

## LOW POWER DUAL OPERATIONAL AMPLIFIER

- INTERNALLY FREQUENCY COMPENSATED
- LARGE DC VOLTAGE GAIN : 100dB
- WIDE BANDWIDTH (unity gain): 1.1MHz (temperature compensated)
- VERY LOW SUPPLY CURRENT/OP (500µA) ESSENTIALLY INDEPENDENT OF SUPPLY VOLTAGE
- LOW INPUT BIAS CURRENT: 20nA (temperature compensated)
- LOW INPUT OFFSET CURRENT: 2nA
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- DIFFERENTIAL INPUT VOLTAGE RANGE EQUAL TO THE POWER SUPPLY VOLTAGE
- LARGE OUTPUT VOLTAGE SWING 0V TO ( $V_{CC} - 1.5V$ )

### DESCRIPTION

This circuit consists of two independent, high gain, internally frequency compensated which were designed specifically for automotive and industrial control system. It operates from a single power supply over a wide range of voltages. The low power supply drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, these circuits can be directly supplied with off the standard +5V which is used in logic systems and will easily provide the required interface electronics without requiring any additional power supply.

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.

### ORDER CODE

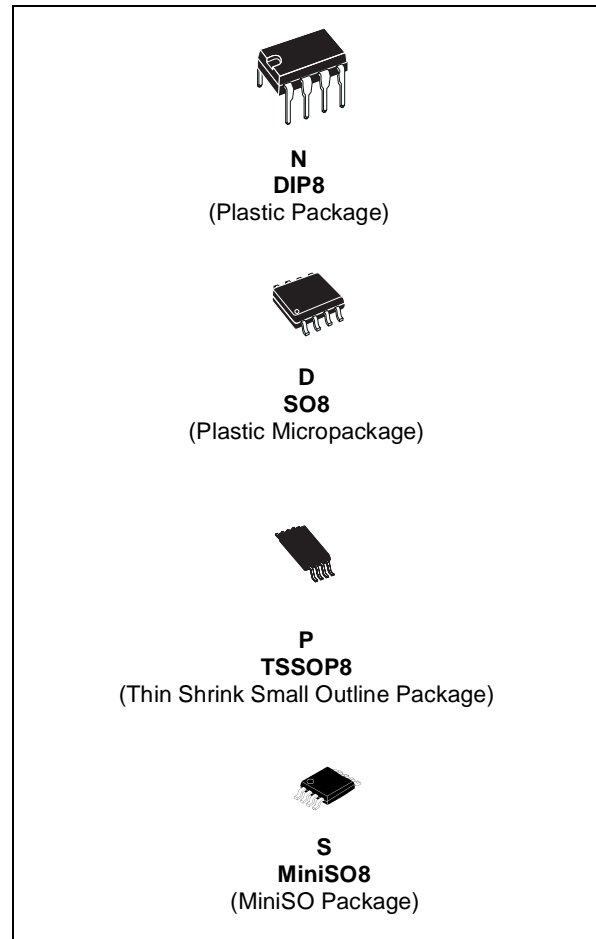
Part Number	Temperature Range	Package			
		N	D	P	S
LM2904	-40°C, +125°C	•	•	•	•

**N** = Dual in Line Package (DIP)

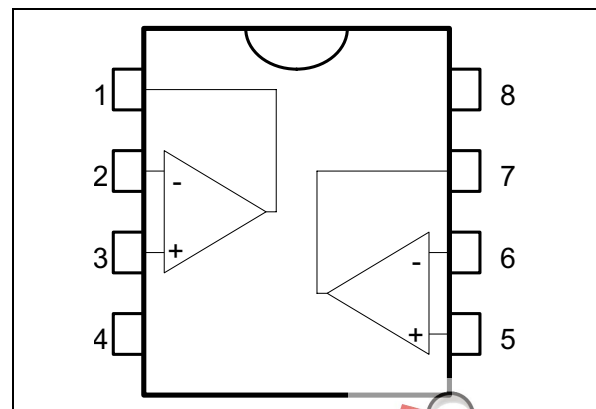
**D** = Small Outline Package (SO) - also available in Tape & Reel (DT)

**P** = Thin Shrink Small Outline Package (TSSOP) only available in Tape & Reel (PT)

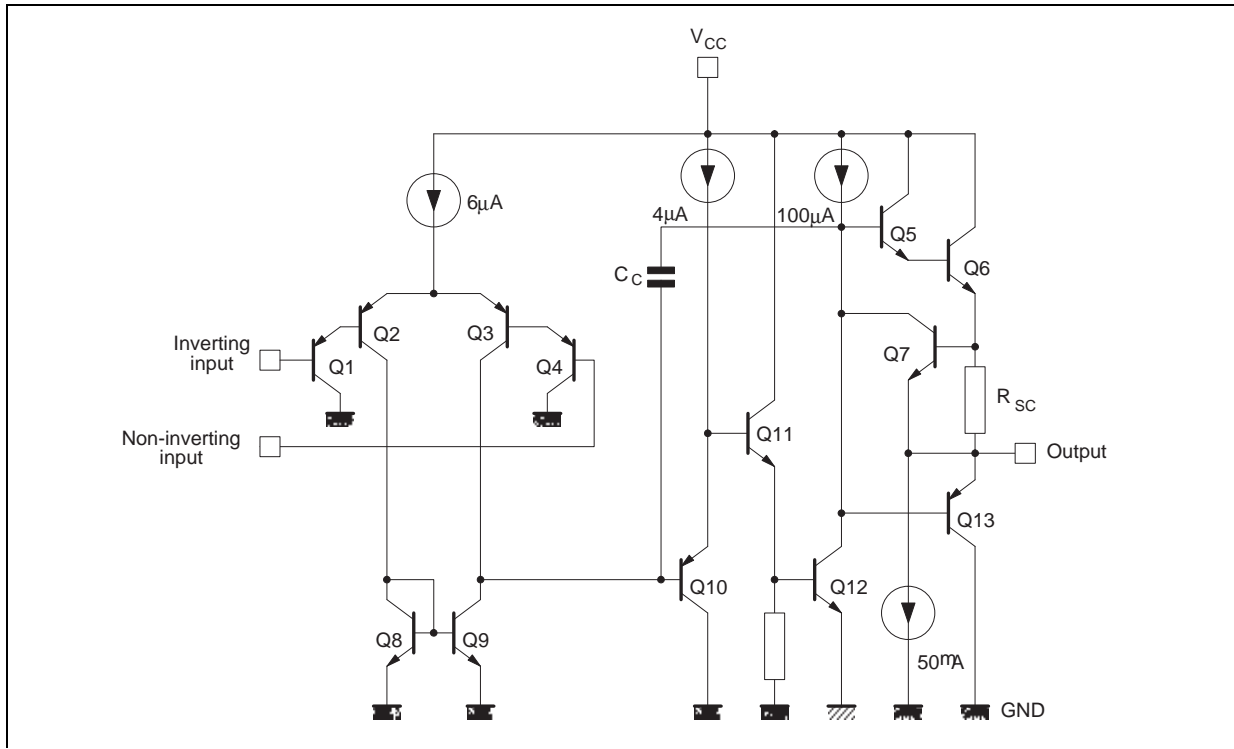
**S** = MiniSO Package (MiniSO) only available in Tape & Reel (ST)



### PIN CONNECTIONS (top view)



**SCHEMATIC DIAGRAM (1/2 LM2904)**



**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply Voltage	+32	V
$V_{id}$	Differential Input Voltage	+32	V
$V_I$	Input Voltage	-0.3 to +32	V
	Output Short-circuit to Ground <sup>1)</sup>		
$P_{tot}$	Power Dissipation <sup>2)</sup>	500	mW
$I_{in}$	Input Current <sup>3)</sup>	50	mA
$T_{oper}$	Operating Free-Air Temperature Range	-40 to +125	°C
$T_{stg}$	Storage Temperature Range	-65 to +150	°C

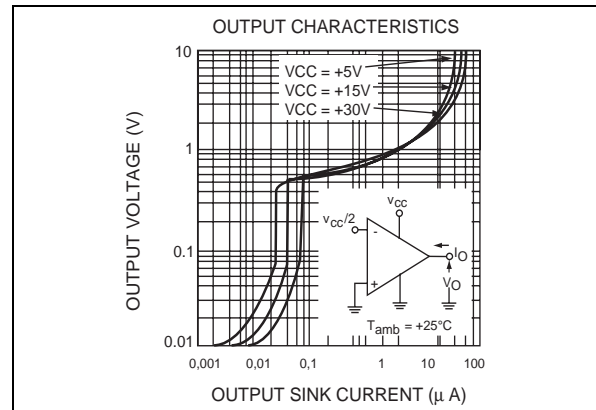
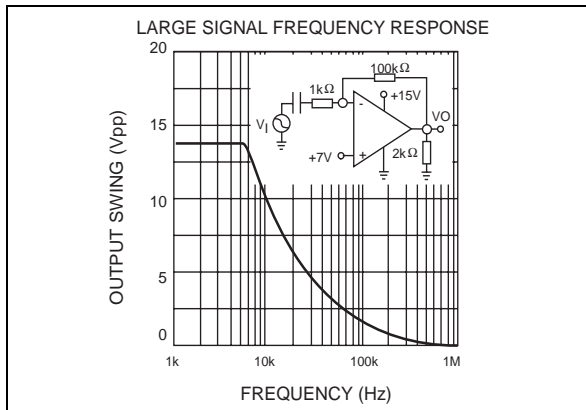
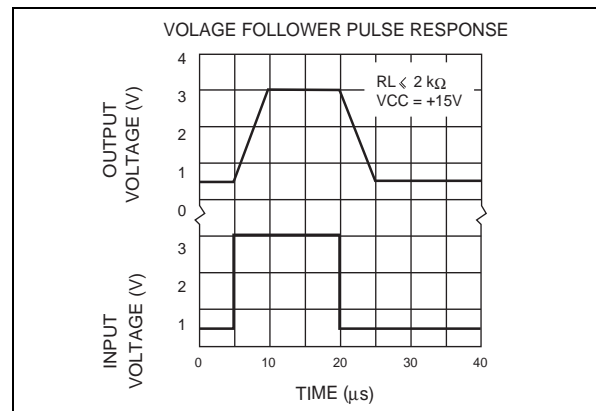
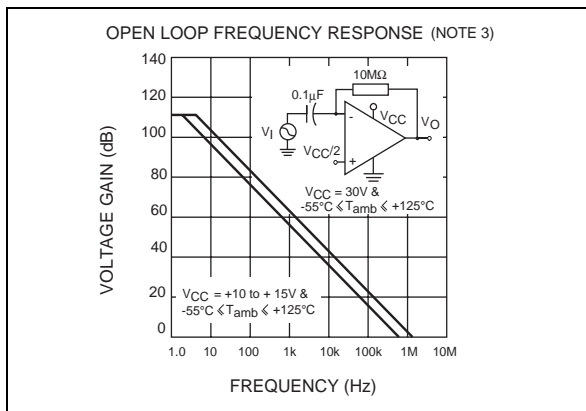
- Short-circuits from the output to  $V_{CC}$  can cause excessive heating if  $V_{CC} > 15V$ . The maximum output current is approximately 40mA, independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
- Power dissipation must be considered to ensure maximum junction temperature ( $T_j$ ) is not exceeded.
- This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the Op-Amps to go to the  $V_{CC}$  voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative. This is not destructive and normal output will set up again for input voltage higher than -0.3V.

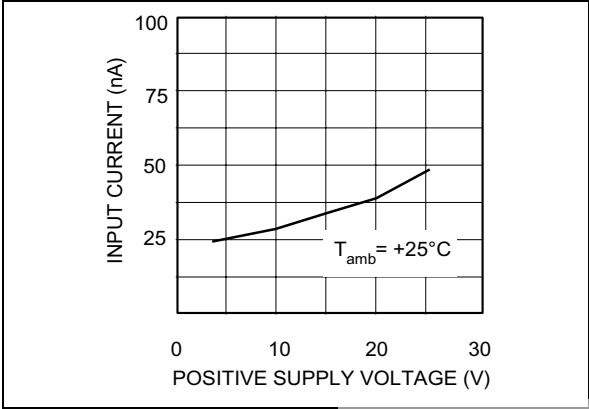
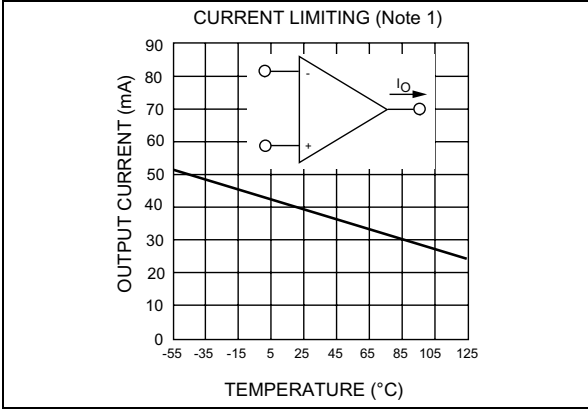
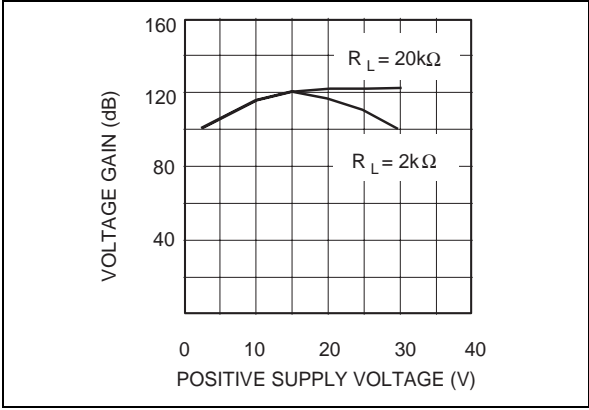
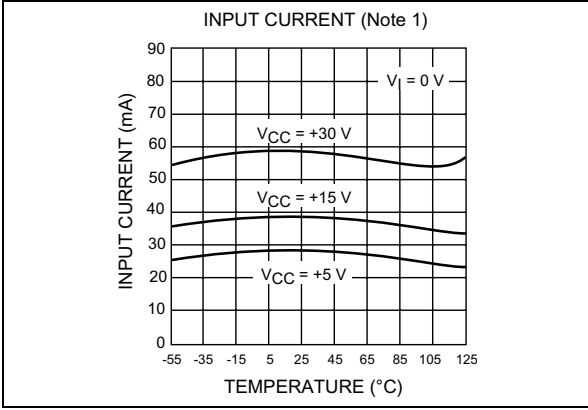
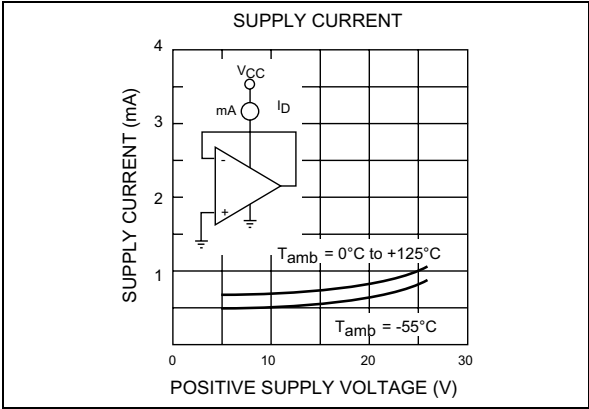
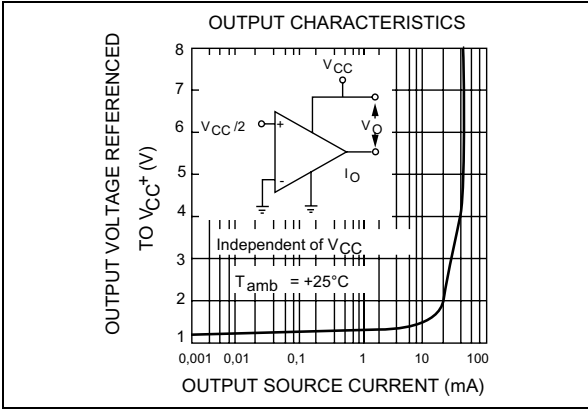
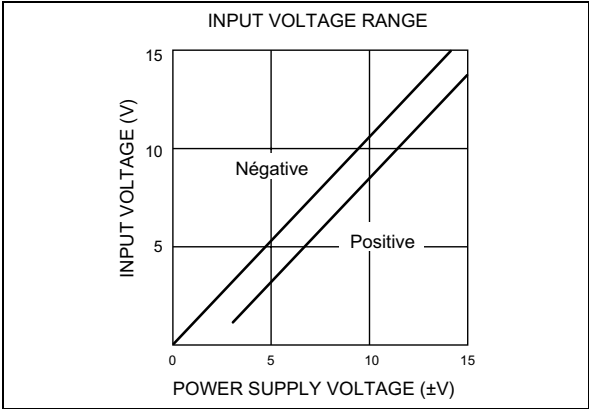
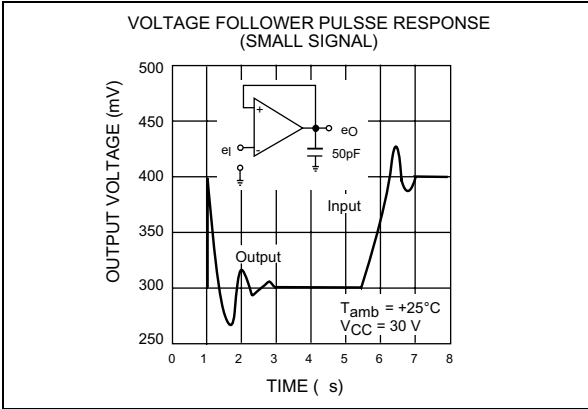
**ELECTRICAL CHARACTERISTICS**
 $V_{CC}^+ = 5V$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_O = 1.4V$ ,  $T_{amb} = 25^\circ\text{C}$  (unless otherwise specified)

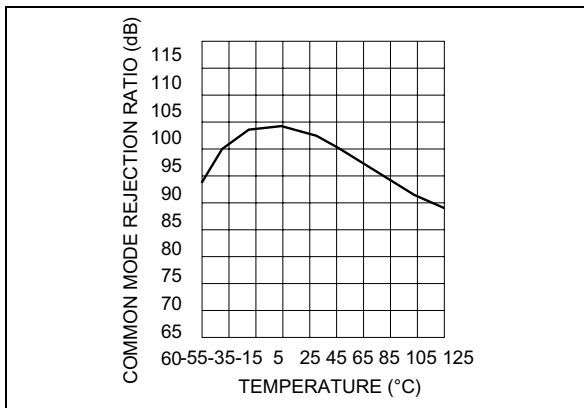
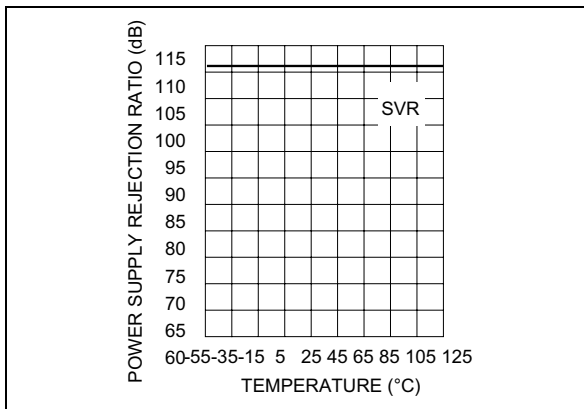
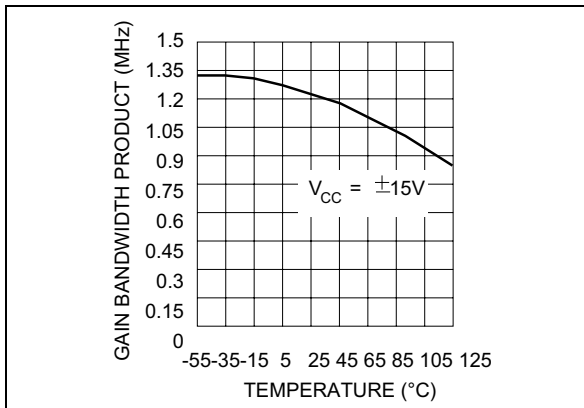
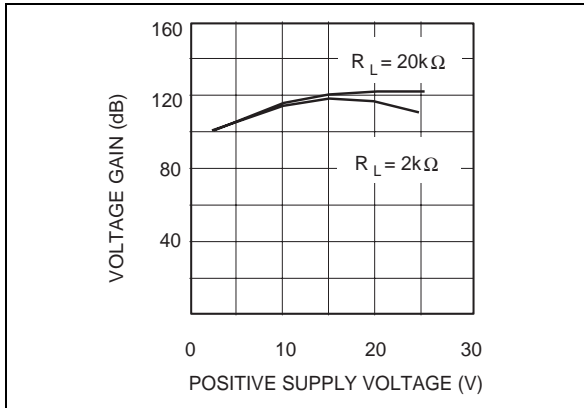
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input Offset Voltage <sup>1)</sup> $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .		2	7 9	mV
$I_{io}$	Input Offset Current $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .		2	30 40	nA
$I_{ib}$	Input Bias Current <sup>2)</sup> $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .		20	150 200	nA
$A_{vd}$	Large Signal Voltage Gain $V_{CC}^+ = +15V, R_L = 2k\Omega, V_O = 1.4V \text{ to } 11.4V$ $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .	50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio ( $R_S \leq 10k\Omega$ ) $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .	65 65	100		dB
$I_{cc}$	Supply Current, all Amp, no load $T_{amb} = 25^\circ\text{C}$ $V_{CC} = +5V$ $T_{min} \leq T_{amb} \leq T_{max}$ . $V_{CC} = +30V$		0.7	1.2 2	mA
$V_{icm}$	Input Common Mode Voltage Range ( $V_{CC} = +30V$ ) <sup>3)</sup> $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .	0 0		$V_{CC}^+ - 1.5$ $V_{CC}^+ - 2$	V
CMR	Common-mode Rejection Ratio ( $R_S = 10k\Omega$ ) $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ .	70 60	85		dB
$I_{source}$	Output Short-circuit Current $V_{CC} = +15V, V_O = +2V, V_{id} = +1V$	20	40	60	mA
$I_{sink}$	Output Sink Current $V_O = 2V$ $V_{CC} = +5V$ $V_O = +0.2V$ $V_{CC} = +15V$	10 12	20 50		mA $\mu\text{A}$
$V_{OPP}$	Output Voltage Swing ( $R_L = 2k\Omega$ ) $T_{amb} = 25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	0 0		$V_{CC}^+ - 1.5$ $V_{CC}^+ - 2$	V
$V_{OH}$	High Level Output Voltage ( $V_{CC} + 30V$ ) $T_{amb} = +25^\circ\text{C}$ $R_L = 2k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ . $T_{amb} = +25^\circ\text{C}$ $R_L = 10k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ .	26 26 27 27	27 28		V
$V_{OL}$	Low Level Output Voltage ( $R_L = 10k\Omega$ ) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$		5	20 20	mV
SR	Slew Rate $V_{CC} = 15V, V_i = 0.5 \text{ to } 3V, R_L = 2k\Omega, C_L = 100\text{pF}$ , unity gain	0.3	0.6		V/ $\mu\text{s}$
GBP	Gain Bandwidth Product $f = 100\text{kHz}$ $V_{CC} = 30V, V_{in} = 10\text{mV}, R_L = 2k\Omega, C_L = 100\text{pF}$	0.7	1.1		MHz

Symbol	Parameter	Min.	Typ.	Max.	Unit
THD	Total Harmonic Distortion f = 1kHz, A <sub>V</sub> = 20dB, R <sub>L</sub> = 2kΩ, V <sub>o</sub> = 2Vpp, C <sub>L</sub> = 100pF, V <sub>CC</sub> = 30V		0.02		%
DV <sub>io</sub>	Input Offset Voltage Drift		7	30	μV/°C
DI <sub>io</sub>	Input Offset Current Drift		10	300	pA/°C
V <sub>O1</sub> /V <sub>O2</sub>	Channel Separation 4) 1kHz ≤ f ≤ 20kHz		120		dB

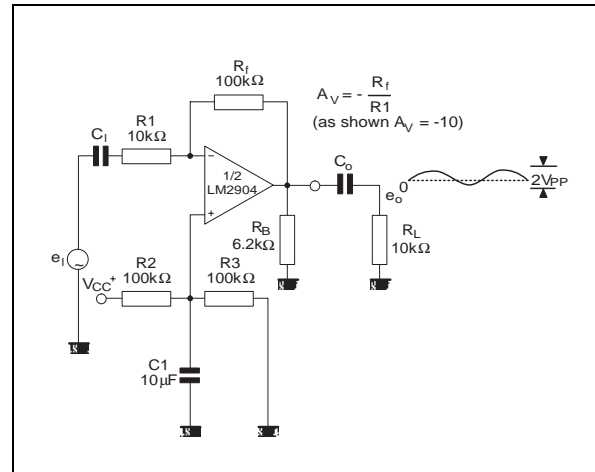
- V<sub>O</sub> = 1.4V, R<sub>S</sub> = 0Ω, 5V < V<sub>CC</sub><sup>+</sup> < 30V, 0V < V<sub>ic</sub> < V<sub>CC</sub><sup>+</sup> - 1.5V
- The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output, so no loading charge change exists on the input lines
- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V<sub>CC</sub><sup>+</sup> - 1.5V, but either or both inputs can go to +32V without damage.
- Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.



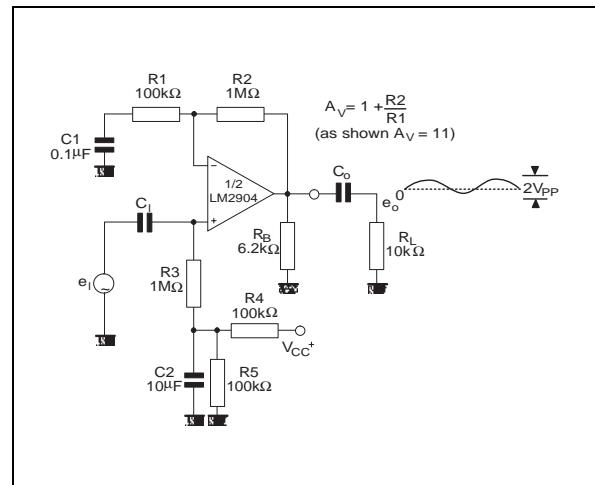




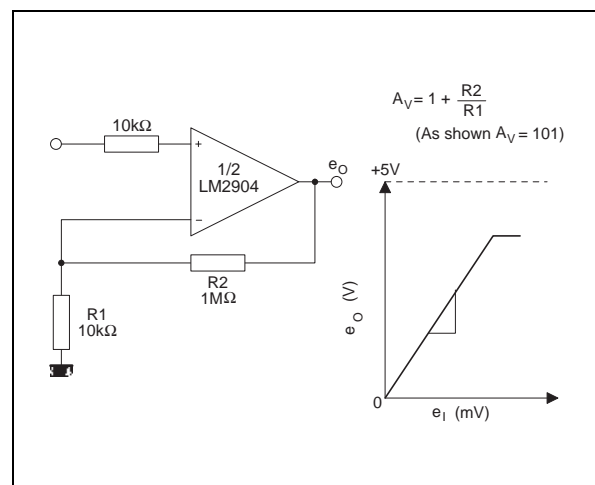
TYPICAL SINGLE - SUPPLY APPLICATIONS  
AC COUPLED INVERTING AMPLIFIER



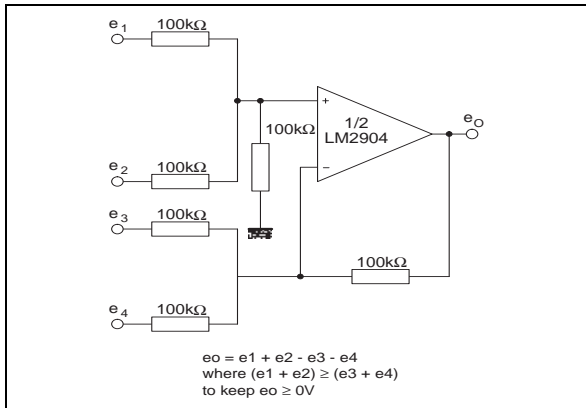
AC COUPLED NON-INVERTING AMPLIFIER



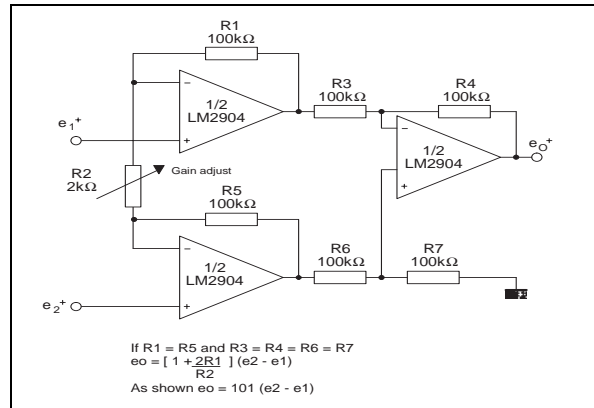
NON-INVERTING DC GAIN



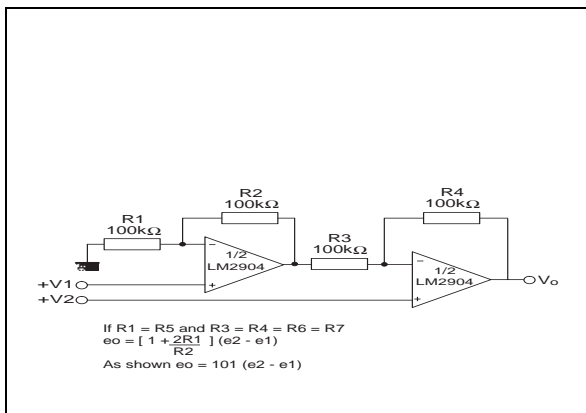
DC SUMMING AMPLIFIER



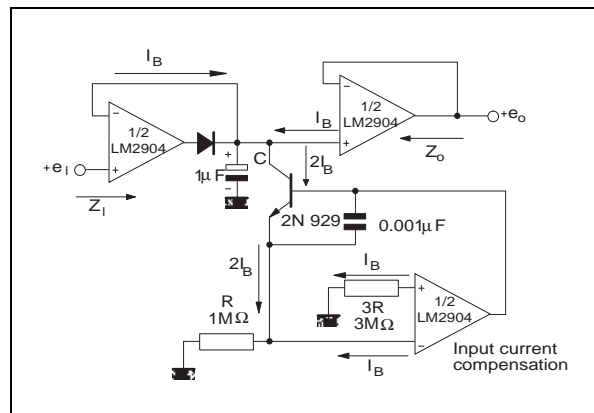
HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER



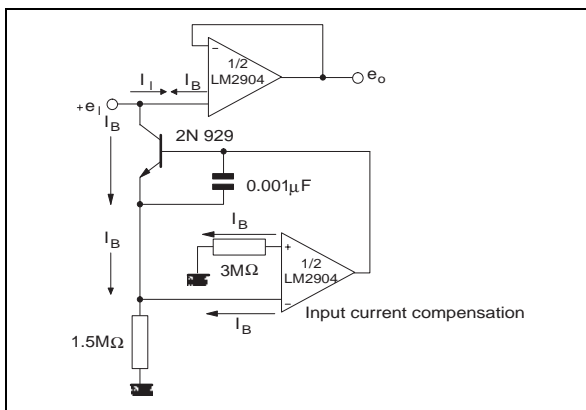
HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER



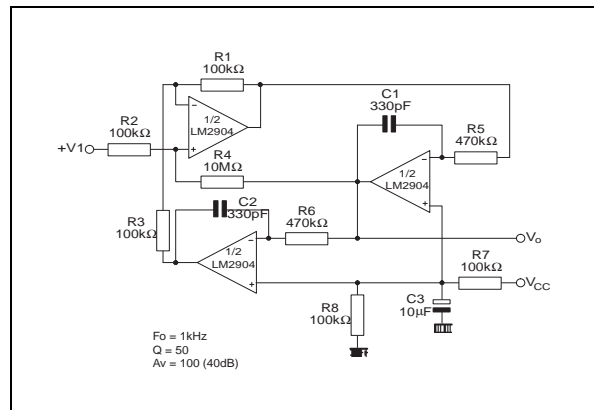
LOW DRIFT PEAK DETECTOR



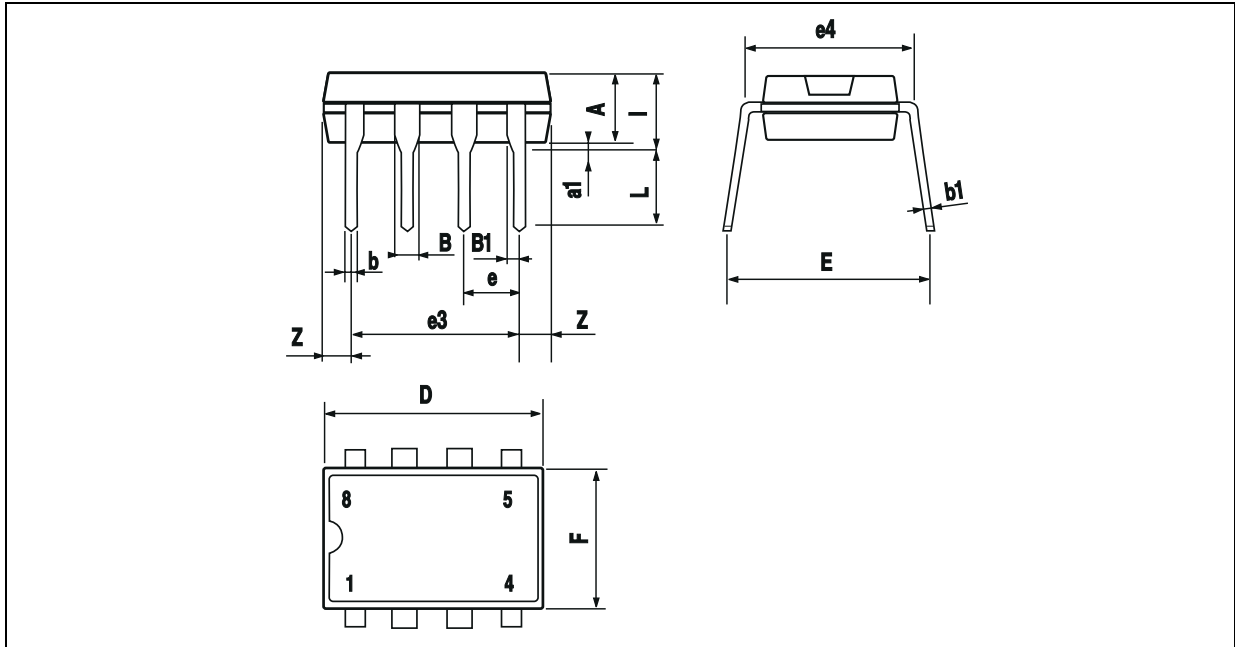
USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT



ACTIVER BADPASS FILTER



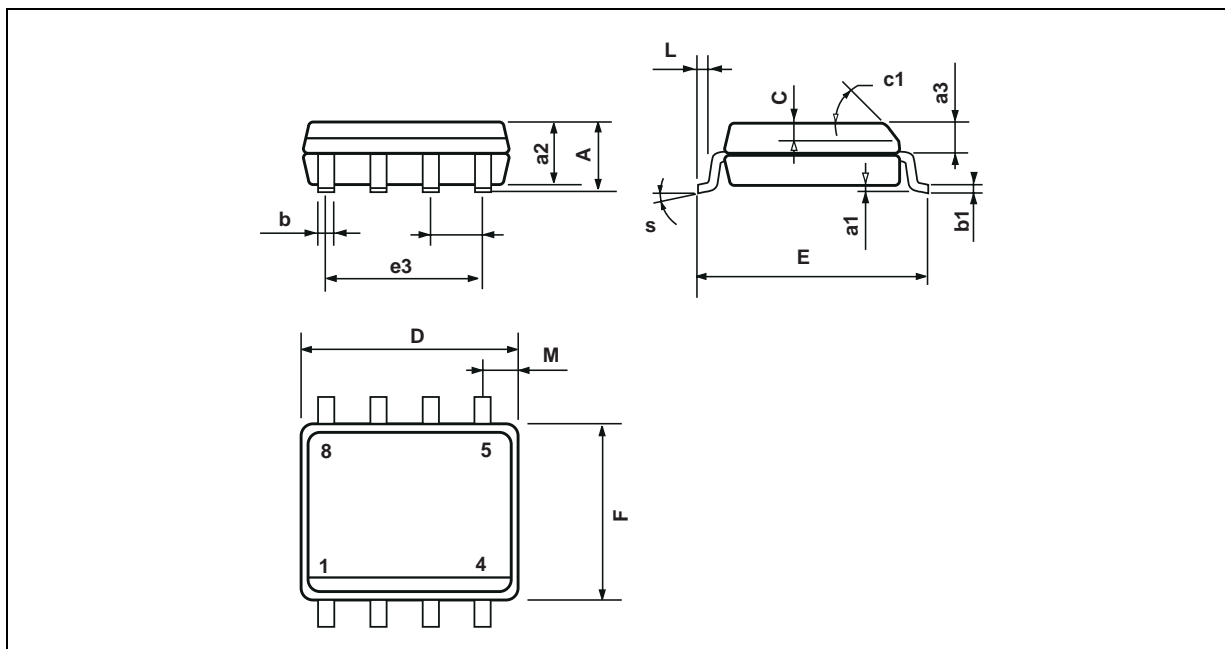
**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC DIP



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

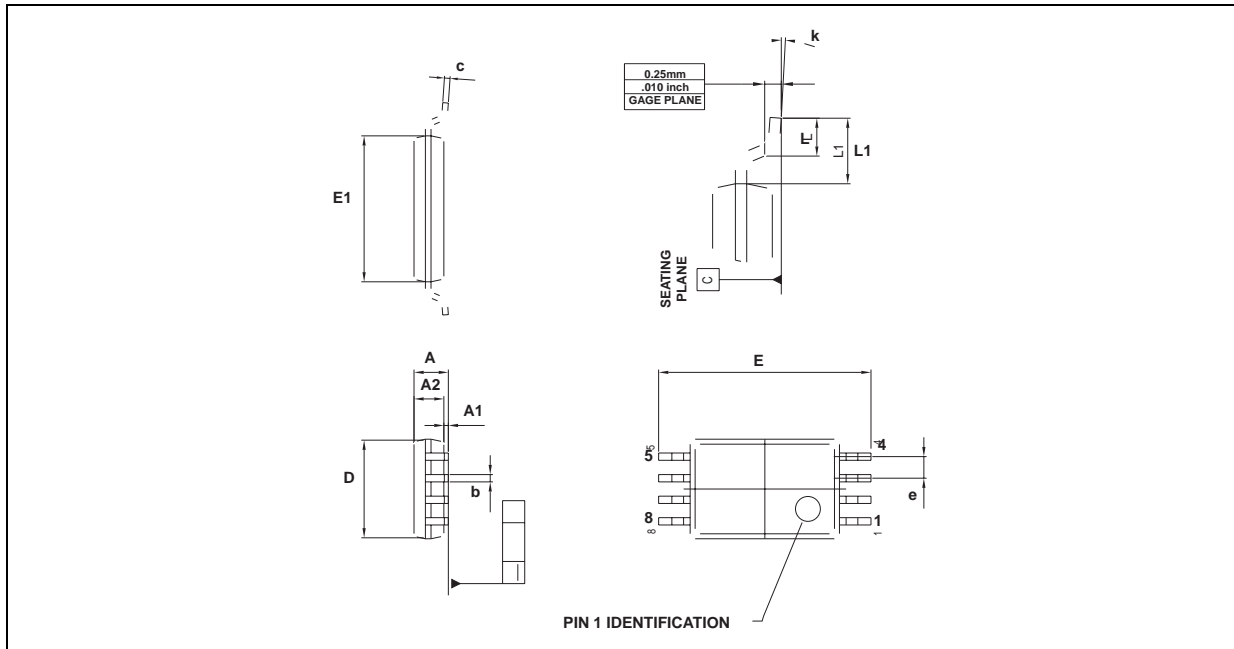


**PACKAGE MECHANICAL DATA**  
8 PINS - PLASTIC MICROPACKAGE (SO)



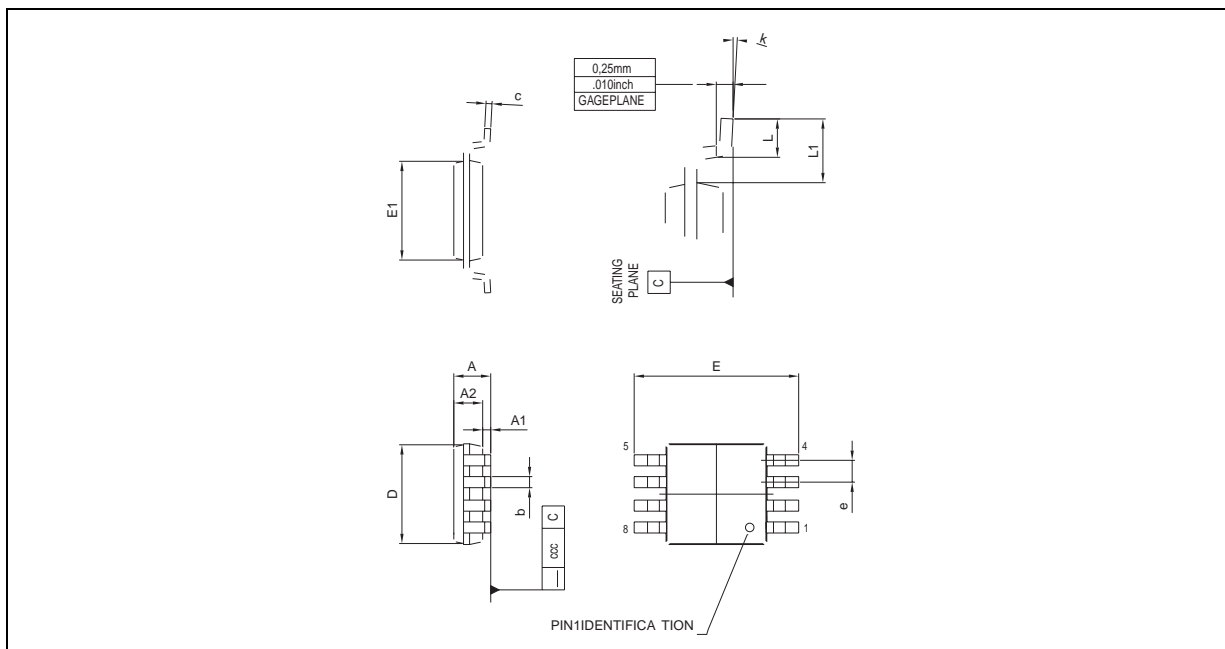
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		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.)					

**PACKAGE MECHANICAL DATA**  
**8 PINS -THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)**



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030
L	0.45	0.600	0.75	0.018	0.024	0.030
L1		1.000			0.039	

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



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.100			0.043
A1	0.050	0.100	0.150	0.002	0.004	0.006
A2	0.780	0.860	0.940	0.031	0.034	0.037
b	0.250	0.330	0.400	0.010	0.013	0.016
c	0.130	0.180	0.230	0.005	0.007	0.009
D	2.900	3.000	3.100	0.114	0.118	0.122
E	4.750	4.900	5.050	0.187	0.193	0.199
E1	2.900	3.000	3.100	0.114	0.118	0.122
e		0.650			0.026	
L	0.400	0.550	0.700	0.016	0.022	0.028
L1		0.950			0.037	
k	0d	3d	6d	0d	3d	6d
aaa			0.100			0.004

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