



TS524

PRECISION LOW NOISE QUAD OPERATIONAL AMPLIFIER

- LOW INPUT OFFSET VOLTAGE **950 μ V max.**
- LOW VOLTAGE NOISE : **4.5nV/ $\sqrt$ Hz**
- HIGH GAIN BANDWIDTH PRODUCT : **15MHz**
- HIGH SLEW RATE : **7V/ μ s**
- LOW DISTORTION : 0.002%
- ESD INTERNAL PROTECTION 2kV
- MACROMODEL INCLUDED IN THIS SPECIFICATION

DESCRIPTION

The TS524 is a monolithic quad operational amplifier particularly well-suited for audio applications. The TS524 offers a very low input offset voltage as well as low voltage noise (**4.5nV/ $\sqrt$ Hz**) and high dynamic performances (15MHz gain bandwidth product, 7V/ μ s slew rate).

The output stage allows a large output voltage swing and symmetrical source and sink currents.

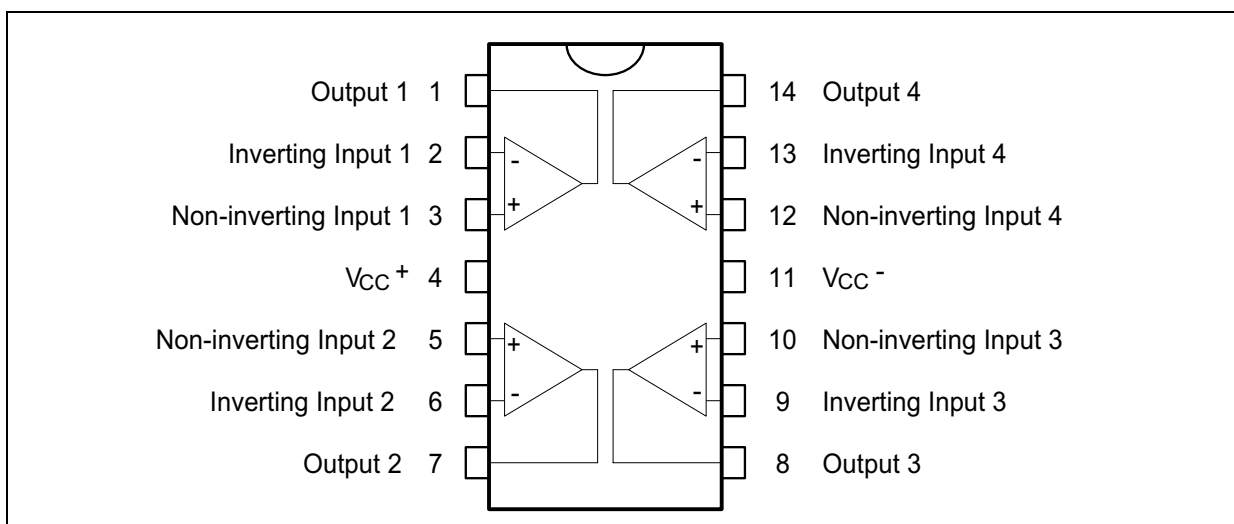
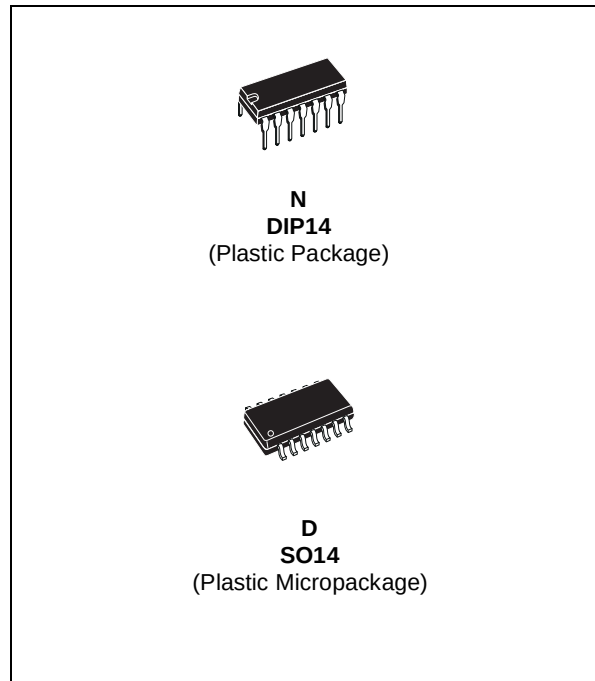
ORDER CODE

Part Number	Temperature Range	Package	
		N	D
TS524I	-40°C, +125°C	•	•

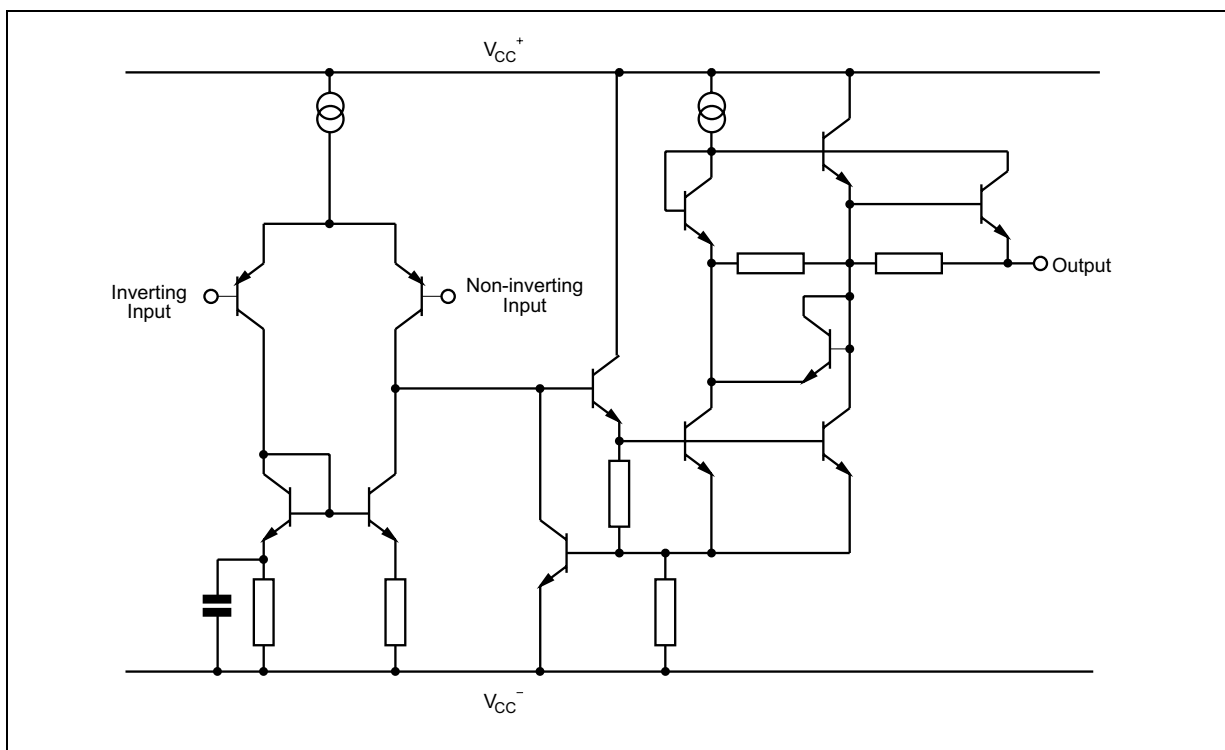
N = Dual in Line Package (DIP)

D = Small Outline Package (SO) - also available in Tape & Reel (DT)

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/4 TS524)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	± 18 to 36	V
V_{id}	Differential Input Voltage ¹⁾	± 30	V
V_i	Input Voltage (see note 1)	± 15	V
	Output Short-circuit Duration ²⁾	Infinite	
T_{oper}	Operating Free-Air Temperature Range	-40 to +105	°C
T_j	Maximum Junction Temperature	+ 150	°C
T_{stg}	Storage Temperature Range	-65 to +150	°C
P_{tot}	Maximum Power Dissipation (see note 2)	500	mW

1. Either or both input voltages must not exceed the magnitude of V_{CC}^+ or V_{CC}^-

2. Power dissipation must be considered to ensure maximum junction temperature (T_j) is not exceeded

OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	± 2.5 to ± 15	V

ELECTRICAL CHARACTERISTICS
 $V_{CC}^{+} = 15V$, $V_{CC}^{-} = -15V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage ($V_o = 0V$, $V_{ic} = 0V$) $T_{min} \leq T_{amb} \leq T_{max}$			0.95 1.8	mV
ΔV_{io}	Input Offset Voltage Drift $V_{ic} = 0V$, $V_o = 0V$, $T_{min} \leq T_{amb} \leq T_{max}$		2		$\mu V/^{\circ}C$
I_{io}	Input Offset Current ($V_{ic} = 0V$, $V_o = 0V$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		10	150 175	nA
I_{ib}	Input Bias Current ($V_{ic} = 0V$, $V_o = 0V$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		250	750 800	nA
V_{icm}	Common Mode Input Voltage Range ($\Delta V_{io} = 5mV$, $V_o = 0V$)	± 13	± 14		V
A_{vd}	Large Signal Voltage Gain ($R_L = 2k\Omega$, $V_o = \pm 10V$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$	90 85	100		dB
$\pm V_{opp}$	Output Voltage Swing ($V_{id} = \pm 1V$) $R_L = 600\Omega$ $R_L = 600\Omega$ $R_L = 2.0k\Omega$ $R_L = 2.0k\Omega$ $R_L = 10k\Omega$ $R_L = 10k\Omega$	13.2 13.5	12.2 -12.7 14 -14.2 14.3 -14.6	-13.2 -14	V
CMR	Common Mode Rejection Ratio ($V_{ic} = \pm 13V$)	80	100		dB
SVR	Supply Voltage Rejection Ratio $V_{CC}^{+}/V_{CC}^{-} = +15V/-15V$ to $+5V/-5V$	80	105		dB
I_o	Output Short Circuit Current ($V_{id} = \pm 1V$, Output to ground) Source Sink	15 20	29 37		mA
I_{cc}	Supply Current ($V_o = 0V$, All amplifiers) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		8	10 12	mA
SR	Slew Rate ($V_i = -10V$ to $+10V$, $R_L = 2k\Omega$, $C_L = 100pF$, $A_v = +1$)	5	7		V/ μs
GBP	Gain Bandwidth Product ($f = 100kHz$, $R_L = 2k\Omega$, $C_L = 100pF$)	10	15		MHz
B	Unity Gain Bandwidth (Open loop)		9		MHz
A_m	Gain Margin ($R_L = 2k\Omega$) $C_L = 0pF$ $C_L = 100pF$		-11 -6		dB
ϕ_m	Phase Margin $C_L = 0pF$ $C_L = 100pF$		55 30		Degrees
e_n	Equivalent Input Noise Voltage ($R_s = 100\Omega$, $f = 1kHz$)		4.5		$\frac{nV}{\sqrt{Hz}}$
i_n	Equivalent Input Noise current ($f = 1kHz$)		0.5		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion $R_L = 2k\Omega$, $f = 20Hz$ to $20kHz$, $V_o = 3V_{rms}$, $A_v = +1$		0.002		%
V_{o1}/V_{o2}	Channel Separation ($f = 20Hz$ to $20kHz$)		120		dB
FPB	Full Power Bandwidth ($V_o = 27V_{pp}$, $R_L = 2k\Omega$, $THD \leq 1\%$)		120		kHz
Z_o	Output Impedance ($V_o = 0V$, $f = 9MHz$)		37		Ω
R_i	Input Resistance ($V_{ic} = 0V$)		175		k Ω
C_i	Input Capacitance ($V_{ic} = 0V$)		12		pF

MACROMODEL

** Standard Linear Ics Macromodels, 1993.

** CONNECTIONS :

* 1 INVERTING INPUT

* 2 NON-INVERTING INPUT

* 3 OUTPUT

* 4 POSITIVE POWER SUPPLY

* 5 NEGATIVE POWER SUPPLY

.SUBCKT TS524 1 3 2 4 5 (analog)

.MODEL MDTH D IS=1E-8 KF=2.286238E-16

CJO=10F

* INPUT STAGE

CIP 2 5 1.200000E-11

CIN 1 5 1.200000E-11

EIP 10 5 2 5 1

EIN 16 5 1 5 1

RIP 10 11 2.363636E+00

RIN 15 16 2.363636E+00

RIS 11 15 1.224040E+01

DIP 11 12 MDTH 400E-12

DIN 15 14 MDTH 400E-12

VOFP 12 13 DC 0

VOFN 13 14 DC 0

IPOL 13 5 1.100000E-04

CPS 11 15 2.35E-09

DINN 17 13 MDTH 400E-12

VIN 17 5 1.000000E+00

DINR 15 18 MDTH 400E-12

VIP 4 18 1.000000E+00

FCP 4 5 VOFP 1.718182E+01

FCN 5 4 VOFN 1.718182E+01

FIBP 2 5 VOFN 4.545455E-03

FIBN 5 1 VOFP 4.545455E-03

* AMPLIFYING STAGE

FIP 5 19 VOFP 9.545455E+02

FIN 5 19 VOFN 9.545455E+02

CC 19 29 1.500000E-08

HZTP 30 29 VOFP 1.523529E+02

HZTN 5 30 VOFN 1.523529E+02

DOPM 51 22 MDTH 400E-12

DONM 21 52 MDTH 400E-12

HOPM 22 28 VOUT 5.172414E+03

VIPM 28 4 1.500000E+02

HONM 21 27 VOUT 4.054054E+03

VINM 5 27 1.500000E+02

DBIDON1 19 53 MDTH 400E-12

V1 51 53 0.68

DBIDON2 54 19 MDTH 400E-12

V2 54 52 0.68

RG11 51 5 3.04E+05

RG12 51 4 3.04E+05

RG21 52 5 0.6072E+05

RG22 52 4 0.6072E+05

E1 50 40 51 0 1 E2 40 39 52 0 1

EDEC1 38 39 4 0 0.5

EDEC2 0 38 5 0 0.5

DOP 51 25 MDTH 400E-12

VOP 4 25 1.474575E+00

DON 24 52 MDTH 400E-12

VON 24 5 1.474575E+00

RAJUS 50 5 1E12

GCOMP 5 4 4 5 8.1566068E-04

RPM1 5 80 1E+06

RPM2 4 80 1E+06

GAVPH 5 82 50 80 3.26E-03

RAVPHGH 82 4 613

RAVPHGB 82 5 613

RAVPHDH 82 83 1000

RAVPHDB 82 84 1000

CAVPHH 4 83 0.159E-09

CAVPHB 5 84 0.159E-09

EOUT 26 23 82 5 1

VOUT 23 5 0

ROUT 26 3 4.780354E+01

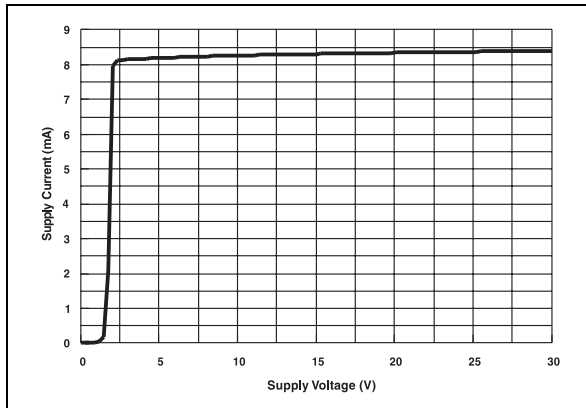
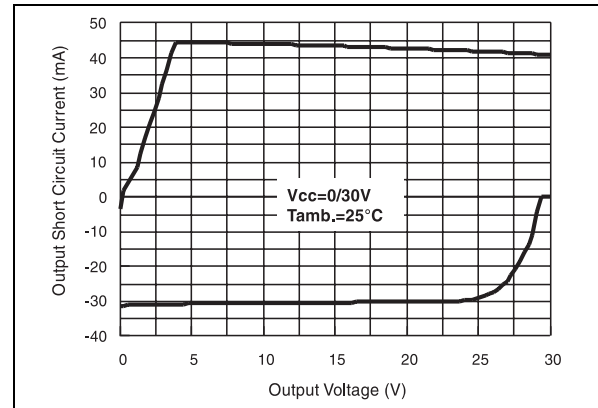
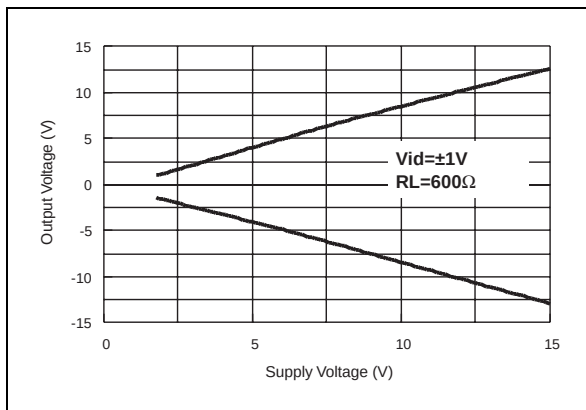
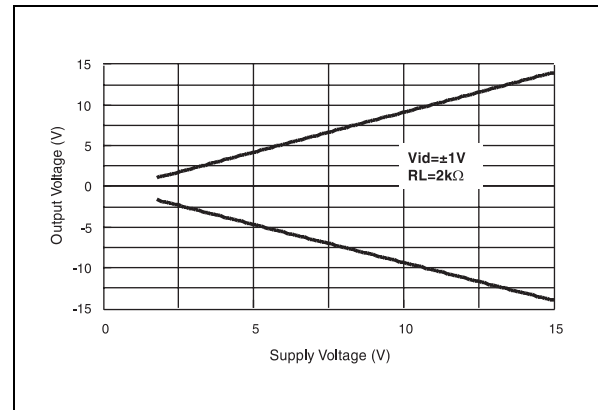
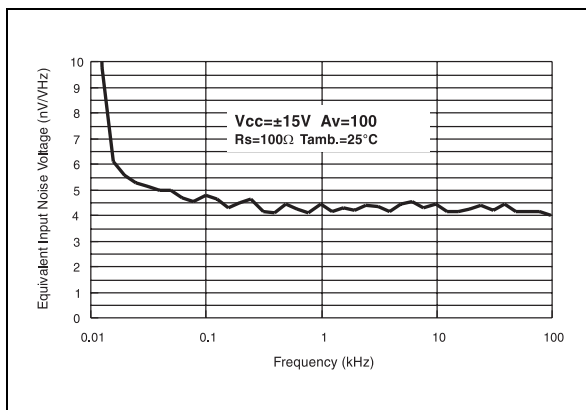
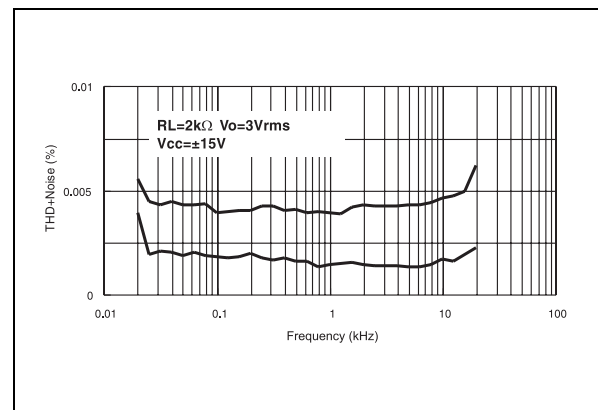
COUT 3 5 1.000000E-12

.ENDS

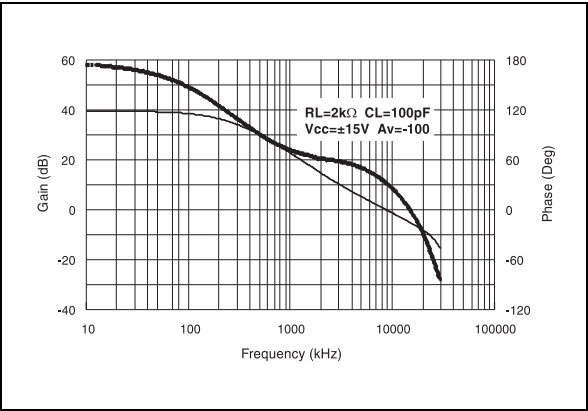
ELECTRICAL CHARACTERISTICS

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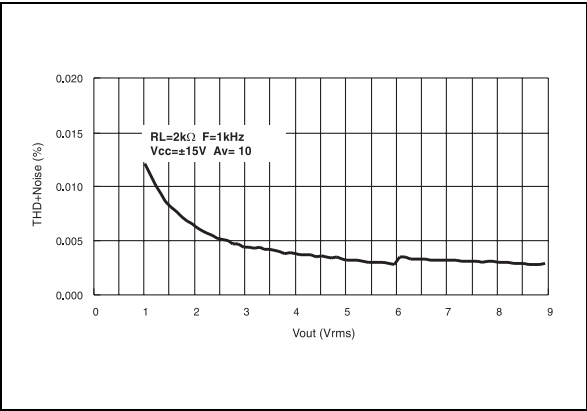
Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	$R_L = 2k\Omega$, $V_o = \pm 10V$	100	dB
I_{cc}	No load, per operator	2	mA
V_{icm}	$\Delta V_{io} = 5mV$, $V_o = 0V$	28	V
V_{opp}	$R_L = 2k\Omega$	28.2	V
I_{sink}	$V_o = 0V$	37	mA
I_{source}	$V_o = 0V$	29	mA
GBP	$R_L = 2k\Omega$, $C_L = 100pF$	15	MHz
SR	$R_L = 2k\Omega$, $C_L = 100pF$, $A_v = +1$	7	V/ μs
$\varnothing m$	$R_L = 2k\Omega$, $C_L = 0pF$	55	Degrees

TOTAL SUPPLY CURRENT vs SUPPLY VOLTAGE**OUTPUT SHORT CIRCUIT CURRENT vs OUTPUT VOLTAGE****OUTPUT VOLTAGE vs SUPPLY VOLTAGE****OUTPUT VOLTAGE vs SUPPLY VOLTAGE****EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY****THD + NOISE vs FREQUENCY**

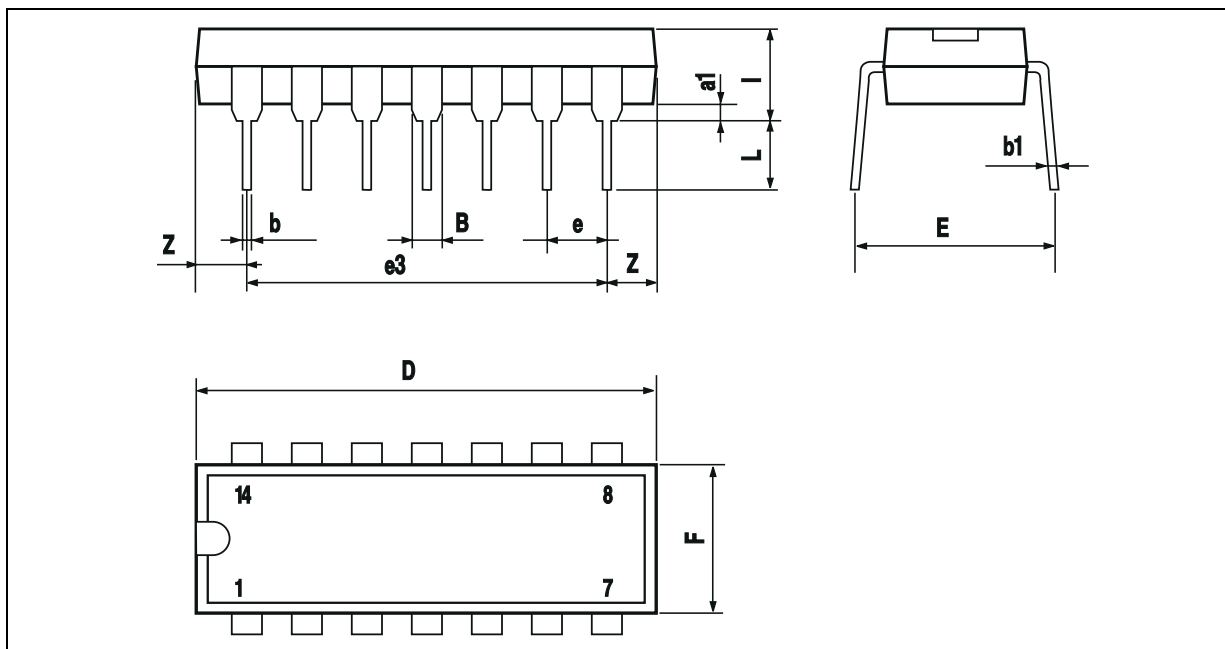
VOLTAGE GAIN AND PHASE vs FREQUENCY



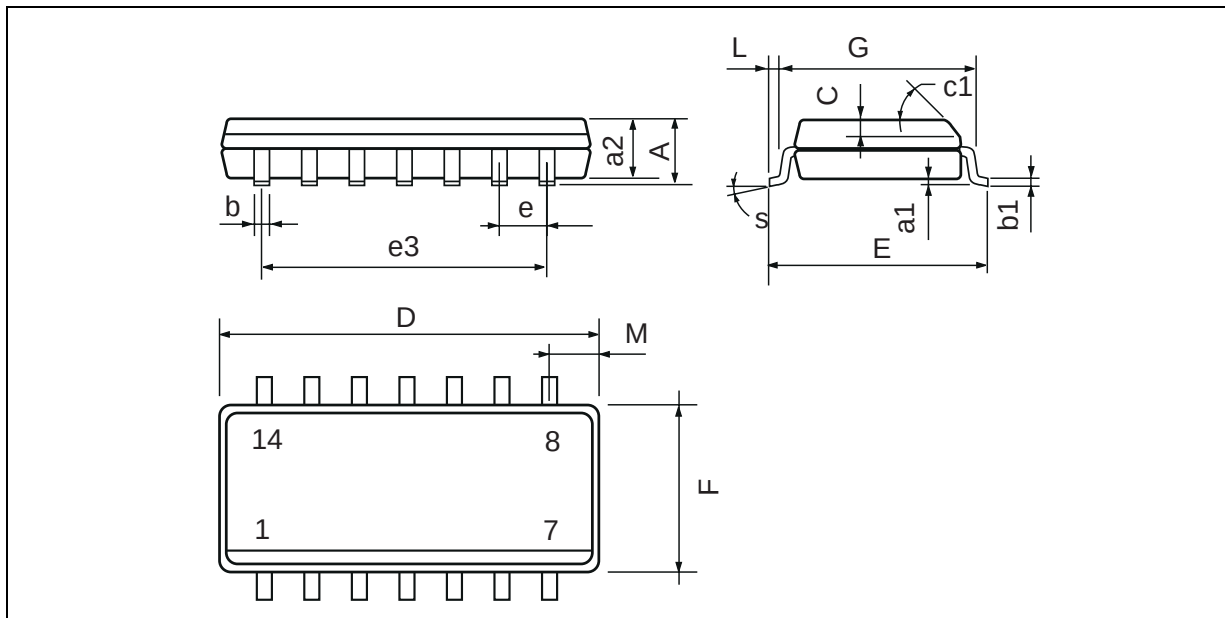
THD + NOISE vs V_{out}



PACKAGE MECHANICAL DATA
14 PINS - PLASTIC DIP



Dim.	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)**

Dim.	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 (1)	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 (1)	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.)					

Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

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