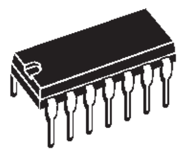
TS914

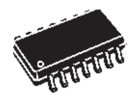
RAIL TO RAIL
CMOS QUAD OPERATIONAL AMPLIFIER

- **RAIL TO RAIL** INPUT AND OUTPUT VOLTAGE RANGES
- SINGLE (OR DUAL) SUPPLY OPERATION FROM **2.7V TO 16V**
- EXTREMELY LOW INPUT BIAS CURRENT : **1pA** TYP
- LOW INPUT OFFSET VOLTAGE : 5mV max.
- SPECIFIED FOR **600Ω** AND **100Ω** LOADS
- LOW SUPPLY CURRENT : 200μA/Ampli

- **SPICE MACROMODEL** INCLUDED IN THIS SPECIFICATION



N
DIP14
(Plastic Package)



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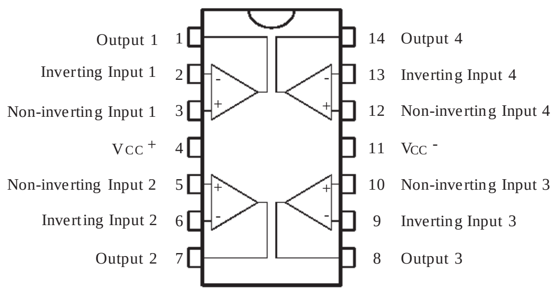
SO14
(Plastic Micropackage)

ORDER CODES

Part Number	Temperature Range	Package	
		N	D
TS914I/AI	-40, +125°C	•	•

PIN CONNECTIONS (top view)



DESCRIPTION

The TS914 is a RAIL TO RAIL quad CMOS operational amplifier designed to operate with a single or dual supply voltage.

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

The output reaches :

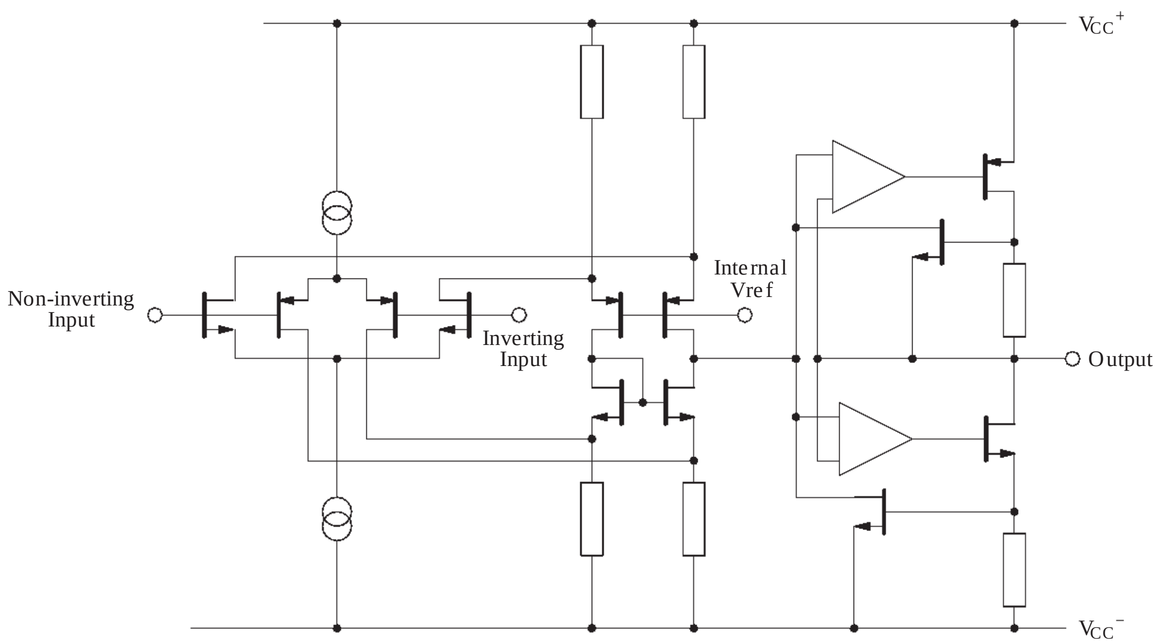
- V_{CC}^- +50mV V_{CC}^+ -50mV   with R_L = 10kΩ
- V_{CC}^- +350mV V_{CC}^+ -350mV   with R_L = 600Ω

This product offers a broad supply voltage operating range from 2.7V to 16V and a supply current of only 200μA/amp. (V_{CC} = 3V).

Source and sink output current capability is typically 40mA (at V_{CC} = 3V), fixed by an internal limitation circuit.

STMicroelectronics is offering a dual op-amp with the same features : TS912.

SCHEMATIC DIAGRAM (1/4 TS914)



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 Rangel	-40 to +125	°C
T_{stg}	Storage Temperature	-65 to +150	°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

$V_{CC}^{+} = 3V$, $V_{CC}^{-} = 0V$, R_L,C_L connected to $V_{CC}/2$, $T_{amb} = 25^oC$ (unless otherwise specified)

Symbol	Parameter	TS914I/AI			Unit
		Min.	Typ.	Max.	
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC}/2$) TS914 TS914A $T_{min.} \leq T_{amb} \leq T_{max.}$ TS914 TS914A			10 5 12 7	mV
DV_{io}	Input Offset Voltage Drift		5		$\mu V/^oC$
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) $T_{min.} \leq T_{amb} \leq T_{max.}$		200	300 400	μA
CMR	Common Mode Rejection Ratio $V_{ic} = 0$ to $3V$, $V_o = 1.5V$		70		dB
SVR	Supply Voltage Rejection Ratio ($V_{CC}^{+} = 2.7$ to $3.3V$, $V_O = V_{CC}/2$)	40	70		dB
A_{vd}	Large Signal Voltage Gain ($R_L = 10k\Omega$, $V_O = 1.2V$ to $1.8V$) $T_{min.} \leq T_{amb} \leq T_{max.}$	3 2	10		V/mV
V_{OH}	High Level Output Voltage ($V_{id} = 1V$) $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $R_L = 10k\Omega$ $R_L = 600\Omega$	 2.9 2.3 2.8 2.1	 2.96 2.6 2		V
V_{OL}	Low Level Output Voltage ($V_{id} = -1V$) $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $R_L = 10k\Omega$ $R_L = 600\Omega$		 50 300 900	 100 400 150 600	mV
I_o	Output Short Circuit Current ($V_{id} = \pm 1V$) Source ($V_o = V_{CC}^{-}$) Sink ($V_o = V_{CC}^{+}$)		40 40		mA
GBP	Gain Bandwidth Product ($A_{VCL} = 100$, $R_L = 10k\Omega$, $C_L = 100pF$, $f = 100kHz$)		0.8		MHz
SR^{+}	Positive Slew Rate $A_{VCL} = 1$, $R_L = 10k\Omega$, $V_i = 1.3V$ to $1.7V$, $C_L = 100pF$		0.5		$V/\mu s$
SR^{-}	Negative Slew Rate		0.4		$V/\mu s$
$\varnothing m$	Phase Margin		30		Degrees
e_n	Equivalent Input Noise Voltage ($R_s = 100\Omega$, $f = 1kHz$)		30		$\frac{nV}{\sqrt{Hz}}$
V_{O1}/V_{O2}	Channel Separation ($f = 1kHz$)		120		dB

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

ELECTRICAL CHARACTERISTICS

$V_{CC}^{+} = 5V$, $V_{CC}^{-} = 0V$, R_L,C_L connected to $V_{CC}/2$, $T_{amb} = 25^oC$ (unless otherwise specified)

Symbol	Parameter	TS914I/AI			Unit
		Min.	Typ.	Max.	
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC}/2$) TS914 TS914A $T_{min.} \leq T_{amb} \leq T_{max.}$ TS914 TS914A			10 5 12 7	mV
DV_{io}	Input Offset Voltage Drift		5		μV/°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) $T_{min.} \leq T_{amb} \leq T_{max.}$		230	350 450	μA
CMR	Common Mode Rejection Ratio $V_{ic} = 1.5$ to $3.5V$, $V_o = 2.5V$	50	75		dB
SVR	Supply Voltage Rejection Ratio ($V_{CC}^{+} = 3$ to $5V$, $V_O = V_{CC}/2$)	50	80		dB
A_{vd}	Large Signal Voltage Gain ($R_L = 10k\Omega$, $V_O = 1.5V$ to $3.5V$) $T_{min.} \leq T_{amb} \leq T_{max.}$	10 7	30		V/mV
V_{OH}	High Level Output Voltage ($V_{id} = 1V$) $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $R_L = 10k\Omega$ $R_L = 600\Omega$	 4.90 4.25 4.8 4.1	 4.95 4.65 3.7		V
V_{OL}	Low Level Output Voltage ($V_{id} = -1V$) $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $R_L = 10k\Omega$ $R_L = 600\Omega$		 50 350 1400	 100 500 150 750	mV
I_o	Output Short Circuit Current ($V_{id} = \pm 1V$) Source ($V_o = V_{CC}^{-}$) Sink ($V_o = V_{CC}^{+}$)	45 45	60 60		mA
GBP	Gain Bandwidth Product ($A_{VCL} = 100$, $R_L = 10k\Omega$, $C_L = 100pF$, $f = 100kHz$)		0.9		MHz
SR^{+}	Positive Slew Rate $A_{VCL} = 1$, $R_L = 10k\Omega$, $V_i = 1V$ to $4V$, $C_L = 100pF$		0.8		V/μs
SR^{-}	Negative Slew Rate		0.5		V/μs
∅m	Phase Margin		30		Degrees

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

ELECTRICAL CHARACTERISTICS

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

Symbol	Parameter		TS914I/AI			Unit
			Min.	Typ.	Max.	
V_{io}	Input Offset Voltage ($V_{ic} = V_o = V_{CC}/2$) $T_{min.} \le T_{amb} \le T_{max.}$	TS914 TS914A TS914 TS914A			10 5 12 7	mV
DV_{io}	Input Offset Voltage Drift			5		$\mu V/^oC$
I_{io}	Input Offset Current - (note 1) $T_{min.} \le T_{amb} \le T_{max.}$			1	100 200	pA
I_{ib}	Input Bias Current - (note 1) $T_{min.} \le T_{amb} \le T_{max.}$			1	150 300	pA
I_{CC}	Supply Current (per amplifier, $A_{VCL} = 1$, no load) $T_{min.} \le T_{amb} \le T_{max.}$			400	600 700	μA
CMR	Common Mode Rejection Ratio	$V_{ic} = 3$ to $7V$, $V_o = 5V$ $V_{ic} = 0$ to $10V$, $V_o = 5V$	50	75 70		dB
SVR	Supply Voltage Rejection Ratio ($V_{CC}^+ = 5$ to $10V$, $V_O = V_{CC}/2$)		50	80		dB
A_{vd}	Large Signal Voltage Gain ($R_L = 10k\Omega$, $V_O = 2.5V$ to $7.5V$) $T_{min.} \le T_{amb} \le T_{max.}$		20 15	60		V/mV
V_{OH}	High Level Output Voltage ($V_{id} = 1V$) $T_{min.} \le T_{amb} \le T_{max.}$	 $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$	 9.85 9.2 9.8 9	 9.95 9.35 7.8		V
V_{OL}	Low Level Output Voltage ($V_{id} = -1V$) $T_{min.} \le T_{amb} \le T_{max.}$	 $R_L = 10k\Omega$ $R_L = 600\Omega$ $R_L = 100\Omega$ $R_L = 10k\Omega$ $R_L = 600\Omega$		 50 650 2300	 150 800 150 900	mV
I_o	Output Short Circuit Current ($V_{id} = \pm 1V$)	Source ($V_o = V_{CC}^-$) Sink ($V_o = V_{CC}^+$)	45 45	60 60		mA
GBP	Gain Bandwidth Product ($A_{VCL} = 100$, $R_L = 10k\Omega$, $C_L = 100pF$, $f = 100kHz$)			1.3		MHz
SR^+	Positive Slew Rate $A_{VCL} = 1$, $R_L = 10k\Omega$, $V_i = 2.5V$ to $7.5V$, $C_L = 100pF$			1.3		$V/\mu s$
SR^-	Negative Slew Rate			0.8		$V/\mu s$
$\varnothing m$	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.

TYPICAL CHARACTERISTICS

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

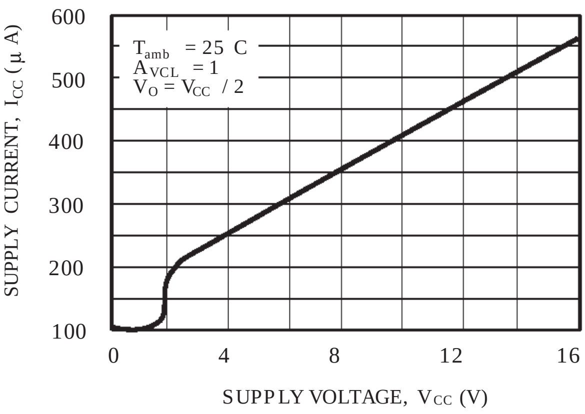


Figure 2 : Input Bias Current vs Temperature

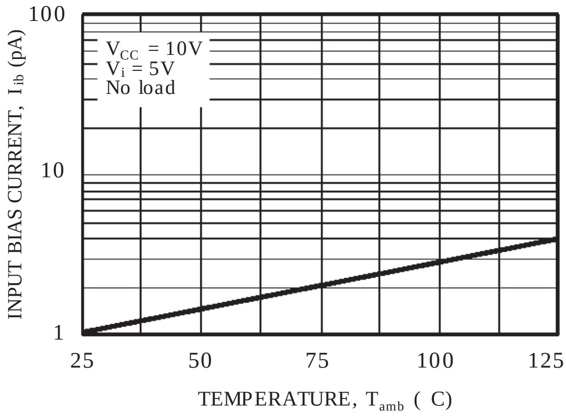


Figure 3a : High Level Output Voltage vs High Level Output Current

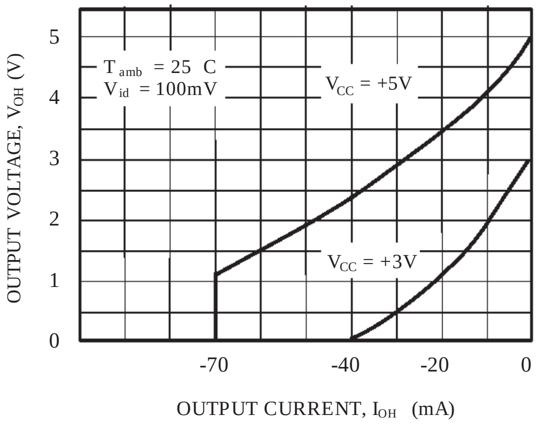


Figure 3b : High Level Output Voltage vs High Level Output Current

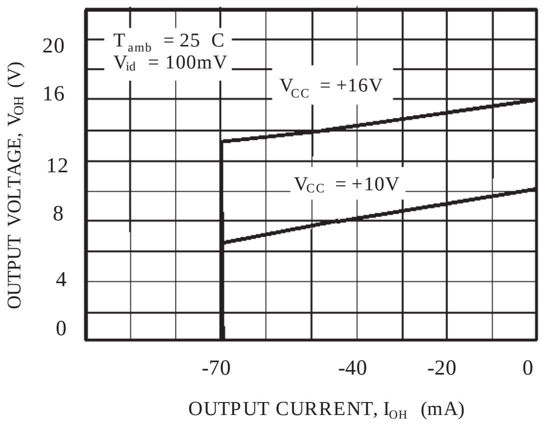


Figure 4a : Low Level Output Voltage vs Low Level Output Current

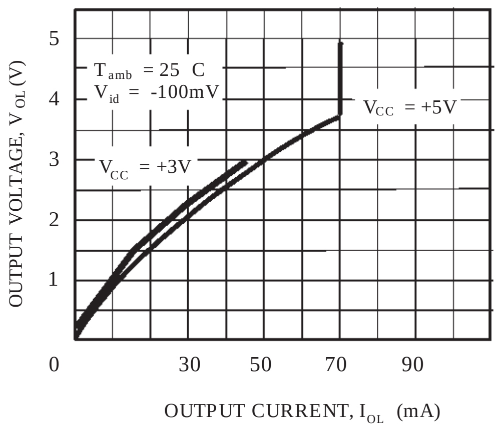


Figure 4b : Low Level Output Voltage vs Low Level Output Current

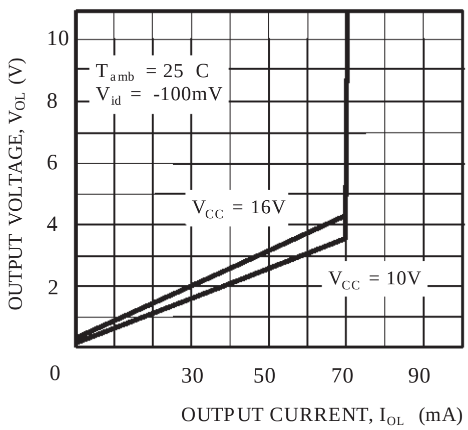


Figure 5a : Gain and Phase vs Frequecy

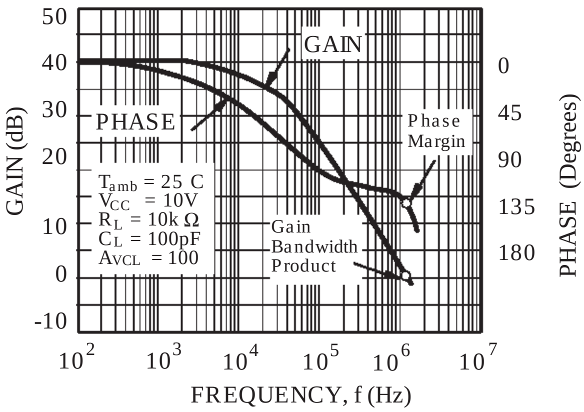


Figure 5b : Gain and Phase vs Frequecy

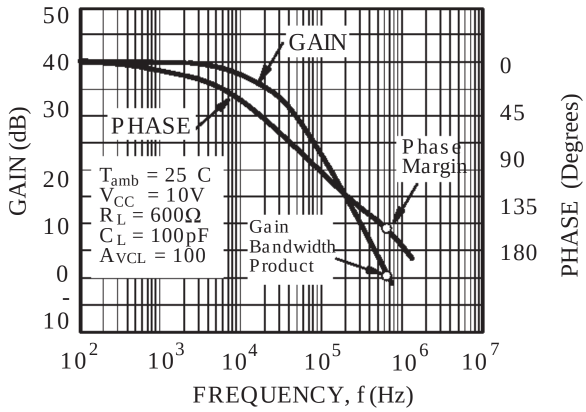


Figure 6a : Gain Bandwidth Product vs Supply Voltage

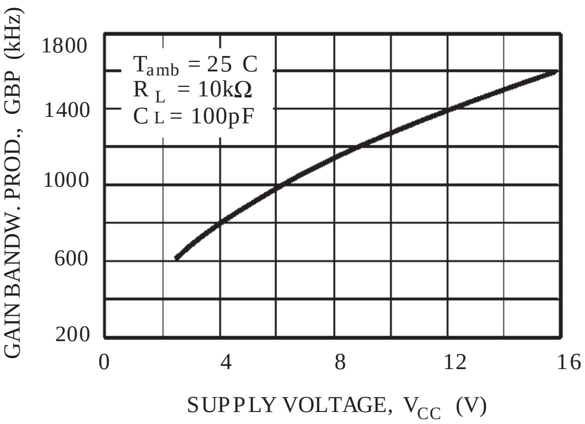


Figure 6b : Gain bandwidth Product vs Supply Voltage

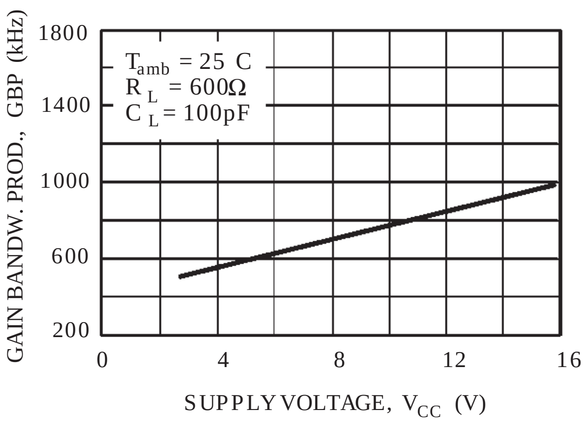


Figure 7a : Phase Margin vs Supply Voltage

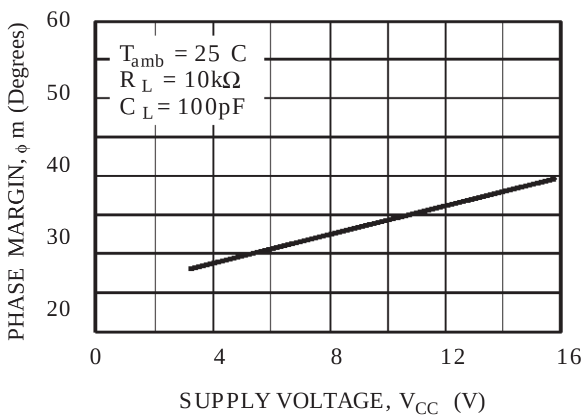


Figure 7b : Phase Margin vs Supply Voltage

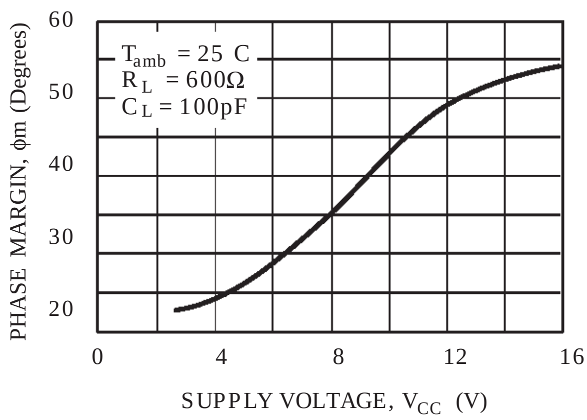
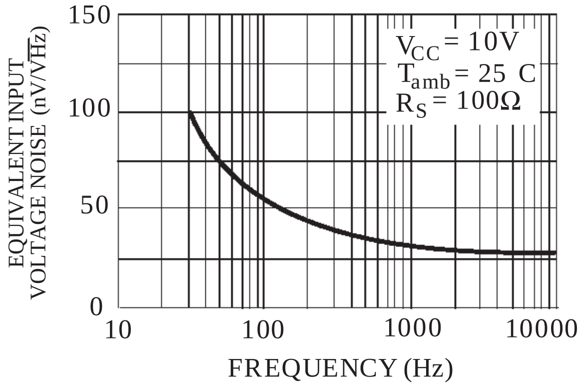


Figure 8 : Input Voltage Noise vs Frequency



MACROMODEL

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

Applies to : TS914I,AI,BI

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** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT TS914_3 1 3 2 4 5 (analog)
***********************************************************
.MODEL MDTH D IS=1E-8 KF=6.564344E-14 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-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 1.271505E+01
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 2.125860E-08
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 0.000000E+00
FCP 4 5 VOFP 5.000000E+00
FCN 5 4 VOFN 5.000000E+00
* AMPLIFYING STAGE
FIP 5 19 VOFP 2.750000E+02
FIN 5 19 VOFN 2.750000E+02
RG1 19 5 1.916825E+05
RG2 19 4 1.916825E+05
CC 19 29 2.200000E-08
HZTP 30 29 VOFP 1.3E+03
HZTN 5 30 VOFN 1.3E+03
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 3800
VIPM 28 4 150
HONM 21 27 VOUT 3800
VINM 5 27 150
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 75
COUT 3 5 1.000000E-12
DOP 19 68 MDTH 400E-12
VOP 4 25 1.724
HSCP 68 25 VSCP1 0.8E8
DON 69 19 MDTH 400E-12
VON 24 5 1.7419107
HSCN 24 69 VSCN1 0.8E+08
VSCTHP 60 61 0.0875
** VSCTHP = le seuil au dessus de vio
* 500
** c.a.d 275U-000U dus a l'offset
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 -0.55
** VSCTHN = le seuil au dessous de vio
* 2000
** c.a.d -375U-000U dus a l'offset
ESCP 60 0 2 1 500
ESCN 70 0 2 1 -2000
.ENDS
```

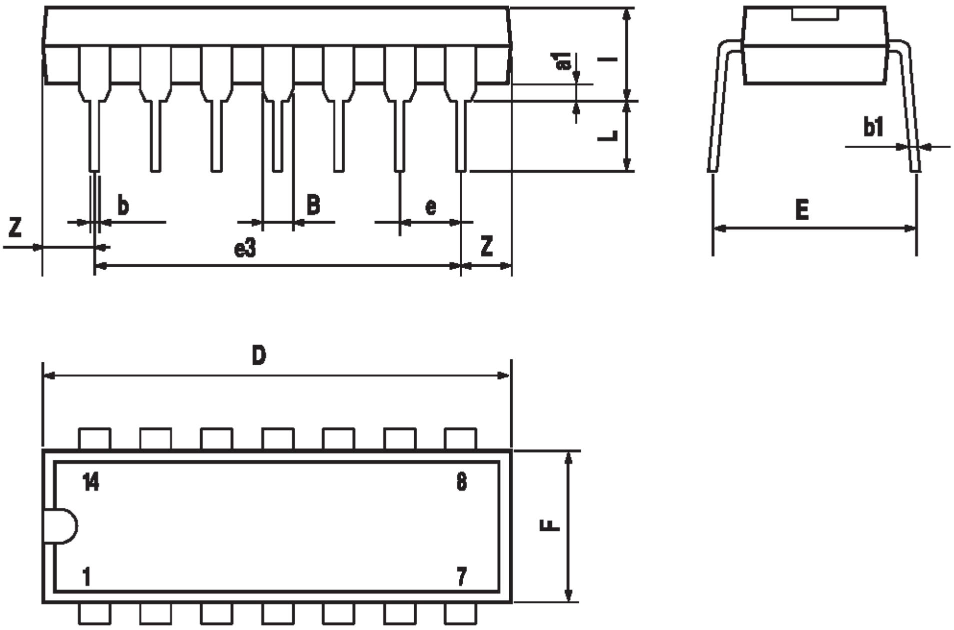
Applies to : TS914I,AI,BI

```
** 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 TS914_5 1 3 2 4 5 (analog)
**********************************************************
.MODEL MDTH D IS=1E-8 KF=6.564344E-14 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-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 7.322092E+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 2.498970E-08
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 0.000000E+00
FCP 4 5 VOFP 5.750000E+00
FCN 5 4 VOFN 5.750000E+00
ISTB0 5 4 500N
* AMPLIFYING STAGE
FIP 5 19 VOFP 4.400000E+02
FIN 5 19 VOFN 4.400000E+02
RG1 19 5 4.904961E+05
RG2 19 4 4.904961E+05
CC 19 29 2.200000E-08
HZTP 30 29 VOFP 1.8E+03
HZTN 5 30 VOFN 1.8E+03
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 3800
VIPM 28 4 230
HONM 21 27 VOUT 3800
VINM 5 27 230
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 82
COUT 3 5 1.000000E-12
DOP 19 68 MDTH 400E-12
VOP 4 25 1.724
HSCP 68 25
VSCP1 0.8E+08
DON 69 19 MDTH 400E-12
VON 24 5 1.7419107
HSCN 24 69
VSCN1 0.8E+08
VSCTHP 60 61 0.0875
** VSCTHP = le seuil au dessus de vio
* 500
** c.a.d 275U-000U dus a l'offset
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 -0.55
** VSCTHN = le seuil au dessous de vio
* 2000
** c.a.d -375U-000U dus a l'offset
ESCP 60 0 2 1 500
ESCN 70 0 2 1 -2000
.ENDS
```

ELECTRICAL CHARACTERISTICS
$V_{CC}^+ = 3V$, $V_{CC}^- = 0V$, R_L,C_L connected to $V_{CC}/2$, $T_{amb} = 25^oC$
(unless otherwise specified)

Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	$R_L = 10k\Omega$	10	V/mV
I_{CC}	No load, per operator	100	µA
V_{icm}		-0.2 to 3.2	V
V_{OH}	$R_L = 600\Omega$	2.6	V
V_{OL}	$R_L = 600\Omega$	300	mV
I_{sink}	$V_O = 3V$	40	mA
I_{source}	$V_O = 0V$	40	mA
GBP	$R_L = 10k\Omega$, $C_L = 100pF$, F = 100kHz	0.8	MHz
SR	$R_L = 10k\Omega$, $C_L = 100pF$	0.5	V/µs
∅m		30	Degrees

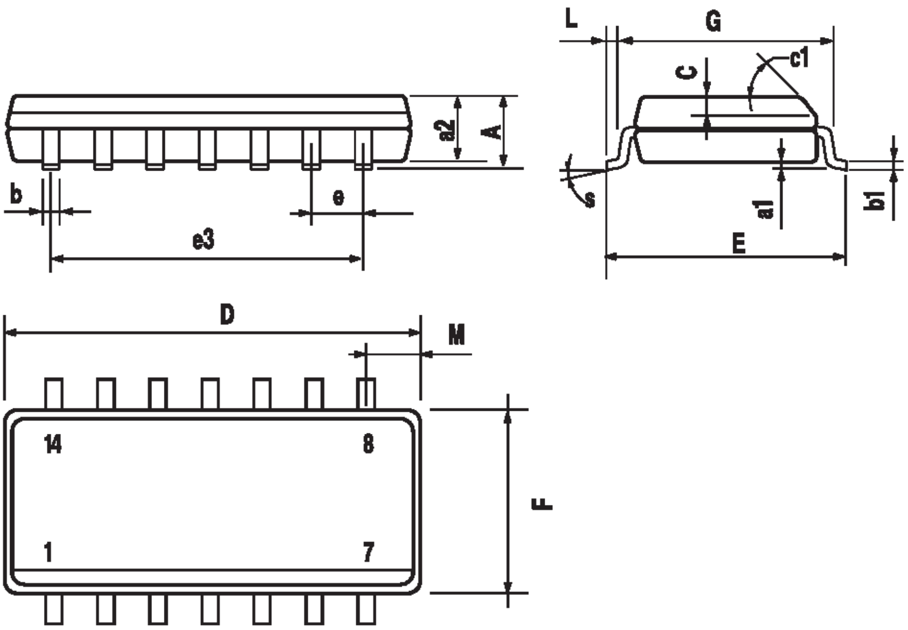
PACKAGE MECHANICAL DATA
14 PINS - PLASTIC DIP



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

PACKAGE MECHANICAL DATA

14 PINS - PLASTIC MICROPACKAGE (so)



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^{o} (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^{o} (max.)					