

## Low-power quad operational amplifier

Datasheet – production data

### Features

- Wide gain bandwidth: 1.3 MHz
- Input common-mode voltage range includes negative rail
- Large voltage gain: 100 dB
- Very low supply current per amplifier: 375  $\mu$ A
- Low input bias current: 20 nA
- Low input offset current: 2 nA
- Wide power supply range:
  - Single supply: +3 V to +30 V
  - Dual supplies:  $\pm$ 1.5 V to  $\pm$ 15 V

### Description

This circuit consists of four independent, high gain operational amplifiers which employ internal frequency compensation and are specifically designed for automotive and industrial control systems.

The device operates from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent from the power supply voltage magnitude.



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# 1 Schematic diagram

Figure 1. Schematic diagram (1/4 LM2902)

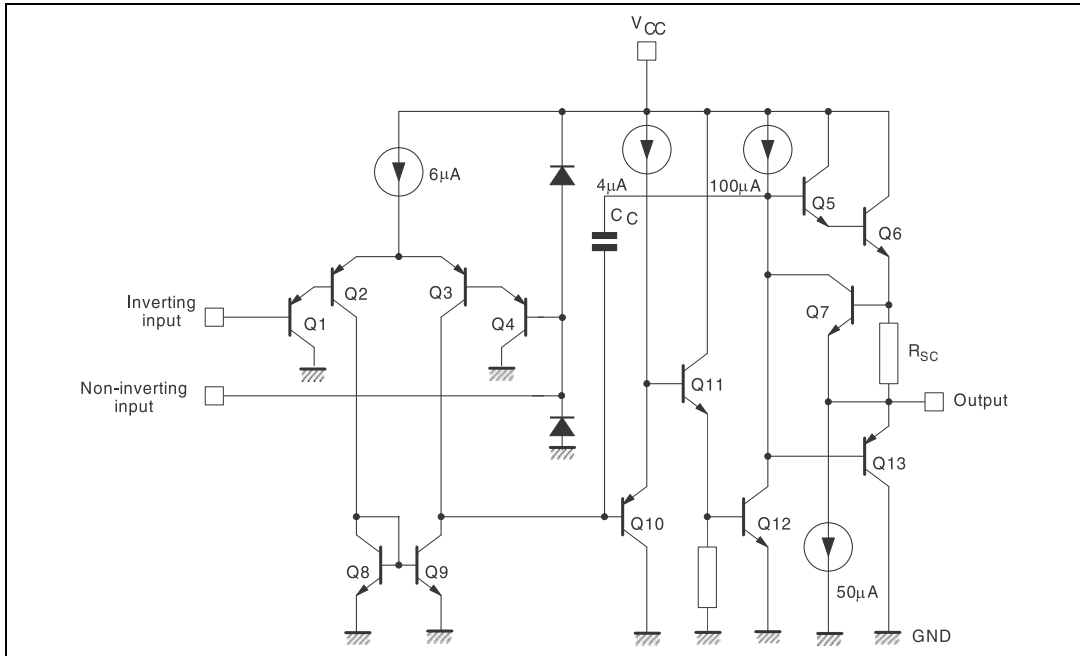
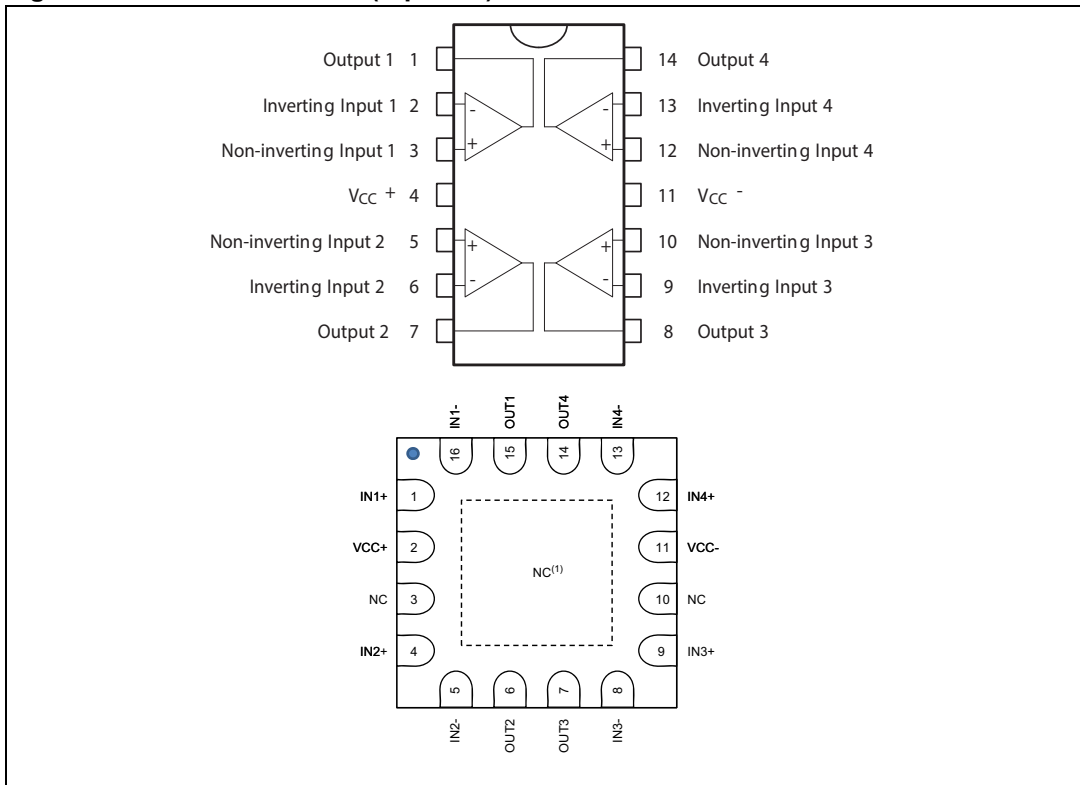


Figure 2. Pin connections (top view)



1. The exposed pads of the QFN16 3x3 can be connected to VCC- or left floating.

## 2 Absolute maximum ratings

**Table 1. Absolute maximum ratings (AMR)**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>(1)</sup>	±16 to 33	V
$V_{id}$	Differential input voltage <sup>(2)</sup>	+32	
$V_{in}$	Input voltage	-0.3 to +32	
	Output short-circuit duration <sup>(3)</sup>	Infinite	s
$T_j$	Maximum junction temperature	150	°C
$I_{in}$	Input current <sup>(4)</sup> : $V_{in}$ driven negative	5 in DC or 50 in AC (duty cycle = 10 %, T = 1 s)	mA
	Input current <sup>(5)</sup> : $V_{in}$ driven positive above AMR value	0.4	
$T_{stg}$	Storage temperature range	-65 to +150	°C
$R_{thja}$	Thermal resistance junction to ambient <sup>(6)</sup>		°C/W
	DIP14	80	
	SO-14	105	
	TSSOP14	100	
$R_{thjc}$	Thermal resistance junction to case <sup>(6)</sup>		°C/W
	DIP14	33	
	SO-14	31	
	TSSOP14	32	
ESD	HBM: human body model <sup>(7)</sup>	370	V
	MM: machine model <sup>(8)</sup>	150	V
	CDM: charged device model <sup>(9)</sup>	1500	V

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. Short-circuit from the output to  $V_{CC}^+$  can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA, independent of the magnitude of  $V_{CC}^+$ .
4. 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 diode clamp. In addition to this diode action, there is 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 during which an input is driven negative. This is not destructive and normal output is restored for input voltages above -0.3 V.
5. The junction base/substrate of the input PNP transistor polarized in reverse must be protected by a resistor in series with the inputs to limit the input current to 400  $\mu$ A max ( $R = (V_{in} - 36 V)/400 \mu$ A).
6.  $R_{thja/c}$  are typical values.
7. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
8. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
9. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

### 3 Operating conditions

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	3 to 30	V
$V_{icm}$	Common mode input voltage range $T_{min} \leq T_{amb} \leq T_{max}$	$V_{CC}^+ - 1.5$ $V_{CC}^+ - 2$	
$T_{oper}$	Operating free-air temperature range	-40 to +125	°C

## 4 Electrical characteristics

**Table 3.**  $V_{CC}^+ = 5V$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4V$ ,  $T_{amb} = 25^\circ C$   
(unless otherwise specified)

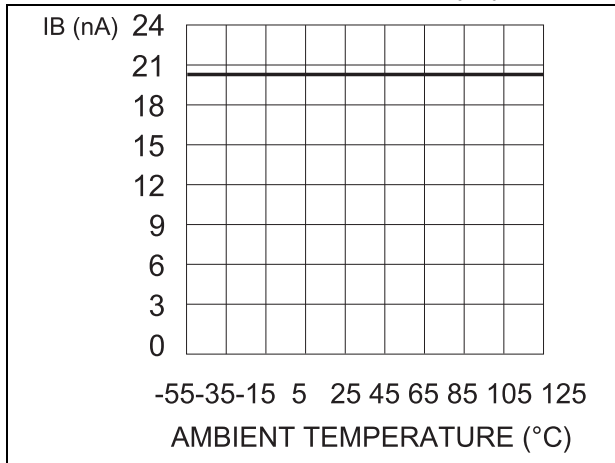
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage <sup>(1)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		2	7 9	mV
$\Delta V_{io}/\Delta T$	Input offset voltage drift		7	30	$\mu V/^\circ C$
$I_{io}$	Input offset current $T_{min} \leq T_{amb} \leq T_{max}$		2	30 40	nA
$DI_{io}$	Input offset current drift		10	200	$pA/^\circ C$
$I_{ib}$	Input bias current <sup>(2)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		20	150 300	nA
$A_{vd}$	Large signal voltage gain ( $V_{CC}^+ = +15V$ , $R_L = 2k\Omega$ , $V_o = 1.4V$ to $11.4V$ ) $T_{min} \leq T_{amb} \leq T_{max}$	50 25	100		V/mV
SVR	Supply voltage rejection ratio ( $R_S \leq 10k\Omega$ ) $T_{min} \leq T_{amb} \leq T_{max}$	65 65	110		dB
$I_{cc}$	Supply current, all amps, no load $V_{CC}^+ = +5V$ $V_{CC}^+ = +30V$ $T_{min} \leq T_{amb} \leq T_{max}$ $V_{CC}^+ = +5V$ $V_{CC}^+ = +30V$		0.7 1.5	1.2 3	mA
CMR	Common-mode rejection ratio ( $R_S \leq 10k\Omega$ ) $T_{min} \leq T_{amb} \leq T_{max}$	70 60	80		dB
$I_o$	Output short-circuit current ( $V_{id} = +1V$ , $V_{CC}^+ = +15V$ , $V_o = +2V$ )	20	40	70	mA
$I_{sink}$	Output sink current ( $V_{id} = -1V$ ) $V_{CC}^+ = +15V$ , $V_o = +2V$ $V_{CC}^+ = +15V$ , $V_o = +0.2V$	10 12	20 50		mA $\mu A$
$V_{OH}$	High level output voltage ( $V_{CC}^+ = +30V$ ) $R_L = 2k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 10k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ $V_{CC}^+ = +5V$ , $R_L = 2k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	26 26 27 27 3 3.5	27 28		V

**Table 3.**  $V_{CC}^+ = 5V$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4V$ ,  $T_{amb} = 25^\circ C$   
(unless otherwise specified) (continued)

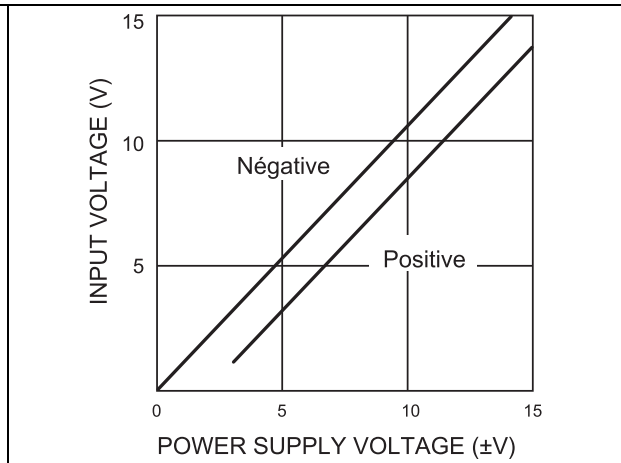
Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{OL}$	Low level output voltage ( $R_L = 10 \text{ k}\Omega$ ) $T_{min} \leq T_{amb} \leq T_{max}$		5	20 20	mV
SR	Slew rate ( $V_{CC}^+ = 15 \text{ V}$ , $V_{in} = 0.5 \text{ to } 3 \text{ V}$ , $R_L = 2 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$ , unity gain)		0.4		V/ $\mu$ s
GBP	Gain bandwidth product ( $V_{CC}^+ = 30 \text{ V}$ , $V_{in} = 10 \text{ mV}$ , $R_L = 2 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$ )		1.3		MHz
THD	Total harmonic distortion ( $f = 1 \text{ kHz}$ , $A_V = 20 \text{ dB}$ , $R_L = 2 \text{ k}\Omega$ , $V_o = 2 \text{ V}_{pp}$ , $C_L = 100 \text{ pF}$ , $V_{CC}^+ = 30 \text{ V}$ )		0.015		%
$e_n$	Equivalent input noise voltage ( $f = 1 \text{ kHz}$ , $R_S = 100 \Omega$ , $V_{CC}^+ = 30 \text{ V}$ )		40		$\frac{nV}{\sqrt{Hz}}$
$V_{O1}/V_{O2}$	Channel separation <sup>(3)</sup> ( $1 \text{ kHz} \leq f \leq 20 \text{ kHz}$ )		120		dB

- $V_o = 1.4 \text{ V}$ ,  $R_S = 0 \Omega$ ,  $5 \text{ V} < V_{CC}^+ < 30 \text{ V}$ ,  $0 \text{ V} < V_{ic} < V_{CC}^+ - 1.5 \text{ V}$ .
- The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output, so there is no change in the loading charge on the input lines.
- Due to the proximity of external components ensure stray capacitance does not cause coupling between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

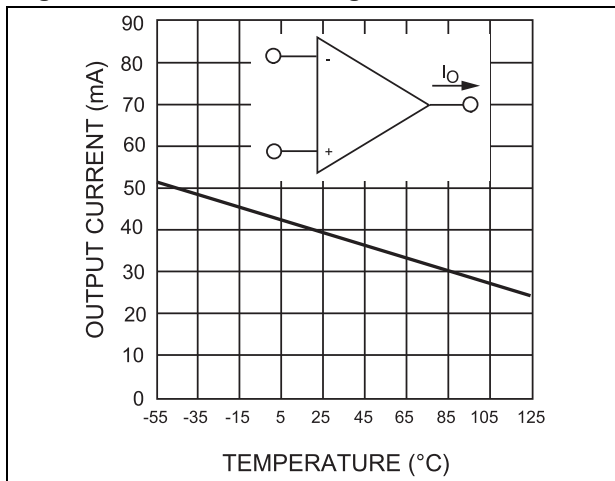
**Figure 3. Input bias current vs.  $T_{amb}$**



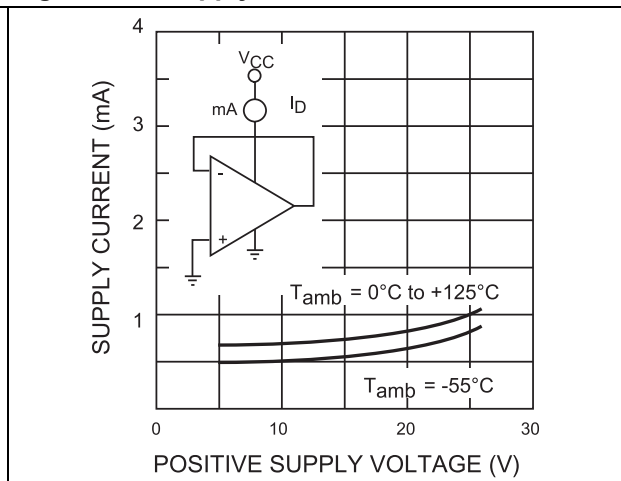
**Figure 4. Input voltage range**



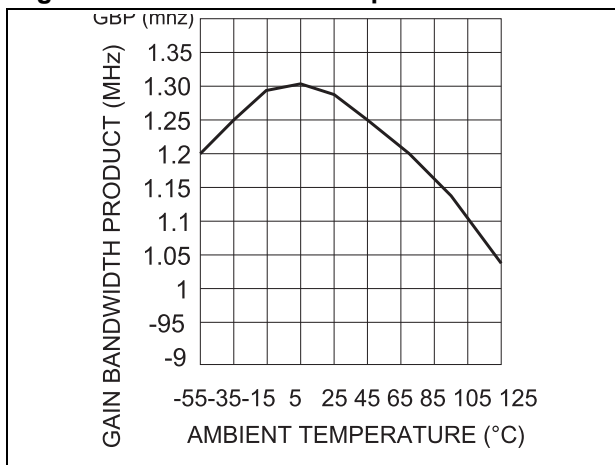
**Figure 5. Current limiting**



**Figure 6. Supply current**



**Figure 7. Gain bandwidth product**



**Figure 8. Voltage follower pulse response**

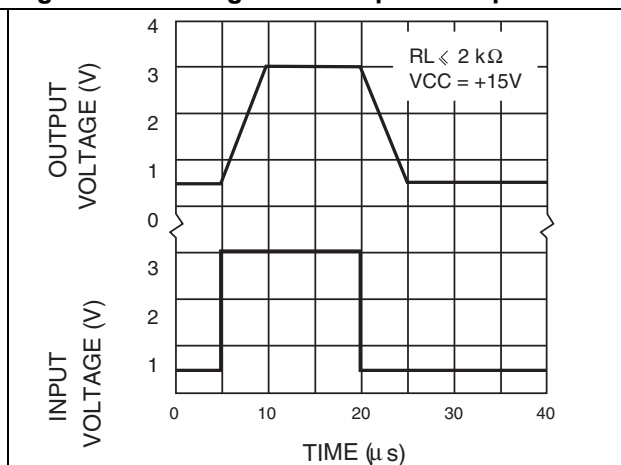




Figure 9. Common mode rejection ratio

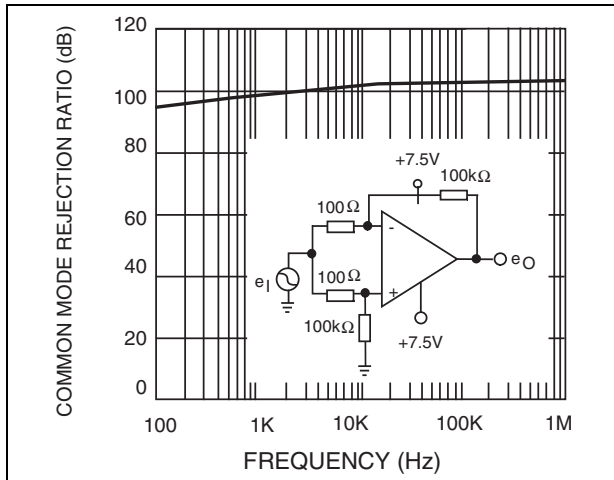


Figure 10. Output characteristics (sink)

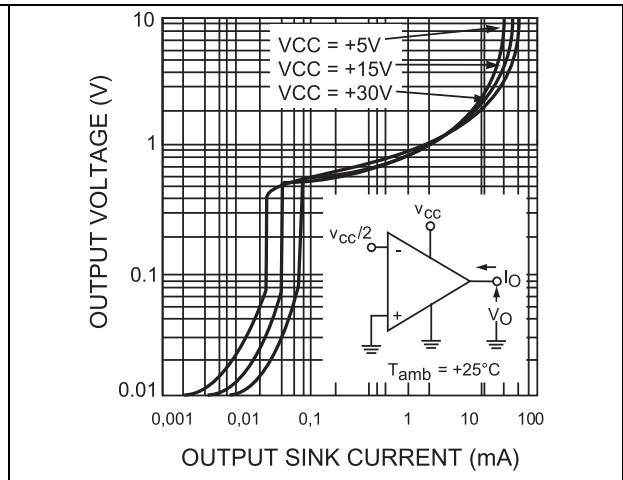


Figure 11. Open-loop frequency response

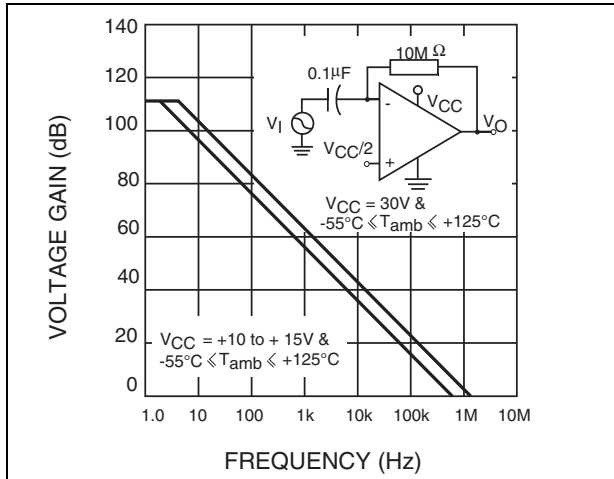


Figure 12. Voltage follower pulse response

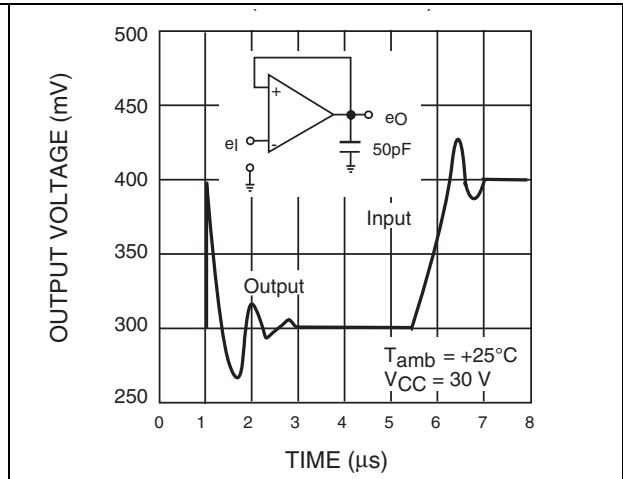


Figure 13. Large signal frequency response

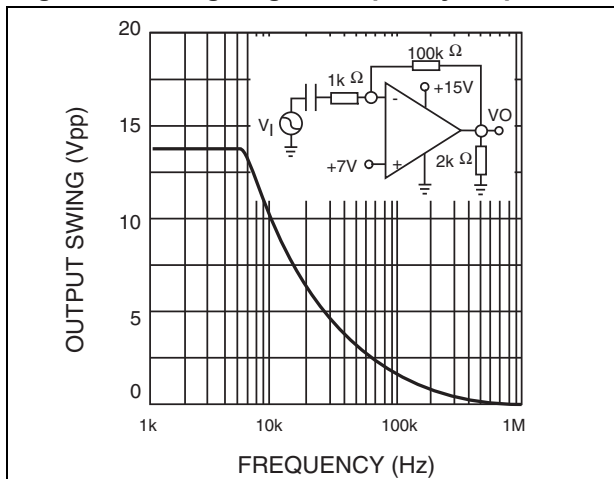


Figure 14. Output characteristics (source)

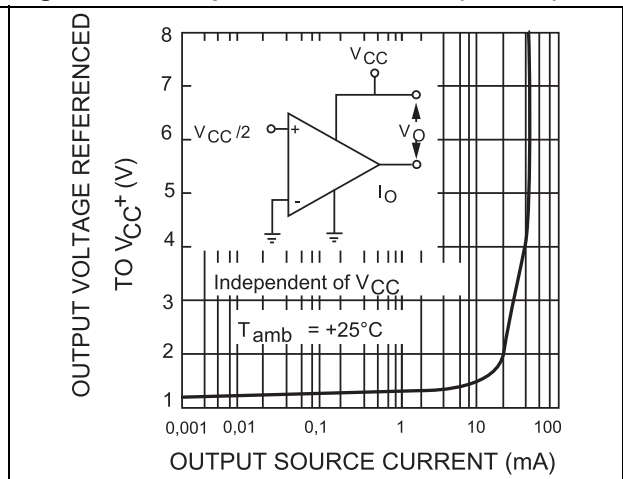


Figure 15. Input current

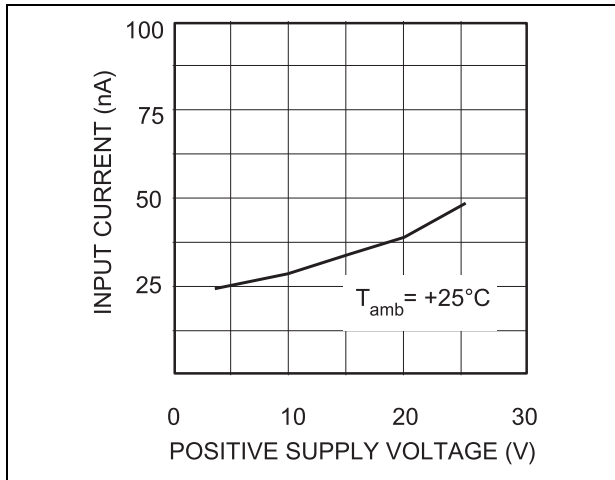


Figure 16. Voltage gain

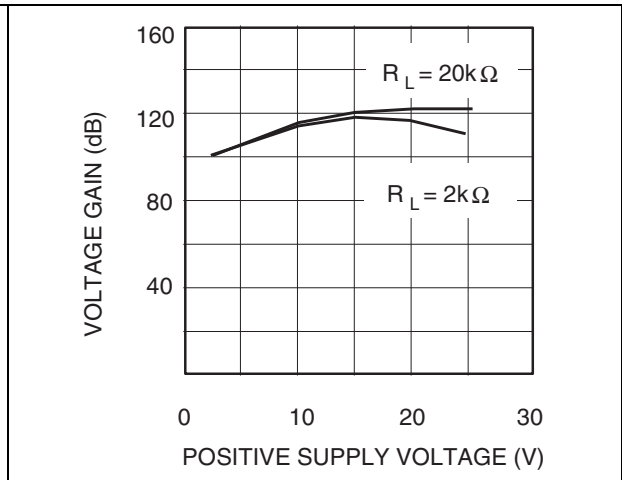


Figure 17. Power supply and common mode rejection ratio

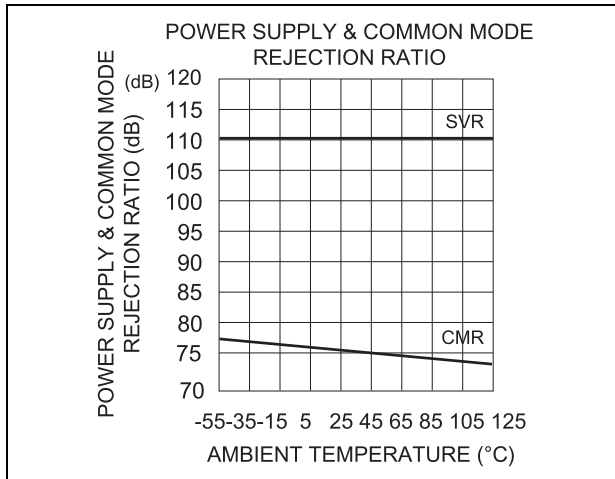
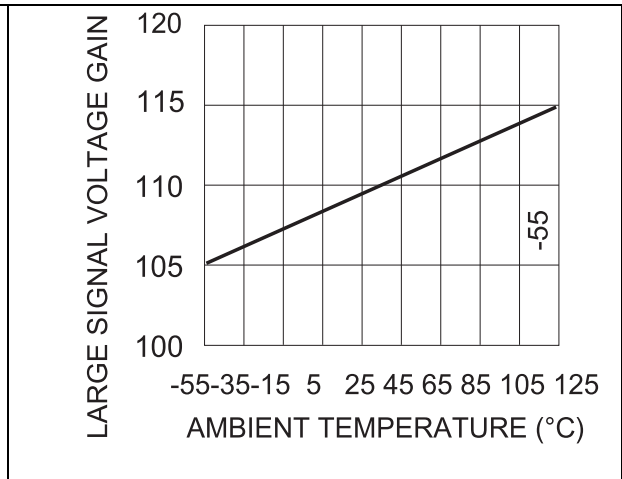


Figure 18. Large signal voltage gain



# 5 Typical single-supply applications

Figure 19. AC coupled inverting amplifier

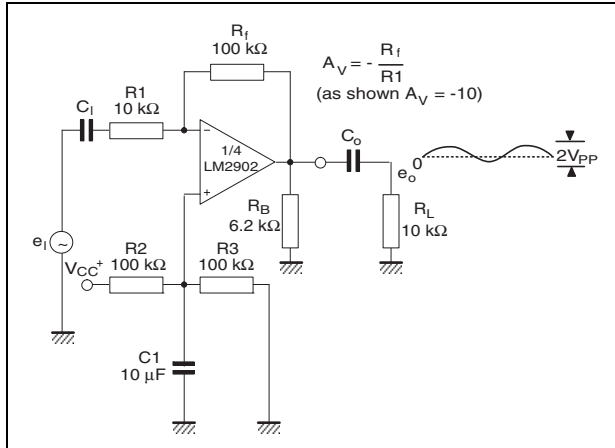


Figure 20. AC coupled non-inverting amplifier

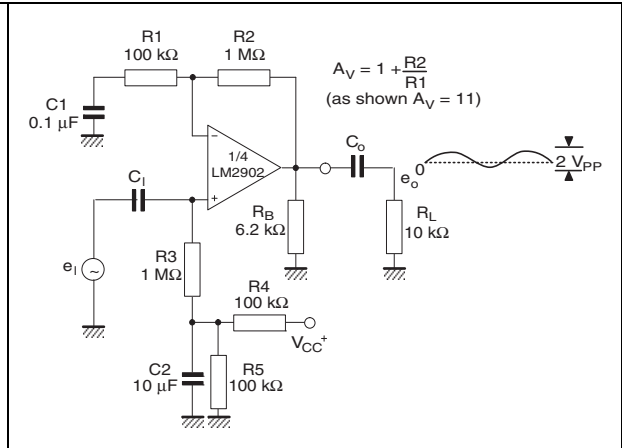


Figure 21. Non-inverting DC gain

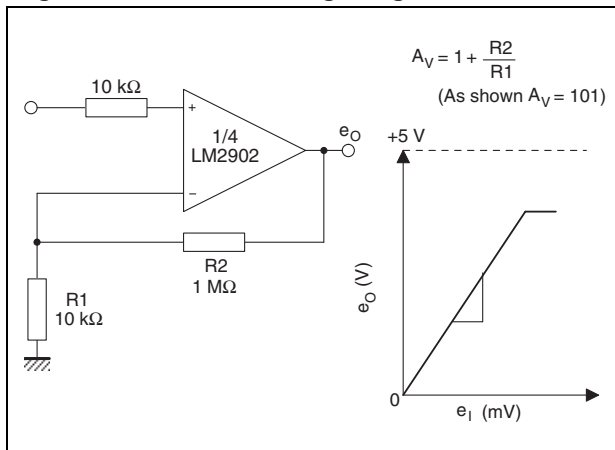


Figure 22. DC summing amplifier

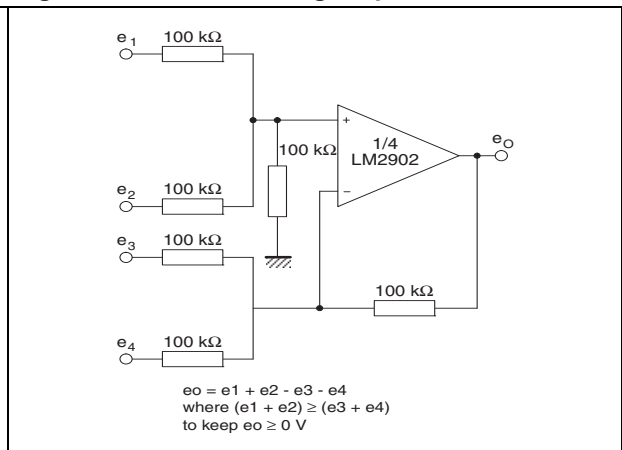


Figure 23. Active bandpass filter

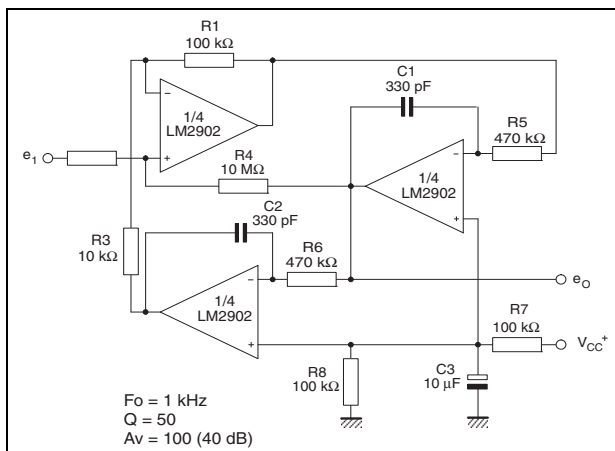


Figure 24. High input Z adjustable gain DC instrumentation amplifier

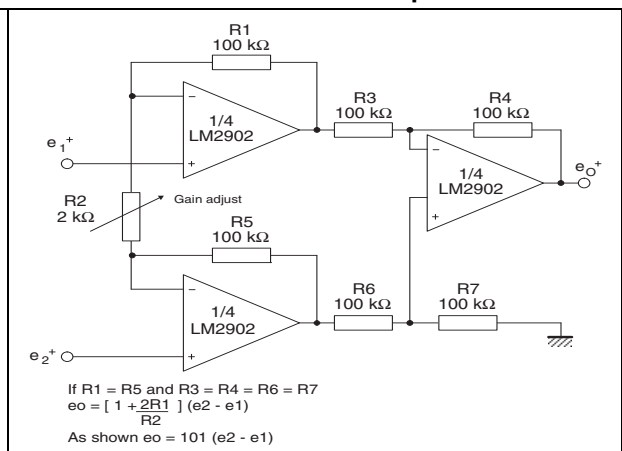


Figure 25. High input Z, DC differential amplifier

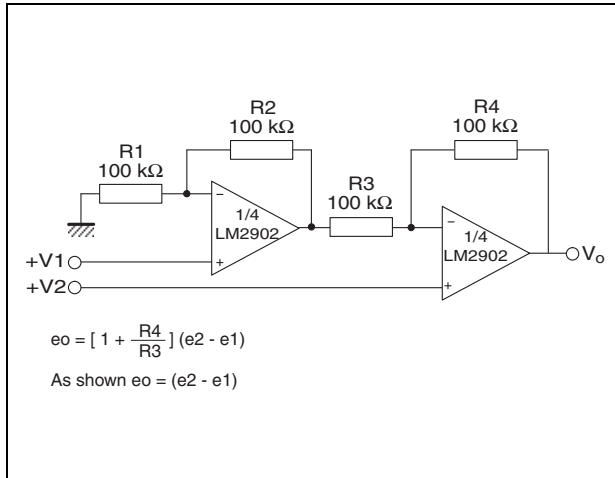


Figure 26. Low drift peak detector

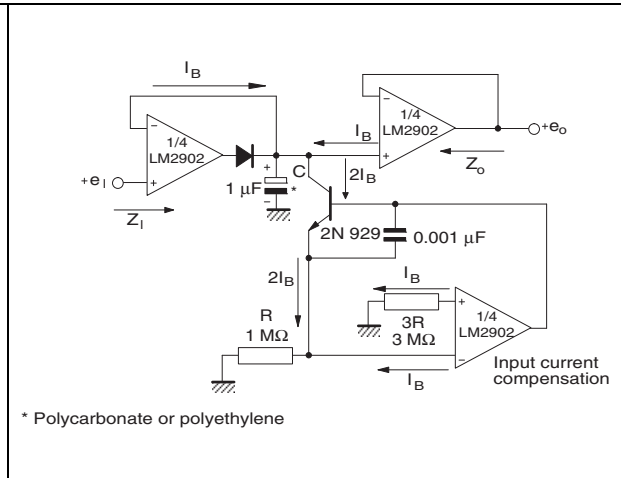
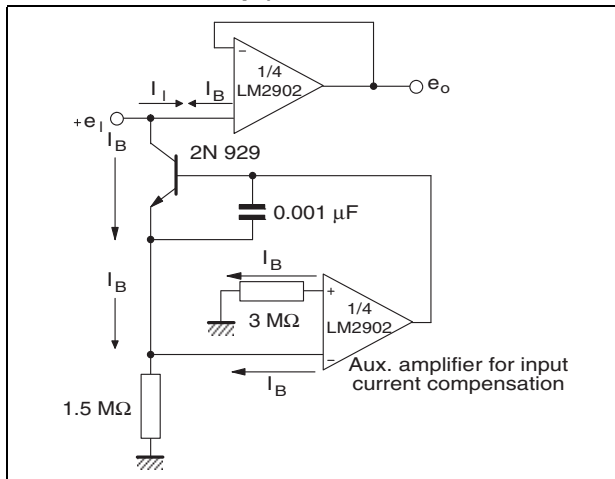


Figure 27. Using symmetrical amplifiers to reduce input current (general concept)



## 6 ECOPACK®

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 6.1 DIP14 package information

Figure 28. DIP14 package mechanical drawing

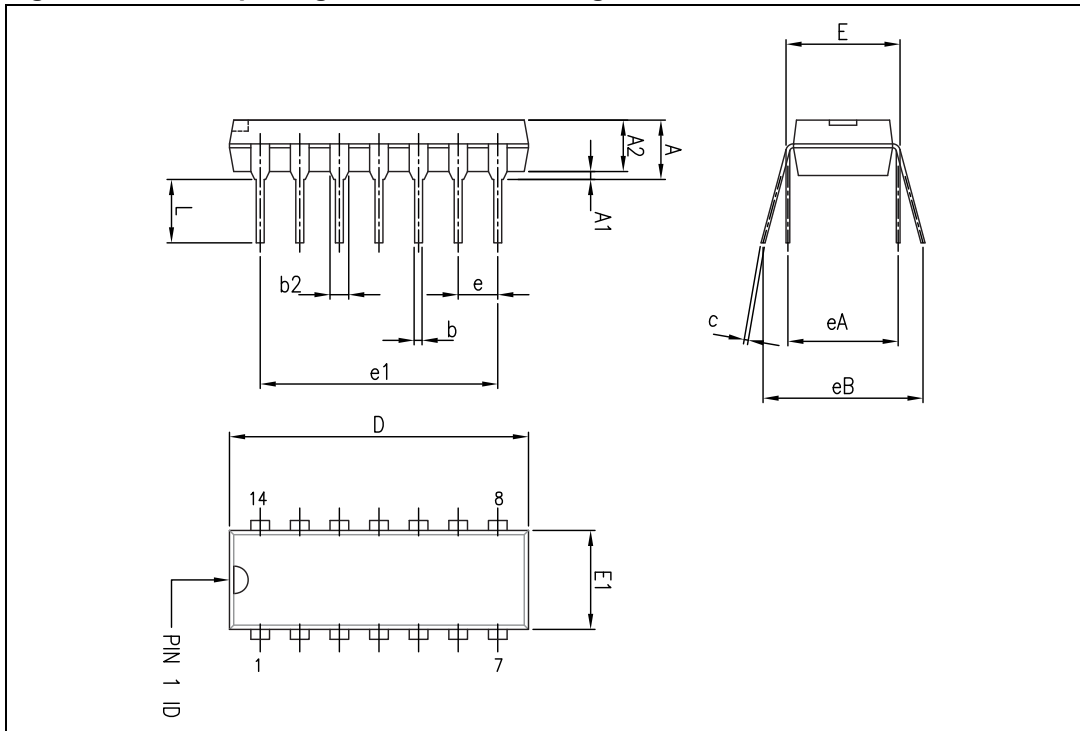


Table 4. DIP14 package mechanical data

Ref.	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

## 6.2 SO-14 package information

Figure 29. SO-14 package mechanical drawing

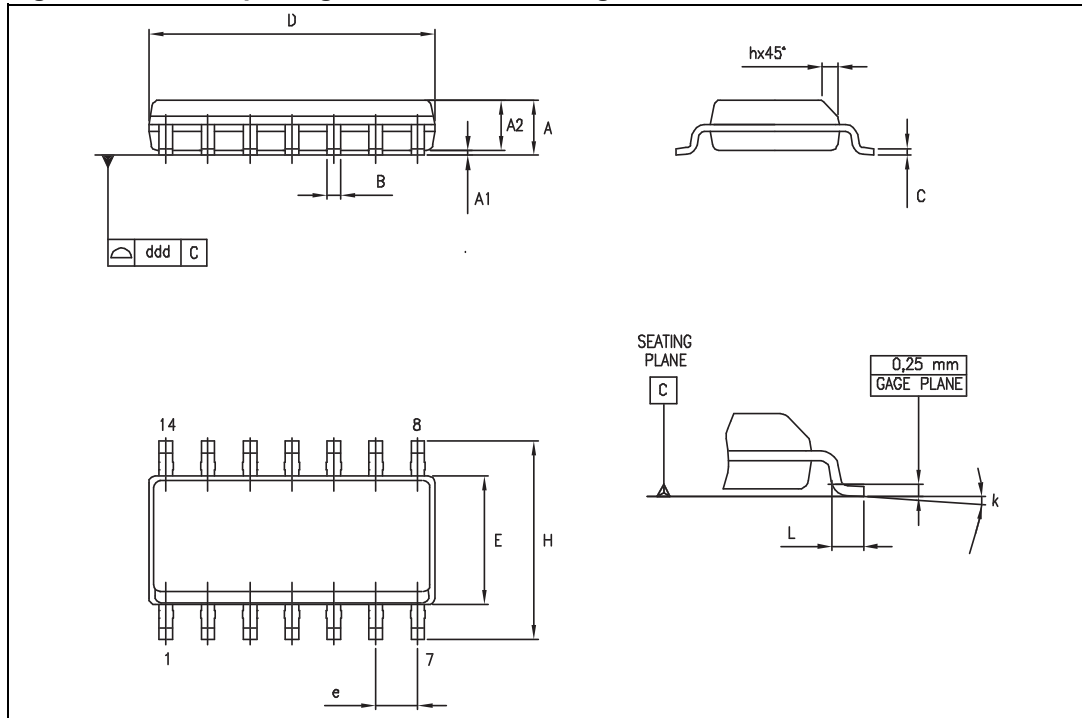


Table 5. SO-14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.05		0.068
A1	0.10		0.25	0.004		0.009
A2	1.10		1.65	0.04		0.06
B	0.33		0.51	0.01		0.02
C	0.19		0.25	0.007		0.009
D	8.55		8.75	0.33		0.34
E	3.80		4.0	0.15		0.15
e		1.27			0.05	
H	5.80		6.20	0.22		0.24
h	0.25		0.50	0.009		0.02
L	0.40		1.27	0.015		0.05
k	8° (max.)					
ddd			0.10			0.004

### 6.3 TSSOP14 package information

Figure 30. TSSOP14 package mechanical drawing

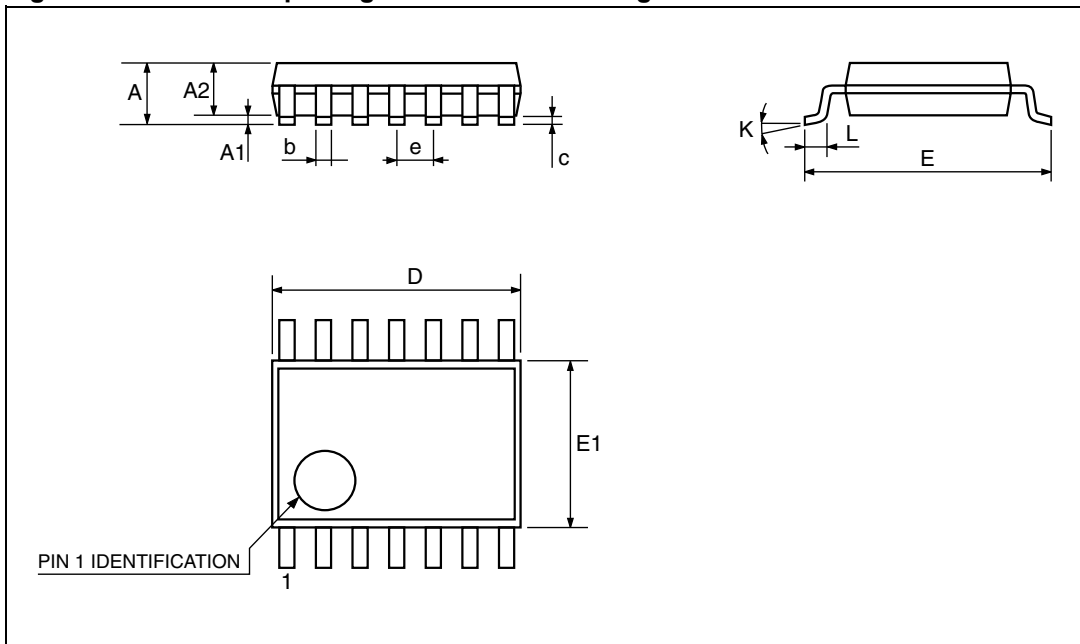


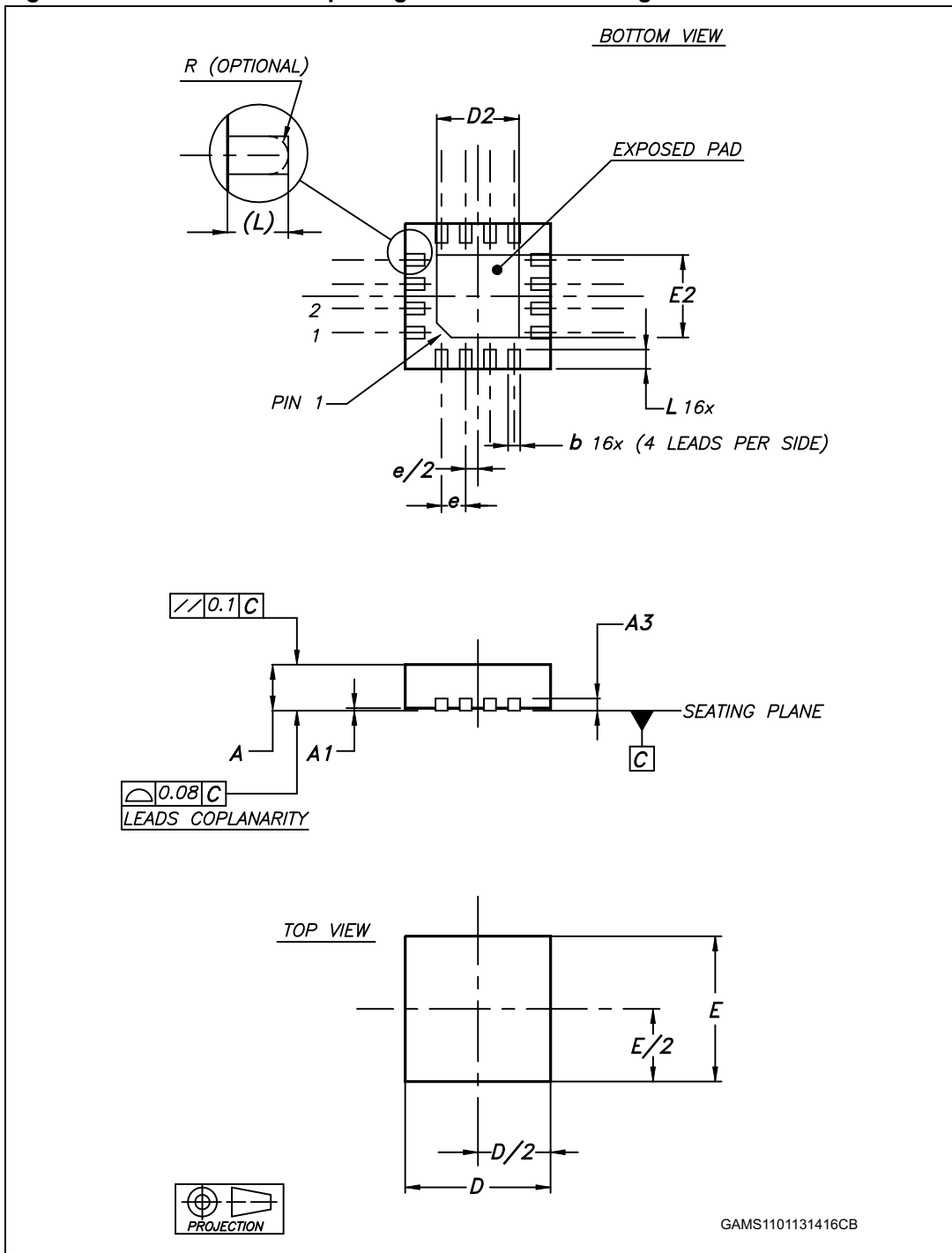
Table 6. TSSOP14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC	
K	0°		8°	0°		8°
L1	0.45	0.60	0.75	0.018	0.024	0.030



### 6.4 QFN16 3 x 3 package mechanical data

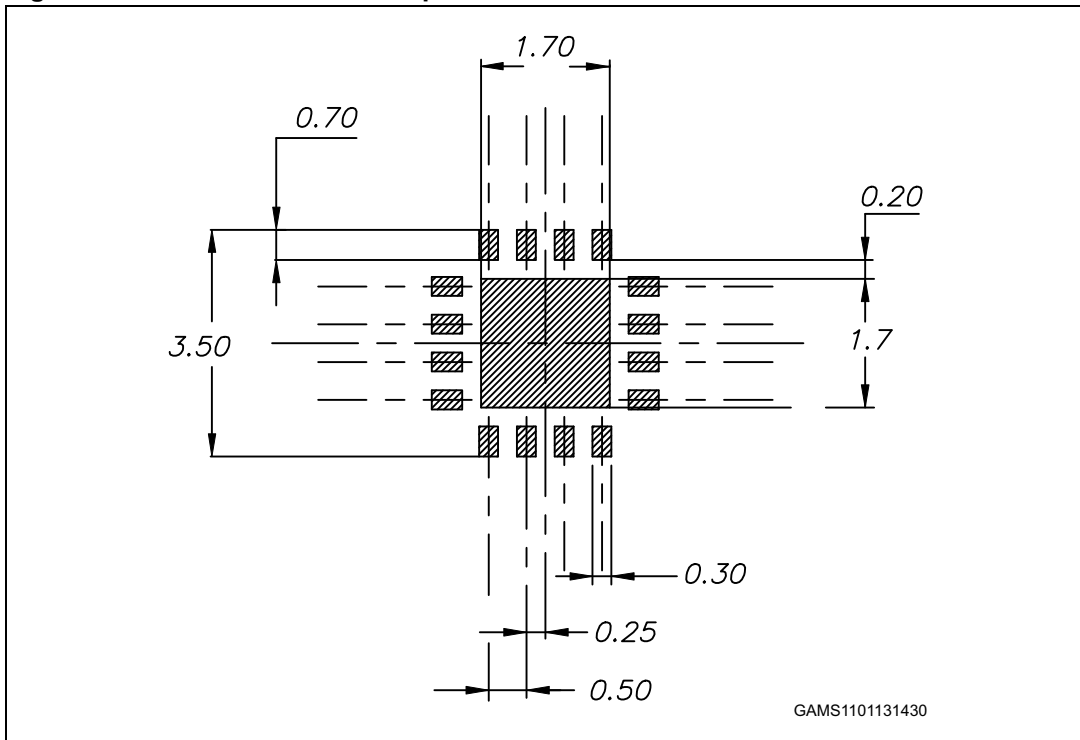
Figure 31. QFN16 3 x 3 mm package mechanical drawing



**Table 7. QFN16 3 x 3 mm package mechanical data (pitch 0.5 mm)**

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80	0.90	1.00	0.031	0.035	0.039
A1	0		0.05	0		0.002
A3		0.20			0.008	
b	0.18		0.30	0.007		0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
D2	1.50		1.80	0.059		0.071
E	2.90	3.00	3.10	0.114	0.118	0.122
E2	1.50		1.80	0.059		0.071
e		0.50			0.020	
L	0.30		0.50	0.012		0.020

**Figure 32. QFN16 3 x 3 mm footprint recommendation**



## 7 Ordering information

**Table 8. Order codes**

Order code	Temperature range	Package	Packing	Marking
LM2902N	-40°C, +125°C	DIP14	Tube	LM2902N
LM2902D LM2902DT		SO-14	Tube or tape & reel	2902
LM2902PT		TSSOP14	Tape & reel	K5H
LM2902Q4T		QFN16 3x3		2902Y
LM2902YDT <sup>(1)</sup>		SO-14 (Automotive grade level)		
LM2902YPT <sup>(1)</sup>		TSSOP14 (Automotive grade level)		

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

## 8 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
30-Nov-2001	1	Initial release.
01-Jul-2005	2	PPAP references inserted in the datasheet, see <a href="#">Table 8: Order codes</a> . ESD protection inserted in <a href="#">Table 1 on page 4</a> .
31-Oct-2005	3	An error in the device description was corrected on page 1. PPAP reference inserted in the datasheet see <a href="#">Table 8: Order codes</a> . Minor grammatical and formatting changes throughout.
18-Jun-2007	4	Values for thermal resistance junction to ambient and ESD HBM corrected in <a href="#">Table 1: Absolute maximum ratings (AMR)</a> . Values for thermal resistance junction to case added in <a href="#">Table 1: Absolute maximum ratings (AMR)</a> . <a href="#">Table 2: Operating conditions</a> added. Electrical characteristics figure captions updated. <a href="#">Section 6: Package information</a> updated. <a href="#">Table 8: Order codes</a> moved to end of document.
18-Dec-2007	5	Removed power dissipation parameter from AMR table and added maximum junction temperature. Updated footnotes for automotive grade order codes. Updated format of package information.
16-Feb-2012	6	Added AMR values for input current in <a href="#">Table 1 on page 4</a> . Added QFN16 3 x 3 mm package information in <a href="#">Chapter 7: Ordering information</a> . Removed LM2902YD order code from <a href="#">Table 8</a> and changed status of LM2902YPT order code.
29-Jan-2013	7	Small text/layout changes in <a href="#">Features</a> and <a href="#">Description</a> . Updated <a href="#">Figure 2: Pin connections (top view)</a> . <a href="#">Table 3: VCC+ = 5V, VCC- = Ground, V<sub>o</sub> = 1.4V, T<sub>amb</sub> = 25°C (unless otherwise specified)</a> : DV <sub>io</sub> replaced by $\Delta V_{io}/\Delta T$ . Replaced SO-14 package silhouette, package mechanical drawing ( <a href="#">Figure 29</a> ) and package mechanical data ( <a href="#">Table 5</a> ).

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