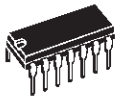
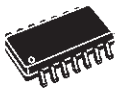
TS524

PRECISION LOW NOISE QUAD OPERATIONAL AMPLIFIER

- LOW INPUT OFFSET VOLTAGE **950µV max.**
- LOW VOLTAGE NOISE : **4.5nV/√Hz**
- HIGH GAIN BANDWIDTH PRODUCT : **15MHz**
- HIGH SLEW RATE : **7V/µs**
- LOW DISTORTION : 0.002%
- ESD INTERNAL PROTECTION 2kV
- MACROMODEL INCLUDED IN THIS SPECI FICATION



N
DIP14
(Plastic Package)



D
SO14
(Plastic Micropackage)

DESCRIPTION

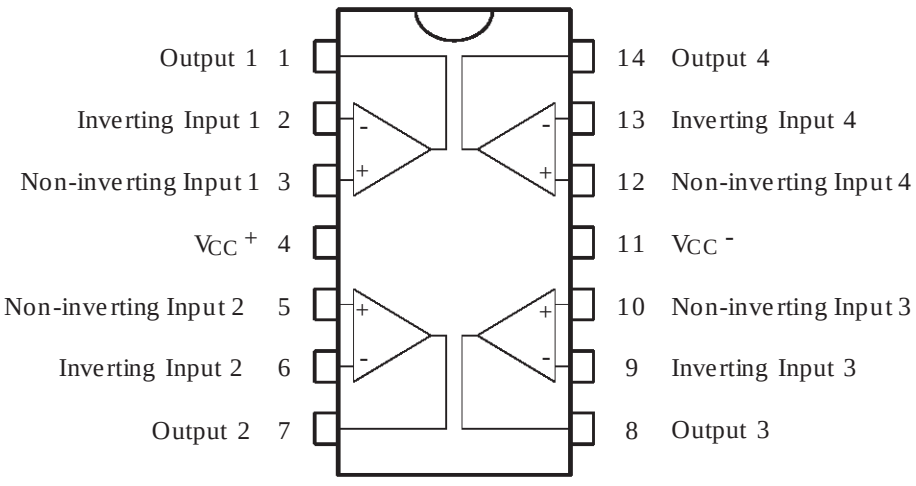
The TS524 is a monolithic quad operational amplifier particularly well-suited for audio applications. The TS524 offers a very low input offset voltage as well as low voltage noise (**4.5nV/√Hz**) and high dynamic performances (15MHz gain bandwidth product, 7V/µs slew rate).
The output stage allows a large output voltage swing and symmetrical source and sink currents.

ORDER CODE

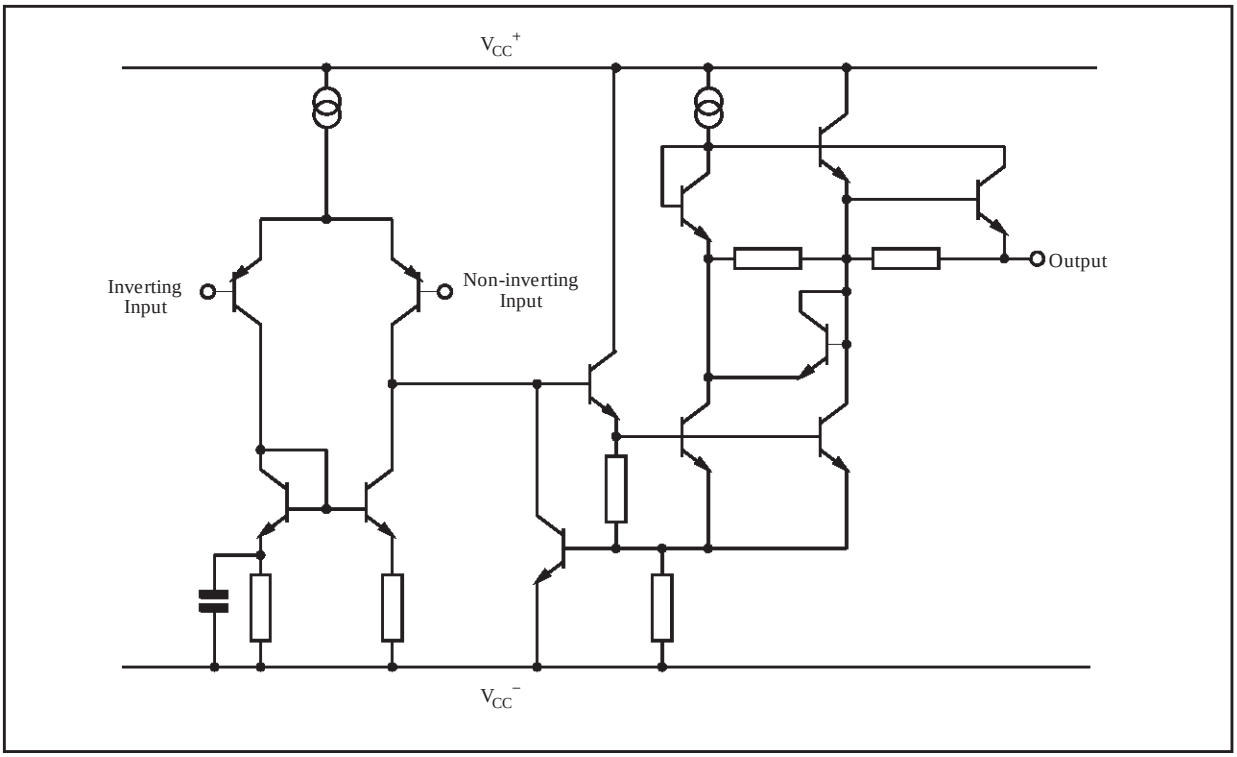
Part Number	Temperature Range	Package	
		N	D
TS524I	-40°C, +125°C	•	•

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°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage (V_o = 0V, V_{ic} = 0V) $T_{min} \le T_{amb} \le T_{max}$			0.95 1.8	mV
ΔV_{io}	Input Offset Voltage Drift V_{ic} = 0V, V_o = 0V, $T_{min} \le T_{amb} \le T_{max}$		2		µV/°C
Iio	Input Offset Current (V_{ic} = 0V, V_o = 0V) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		10	150 175	nA
I_{ib}	Input Bias Current (V_{ic} = 0V, V_o = 0V) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		250	750 800	nA
Vicm	Common Mode Input Voltage Range (ΔV_{io} = 5mV, Vo = 0V)	±13	±14		V
A_{vd}	Large Signal Voltage Gain (R_L = 2kΩ, Vo = ±10V T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 90 85	 100		dB
$\pm V_{opp}$	Output Voltage Swing (Vid = ±1V) R_L = 600Ω R_L = 600Ω R_L = 2.0kΩ R_L = 2.0kΩ R_L = 10kΩ R_L =10kΩ	 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} = ±13V)	80	100		dB
SVR	Supply Voltage Rejection Ratio Vcc^+/Vcc^- = +15V/-15V to +5V/-5V	 80	 105		dB
I_o	Output Short Circuit Current (V_{id} = ±1V, Output to ground) Source Sink	 15 20	 29 37		mA
I_{cc}	Supply Current (V_o = 0V, All amplifiers) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		 8	 10 12	mA
SR	Slew Rate (V_i = -10V to +10V, R_L = 2kΩ, C_L = 100pF, A_V = +1)	5	7		V/µs
GBP	Gain Bandwith Product (f = 100kHz, R_L = 2kΩ, C_L = 100pF)	10	15		MHz
B	Unity Gain Bandwith (Open loop)		9		MHz
A_m	Gain Margin (R_L = 2kΩ) C_L = 0pF C_L = 100pF		-11 -6		dB
∅m	Phase Margin C_L = 0pF C_L = 100pF		55 30		Degrees
e_n	Equivalent Input Noise Voltage (R_S = 100Ω, 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 = 2kΩ, 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 Bandwith (V_o = $27V_{pp}$, R_L = 2kΩ, THD ≤ 1%)		120		kHz
Z_o	Output Impedance (V_o = 0V, f = 9MHz)		37		Ω
R_i	Input Resistance (V_{ic} = 0V)		175		kΩ
C_i	Input Capacitance (V_{ic} = 0V)		12		pF

MACROMODEL

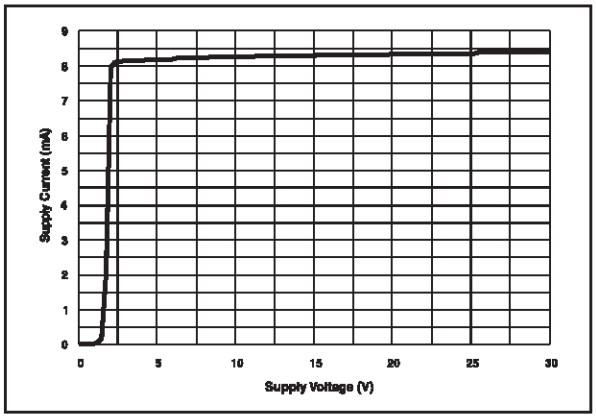
```
** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT TS524 1 3 2 4 5 (analog)
**********************************************************
.MODEL MDTH D IS=1E-8 KF=2.286238E-16 CJO=10F
* 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

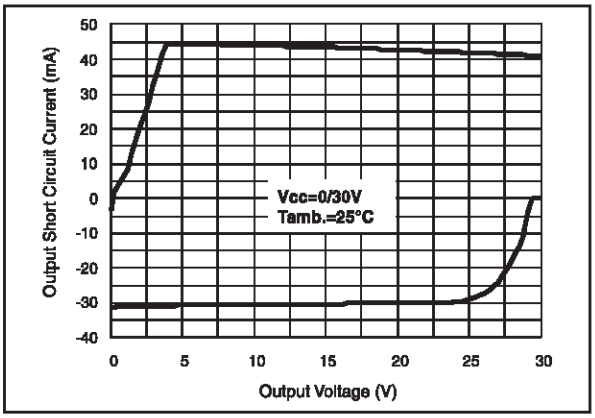
V_{cc} = ±15V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	R_L = 2kΩ, V_o = ±10V	100	dB
I_{cc}	No load, per operator	2	mA
V_{icm}	ΔV_{io} = 5mV, V_o = 0V	28	V
V_{opp}	R_L = 2kΩ	28.2	V
I_{sink}	V_o = 0V	37	mA
I_{source}	V_o = 0V	29	mA
GBP	R_L = 2kΩ, C_L = 100pF	15	MHz
SR	R_L = 2kΩ, C_L = 100pF, A_V = +1	7	V/µs
∅m	R_L = 2kΩ, C_L = 0pF	55	Degrees

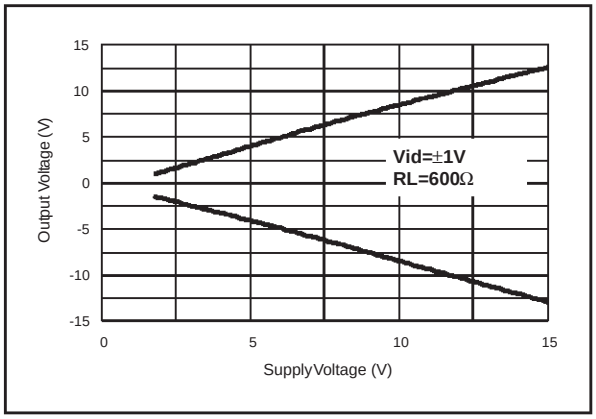
TOTAL SUPPLY CURRENT vs SUPPLY VOLTAGE



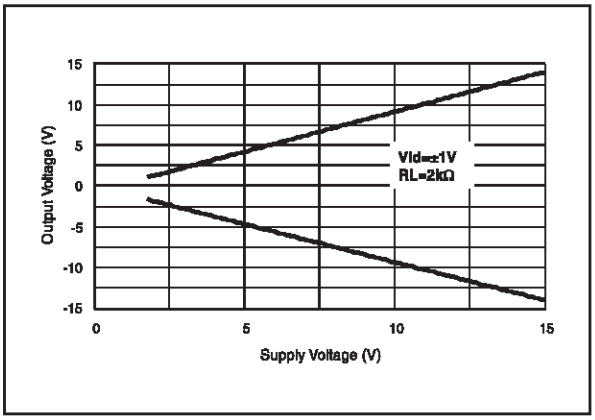
OUTPUT SHORT CIRCUIT CURRENT vs OUTPUT VOLTAGE



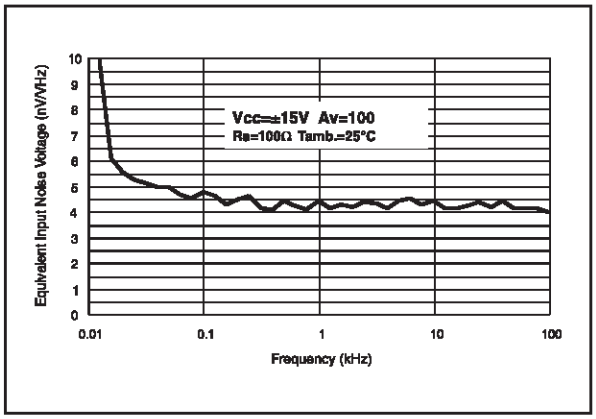
OUTPUT VOLTAGE vs SUPPLY VOLTAGE



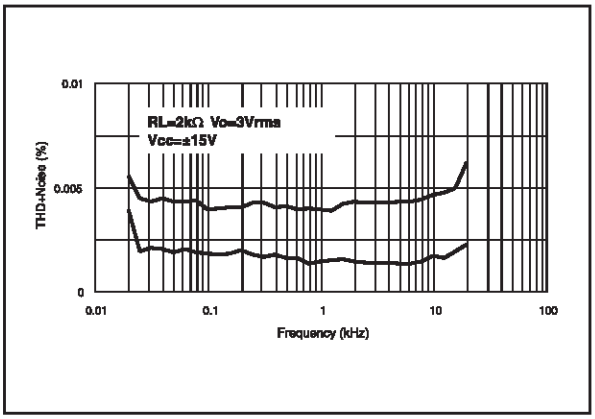
OUTPUT VOLTAGE vs SUPPLY VOLTAGE



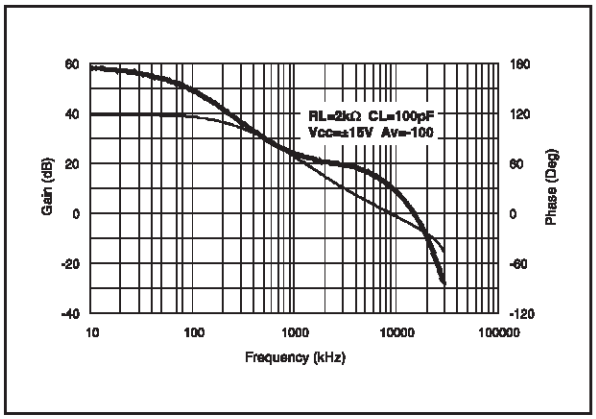
EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY



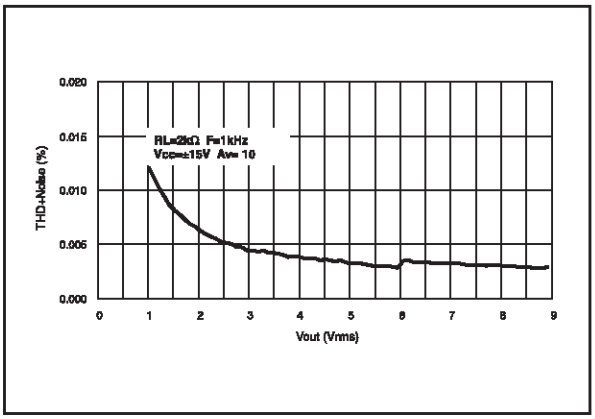
THD + NOISE vs FREQUENCY



VOLTAGE GAIN AND PHASE vs FREQUENCY

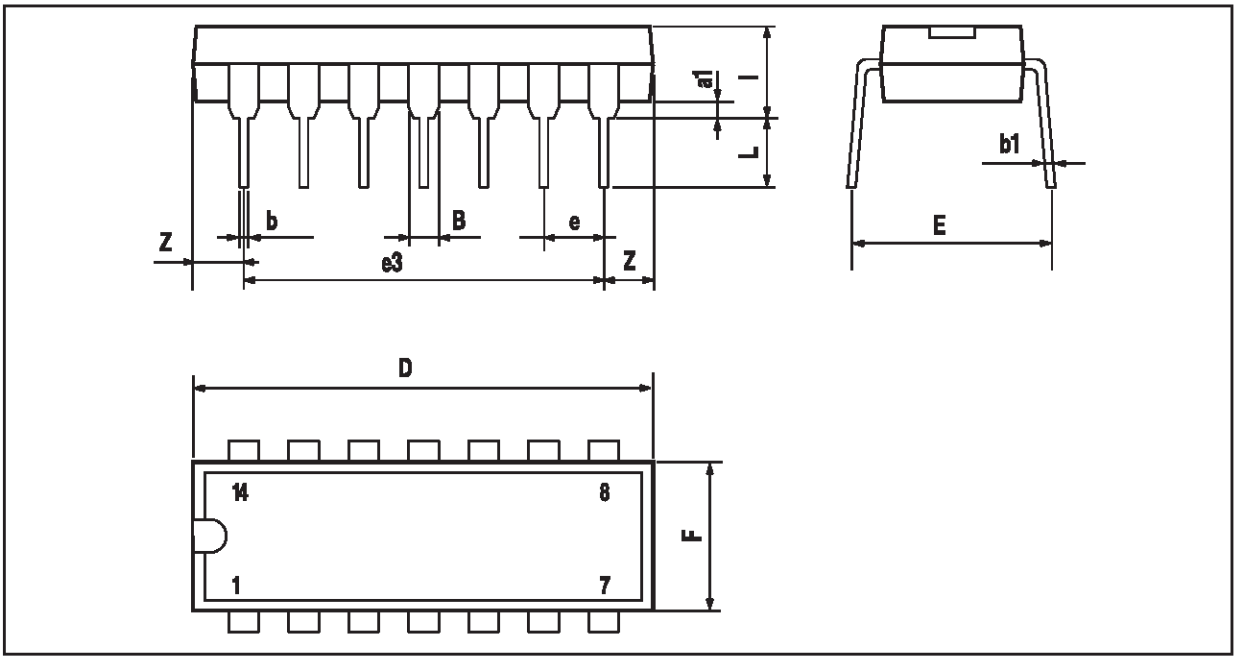


THD + NOISE vs V_{out}



PACKAGE MECHANICAL DATA

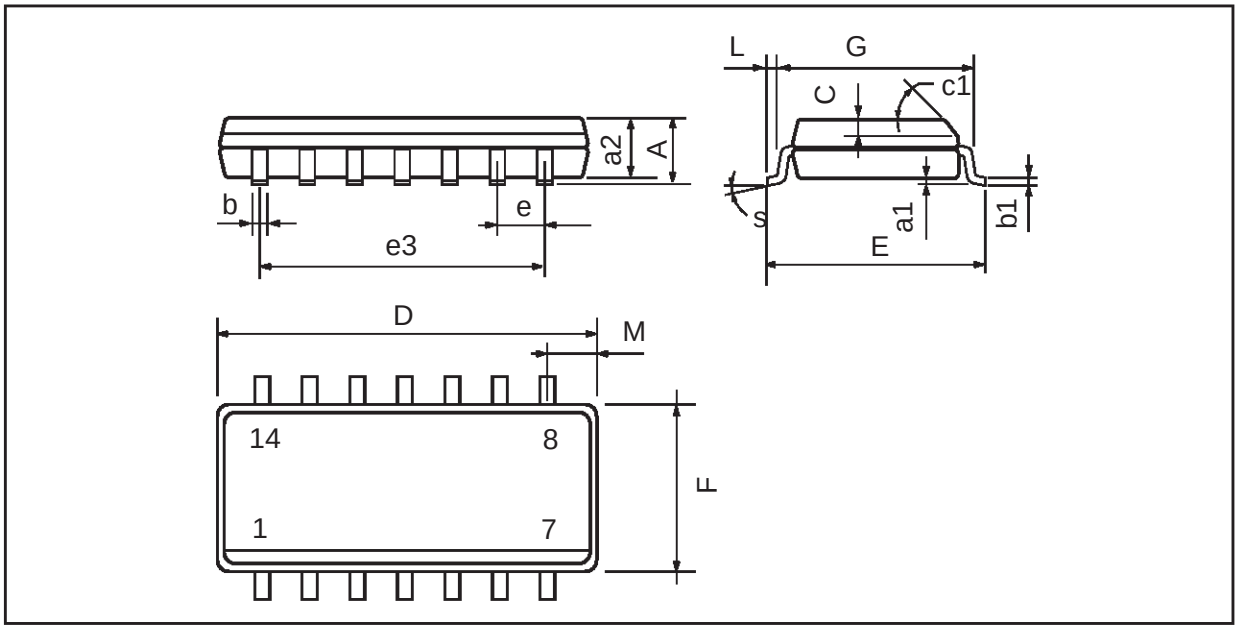
14 PINS - PLASTIC DIP



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.