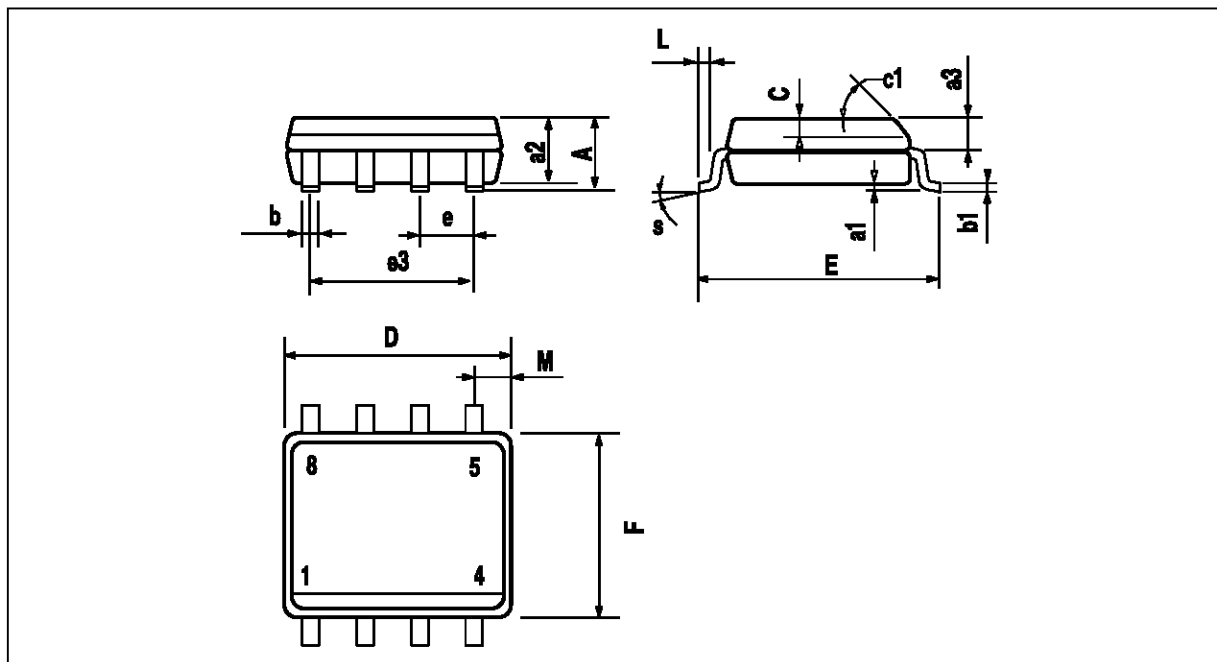


PM-DIP8.EPS

| Dimensions | Millimeters |      |       | Inches |       |       |
|------------|-------------|------|-------|--------|-------|-------|
|            | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A          |             | 3.32 |       |        | 0.131 |       |
| a1         | 0.51        |      |       | 0.020  |       |       |
| B          | 1.15        |      | 1.65  | 0.045  |       | 0.065 |
| b          | 0.356       |      | 0.55  | 0.014  |       | 0.022 |
| b1         | 0.204       |      | 0.304 | 0.008  |       | 0.012 |
| D          |             |      | 10.92 |        |       | 0.430 |
| E          | 7.95        |      | 9.75  | 0.313  |       | 0.384 |
| e          |             | 2.54 |       |        | 0.100 |       |
| e3         |             | 7.62 |       |        | 0.300 |       |
| e4         |             | 7.62 |       |        | 0.300 |       |
| F          |             |      | 6.6   |        |       | 0.260 |
| i          |             |      | 5.08  |        |       | 0.200 |
| L          | 3.18        |      | 3.81  | 0.125  |       | 0.150 |
| Z          |             |      | 1.52  |        |       | 0.060 |

DIP8.TBL

**PACKAGE MECHANICAL DATA**  
 8 PINS - PLASTIC MICROPACKAGE (SO)



PM-S06.EPS

| Dimensions | Millimeters |      |      | Inches |       |       |
|------------|-------------|------|------|--------|-------|-------|
|            | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A          |             |      | 1.75 |        |       | 0.069 |
| a1         | 0.1         |      | 0.25 | 0.004  |       | 0.010 |
| a2         |             |      | 1.65 |        |       | 0.065 |
| a3         | 0.65        |      | 0.85 | 0.026  |       | 0.033 |
| b          | 0.35        |      | 0.48 | 0.014  |       | 0.019 |
| b1         | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C          | 0.25        |      | 0.5  | 0.010  |       | 0.020 |
| c1         | 45° (typ.)  |      |      |        |       |       |
| D          | 4.8         |      | 5.0  | 0.189  |       | 0.197 |
| E          | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e          |             | 1.27 |      |        | 0.050 |       |
| e3         |             | 3.81 |      |        | 0.150 |       |
| F          | 3.8         |      | 4.0  | 0.150  |       | 0.157 |
| L          | 0.4         |      | 1.27 | 0.016  |       | 0.050 |
| M          |             |      | 0.6  |        |       | 0.024 |
| S          | 8° (max.)   |      |      |        |       |       |

S08.TBL

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