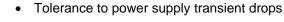


# OA1NP, OA2NP, OA4NP

## Low power, rail-to-rail input and output, CMOS op amp

#### Datasheet - production data



- Accurate signal conditioning of high impedance sensors
- Fast desaturation

## Applications

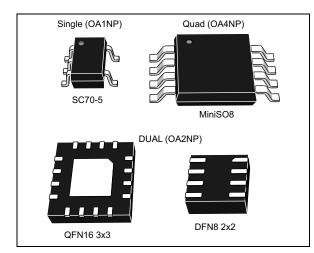
- Wearable
- Fitness and healthcare
- Medical instrumentation

## Description

The OA1NP, OA2NP, OA4NP series of CMOS operational amplifiers offer a low power consumption of 580 nA typical and 750 nA maximum per channel when supplied by 1.8 V. Combined with a supply voltage range of 1.5 V to 5.5 V, these features allow the OA1NP, OA2NP, OA4NP op amp series to be efficiently supplied by a coin type Lithium battery or a regulated voltage in low power applications.

The OA1NP, OA2NP, OA4NP are respectively the single, dual and quad operational amplifier versions.

The 8 kHz gain bandwidth of these devices make them ideal for wearable, fitness and healthcare and sensors signal conditioning applications.



## Features

- Low power: 580 nA typ. per channel at 25 °C at  $V_{CC}$  = 1.8 V
- Low supply voltage: 1.5 V 5.5 V
- Unity gain stable
- Rail-to-rail input and output
- Gain bandwidth product: 8 kHz typ.
- Low input bias current: 5 pA max at 25 °C
- High tolerance to ESD: 2 kV HBM
- Industrial temperature range: -40 °C to +85 °C

### Benefits

 42 years of typical equivalent lifetime (OA1NP) if supplied by a 220 mAh coin type Lithium battery

Order codes	Temperature range	Packages	Packing	Marking
OA1NP22C		SC70-5		K22
OA2NP22Q	-40 ° C to +85 ° C	DFN8 2x2	Tapa and real	K24
OA2NP34S	-40 0 10 +85 0	MiniSO8	Tape and reel	K160
OA4NP33Q		QFN16 3x3		K160

#### Table 1. Device summary

March 2014

DocID025993 Rev 2

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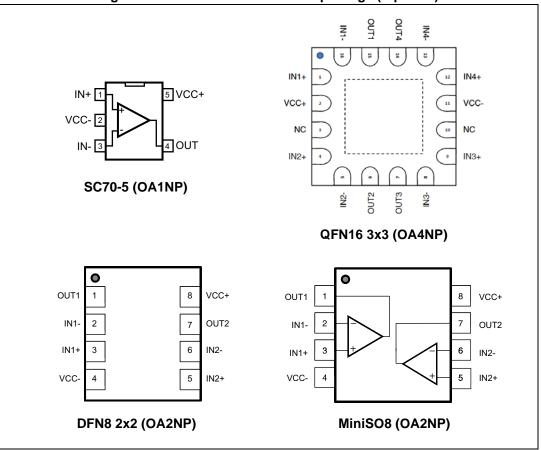
This is information on a product in full production.

## Contents

1	Packa	age pin connections
2	Abso	lute maximum ratings and operating conditions
3	Electr	rical characteristics
4	Appli	cation information
	4.1	Operating voltages 17
	4.2	Rail-to-rail input 17
	4.3	Input offset voltage drift over temperature
	4.4	Long term input offset voltage drift 18
	4.5	Schematic optimization aiming for low power
	4.6	PCB layout considerations 20
	4.7	Using the OA1NP, OA2NP, OA4NP series with sensors $\ldots \ldots \ldots 21$
	4.8	Fast desaturation
	4.9	Using the OA1NP, OA2NP, OA4NP series in comparator mode $\hdots$ 22
	4.10	ESD structure of OA1NP, OA2NP, OA4NP series
5	Packa	age information
	5.1	SC70-5 package mechanical data 25
	5.2	DFN8 2x2 package information 26
	5.3	MiniSO8 package information 27
	5.4	QFN16 package information 28
6	Revis	ion history



## 1 Package pin connections







## 2 Absolute maximum ratings and operating conditions

Symbol	Parameter	Value	Unit
V <sub>cc</sub>	Supply voltage <sup>(1)</sup>	6	
V <sub>id</sub>	Differential input voltage <sup>(2)</sup>	±V <sub>cc</sub>	V
V <sub>in</sub>	Input voltage <sup>(3)</sup>	V <sub>cc-</sub> - 0.2 to V <sub>cc+</sub> + 0.2	
l <sub>in</sub>	Input current <sup>(4)</sup>	10	mA
T <sub>stg</sub>	Storage temperature	-65 to +150	°C
R <sub>thja</sub>	Thermal resistance junction to ambient <sup>(5)(6)</sup> SC70-5 DFN8 2x2 MiniSO8 QFN16 3x3	205 117 190 45	°C/W
Тj	Maximum junction temperature	150	°C
	HBM: human body model <sup>(7)</sup> MM: machine model <sup>(8)</sup>	2000	-
ESD	CDM: charged device model <sup>(9)</sup> All other packages except SC70-5 SC70-5	200 1000 900	V
	Latch-up immunity <sup>(10)</sup>	200	mA

#### Table 2. Absolute maximum ratings (AMR)

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

2. The differential voltage is the non-inverting input terminal with respect to the inverting input terminal.

3.  $(V_{cc+} - V_{in})$  must not exceed 6 V,  $(V_{in} - V_{cc-})$  must not exceed 6 V.

4. The input current must be limited by a resistor in series with the inputs.

5. Short-circuits can cause excessive heating and destructive dissipation.

6. R<sub>th</sub> are typical values.

- 7. Related to ESDA/JEDEC JS-001 Apr. 2010
- 8. Related to JEDEC JESD22-A115C Nov.2010
- 9. Related to JEDEC JESD22-C101-E Dec. 2009
- 10. Related to JEDEC JESD78C Sept. 2010

#### Table 3. Operating conditions

Symbol	Parameter	Value	Unit
V <sub>cc</sub>	Supply voltage	1.5 to 5.5	V
V <sub>icm</sub>	Common mode input voltage range	$V_{cc-} - 0.1$ to $V_{cc+} + 0.1$	v
T <sub>oper</sub>	Operating free air temperature range	-40 to +85	°C



## 3 Electrical characteristics

 $V_{CC}+$  = 1.8 V with  $V_{CC}-$  = 0 V,  $V_{icm}$  =  $V_{CC}/2,$   $T_{amb}$  = 25 ° C, and  $R_L$  = 1  $M\Omega$  connected to  $V_{CC}/2$  (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit	
DC perfor	mance		ł		4		
			-3	0.1	3		
V <sub>io</sub>	Input offset voltage	-40 °C < T< 85 °C	-3.4		3.4	- mV	
$\Delta V_{io} / \Delta T$	Input offset voltage drift	-40 °C < T< 85 °C			5	μV/°C	
$\Delta V_{io}$	Long-term input offset voltage drift	$T = 25 \ ^{\circ}C^{(1)}$		0.18		_μV √montl	
I.	Input offset current <sup>(2)</sup>			1	5		
I <sub>io</sub>		-40 °C < T< 85 °C			30	pA	
I <sub>ib</sub>	Input bias current <sup>(2)</sup>			1	5	рд	
'ib		-40 °C < T< 85 °C			30		
		$V_{icm}$ = 0 to 0.6 V, $V_{out}$ = $V_{CC}/2$	65	85			
CMR	Common mode rejection	-40 °C < T< 85 °C	65			dB	
CIVIR	ratio 20 log ( $\Delta V_{icm}/\Delta V_{io}$ )	$V_{icm} = 0$ to 1.8 V, $V_{out} = V_{CC}/2$	55	74			
		-40°C < T< 85 °C	55				
A <sub>vd</sub>	Large signal voltage gain	$V_{out} = 0.3$ V to (V <sub>CC+</sub> - 0.3 V) R <sub>L</sub> = 100 kΩ	95	115			
		-40 °C < T< 85 °C	95				
M	High level output voltage	R <sub>L</sub> = 100 kΩ			40		
V <sub>OH</sub>	(drop from V <sub>CC</sub> +)	-40 °C < T< 85 °C			40		
V		R <sub>L</sub> = 100 kΩ			40	mV	
V <sub>OL</sub>	Low level output voltage	-40 °C < T< 85 °C			40		
	Output sink surrent	$V_{out} = V_{CC}, V_{ID} = -200 \text{ mV}$	4	5			
	Output sink current	-40 °C < T< 85 °C	4				
l <sub>out</sub>		$V_{out} = 0 V, V_{ID} = + 200 mV$	4	5		- mA	
	Output source current	-40 °C < T< 85 °C	4				
	Supply current	No load, $V_{out} = V_{CC}/2$		580	750	<b>n</b> A	
I <sub>CC</sub>	(per channel)	-40 °C < T< 85 °C			800	nA	
AC perfor	mance	·					
GBP	Gain bandwidth product			8			
$F_{u}$	Unity gain frequency			8		kHz	
$\Phi_{\sf m}$	Phase margin	$-R_{L} = 1 M\Omega, C_{L} = 60 \text{ pF}$		60		degree	
G <sub>m</sub>	Gain margin	1		10		dB	

Table 4.	Electrical	characteristics
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Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
SR	Slew rate (10 % to 90 %)	$\label{eq:RL} \begin{array}{l} R_{L} = 1 \ M\Omega, \ C_{L} = 60 \ pF \\ V_{out} = 0.3 \ V \ to \ (V_{CC+} - 0.3 \ V) \end{array}$		3		V/ms
	Equivalent input noise voltage	f = 100 Hz		265		nV
e <sub>n</sub>		f = 1 kHz		265		$\frac{nV}{\sqrt{Hz}}$
∫e <sub>n</sub>	Low-frequency peak-to- peak input noise	Bandwidth: f = 0.1 to 10 Hz		9		$\mu V_{pp}$
;	Equivalent input noise	f = 100 Hz		0.64		<u>_fA</u> √Hz
i <sub>n</sub>	current	f = 1 kHz		4.4		$\sqrt{Hz}$
t <sub>rec</sub>	Overload recovery time	100 mV from rail in comparator $R_L = 100 \text{ k}\Omega$ , $V_{ID} = \pm V_{CC}$ -40 °C < T< 85 °C		30		μs

Table 4.	Electrical	characteristics	(continued)
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Typical value is based on the V<sub>io</sub> drift observed after 1000h at 125 °C extrapolated to 25 °C using the Arrhenius law and assuming an activation energy of 0.7 eV. The operational amplifier is aged in follower mode configuration.

2. Guaranteed by design.



 $V_{CC}+$  = 3.3 V with  $V_{CC}-$  = 0 V,  $V_{icm}$  =  $V_{CC}/2,$   $T_{amb}$  = 25 ° C, and  $R_L$  = 1  $M\Omega$  connected to  $V_{CC}/2$  (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
DC perfor	mance					
	lument offenst coeffense		-3	0.1	3	
V <sub>io</sub>	Input offset voltage	-40 °C < T< 85 °C	-3.4		3.4	mV
$\Delta V_{io} / \Delta T$	Input offset voltage drift	-40 °C < T< 85 °C			5	μV/°C
$\Delta V_{io}$	Long-term input offset voltage drift	T = 25 °C <sup>(1)</sup>		0.36		$\frac{\mu V}{\sqrt{month}}$
I.	Input offset current <sup>(2)</sup>			1	5	
I <sub>io</sub>	input onset current.	-40 °C < T< 85 °C			30	pA
I.,	Input bias current <sup>(2)</sup>			1	5	
l <sub>ib</sub>	input bias current.	-40 °C < T< 85 °C			30	
		$V_{icm} = 0$ to 2.1 V, $V_{out} = V_{CC}/2$	70	92		
CMR	Common mode rejection	-40 °C < T< 85 °C	70			dB
CIVIN	ratio 20 log ( $\Delta V_{icm}/\Delta V_{io}$ )	$V_{icm} = 0$ to 3.3 V, $V_{out} = V_{CC}/2$	60	77		
		-40 °C < T< 85 °C	60			
A <sub>vd</sub>	Large signal voltage gain	$V_{out}$ = 0.3 V to (V <sub>CC+</sub> - 0.3 V) R <sub>L</sub> = 100 kΩ	105	120		
		-40 °C < T< 85 °C	105			
	High level output voltage	R <sub>L</sub> = 100 kΩ			40	<u> </u>
V <sub>OH</sub>	(drop from V <sub>CC</sub> +)	-40 °C < T< 85 °C			40	
		R <sub>L</sub> = 100 kΩ			40	mV
V <sub>OL</sub>	Low level output voltage	-40 °C < T< 85 °C			40	
	Output sink current	$V_{out} = V_{CC}, V_{ID} = -200 \text{ mV}$	6	9		
		-40 °C < T< 85 °C	6			m 4
l <sub>out</sub>		$V_{out} = 0 V, V_{ID} = + 200 mV$	8	11		mA
	Output source current	-40 °C < T< 85 °C	8			
	Supply current (per channel)	No load, $V_{out} = V_{CC}/2$		600	800	nA
I <sub>CC</sub>		-40 °C < T< 85 °C			850	
AC perfor	mance					
GBP	Gain bandwidth product			8		
Fu	Unity gain frequency			8		kHz
$\Phi_{\sf m}$	Phase margin	R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 60 pF		60		degrees
G <sub>m</sub>	Gain margin			11		dB
	1					



Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
SR	Slew rate (10 % to 90 %)	$      R_L = 1 \ M\Omega, \ C_L = 60 \ pF, \\ V_{out} = 0.3 \ V \ to \ (V_{CC+} - 0.3 \ V) $		3		V/ms
0	Equivalent input noise voltage	f = 100 Hz		260		<u>nV</u> √Hz
e <sub>n</sub>		f = 1 kHz		255		$\sqrt{Hz}$
∫e <sub>n</sub>	Low-frequency peak-to- peak input noise	Bandwidth: f = 0.1 to 10 Hz		8.6		$\mu V_{pp}$
i	Equivalent input noise	f = 100 Hz		0.55		<u>_fA</u> √Hz
i <sub>n</sub>	current	f = 1 kHz		3.8		√Hz
t <sub>rec</sub>	Overload recovery time	100 mV from rail in comparator $R_L = 100 \text{ k}\Omega$ , $V_{ID}= \pm V_{CC}$ -40 °C < T< 85 °C		30		μs

#### Table 5. Electrical characteristics (continued)

1. Typical value is based on the V<sub>io</sub> drift observed after 1000h at 125 °C extrapolated to 25 °C using the Arrhenius law and assuming an activation energy of 0.7 eV. The operational amplifier is aged in follower mode configuration.

2. Guaranteed by design.



 $V_{CC}$  + = 5 V with  $V_{CC}$  - = 0 V,  $V_{icm}$  =  $V_{CC}/2,$   $T_{amb}$  = 25 ° C, and  $R_L$  = 1  $M\Omega$  connected to  $V_{CC}/2$  (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
DC perfor	mance					
M			-3	0.1	3	mV
V <sub>io</sub>	Input offset voltage	-40 °C < T< 85 °C	-3.4		3.4	
$\Delta V_{io} / \Delta T$	Input offset voltage drift	-40 °C < T< 85 °C			5	μV/°C
$\Delta V_{io}$	Long-term input offset voltage drift	$T = 25 °C^{(1)}$		1.1		$\frac{\mu V}{\sqrt{month}}$
I.	l <sub>io</sub> Input offset current <sup>(2)</sup>			1	5	
I <sub>io</sub>		-40 °C < T< 85 °C			30	pА
I <sub>ib</sub>	Input bias current <sup>(2)</sup>			1	5	5 30
lip		-40 °C < T< 85 °C			30	
		$V_{icm} = 0$ to 3.8 V, $V_{out} = V_{CC}/2$	70	90		
CMR	Common mode rejection	-40 °C < T< 85 °C	70			
CIVIR	ratio 20 log ( $\Delta V_{icm} / \Delta V_{io}$ )	$V_{icm} = 0$ to 5 V, $V_{out} = V_{CC}/2$	65	82		
		-40 °C < T< 85 °C	65			
SVR	Supply voltage rejection	$V_{CC}$ = 1.5 to 5.5 V, $V_{icm}$ = 0 V	70	90		dB
SVR	ratio	-40 °C < T< 85 °C	70			
A <sub>vd</sub>	Large signal voltage gain	$V_{out}$ = 0.3 V to (V <sub>cc+</sub> - 0.3 V) R <sub>L</sub> = 100 kΩ	110	130		
		-40°C < T< 85 °C	110			
	High level output voltage	R <sub>L</sub> = 100 kΩ			40	
V <sub>OH</sub>	(drop from V <sub>CC</sub> +)	-40 °C < T< 85 °C			40	m)/
N/		R <sub>L</sub> = 100 kΩ			40	mV
V <sub>OL</sub>	Low level output voltage	-40 °C < T< 85 °C			40	
		$V_{out} = V_{CC}, V_{ID} = -200 \text{ mV}$	6	9		
	Output sink current	-40 °C < T< 85 °C	6			
l <sub>out</sub>		$V_{out} = 0 V, V_{ID} = + 200 mV$	8	11		mA
	Output source current	-40 °C < T< 85 °C	8			
	Supply ourront (per charge)	No load, $V_{out} = V_{CC}/2$		650	850	nA
I <sub>CC</sub>	Supply current (per channel)	-40 °C < T< 85 °C			950	

Table 6	6. Electrical	characteristics
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Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
AC perform	mance					
GBP	Gain bandwidth product			9		kHz
Fu	Unity gain frequency	R <sub>I</sub> = 1 MΩ, C <sub>I</sub> = 60 pF		8.6		КПД
$\Phi_{\sf m}$	Phase margin	112 - 1022, 02 - 00 pi		60		degrees
G <sub>m</sub>	Gain margin			12		dB
SR	Slew rate (10 % to 90 %)	$\label{eq:RL} \begin{split} R_L &= 1 \; M\Omega,  C_L = 60 \; pF, \\ V_out &= 0.3 \; V \; to \; (V_CC+ \text{-} 0.3 \; V) \end{split}$		3		V/ms
e <sub>n</sub> Equivalent input noise voltage	f = 100 Hz		240		nV	
	voltage	f = 1 kHz		225		<u>nV</u> √Hz
∫e <sub>n</sub>	Low-frequency peak-to-peak input noise	Bandwidth: f = 0.1 to 10 Hz		8.1		μV <sub>pp</sub>
:	Equivalent input noise	f = 100 Hz		0.18		<u>_fA</u> √Hz
i <sub>n</sub>	current	f = 1 kHz		3.5		√Hz
t <sub>rec</sub>	Overload recovery time	100 mV from rail in comparator $R_L = 100 \text{ k}\Omega$ , $V_{ID}= \pm V_{CC}$ -40 °C < T< 85 °C		30		μs
		V <sub>in</sub> = -10 dBm, f = 400 MHz		73		1
	Electromagnetic	V <sub>in</sub> = -10 dBm, f = 900 MHz		88		- dB
EMIRR	interference rejection ratio <sup>(3)</sup>	V <sub>in</sub> = -10 dBm, f = 1.8 GHz		80		
		V <sub>in</sub> = -10 dBm, f = 2.4 GHz		80		

Table 6. Electrical characteristics (continued)

1. Typical value is based on the  $V_{io}$  drift observed after 1000h at 125 °C extrapolated to 25 °C using the Arrhenius law and assuming an activation energy of 0.7 eV. The operational amplifier is aged in follower mode configuration.

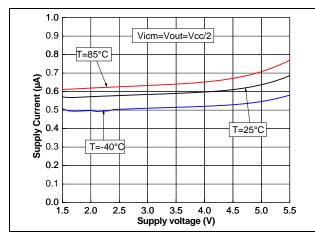
2. Guaranteed by design.

3. Based on evaluations performed only in conductive mode.



#### Figure 2. Supply current vs. supply voltage

# Figure 3. Supply current vs. input common mode voltage





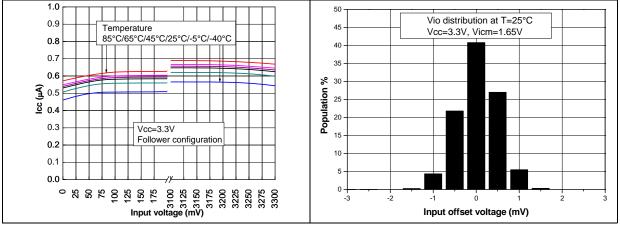


Figure 6. Input offset voltage vs. common mode Figure 7. Input offset voltage vs. temperature at voltage 3.3 V supply voltage

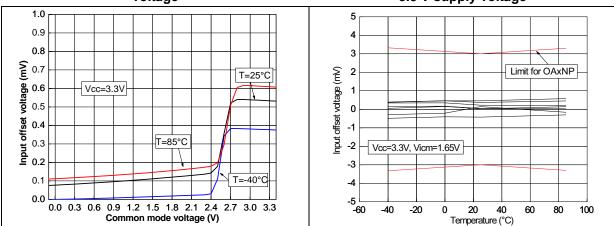
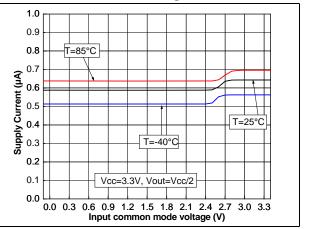




Figure 5. Input offset voltage distribution



30 -

25

20 %

10

5

0 -5

1.8

1.6

1.4

Output Voltage (V) 0.8 0.0 0.6

0.4

0.2

0.0

Source

Vid=0.2V

Vcc=1.8V

Vicm=0.1V

Sink

Vid=-0.2V

0.0 0.5 1.0 1.5

Population 15 Figure 9. Input bias current vs. temperature at

Figure 8. Input offset voltage temperature coefficient distribution

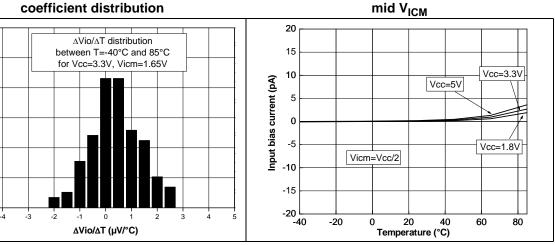


Figure 10. Input bias current vs. temperature at Figure 11. Input bias current vs. temperature at low V<sub>ICM</sub> high V<sub>ICM</sub>

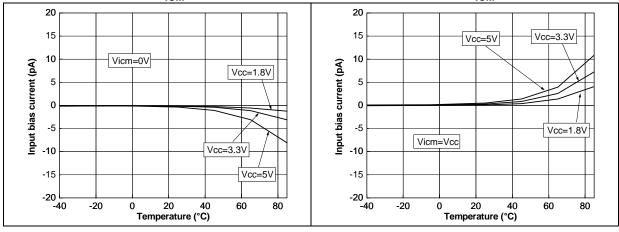
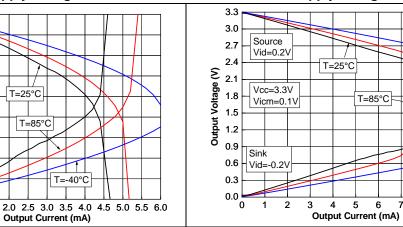


Figure 12. Output characteristics at 1.8 V supply voltage

T=25°C

T=85°C

Figure 13. Output characteristics at 3.3 V supply voltage



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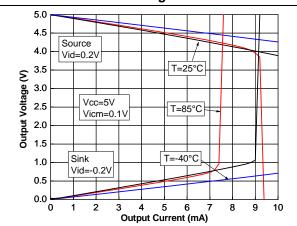


10

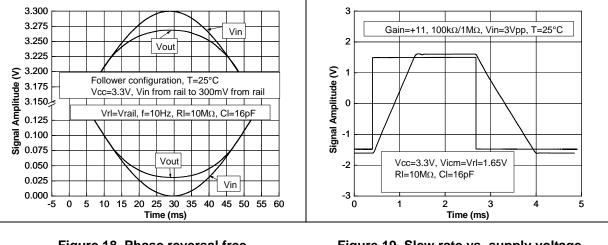
T=-40°C

8 9

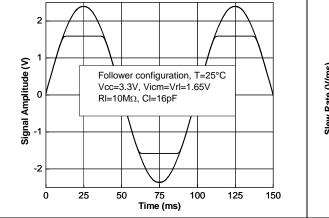
Figure 14. Output characteristics at 5 V supply voltage







#### Figure 18. Phase reversal free



#### Figure 15. Output voltage vs. input voltage close to the rails

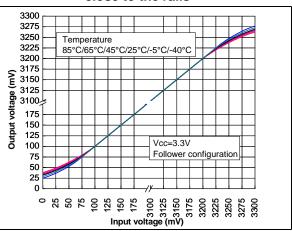
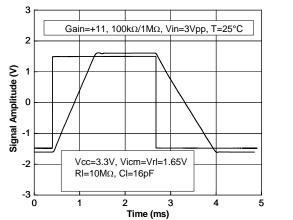
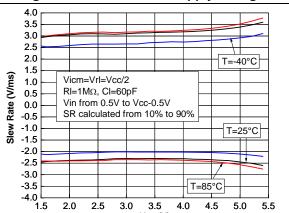


Figure 17. Desaturation time





4.0

4.5

2.0

2.5

3.0

3.5

Vcc (V)

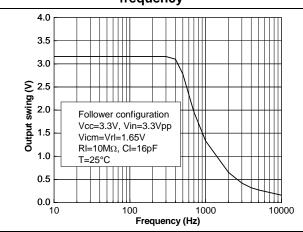
Figure 19. Slew rate vs. supply voltage

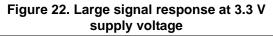


5.5

5.0

Figure 20. Output swing vs. input signal frequency





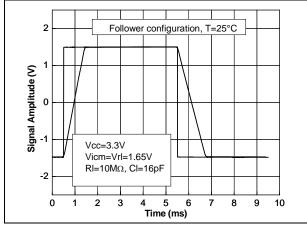


Figure 24. Overshoot vs. capacitive load at 3.3 V supply voltage

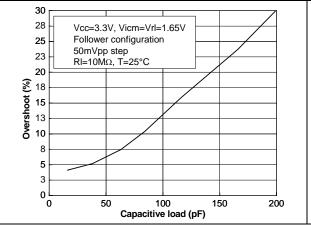


Figure 21. Triangulation of a sine wave

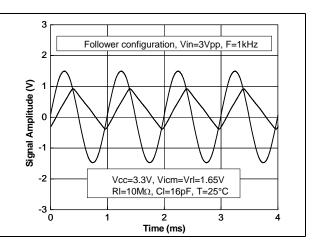


Figure 23. Small signal response at 3.3 V supply voltage

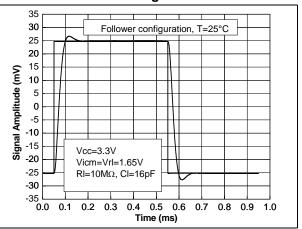


Figure 25. Phase margin vs. capacitive load at 3.3 V supply voltage

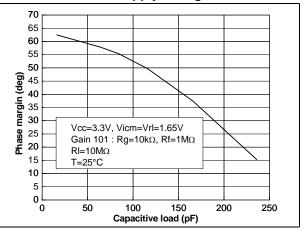




Figure 26. Bode diagram for different feedback Figure 27. Bode diagram at 1.8 V supply voltage values

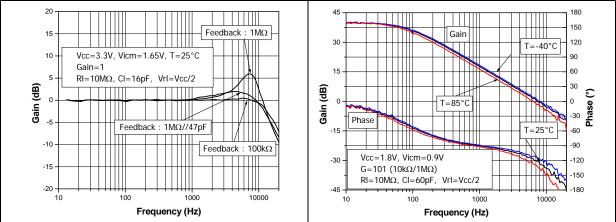


Figure 28. Bode diagram at 3.3 V supply voltage Figure 29. Bode diagram at 5 V supply voltage

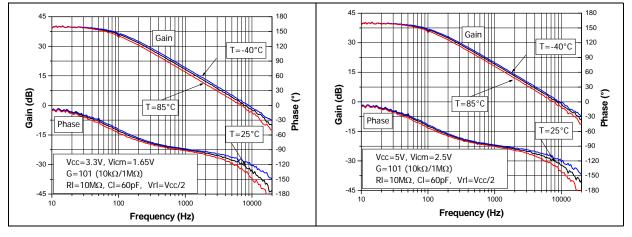


Figure 30. Gain bandwidth product vs. input common mode voltage

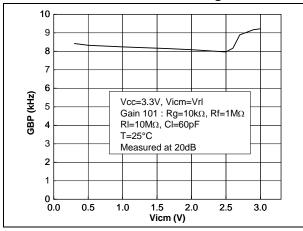
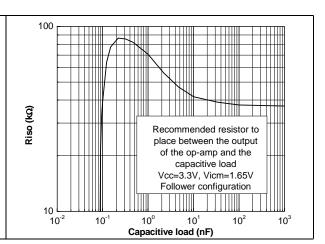


Figure 31. Gain vs. input common mode voltage





10000

1000

100

10 ∟ 10

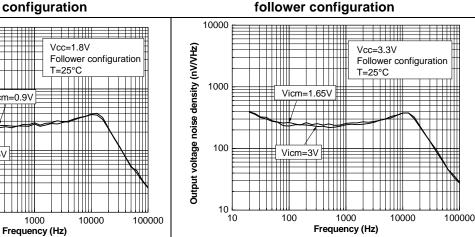
Output voltage noise density (nV/VHz)

Figure 32. Noise at 1.8 V supply voltage in follower configuration

Vicm=0.9V

100

Vicm=1.5V



#### Figure 34. Noise at 5 V supply voltage in follower configuration

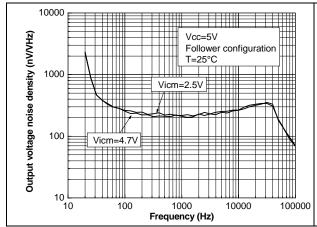


Figure 36. Channel separation on OA2NP

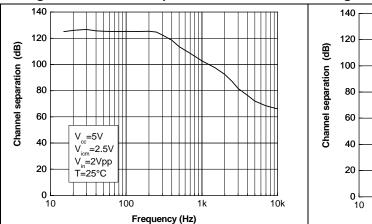
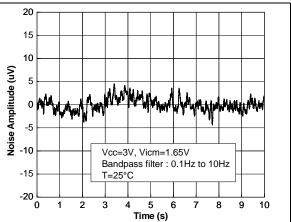
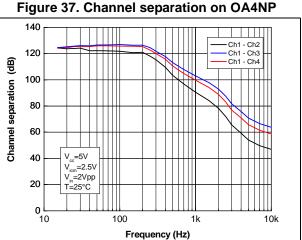


Figure 35. Noise amplitude on 0.1 to 10 Hz frequency range

Figure 33. Noise at 3.3 V supply voltage in







## 4 Application information

### 4.1 Operating voltages

The OA1NP, OA2NP and OA4NP series of low power op amp can operate from 1.5 V to 5.5 V. Their parameters are fully specified at 1.8 V, 3.3 V, and 5 V supply voltages and are very stable in the full V<sub>CC</sub> range. Additionally, main specifications are guaranteed on the industrial temperature range from -40 to +85 ° C.

### 4.2 Rail-to-rail input

The OA1NP, OA2NP and OA4NP series is built with two complementary PMOS and NMOS input differential pairs. Thus, these devices have a rail-to-rail input, and the input common mode range is extended from  $V_{CC-}$  - 0.1 V to  $V_{CC+}$  + 0.1 V.

The devices have been designed to prevent phase reversal behavior.

### 4.3 Input offset voltage drift over temperature

The maximum input voltage drift over the temperature variation is defined as the offset variation related to the offset value measured at 25 °C. The operational amplifier is one of the main circuits of the signal conditioning chain, and the amplifier input offset is a major contributor to the chain accuracy. The signal chain accuracy at 25 °C can be compensated during production at application level. The maximum input voltage drift over temperature enables the system designer to anticipate the effects of temperature variations.

The maximum input voltage drift over temperature is computed in *Equation 1*.

#### **Equation 1**

$$\frac{\Delta V_{io}}{\Delta T} = \max \left| \frac{V_{io}(T) - V_{io}(25^{\circ}C)}{T - 25^{\circ}C} \right|$$

with T = -40 °C and 85 °C.

The datasheet maximum value is guaranteed by measurements on a representative sample size ensuring a  $C_{pk}$  (process capability index) greater than 2.



### 4.4 Long term input offset voltage drift

To evaluate product reliability, two types of stress acceleration are used:

- Voltage acceleration, by changing the applied voltage
- Temperature acceleration, by changing the die temperature (below the maximum junction temperature allowed by the technology) with the ambient temperature.

The voltage acceleration has been defined based on JEDEC results, and is defined using *Equation 2*.

#### **Equation 2**

$$A_{FV} = e^{\beta \cdot (V_S - V_U)}$$

Where:

A<sub>FV</sub> is the voltage acceleration factor

 $\beta$  is the voltage acceleration constant in 1/V, constant technology parameter ( $\beta$  = 1)

 $V_S$  is the stress voltage used for the accelerated test

V<sub>U</sub> is the voltage used for the application

The temperature acceleration is driven by the Arrhenius model, and is defined in Equation 3.

#### **Equation 3**

$$A_{FT} = e^{\frac{E_a}{k} \cdot \left(\frac{1}{T_U} - \frac{1}{T_s}\right)}$$

Where:

A<sub>FT</sub> is the temperature acceleration factor

 $\mathsf{E}_{\mathsf{a}}$  is the activation energy of the technology based on the failure rate

k is the Boltzmann constant (8.6173 x  $10^{-5}$  eVk<sup>-1</sup>)

 $T_U$  is the temperature of the die when  $V_U$  is used (°K)

T<sub>S</sub> is the temperature of the die under temperature stress (°K)

The final acceleration factor,  $A_{F_{r}}$  is the multiplication of the voltage acceleration factor and the temperature acceleration factor (*Equation 4*).

#### Equation 4

 $A_F = A_{FT} \times A_{FV}$ 

 $A_F$  is calculated using the temperature and voltage defined in the mission profile of the product. The  $A_F$  value can then be used in *Equation 5* to calculate the number of months of use equivalent to 1000 hours of reliable stress duration.



#### **Equation 5**

Months =  $A_F \times 1000 \text{ h} \times 12 \text{ months}/(24 \text{ h} \times 365.25 \text{ days})$ 

To evaluate the op amp reliability, a follower stress condition is used where  $V_{CC}$  is defined as a function of the maximum operating voltage and the absolute maximum rating (as recommended by JEDEC rules).

The V<sub>io</sub> drift (in  $\mu$ V) of the product after 1000 h of stress is tracked with parameters at different measurement conditions (see *Equation 6*).

#### **Equation 6**

 $V_{CC} = maxV_{op}$  with  $V_{icm} = V_{CC}/2$ 

The long term drift parameter ( $\Delta V_{io}$ ), estimating the reliability performance of the product, is obtained using the ratio of the  $V_{io}$  (input offset voltage value) drift over the square root of the calculated number of months (*Equation 7*).

#### **Equation 7**

$$\Delta V_{io} = \frac{V_{io} drift}{\sqrt{(months)}}$$

where  $V_{io}\xspace$  drift is the measured drift value in the specified test conditions after 1000 h stress duration.

### 4.5 Schematic optimization aiming for low power

To benefit from the full performance of the The OA1NP, OA2NP and OA4NP series, the impedances must be maximized so that current consumption is not lost where it is not required.

For example, an aluminum electrolytic capacitance can have significantly high leakage. This leakage may be greater than the current consumption of the op amp. For this reason, ceramic type capacitors are preferred.

For the same reason, big resistor values should be used in the feedback loop. However, there are three main limitations to be considered when choosing a resistor.

- 1. When the The OA1NP, OA2NP and OA4NP series is used with a sensor: the resistance connected between the sensor and the input must remain much higher than the impedance of the sensor itself.
- 2. Noise generated: a100 k $\Omega$  resistor generates 40  $\frac{nV}{\sqrt{Hz}}$ , a bigger resistor value generates even more noise.
- 3. Leakage on the PCB: leakage can be generated by moisture. This can be improved by using a specific coating process on the PCB.

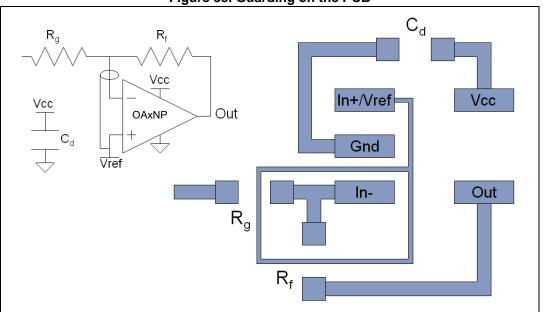


## 4.6 PCB layout considerations

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.

Minimizing the leakage from sensitive high impedance nodes on the inputs of the OA1NP, OA2NP, OA4NP series can be performed with a guarding technique. The technique consists of surrounding high impedance tracks by a low impedance track (the ring). The ring is at the same electrical potential as the high impedance node.

Therefore, even if some parasitic impedance exists between the tracks, no leakage current can flow through them as they are at the same potential (see *Figure 38*).







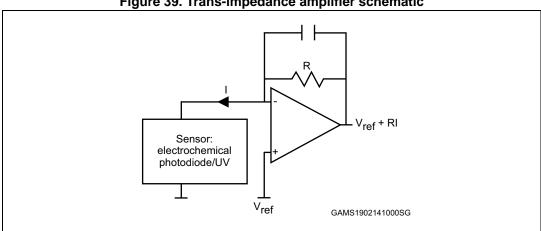
#### 4.7 Using the OA1NP, OA2NP, OA4NP series with sensors

The OA1NP, OA2NP, OA4NP series has MOS inputs, thus input bias currents can be guaranteed down to 5 pA maximum at ambient temperature. This is an important parameter when the operational amplifier is used in combination with high impedance sensors.

The OA1NP, OA2NP, and OA4NP series is perfectly suited for trans-impedance configuration as shown in Figure 39. This configuration allows a current to be converted into a voltage value with a gain set by the user. It is an ideal choice for portable electrochemical gas sensing or photo/UV sensing applications. The OA1NP, OA2NP, OA4NP series, using trans-impedance configuration, is able to provide a voltage value based on the physical parameter sensed by the sensor.

#### **Electrochemical gas sensors**

The output current of electrochemical gas sensors is generally in the range of tens of nA to hundreds of  $\mu$ A. As the input bias current of the OA1NP, OA2NP, and OA4NP is very low (see Figure 9, Figure 10, and Figure 11) compared to these current values, the OA1NP, OA2NP, OA4NP series is well adapted for use with the electrochemical sensors of two or three electrodes. Figure 40 shows a potentiostat (electronic hardware required to control a three electrode cell) schematic using the OA1NP, OA2NP, and OA4NP. In such a configuration, the devices minimize leakage in the reference electrode compared to the current being measured on the working electrode.



#### Figure 39. Trans-impedance amplifier schematic



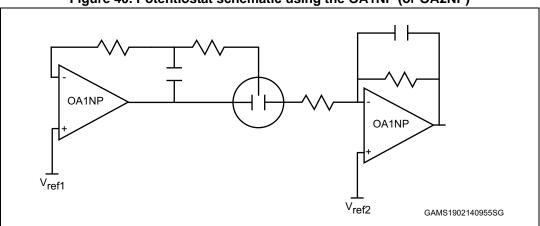


Figure 40. Potentiostat schematic using the OA1NP (or OA2NP)

### 4.8 Fast desaturation

When the OA1NP, OA2NP, and OA4NP, operational amplifiers go into saturation mode, they take a short period of time to recover, typically thirty microseconds. When recovering after saturation, the OA1NP, OA2NP, and OA4NP series does not exhibit any voltage peaks that could generate issues (such as false alarms) in the application (see *Figure 17*). This is because the internal gain of the amplifier decreases smoothly when the output signal gets close to the V<sub>CC+</sub> or V<sub>CC-</sub> supply rails (see *Figure 15* and *Figure 16*).

Thus, to maintain signal integrity, the user should take care that the output signal stays at 100 mV from the supply rails.

With a trans-impedance schematic, a voltage reference can be used to keep the signal away from the supply rails.

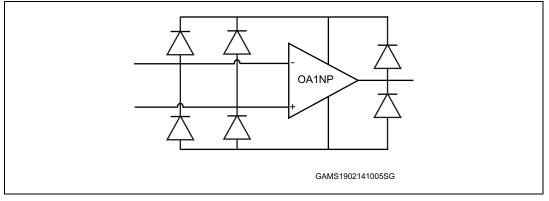
## 4.9 Using the OA1NP, OA2NP, OA4NP series in comparator mode

The OA1NP, OA2NP, and OA4NP series can be used as a comparator. In this case, the output stage of the device always operates in saturation mode. In addition, *Figure 4* shows the current consumption is not bigger and even decreases smoothly close to the rails. The OA1NP, OA2NP, and OA4NP are obviously operational amplifiers and are therefore optimized to be used in linear mode. We recommend to use the TS88 series of nanopower comparators if the primary function is to perform a signal comparison only.



## 4.10 ESD structure of OA1NP, OA2NP, OA4NP series

The OA1NP, OA2NP and OA4NP are protected against electrostatic discharge (ESD) with dedicated diodes (see *Figure 41*). These diodes must be considered at application level especially when signals applied on the input pins go beyond the power supply rails (V<sub>CC+</sub> or V<sub>CC-</sub>).





Current through the diodes must be limited to a maximum of 10 mA as stated in *Table 2*. A serial resistor or a Schottky diode can be used on the inputs to improve protection but the 10 mA limit of input current must be strictly observed.

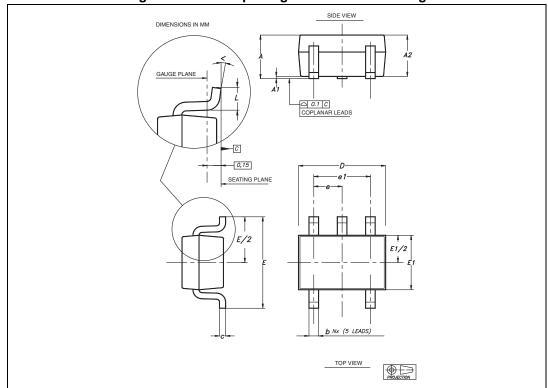


## 5 Package information

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



## 5.1 SC70-5 package mechanical data



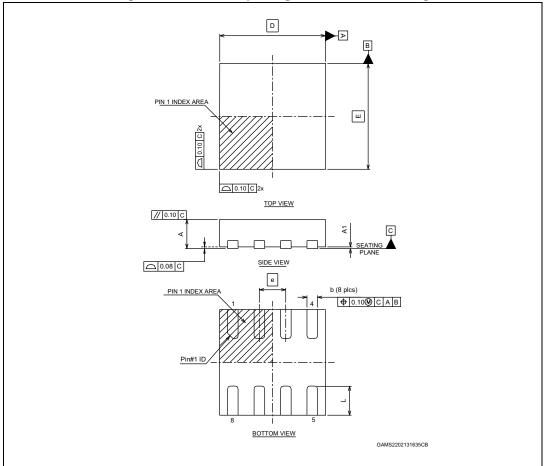
#### Figure 42. SC70-5 package mechanical drawing

#### Table 7. SC70-5 package mechanical data

	Dimensions						
Ref		Millimeters			Inches		
	Min	Тур	Max	Min	Тур	Max	
А	0.80		1.10	0.315		0.043	
A1			0.10			0.004	
A2	0.80	0.90	1.00	0.315	0.035	0.039	
b	0.15		0.30	0.006		0.012	
С	0.10		0.22	0.004		0.009	
D	1.80	2.00	2.20	0.071	0.079	0.087	
E	1.80	2.10	2.40	0.071	0.083	0.094	
E1	1.15	1.25	1.35	0.045	0.049	0.053	
е		0.65			0.025		
e1		1.30			0.051		
L	0.26	0.36	0.46	0.010	0.014	0.018	
<	0 °		8 °	0 °		8 °	



## 5.2 DFN8 2x2 package information



#### Figure 43. DFN8 2x2 package mechanical drawing

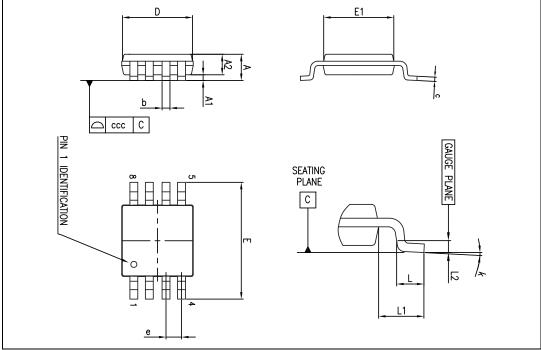
#### Table 8. DFN8 2x2 package mechanical data

	Dimensions					
Ref.		Millimeters			Inches	
	Min.	Тур.	Max.	Min.	Тур.	Max.
А	0.70	0.75	0.80	0.028	0.030	0.031
A1	0.00	0.02	0.05	0.000	0.001	0.002
b	0.15	0.20	0.25	0.006	0.008	0.010
D		2.00			0.079	
E		2.00			0.079	
е		0.50			0.020	
L	0.045	0.55	0.65	0.018	0.022	0.026
N			1	8		



## 5.3 MiniSO8 package information



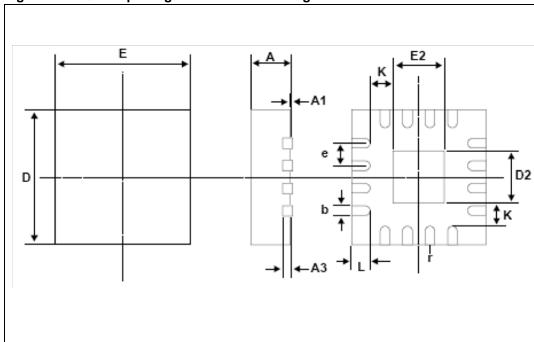


#### Table 9. MiniSO8 package mechanical data

ibie 3.	Millioco pu	chaye mecha				
	Dimensions					
Ref.		Millimeters			Inches	
	Min.	Тур.	Max.	Min.	Тур.	Max.
А			1.1			0.043
A1	0		0.15	0		0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.22		0.40	0.009		0.016
С	0.08		0.23	0.003		0.009
D	2.80	3.00	3.20	0.11	0.118	0.126
Е	4.65	4.90	5.15	0.183	0.193	0.203
E1	2.80	3.00	3.10	0.11	0.118	0.122
е		0.65			0.026	
L	0.40	0.60	0.80	0.016	0.024	0.031
L1		0.95			0.037	
L2		0.25			0.010	
k	0 °		8 °	0 °		8 °
CCC			0.10			0.004



## 5.4 QFN16 package information

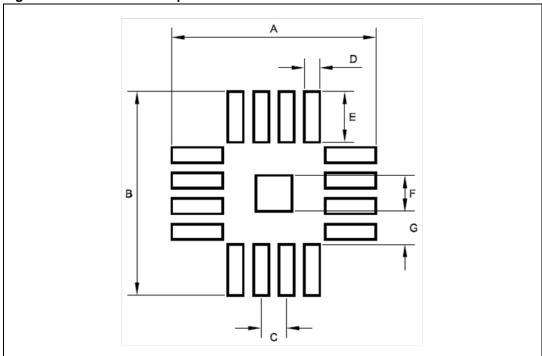


#### Figure 45. QFN16 package mechanical drawing

#### Table 10. QFN16 package mechanical data

	Dimensions						
Ref.		Millimeters			Inches		
	Min.	Тур.	Max.	Min.	Тур.	Max.	
А	0.80	0.90	1.00	0.032	0.035	0.039	
A1		0.02	0.05		0.001	0.002	
A3		0.2			0.008		
b	0.18	0.23	0.30	0.007	0.009	0.012	
D		3.00			0.118		
D2	1.00	1.15	1.25	0.039	0.045	0.049	
Е		3.00			0.118		
E2	1.00	1.15	1.25	0.039	0.045	0.049	
е		0.5			0.02		
К		0.2			0.008		
L	0.30	0.40	0.50	0.012	0.016	0.020	
r	0.09			0.006			





#### Figure 46. QFN16 3x3 footprint recommendation

### Table 11. Footprint data

Footprint data					
Ref	Millimeters	Inches			
A	4.00	0.158			
В	4.00	0.136			
С	0.50	0.020			
D	0.30	0.012			
E	1.00	0.039			
F	0.70	0.028			
G	0.66	0.026			



# 6 Revision history

Table 12. Document revision history	Table 12.	Document	revision	history
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Date	Revision	Changes
28-Feb-2014	1	Initial release
06-Mar-2014	2	Update Section 4.8 on page 22



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