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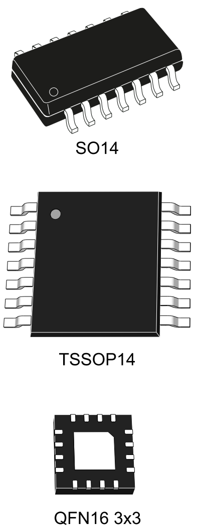
Low-power quad operational amplifiers

Datasheet - production data



Features

- Wide gain bandwidth: 1.3 MHz
- Input common-mode voltage range includes negative rail
- Large voltage gain: 100 dB
- Supply current per amplifier: 375 µA
- 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: ± 1.5 V to ± 15 V

Description

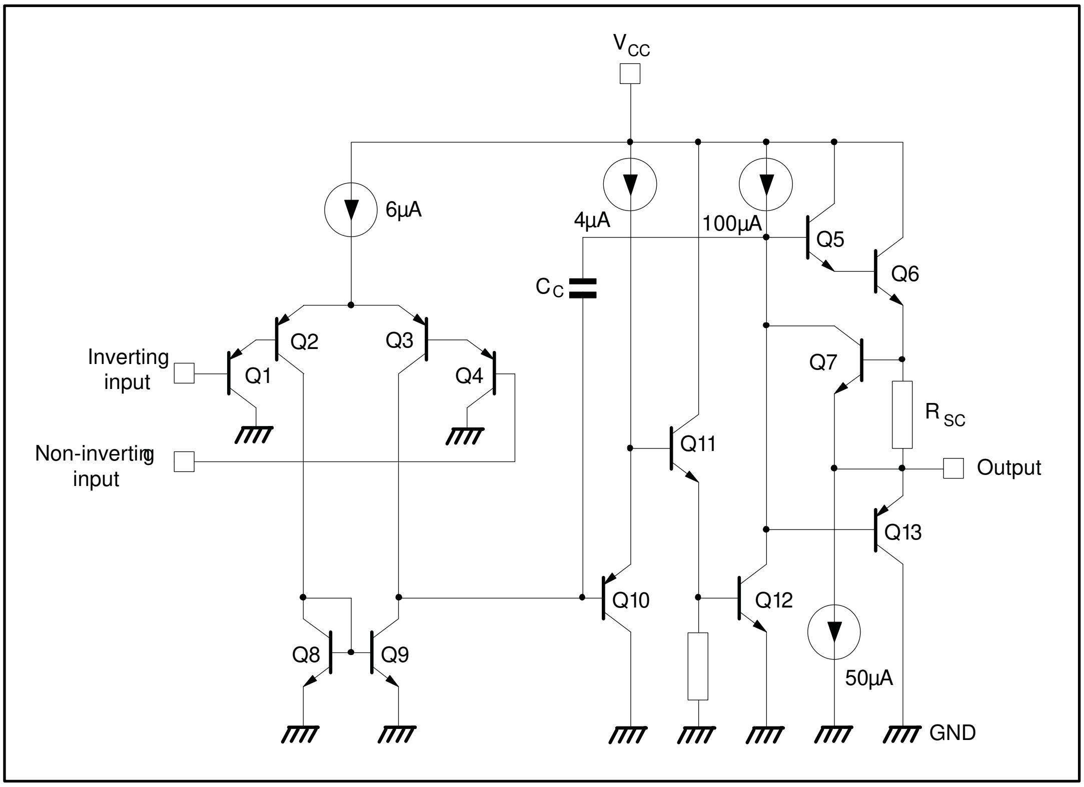
This circuit consists of four independent, high-gain operational amplifiers (op amps) which employ internal frequency compensation and are specifically designed for automotive and industrial control systems.

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.

Contents

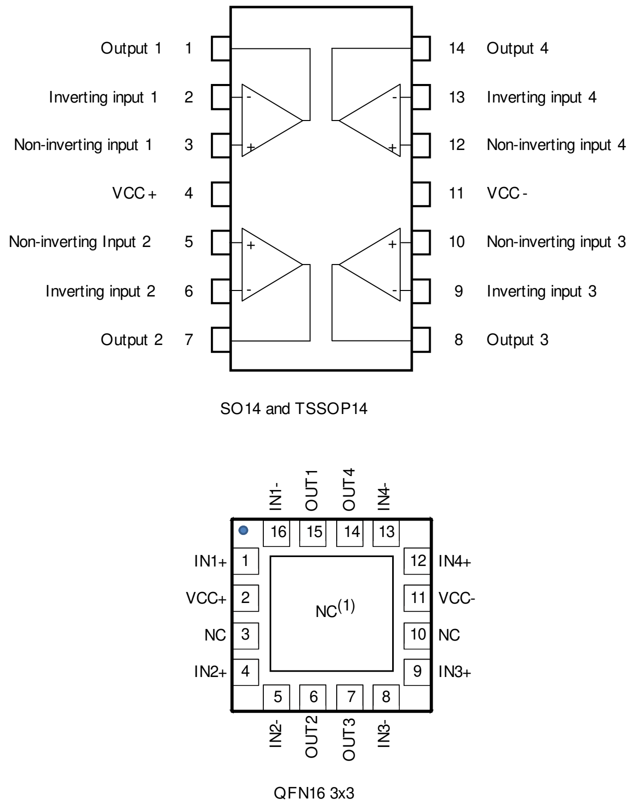
1 Schematic diagram

Figure 1: Schematic diagram (1/4 LM2902)



2 Pinout information

Figure 2: Package pin connections (top view)



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

3 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings (AMR)

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage [(1)]		± 16 to 32	V
V_{id}	Differential input voltage [(2)]		32	
V_{in}	Input voltage		-0.3 to 32	
	Output short-circuit duration [(3)]		Infinite	s
T_j	Maximum junction temperature		150	° C
T_{stg}	Storage temperature range		-65 to 150	
I_{in}	Input current : V_{in} driven negative [(4)]		5 in DC or 50 in AC (duty cycle = 10 %, T = 1 s)	mA
	Input current : V_{in} driven positive above AMR value [(5)]		0.4	
R_{thja}	Thermal resistance junction-to-ambient [(6)]	SO14	105	° C/W
		TSSOP14	100	
		QFN16 3x3	45	
R_{thjc}	Thermal resistance junction-to-case	SO14	31	
		TSSOP14	32	
		QFN16 3x3	14	
ESD	HBM: human body model [(7)]		370	V
	MM: machine model [(8)]		150	
	CDM: charged device model [(9)]		1500	

Notes:

(1)All voltage values, except the differential voltage are with respect to the network ground terminal.

(2)Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.

(3)Short-circuits 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 an input diode clamp. In addition to this diode action, there is an 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 µ A max (R = (Vin - 36 V)/400 µ 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 kΩ 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 Ω). 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.

Table 2: Operating conditions

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

4 Electrical characteristics

Table 3: VCC+ = 5 V, VCC- = Ground, VO = 1.4 V, Tamb = 25 °C (unless otherwise stated)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage [(1)]	T_{amb} = 25 °C		2	7	mV
		$T_{min} \leq T_{amb} \leq T_{max}$			9	
$\Delta V_{io}/\Delta T$	Input offset voltage drift			7	30	µV/°C
I_{io}	Input offset current	T_{amb} = 25 °C		2	30	nA
		$T_{min} \leq T_{amb} \leq T_{max}$			40	
DI_{io}	Input offset current drift			10	200	pA/°C
I_{ib}	Input bias current [(2)]	T_{amb} = 25 °C		20	150	nA
		$T_{min} \leq T_{amb} \leq T_{max}$			300	
A_{vd}	Large signal voltage gain	V_{CC}^+ = 15 V, R_L = 2 kΩ, V_o = 1.4 V to 11.4 V, T_{amb} = 25 °C	50	100		V/mV
		V_{CC}^+ = 15 V, R_L = 2 kΩ, V_o = 1.4 V to 11.4 V, $T_{min} \leq T_{amb} \leq T_{max}$	25			
SVR	Supply voltage rejection ratio	$R_S \leq$ 10 kΩ, T_{amb} = 25 °C	65	110		dB
		$R_S \leq$ 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	65			
I_{CC}	Supply current, all op amps, no load	T_{amb} = 25 °C, V_{CC}^+ = 5 V		0.7	1.2	mA
		T_{amb} = 25 °C, V_{CC}^+ = 30 V		1.5	3	
		$T_{min} \leq T_{amb} \leq T_{max}$, V_{CC}^+ = 5 V		0.8	1.2	
		$T_{min} \leq T_{amb} \leq T_{max}$, V_{CC}^+ = 30 V		1.5	3	
CMR	Common-mode rejection ratio	$R_S \leq$ 10 kΩ, T_{amb} = 25 °C	70	80		dB
		$R_S \leq$ 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	60			
I_o	Output short-circuit current	V_{id} = 1 V, V_{CC}^+ = 15 V, V_o = 2 V	20	40	70	mA
I_{sink}	Output sink current	V_{id} = -1 V, V_{CC}^+ = 15 V, V_o = 2 V	10	20		mA
		V_{id} = -1 V, V_{CC}^+ = 15 V, V_o = 0.2 V	12	50		µA
V_{OH}	High-level output voltage	V_{CC}^+ = 30 V, R_L = 2 kΩ, T_{amb} = 25 °C	26	27		V
		V_{CC}^+ = 30 V, R_L = 2 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	26			
		V_{CC}^+ = 30 V, R_L = 10 kΩ, T_{amb} = 25 °C	27	28		
		V_{CC}^+ = 30 V, R_L = 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	27			
		V_{CC}^+ = 5 V, R_L = 2 kΩ, T_{amb} = 25 °C	3			
		V_{CC}^+ = 5 V, R_L = 2 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$	3.5			
V_{OL}	Low-level output voltage	R_L = 10 kΩ, T_{amb} = 25 °C		5	20	mV
		R_L = 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$			20	
SR	Slew rate	V_{CC}^+ = 15 V, V_{in} = 0.5 to 3 V, R_L = 2 kΩ, C_L = 100 pF, unity gain		0.4		V/µs
GBP	Gain bandwidth product	V_{CC}^+ = 30 V, V_{in} = 10 mV, R_L = 2 kΩ, C_L = 100 pF		1.3		MHz
THD	Total harmonic distortion	f = 1 kHz, A_V = 20 dB, R_L = 2 kΩ, V_o = 2 V_{pp}, C_L = 100 pF, V_{CC}^+ = 30 V		0.015		%

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
e_n	Equivalent input noise voltage	f = 1 kHz, R_S = 100 Ω, V_{CC}^+ = 30 V		40		nV/√Hz
V_{O1}/V_{O2}	Channel separation (3)	1 kHz ≤ f ≤ 20 kHz		120		dB

Notes:

(1) V_O = 1.4 V, R_S = 0 Ω, 5 V < V_{CC}^+ < 30 V, 0 V < V_{ic} < (V_{CC}^+) - 1.5 V.

(2) 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 load on the input lines.

(3) Due to the proximity of external components, ensure that stray capacitance does not cause coupling between these external parts. Typically, this can be detected as this type of capacitance increases at higher frequencies.

5 Electrical characteristic curves

Figure 3: Input bias current vs. Tamb

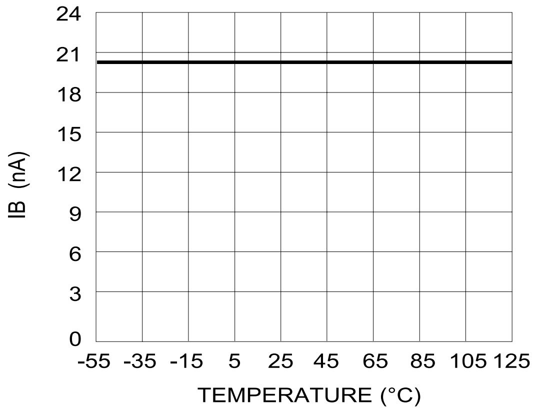


Figure 4: Input voltage range

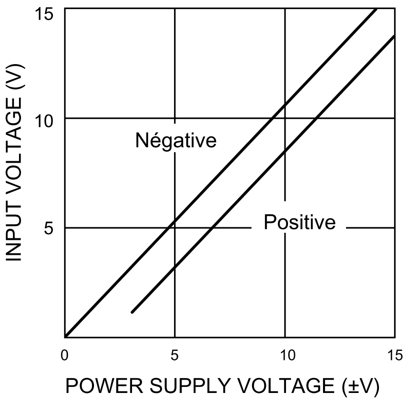


Figure 5: Current limiting

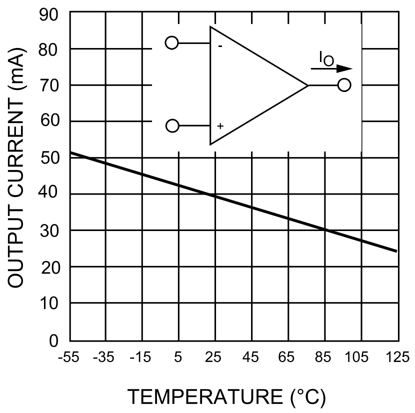


Figure 6: Supply current

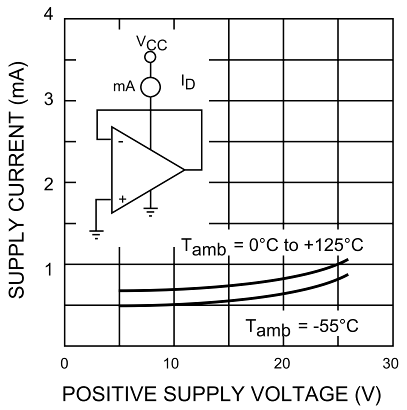


Figure 7: Gain bandwidth product

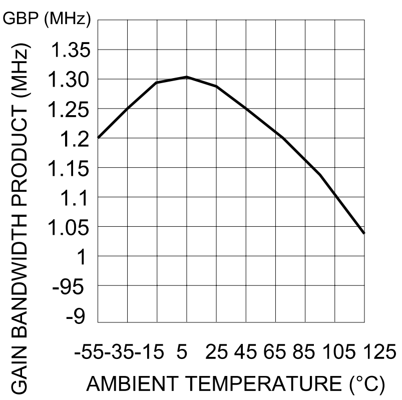


Figure 8: Voltage follower pulse response

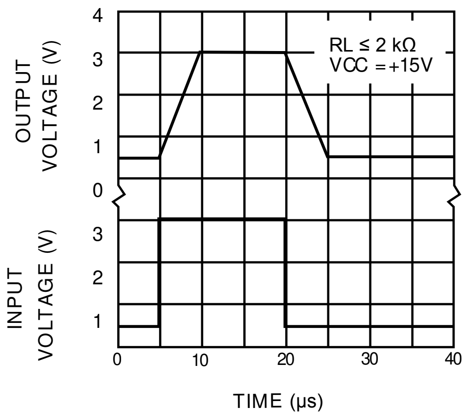


Figure 9: Common-mode rejection ratio

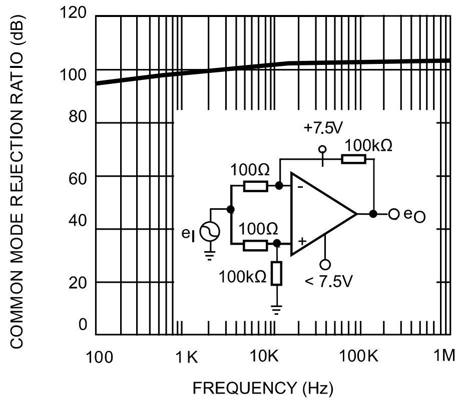


Figure 10: Output characteristics (sink)

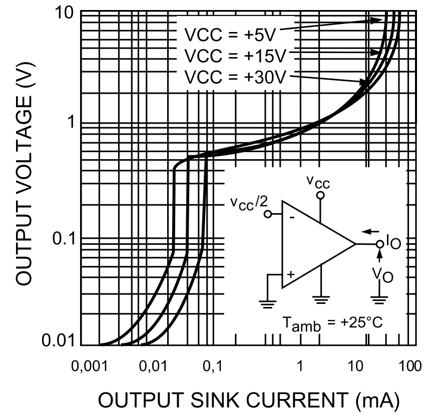


Figure 11: Open-loop frequency response

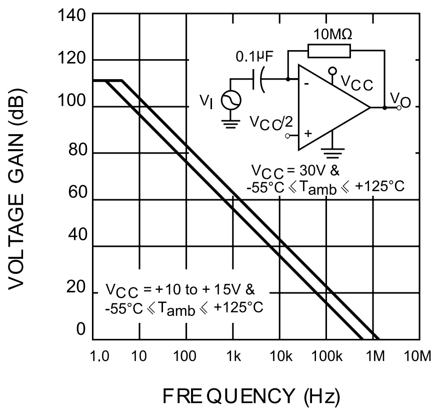


Figure 12: Voltage follower pulse response

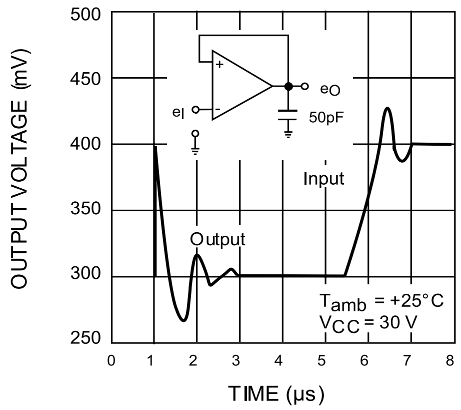


Figure 13: Large signal frequency response

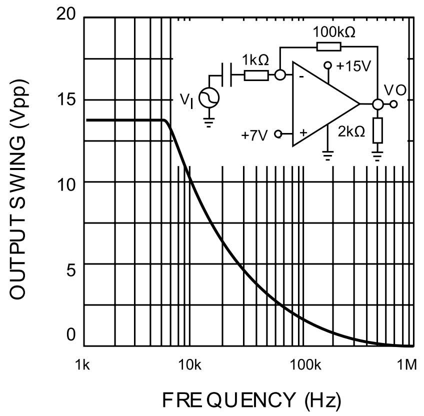


Figure 14: Output characteristics (source)

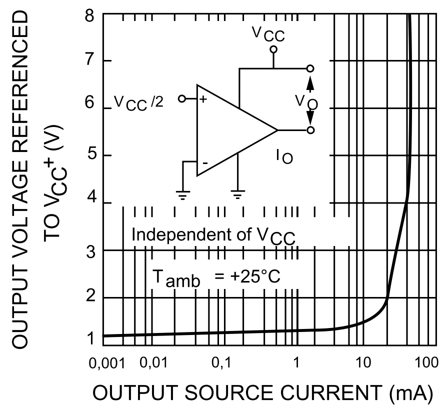


Figure 15: Input current

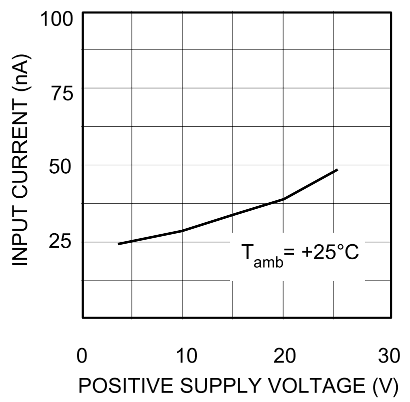


Figure 16: Voltage gain

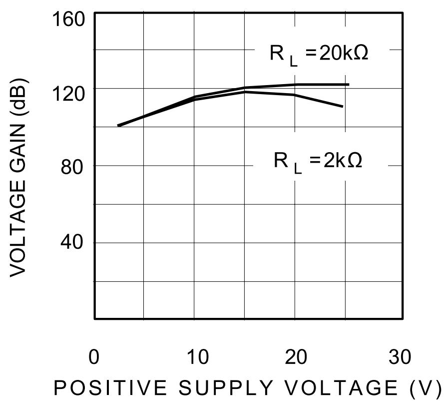


Figure 17: Power supply and common-mode rejection ratio

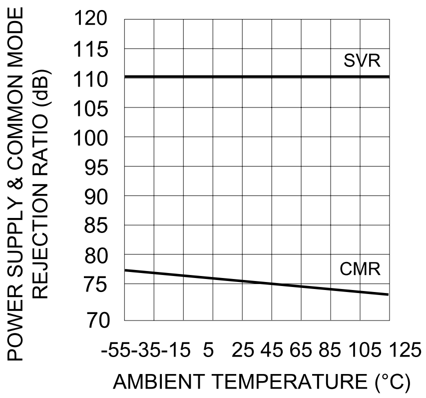
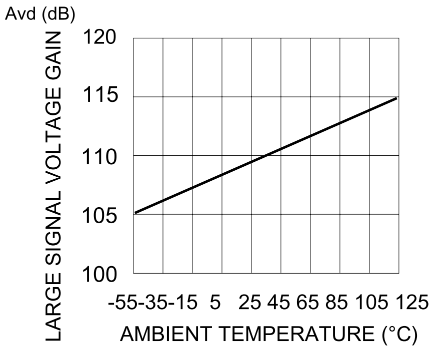


Figure 18: Large signal voltage gain



6 Typical single-supply applications

Figure 19: AC coupled inverting amplifier

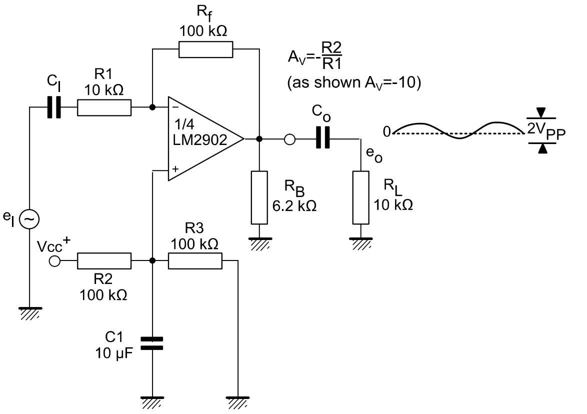


Figure 20: AC coupled non-inverting amplifier

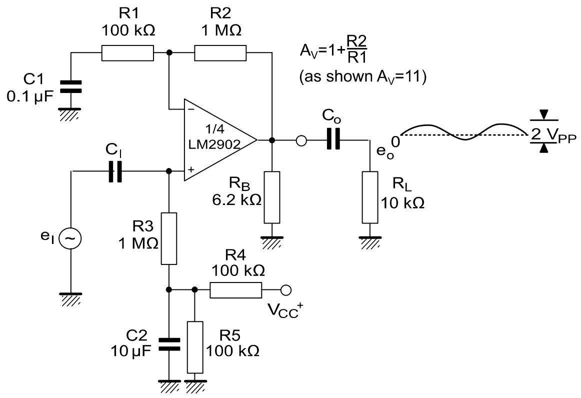


Figure 21: Non-inverting DC gain

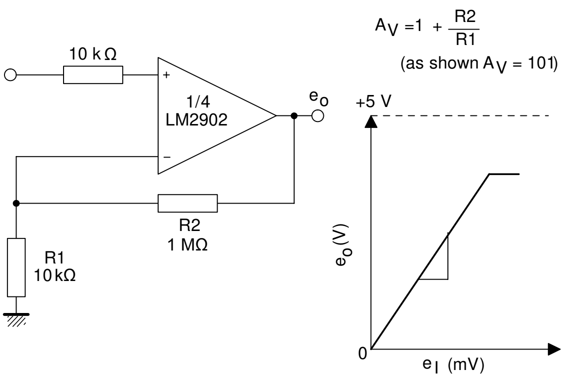
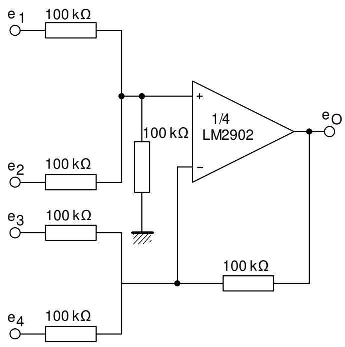


Figure 22: DC summing amplifier



e0 = e1 + e2 - e3 - e4
where (e1 + e2) ≥ (e3 + e4)
to keep e0 ≥ 0 V

Figure 23: Active bandpass filter

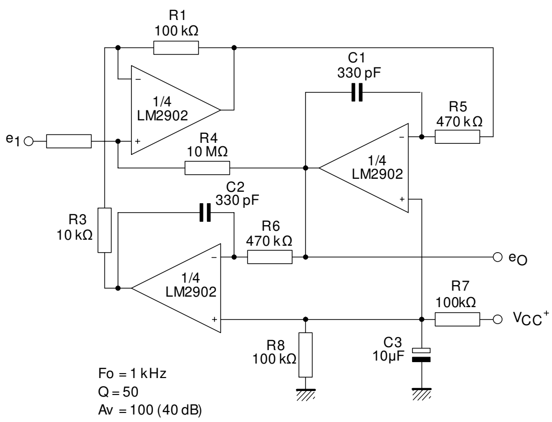
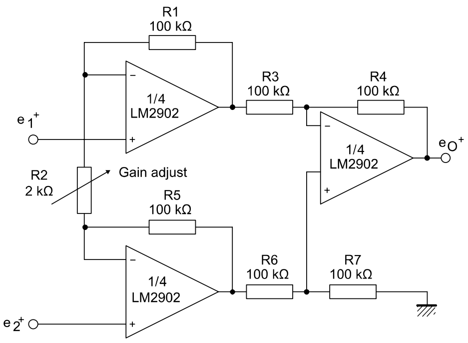


Figure 24: High input Z adjustable gain DC instrumentation amplifier



If R1 = R5 and R3 = R4 = R6 = R7

$$eo = \left[1 + \frac{2R1}{R2}\right](e2 - e1)$$

As shown eo = 101 (e2 - e1)

Figure 25: High input Z, DC differential amplifier

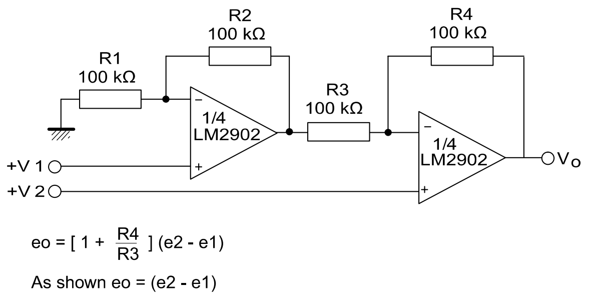


Figure 26: Low drift peak detector

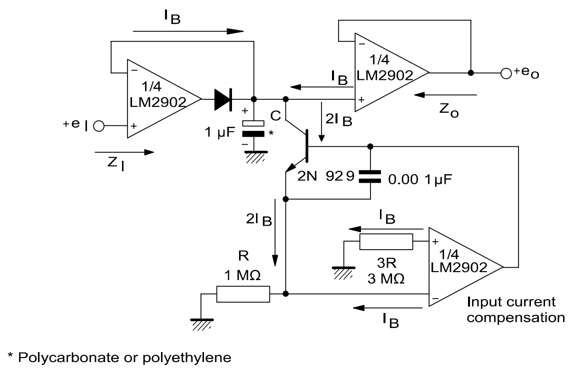
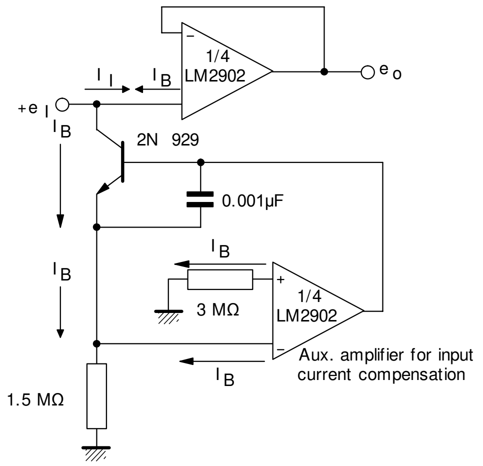


Figure 27: Using symmetrical amplifiers to reduce input current (general concept)



7 Package information

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***. ECOPACK® is an ST trademark.

7.1 SO14 package information

Figure 28: SO14 package outline

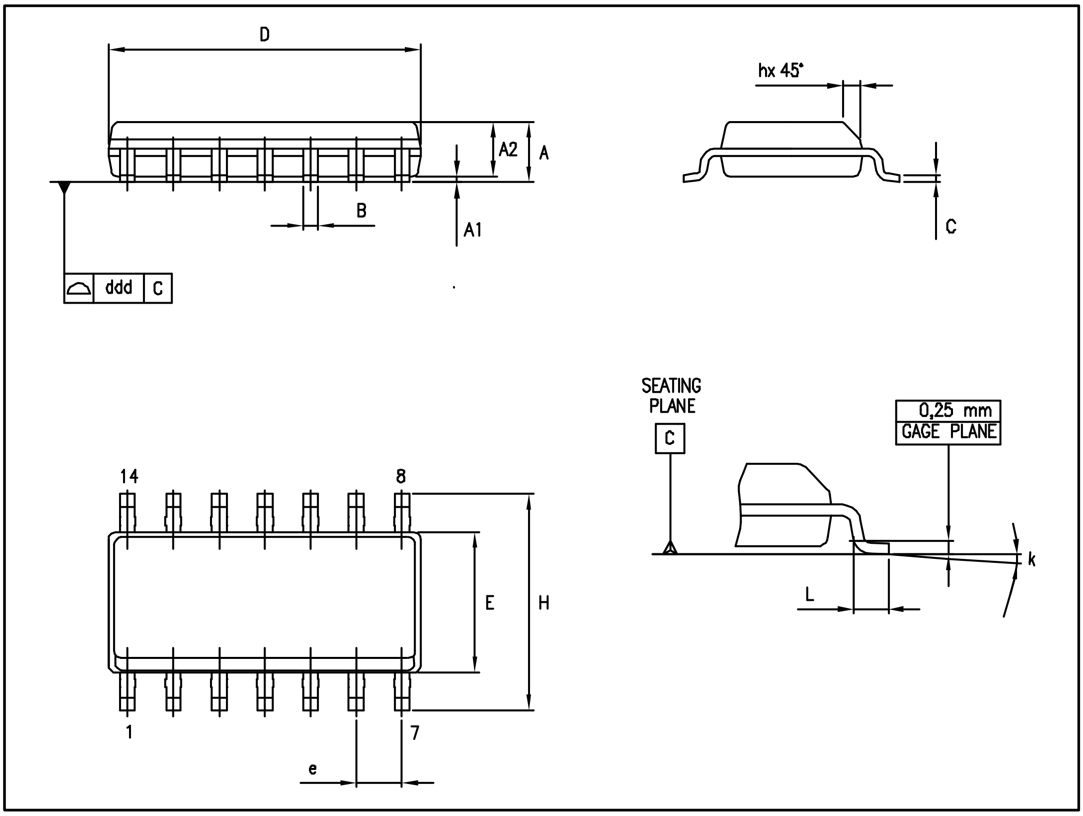


Table 4: SO14 mechanical data

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

7.2 TSSOP14 package information

Figure 29: TSSOP14 package outline

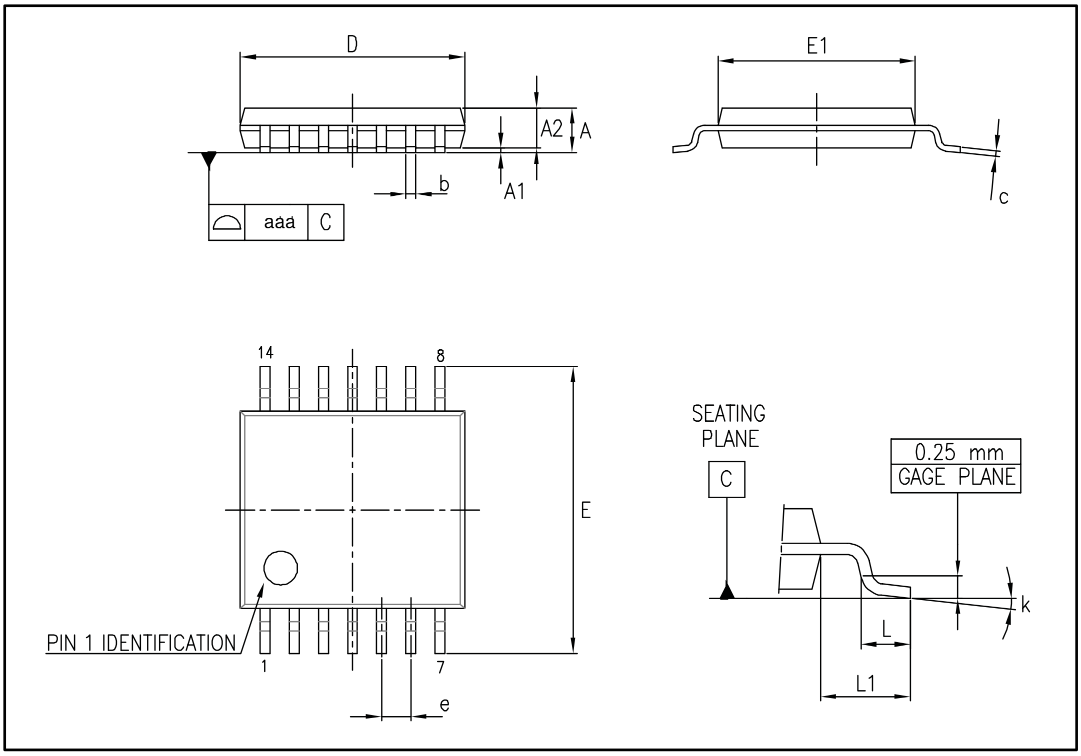


Table 5: TSSOP14 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.80	1.00	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	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0°		8°	0°		8°
aaa			0.10			0.004

7.3 QFN16 3x3 package information

Figure 30: QFN16 3x3 package outline

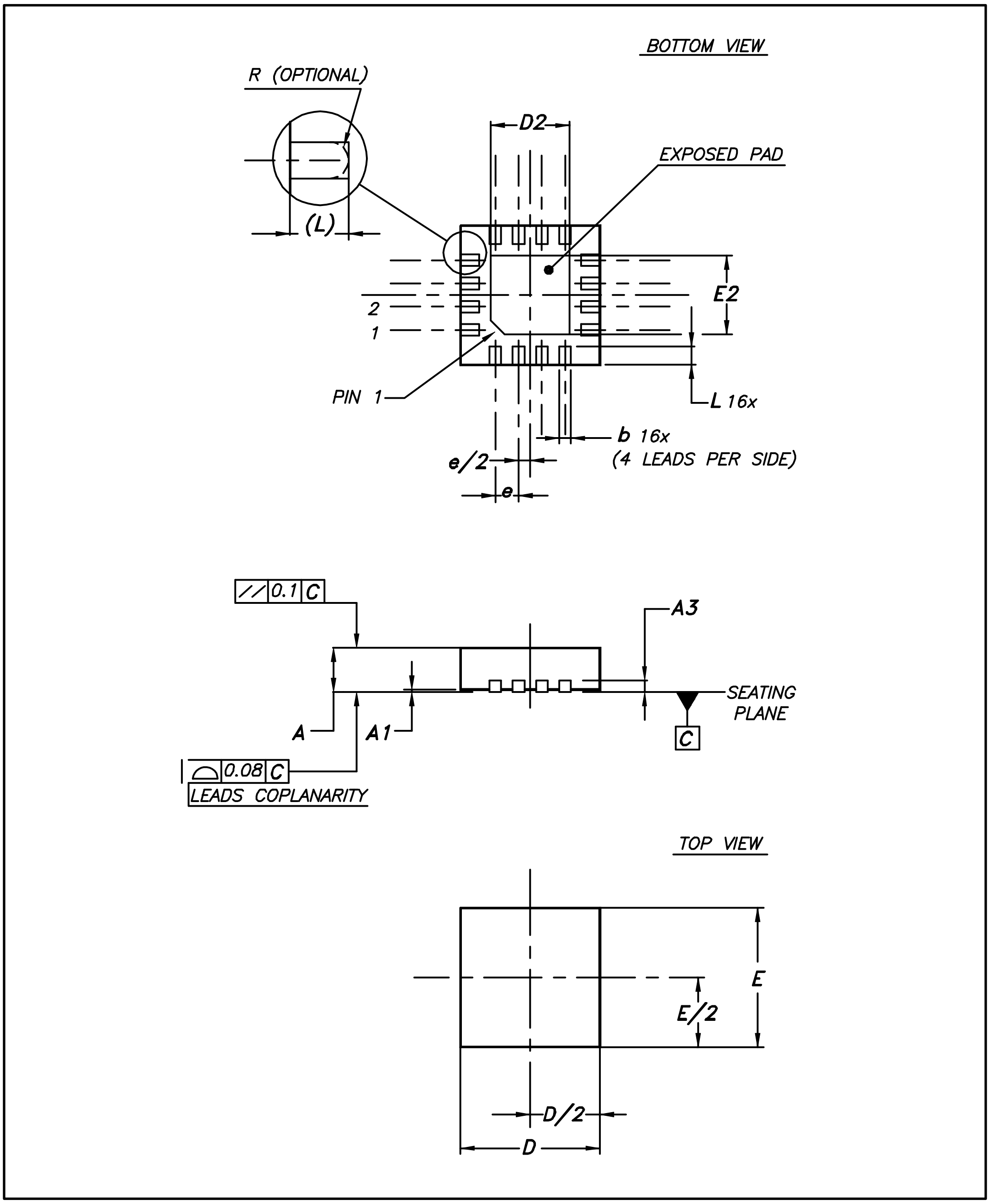
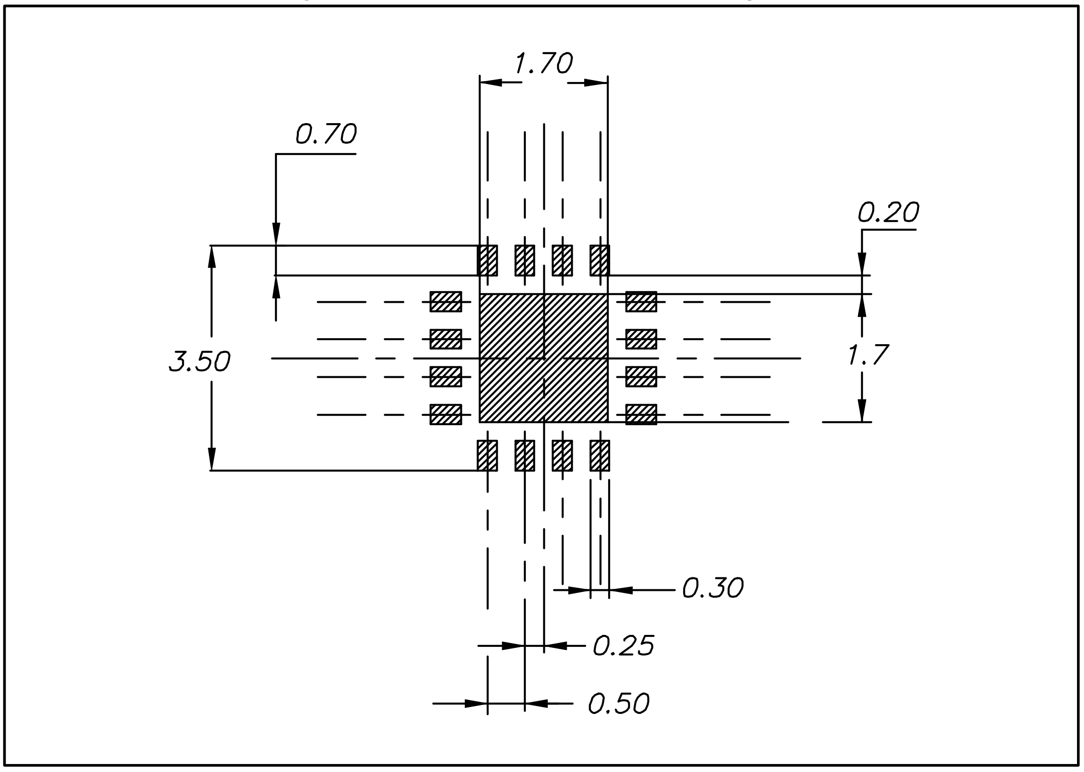


Table 6: QFN16 3x3 mechanical data

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 31: QFN16 3x3 recommended footprint



8 Ordering information

Table 7: Order codes

Order code	Temperature range	Package	Packing	Marking
LM2902D	-40 ° C to 125 ° C	SO14	Tube or tape and reel	2902
LM2902DT				
LM2902PT		TSSOP14	Tape and reel	
LM2902Q4T		QFN16 3x3		K5H
LM2902YDT (1)		SO14, automotive grade level		2902Y
LM2902YPT (1)		TSSOP14, automotive grade level		

Notes:

(1)Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent.

9 Revision history

Table 8: Document revision history

Date	Revision	Changes
30-Nov-2001	1	Initial release.
01-Jul-2005	2	PPAP references inserted in the datasheet, see Table 3: Order codes. ESD protection inserted in Table 1 on page 4.
31-Oct-2005	3	An error in the device description was corrected on page 1. PPAP reference inserted in the datasheet see Table 3: Order codes. Minor grammatical and formatting changes throughout.
18-Jun-2007	4	Values for thermal resistance junction to ambient and ESD HBM corrected in Table 1: Absolute maximum ratings (AMR). Values for thermal resistance junction to case added in Table 1: Absolute maximum ratings (AMR). Table 2: Operating conditions added. Electrical characteristics figure captions updated. Section 6: Package information updated. Table 3: Order codes 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 Table 1 on page 4. Added QFN16 3 x 3 mm package information in Chapter 7: Ordering information. Removed LM2902YD order code from Table 3 and changed status of LM2902YPT order code.
29-Jan-2013	7	Small text/layout changes in Features and Description. Updated Figure 2: Pin connections (top view). Table 3: VCC+ = 5V, VCC- = Ground, V_o = 1.4V, Tamb = 25° C (unless otherwise specified): DV_{io} replaced by DV_{io}/DT. Replaced SO-14 package silhouette, package mechanical drawing (Figure 29) and package mechanical data (Table 5).
11-Jan-2017	8	Removed DIP package *Figure 1: "Schematic diagram (1/4 LM2902)"*: removed two diodes *Table 1: "Absolute maximum ratings (AMR)"*: updated value of V_{CC} Updated TSSOP14 package for L and aaa parameters