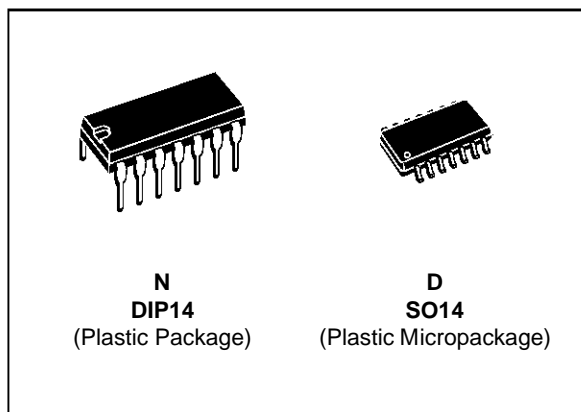


INPUT/OUTPUT RAIL TO RAIL DUAL CMOS OPERATIONAL AMPLIFIER (WITH STANDBY POSITION)

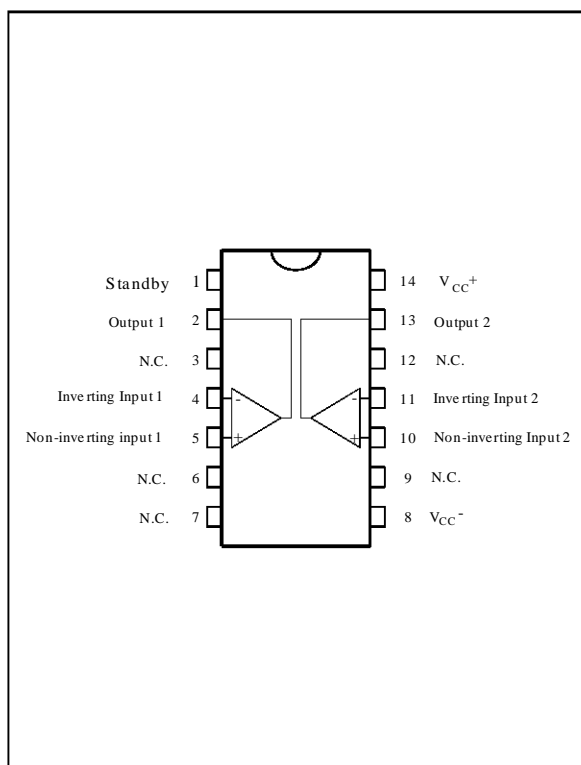
- RAIL TO RAIL INPUT AND OUTPUT VOLTAGE RANGES
 - STANDBY POSITION : REDUCED CONSUMPTION (1 μ A) AND HIGH IMPEDANCE OUTPUTS
 - SINGLE (OR DUAL) SUPPLY OPERATION FROM 2.7V TO 16V (± 1.35 V to ± 8 V)
 - EXTREMELY LOW INPUT BIAS CURRENT : 1pA TYP
 - LOW INPUT OFFSET VOLTAGE : 1.5mV max.
 - SPECIFIED FOR 600 Ω AND 100 Ω LOADS
 - LOW SUPPLY CURRENT : 400 μ A/Ampli
 - SPEED : 1.3MHz - 1.3V/ μ s
-
- SPICE MACROMODEL INCLUDED IN THIS SPECIFICATION



ORDER CODES

Part Number	Temperature Range	Package	
		N	D
TS902I/AI/BI	-40, +125°C	•	•

PIN CONNECTIONS (top view)



DESCRIPTION

The TS902 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 :

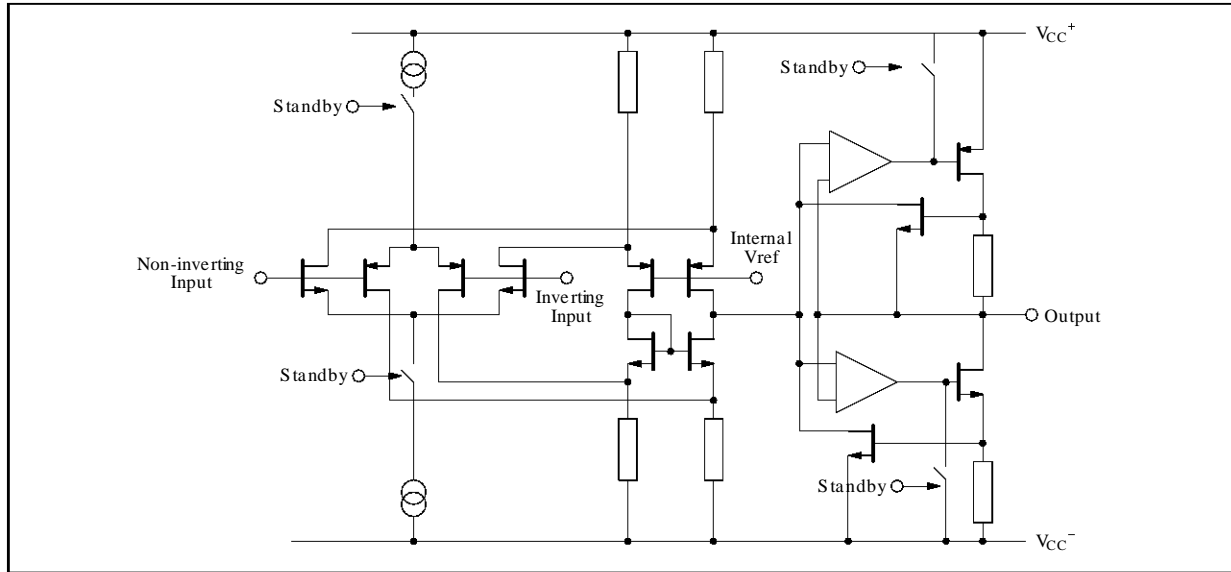
- $V_{CC}^- + 50mV$ $V_{CC}^+ - 50mV$ with $R_L = 10k\Omega$
- $V_{CC}^- + 650mV$ $V_{CC}^+ - 650mV$ with $R_L = 600\Omega$

This product offers a broad supply voltage operating range from 2.7V to 16V and a supply current of only 400 μ A/amp. ($V_{CC} = 10V$).

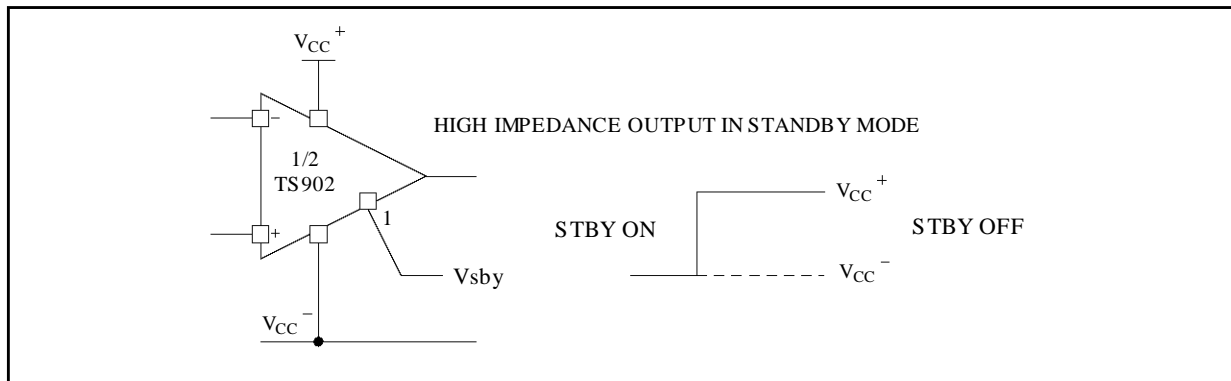
Source and sink output current capability is typically 60mA (at $V_{CC} = 10V$), fixed by an internal limitation circuit.

The TS902 can be put on STANDBY position (only 1 μ A and high impedance outputs).

SCHEMATIC DIAGRAM (1/2 TS902)



STANDBY POSITION



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage - (note 1)	18	V
V_{id}	Differential Input Voltage - (note 2)	± 18	V
V_i	Input Voltage - (note 3)	-0.3 to 18	V
I_{in}	Current on Inputs	± 50	mA
I_o	Current on Outputs	± 130	mA
T_{oper}	Operating Free Air Temperature Range	-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 $V_{CC}/2$, Standby OFF, $T_{amb} = 25^\circ C$
(unless otherwise specified)

Symbol	Parameter	TS902I/AI/BI			Unit
		Min.	Typ.	Max.	
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC}/2$) $T_{min.} \leq T_{amb} \leq T_{max.}$			12 5 1.5 12 7 3	mV
DV_{io}	Input Offset Voltage Drift		5		$\mu V/^\circ C$
I_{io}	Input Offset Current - (note 1) $T_{min.} \leq T_{amb} \leq T_{max.}$		1	100 200	pA
I_{ib}	Input Bias Current - (note 1) $T_{min.} \leq T_{amb} \leq T_{max.}$		1	150 300	pA
I_{CC}	Supply Current (per amplifier, $A_{VCL} = 1$, no load) $T_{min.} \leq T_{amb} \leq T_{max.}$		400	600 700	μA
CMR	Common Mode Rejection Ratio $V_{ic} = 3$ to $7V$, $V_o = 5V$ $V_{ic} = 0$ to $10V$, $V_o = 5V$		90 70		dB
SVR	Supply Voltage Rejection Ratio ($V_{CC}^+ = 5$ to $10V$, $V_o = V_{CC}/2$)		80		dB
A_{vd}	Large Signal Voltage Gain ($R_L = 10k\Omega$, $V_o = 2.5V$ to $7.5V$) $T_{min.} \leq T_{amb} \leq T_{max.}$	10 10	40		V/mV
V_{OH}	High Level Output Voltage ($V_{id} = 1V$) $T_{min.} \leq T_{amb} \leq T_{max.}$	$R_L = 100k\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$	9.95 9.85 9.2 9.8 9	9.95 9.35 7.8	V
V_{OL}	Low Level Output Voltage ($V_{id} = -1V$) $T_{min.} \leq T_{amb} \leq T_{max.}$	$R_L = 100k\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$		50 150 650 800 150 900	mV
I_o	Output Short Circuit Current ($V_{id} = \pm 1V$) Source ($V_o = V_{CC}^-$) Sink ($V_o = V_{CC}^+$)		60 60		mA
GBP	Gain Bandwidth Product ($A_{VCL} = 100$, $R_L = 10k\Omega$, $C_L = 100pF$, $f = 100kHz$)		1.3		MHz
SR	Slew Rate ($A_{VCL} = 1$, $R_L = 10k\Omega$, $C_L = 100pF$, $V_i = 2.5V$ to $7.5V$)		1.3		V/ μs
ϕ_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 ($A_{VCL} = 1$, $R_L = 10k\Omega$, $C_L = 100pF$, $V_o = 4.75V$ 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.

STANDBY MODE

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

Symbol	Parameter	TS902I/AI/BI			Unit
		Min.	Typ.	Max.	
$V_{inSBY/ON}$	Pin 1 Threshold Voltage for STANDBY ON		8.2		V
$V_{inSBY/OFF}$	Pin 1 Threshold Voltage for STANDBY OFF		8.5		V
$I_{CC SBY}$	Total Consumption in Standby Position (STANDBY ON)		1		μA

TYPICAL CHARACTERISTICS

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

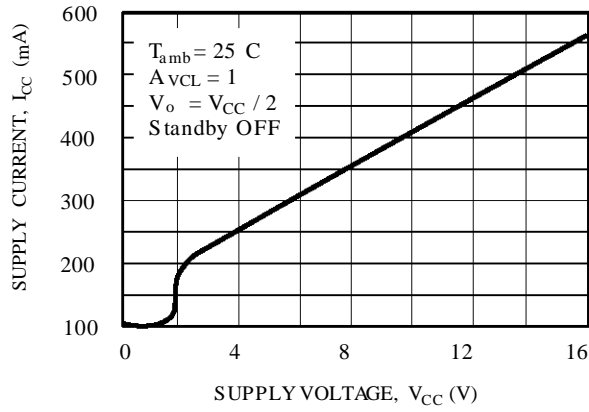


Figure 1b : Supply Current (each amplifier) versus Supply Voltage (in STANDBY)

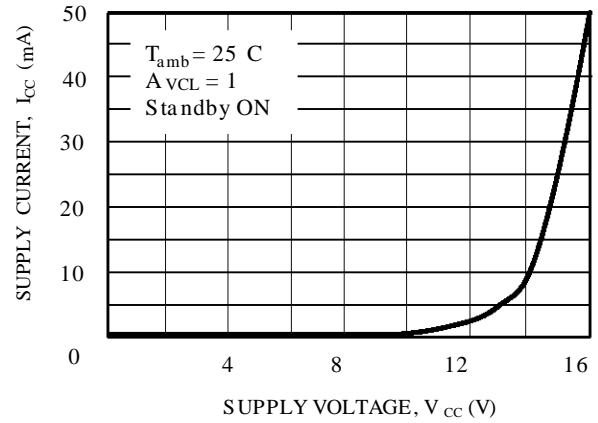


Figure 2 : Input Bias Current versus Temperature

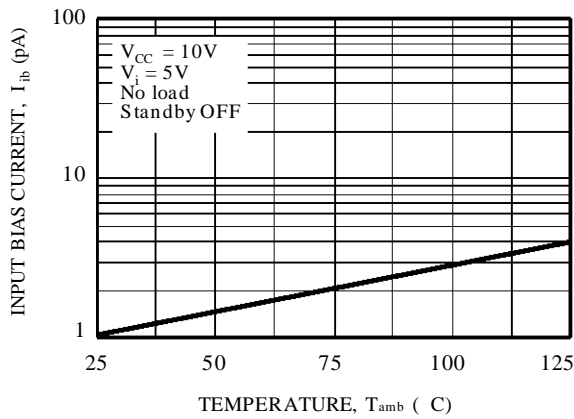


Figure 3a : High Level Output Voltage versus High Level Output Current

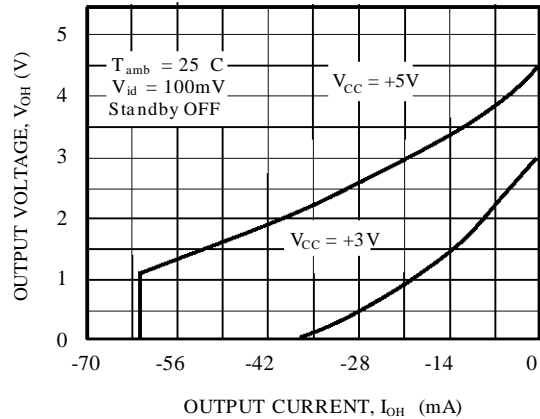


Figure 3b : High Level Output Voltage versus High Level Output Current

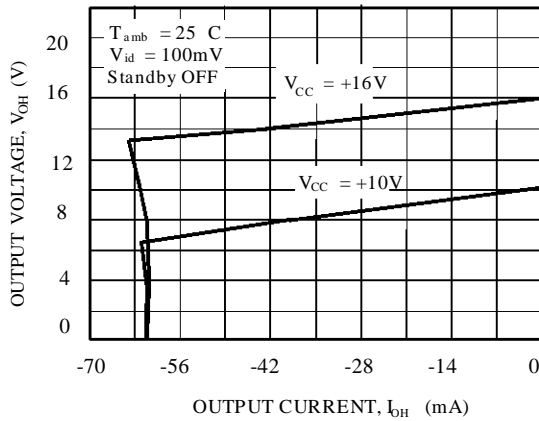


Figure 4a : Low Level Output Voltage versus Low Level Output Current

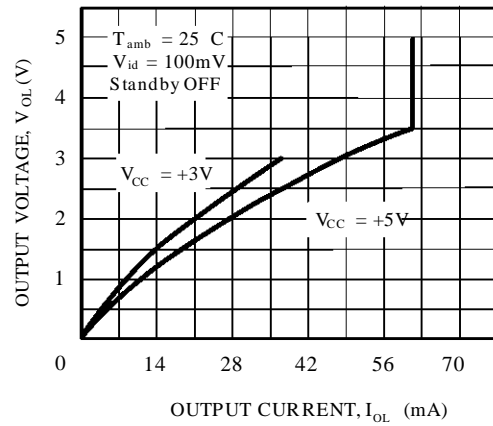


Figure 4b : Low Level Output Voltage versus Low Level Output Current

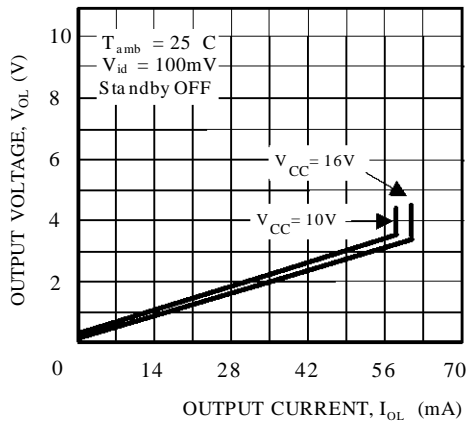


Figure 5a : Open Loop Frequency Response and Phase Shift

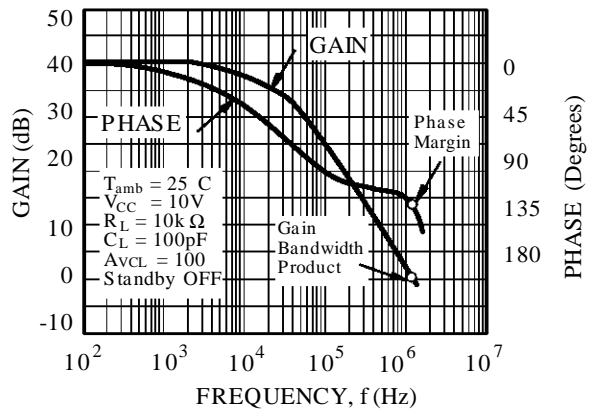


Figure 5b : Open Loop Frequency Response and Phase Shift

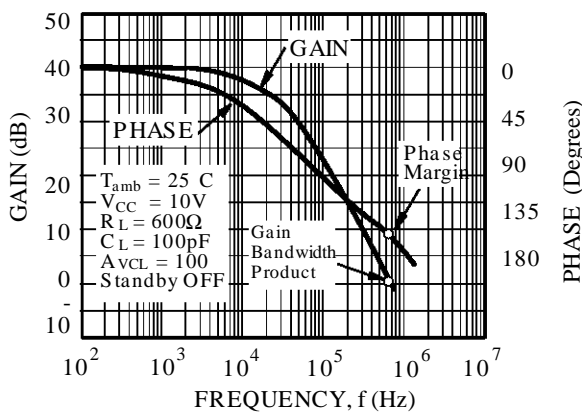


Figure 6a : Gain Bandwidth Product versus Supply Voltage

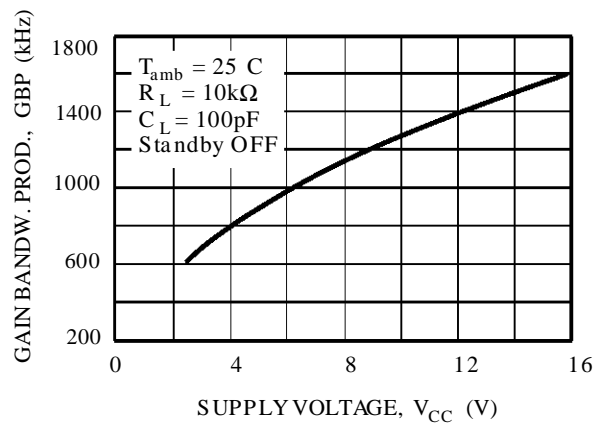


Figure 6b : Gain bandwidth Product versus Supply Voltage

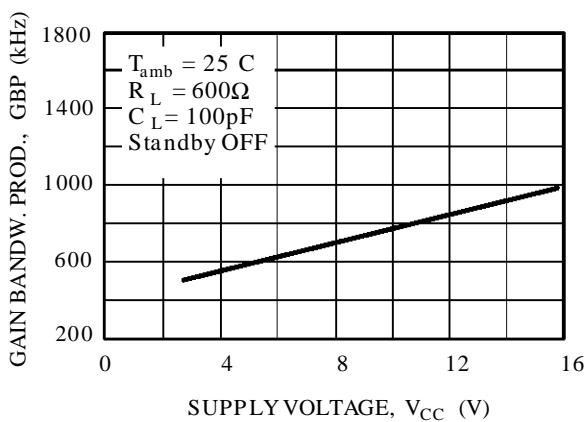


Figure 7a : Phase Margin versus Supply Voltage

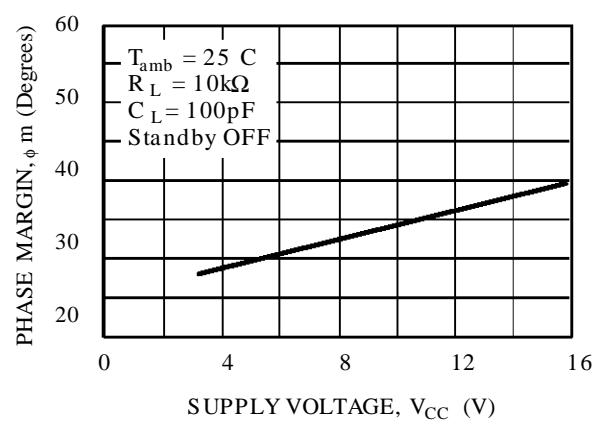


Figure 7b : Phase Margin versus Supply Voltage

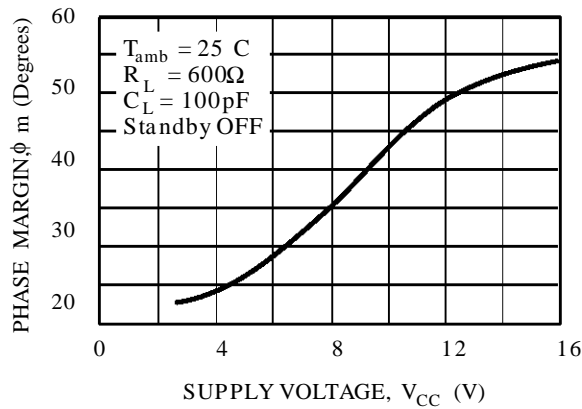
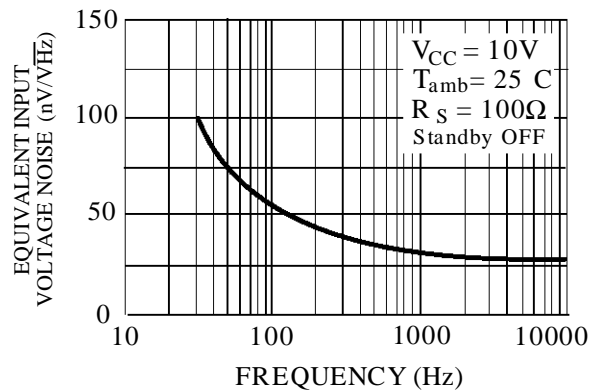


Figure 8 : Input Voltage Noise versus Frequency



STANDBY APPLICATION

The two operators of the TS902 are **both** put on **STANDBY**.

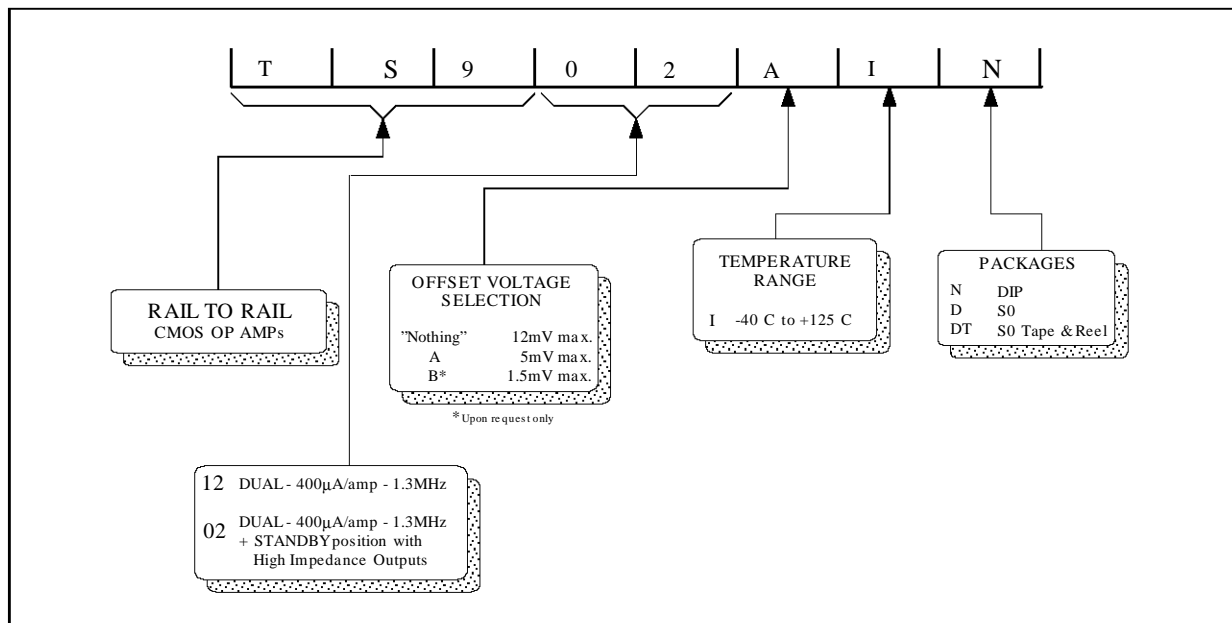
In this configuration (standby ON) :

- The **total consumption** of the circuit is considerably **reduced** down to **1μA** ($V_{CC} = 10V$). This standby consumption versus V_{CC} curve is given figure 1b.
- The **both outputs** are in **high impedance** state. No output current can then be sourced or sinked by the device.

The standby pin 1 should never stay unconnected.

- The **"standby OFF"** state, is reached when the pin 1 voltage is **higher than $V_{in SBY/OFF}$** .
- The **"standby ON"** state is assured by a pin 1 voltage **lower than $V_{in SBY/ON}$** . (see electrical characteristics)

ORDERING INFORMATION



MACROMODEL

- **RAIL TO RAIL** INPUT AND OUTPUT VOLTAGE RANGES
- **STANDBY POSITION** : REDUCED **CONSUMPTION (1 μ A)** AND **HIGH IMPEDANCE OUTPUTS**
- 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** : **1.5mV max.**
- SPECIFIED FOR **600 Ω** AND **100 Ω** LOADS
- **LOW SUPPLY CURRENT** : 400 μ A/Ampli
- **SPEED** : 1.3MHz - 1.3V/ μ s

Applies to : TS902I,AI,BI

** Standard Linear Ics Macromodels, 1993.

** CONNECTIONS :

- * 1 INVERTING INPUT
- * 2 NON-INVERTING INPUT
- * 3 OUTPUT
- * 4 POSITIVE POWER SUPPLY
- * 5 NEGATIVE POWER SUPPLY
- * 6 STANDBY

.SUBCKT TS902 1 3 2 4 5 6 (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 0 2 0 1

EIN 16 0 1 0 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

FPOL 13 0 VSTB 1

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 8.6E+00

FCN 5 4 VOFN 8.6E+00

ISTB0 5 4 900NA

* AMPLIFYING STAGE

FIP 0 19 VOFP 5.500000E+02

FIN 0 19 VOFN 5.500000E+02

RG1 19 120 5.087344E+05

GCOM1 120 5 POLY(1) 110 109 LEVEL=1 6.25E+11

RG2 121 19 5.087344E+05

GCOM2 121 4 POLY(1) 110 109 LEVEL=1 6.25E+11

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 26 103 65

COU1 103 5 1.000000E-12

GCOM 103 3 POLY(1) 110 109 LEVEL=1 6.25E+11

* OUTPUT SWING

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

* STANDBY

RMI1 4 111 1E+12

RMI2 5 111 1E+12

RSTBIN 6 0 1E+12

ESTBIN 106 0 6 0 1

ESTBREF 106 107 111 0 1

DSTB1 107 108 MDTH 400E-12

VSTB 108 109 0

ISTB 109 0 40U

RSTB 109 110 1

DSTB2 0 110 MDTH 400E-12

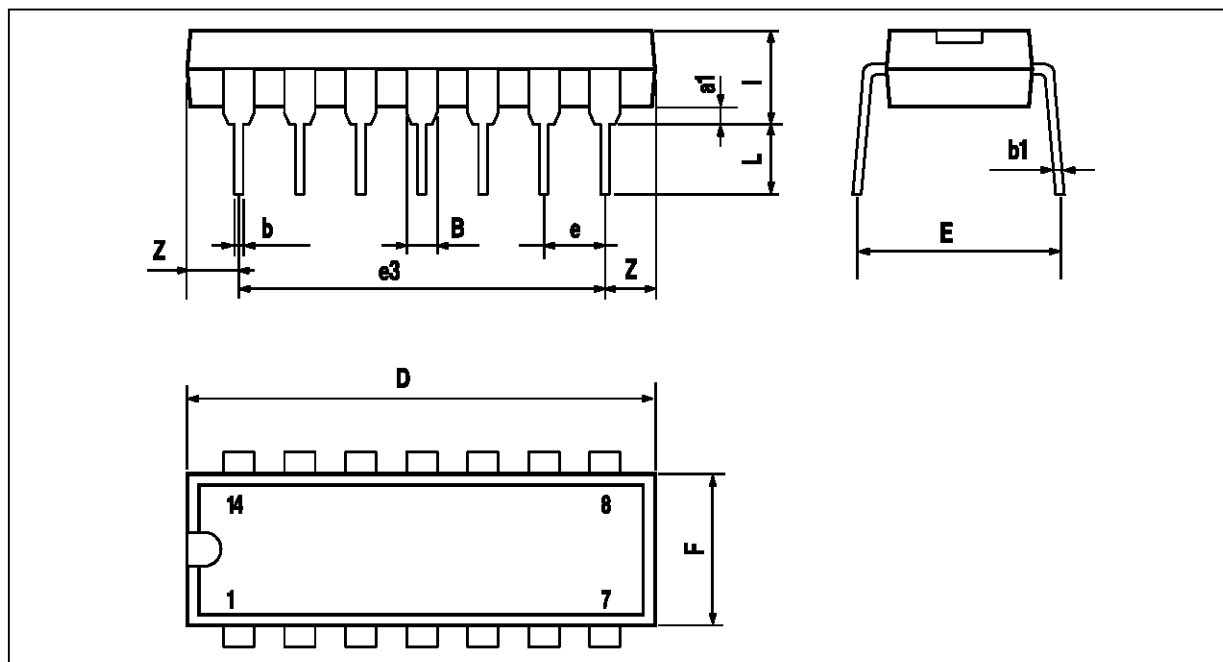
.ENDS

ELECTRICAL CHARACTERISTICS

$V_{CC}^+ = 10V$, $V_{CC}^- = 0V$, R_L, C_L connected to $V_{CC}/2$, standby off, $T_{amb} = 25^\circ C$
 (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	μA
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/ μs
$\varnothing m$	$R_L = 10k\Omega, C_L = 100pF$	40	Degrees
$I_{CC STBY}$	$V_{STBY} = 0V$	800	nA

PACKAGE MECHANICAL DATA
14 PINS - PLASTIC DIP

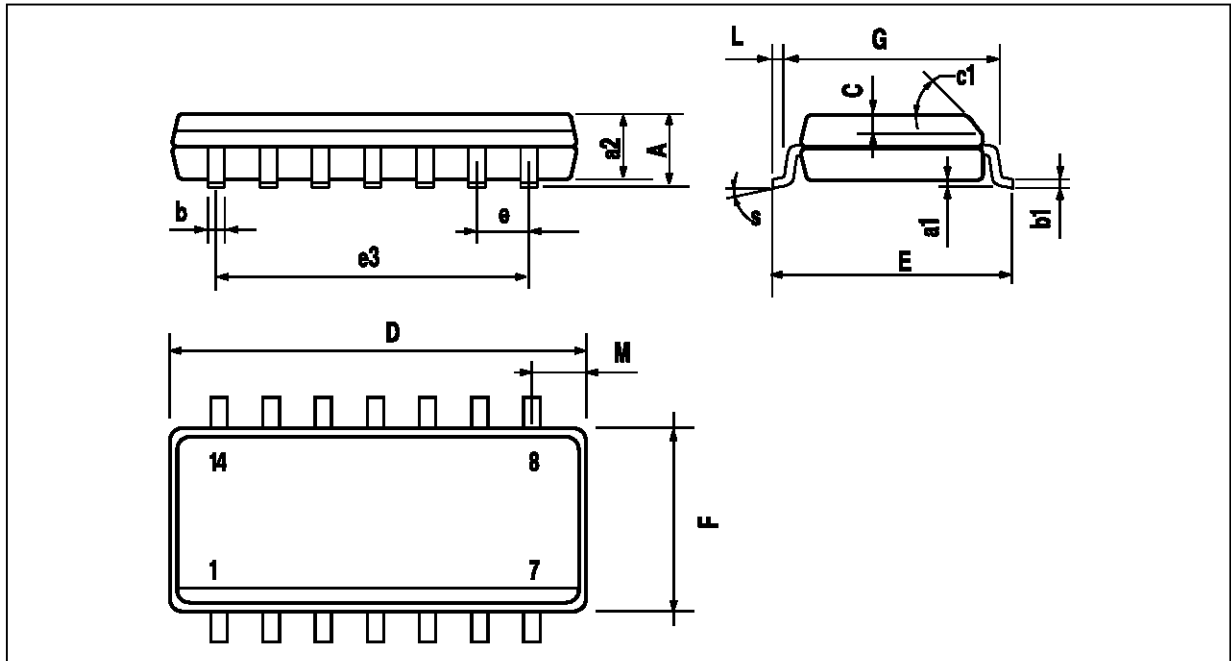


PM-DIP14EPS

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
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

DIP14_TBL

PACKAGE MECHANICAL DATA
 14 PINS - PLASTIC MICROPACKAGE (SO)



PM-SO14.EPS

Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

SO14.TBL

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