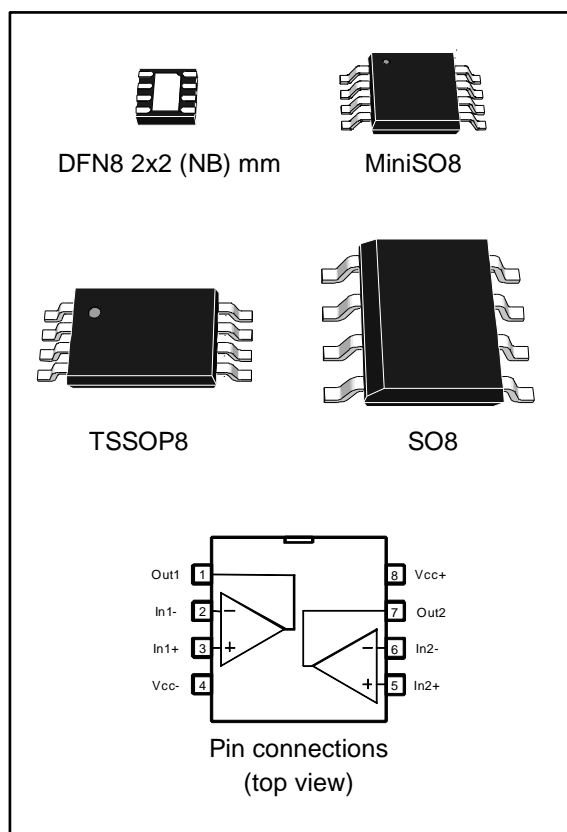


## Low-power dual operational amplifiers

Datasheet - production data



### Features

- Internally frequency-compensated
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1.1 MHz (temperature compensated)
- Very low supply current per channel essentially independent of supply voltage
- Low input bias current: 20 nA (temperature compensated)

- Low input offset voltage: 2 mV
- Low input offset current: 2 nA
- Input common-mode voltage range includes negative rails
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V to ( $V_{CC}^+ - 1.5 V$ )

### Related products

- See LM158W for enhanced ESD ratings

### Description

These circuits consist of two independent, high-gain, internally frequency-compensated op-amps, specifically designed to operate 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 can now be more easily implemented in single power supply systems. For example, these circuits can be directly supplied with the standard +5 V, which is used in logic systems and will easily provide the required interface electronics with no additional power supply.

In 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.

**Contents**

**1 Schematic diagram..... 3**

**2 Absolute maximum ratings..... 4**

**3 Operating conditions ..... 5**

**4 Electrical characteristics ..... 6**

**5 Typical applications ..... 11**

**6 Package information ..... 14**

    6.1 SO8 package information..... 15

    6.2 MiniSO8 package information ..... 16

    6.3 DFN8 2 x 2 (NB) package information ..... 17

    6.4 TSSOP8 package information..... 19

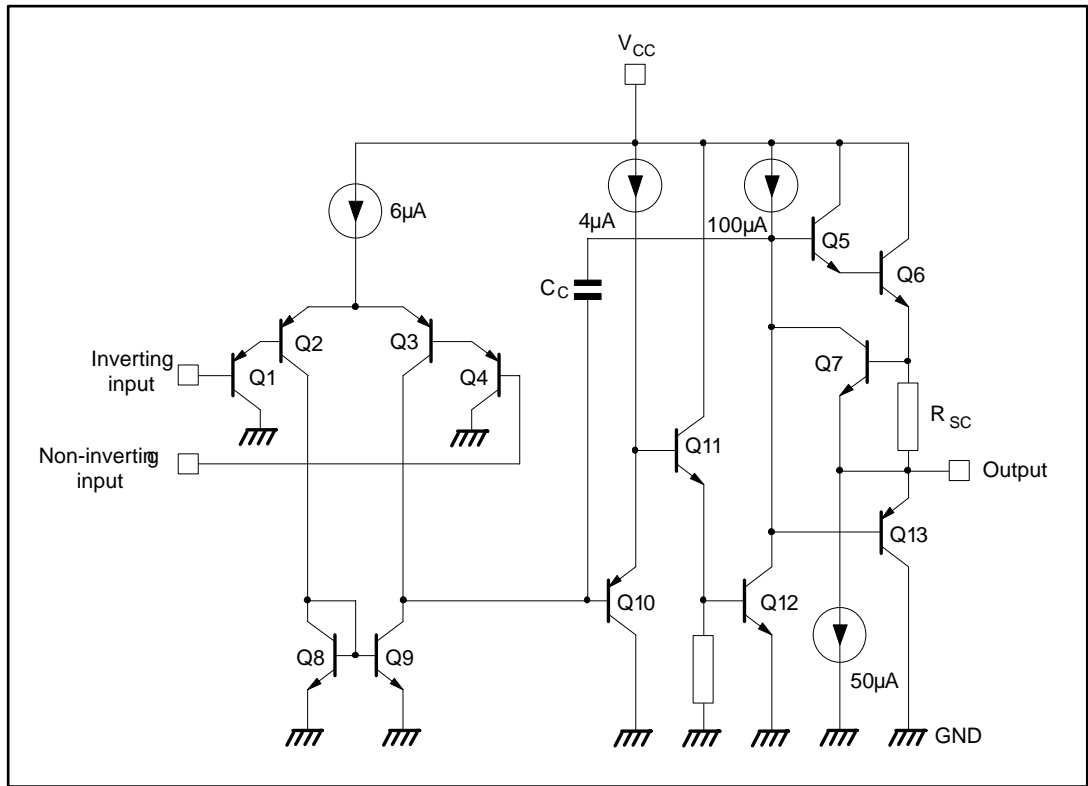
**7 Ordering information..... 20**

**8 Revision history ..... 21**



# 1 Schematic diagram

Figure 1: Schematic diagram (1/2 LM158)



## 2 Absolute maximum ratings

Table 1: Absolute maximum ratings

Symbol	Parameter	LM158,A	LM258,A	LM358,A	Unit
$V_{CC}$	Supply voltage	±16 or 32			V
$V_i$	Input voltage	32			
$V_{id}$	Differential input voltage	32			
	Output short-circuit duration <sup>(1)</sup>	Infinite			
$I_{in}$	Input current <sup>(2)</sup>	5 mA in DC or 50 mA in AC (duty cycle = 10 %, T = 1 s)			mA
$T_{oper}$	Operating free-air temperature range	-55 to 125	-40 to 105	0 to 70	°C
$T_{stg}$	Storage temperature range	-65 to 150			
$T_j$	Maximum junction temperature	150			
$R_{thja}$	Thermal resistance junction to ambient <sup>(3)</sup>	SO8	125		°C/W
		MiniSO8	190		
		DFN8 2x2 (NB)	57		
		TSSOP8	120		
$R_{thjc}$	Thermal resistance junction to case <sup>(3)</sup>	SO8	40		
		MiniSO8	39		
		TSSOP8	37		
ESD	HBM: human body model <sup>(4)</sup>	300			V
	MM: machine model <sup>(5)</sup>	200			
	CDM: charged device model <sup>(6)</sup>	1.5			kV

### Notes:

<sup>(1)</sup>Short-circuits from the output to  $V_{CC}$  can cause excessive heating if  $V_{CC} > 15$  V. The maximum output current is approximately 40 mA independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short circuits on all amplifiers.

<sup>(2)</sup>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.

<sup>(3)</sup>Short-circuits can cause excessive heating and destructive dissipation.  $R_{th}$  are typical values.

<sup>(4)</sup>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.

<sup>(5)</sup>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.

<sup>(6)</sup>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 <sup>(1)</sup>		$V_{CC}^- - 0.3$ to $V_{CC}^+ - 1.5$	
$T_{oper}$	Operating free air temperature range	LM158	-55 to +125	°C
		LM258	-40 to +105	
		LM358	0 to +70	

**Notes:**

<sup>(1)</sup>When used in comparator, the functionality is guaranteed as long as at least one input remains within the operating common mode voltage range.

## 4 Electrical characteristics

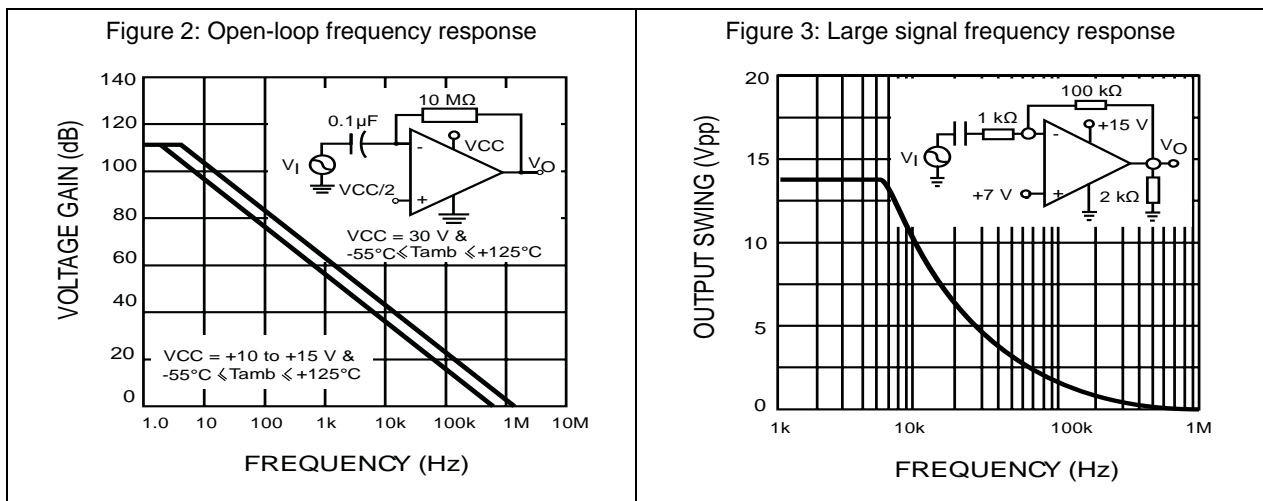
**Table 3: Electrical characteristics for VCC+ = +5 V, VCC- = Ground, Vo = 1.4 V, Tamb = +25 °C (unless otherwise specified)**

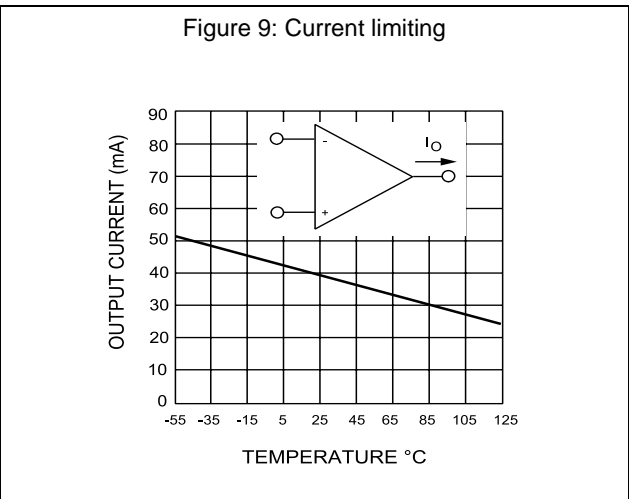
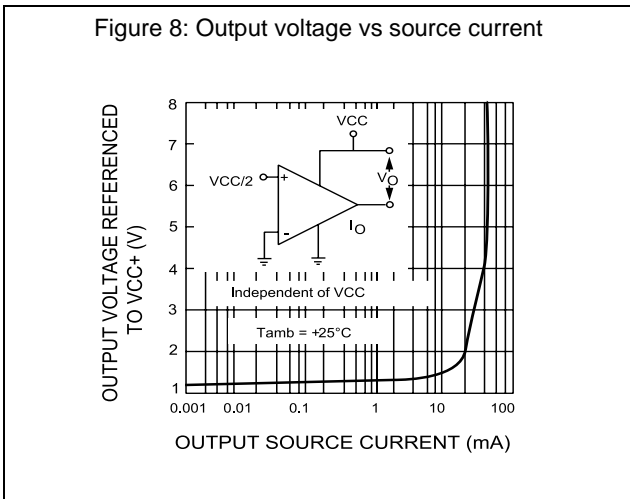
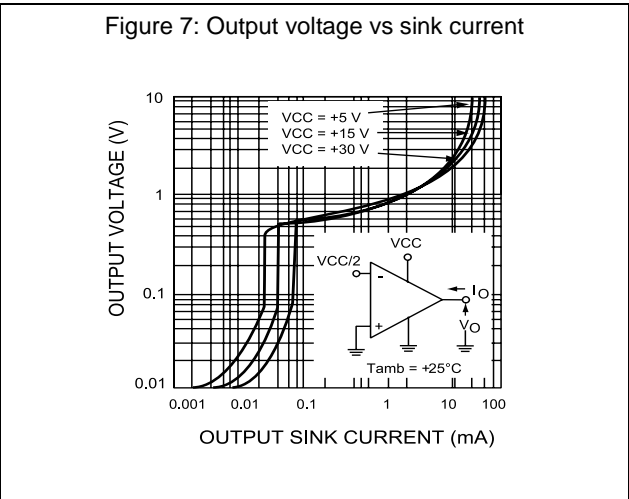
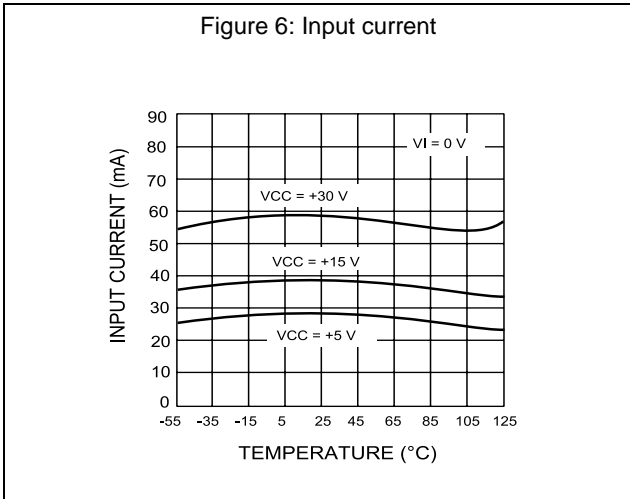
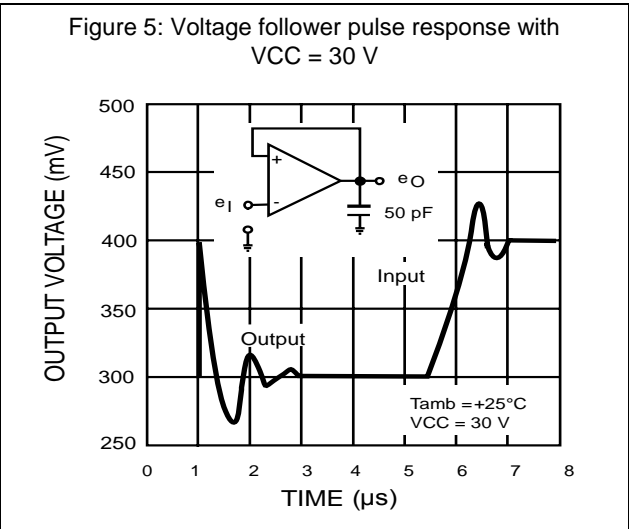
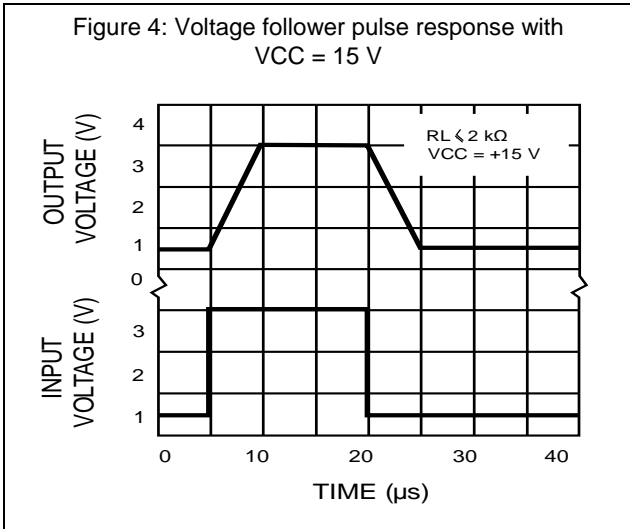
Symbol	Parameter	Min.	Typ.	Max.	Unit		
V <sub>io</sub>	Input offset voltage <sup>(1)</sup>	LM158A		2	mV		
		LM258A, LM358A		1			
		LM158, LM258		5			
		LM358		2			
	T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>	LM158A, LM258A, LM358A			4		
		LM158, LM258			7		
LM358				9			
ΔV <sub>io</sub> /ΔT	Input offset voltage drift	LM158A, LM258A, LM358A		7	μV/°C		
		LM158, LM258, LM358		7			
I <sub>io</sub>	Input offset current	LM158A, LM258A, LM358A		2	nA		
		LM158, LM258, LM358		2			
	T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>	LM158A, LM258A, LM358A			30		
		LM158, LM258, LM358			40		
ΔI <sub>io</sub> /ΔT	Input offset current drift	LM158A, LM258A, LM358A		10	pA/°C		
		LM158, LM258, LM358		10			
I <sub>ib</sub>	Input bias current <sup>(2)</sup>	LM158A, LM258A, LM358A		20	nA		
		LM158, LM258, LM358		20			
	T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>	LM158A, LM258A, LM358A			100		
		LM158, LM258, LM358			200		
A <sub>vd</sub>	Large signal voltage gain	V <sub>CC</sub> <sup>+</sup> = +15 V, R <sub>L</sub> = 2 kΩ, V <sub>o</sub> = 1.4 V to 11.4 V		50	V/mV		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>		25			
SVR	Supply voltage rejection ratio	V <sub>CC</sub> <sup>+</sup> = 5 V to 30 V, R <sub>s</sub> ≤ 10 kΩ		65	dB		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>		65			
I <sub>CC</sub>	Supply current, all amp, no load	T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> V <sub>CC</sub> <sup>+</sup> = +5 V		0.7	mA		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> V <sub>CC</sub> <sup>+</sup> = +30 V		2			
V <sub>icm</sub>	Input common mode voltage range	V <sub>CC</sub> <sup>+</sup> = +30 V <sup>(3)</sup>		0	V		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>		0			
CMR	Common mode rejection ratio	R <sub>s</sub> ≤ 10 kΩ		70	dB		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>		60			
I <sub>source</sub>	Output current source	V <sub>CC</sub> <sup>+</sup> = +15 V, V <sub>o</sub> = +2 V, V <sub>id</sub> = +1 V		20	40	60	mA

Symbol	Parameter		Min.	Typ.	Max.	Unit
I <sub>sink</sub>	Output sink current	V <sub>CC</sub> <sup>+</sup> = +15 V, V <sub>o</sub> = +2 V, V <sub>id</sub> = -1 V	10	20		mA
		V <sub>CC</sub> <sup>+</sup> = +15 V, V <sub>o</sub> = +0.2 V, V <sub>id</sub> = -1V	12	50		μA
V <sub>OH</sub>	High level output voltage	R <sub>L</sub> = 2 kΩ, V <sub>CC</sub> <sup>+</sup> = 30 V	26	27		V
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>	26			
		R <sub>L</sub> = 10 kΩ, V <sub>CC</sub> <sup>+</sup> = 30 V	27	28		
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>	27			
V <sub>OL</sub>	Low level output voltage	R <sub>L</sub> = 10 kΩ		5	20	mV
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			20	
SR	Slew rate	V <sub>CC</sub> <sup>+</sup> = 15 V, V <sub>i</sub> = 0.5 to 3 V, R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, unity gain	0.3	0.6		V/μs
GBP	Gain bandwidth product	V <sub>CC</sub> <sup>+</sup> = 30 V, f = 100 kHz, V <sub>in</sub> = 10 mV, R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF	0.7	1.1		MHz
THD	Total harmonic distortion	f = 1 kHz, A <sub>v</sub> = 20 dB, R <sub>L</sub> = 2 kΩ, V <sub>o</sub> = 2 V <sub>pp</sub> , C <sub>L</sub> = 100 pF, V <sub>O</sub> = 2 V <sub>pp</sub>		0.02		%
e <sub>n</sub>	Equivalent input noise voltage	f = 1 kHz, R <sub>s</sub> = 100 Ω, V <sub>CC</sub> <sup>+</sup> = 30V		55		$\frac{nV}{\sqrt{Hz}}$
V <sub>o1</sub> /V <sub>o2</sub>	Channel separation <sup>(4)</sup>	1kHz ≤ f ≤ 20 kHz		120		dB

**Notes:**

- (1) V<sub>o</sub> = 1.4 V, R<sub>s</sub> = 0 Ω, 5 V < V<sub>CC</sub><sup>+</sup> < 30 V, 0 < V<sub>ic</sub> < V<sub>CC</sub><sup>+</sup> - 1.5V
- (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) 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> - 1.5 V, but either or both inputs can go to +32 V without damage.
- (4) Due to the proximity of external components, ensure that stray capacitance between these external parts does not cause coupling. Typically, this can be detected because this type of capacitance increases at higher frequencies.







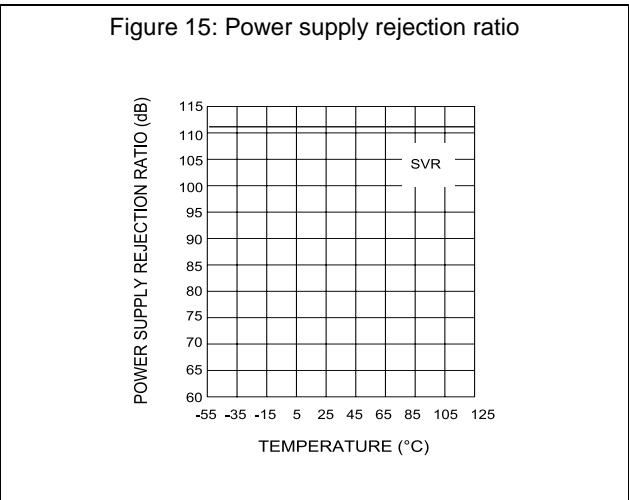
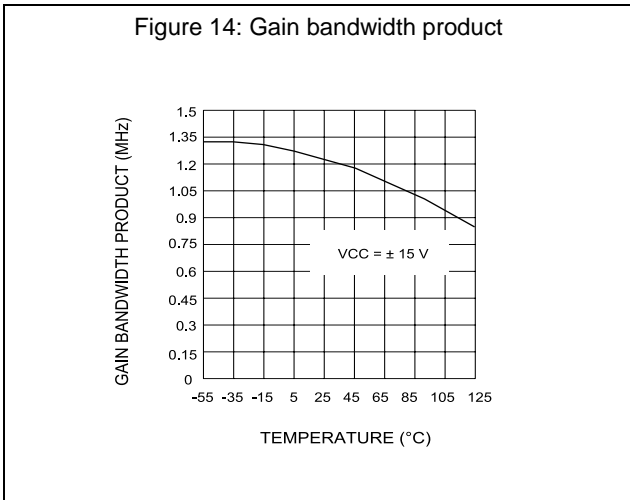
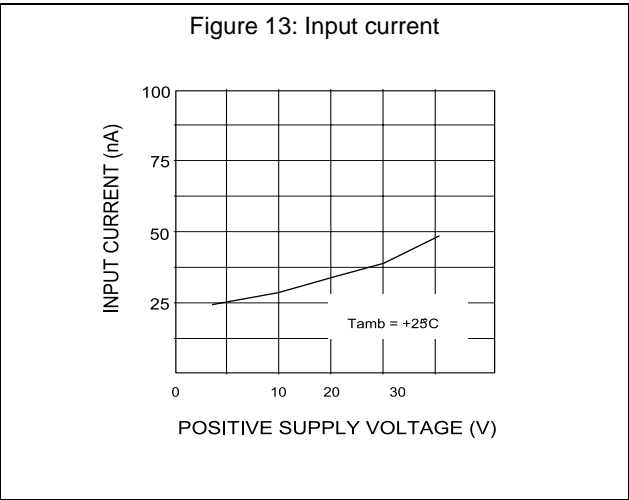
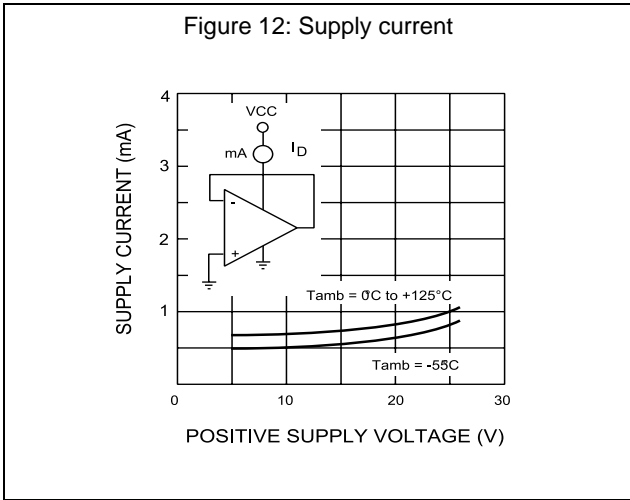
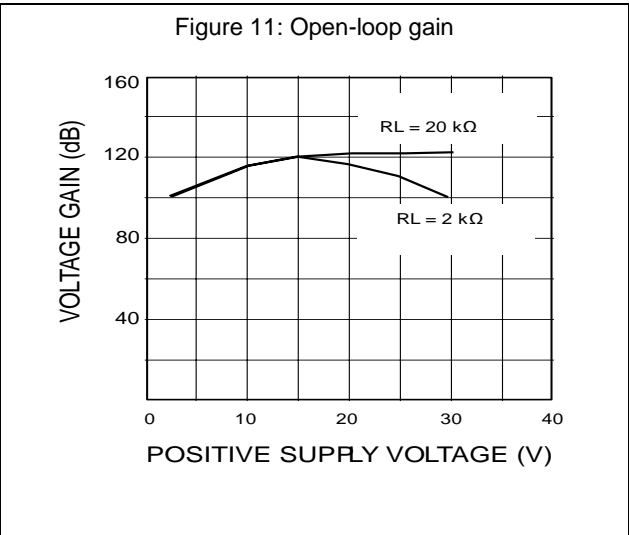
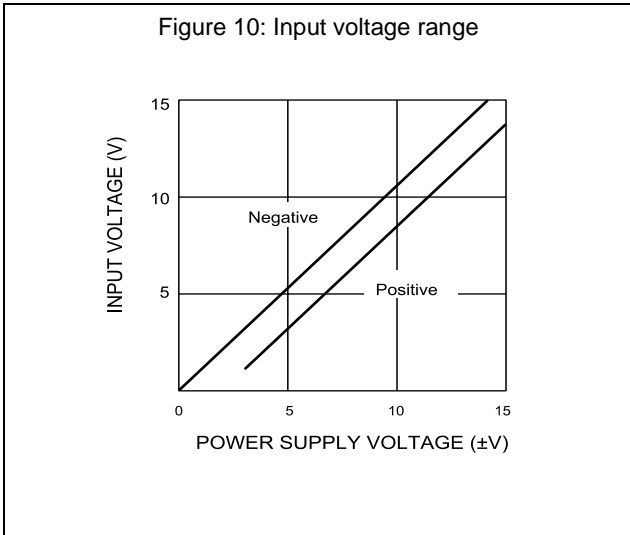


Figure 16: Common-mode rejection ratio

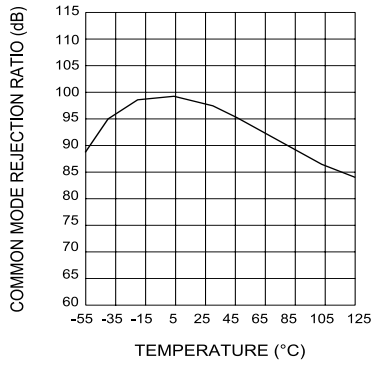
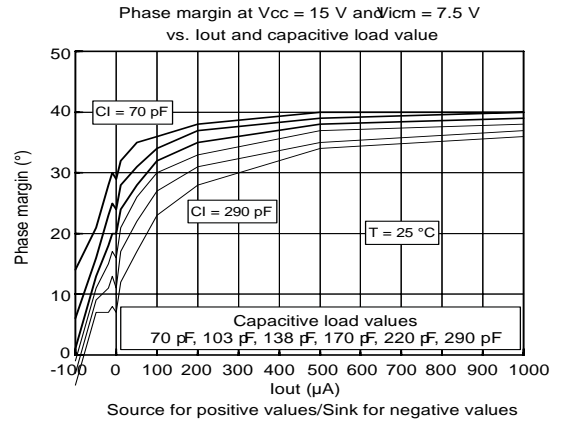


Figure 17: Phase margin vs. capacitive load



# 5 Typical applications

Single supply voltage  $V_{CC} = +5 V_{DC}$ .

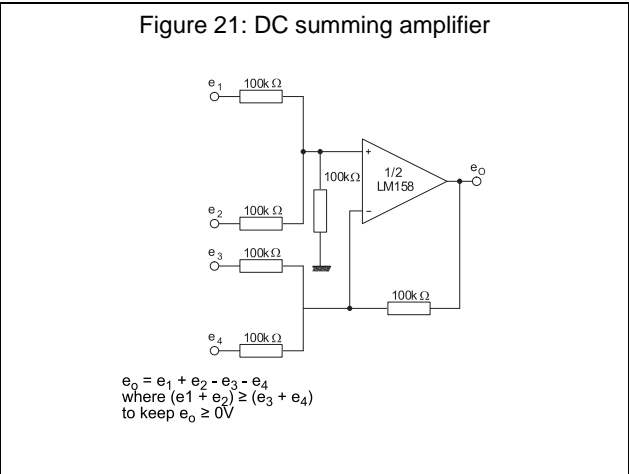
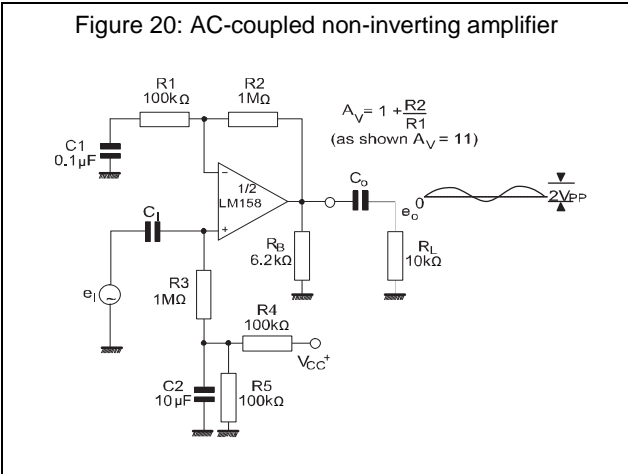
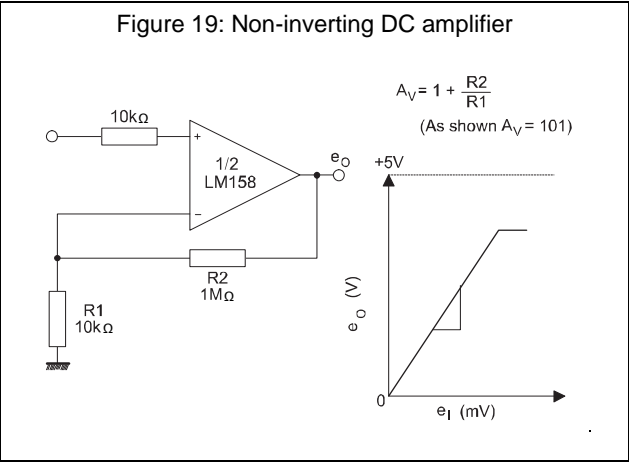
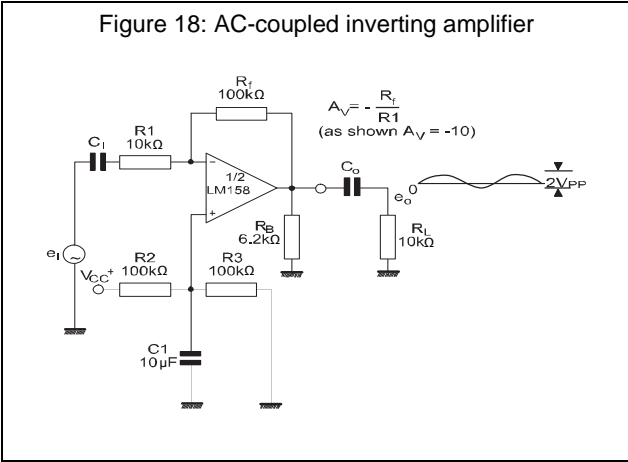
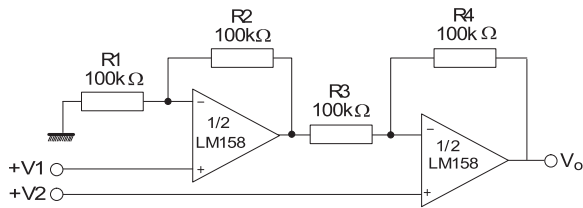
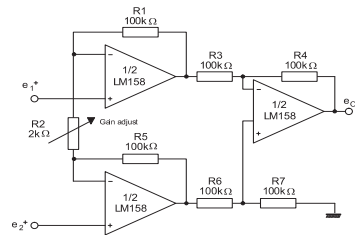


Figure 22: High input Z, DC differential amplifier



if  $R1 = R5$  and  $R3 = R4 = R6 = R7$   
 $e_o = [1 + \frac{2R1}{R2}] (e_2 + e_1)$   
 As shown  $e_o = 101 (e_2 + e_1)$

Figure 23: High input Z adjustable gain DC instrumentation amplifier



if  $R1 = R5$  and  $R3 = R4 = R6 = R7$   
 $e_o = [1 + \frac{2R1}{R2}] (e_2 + e_1)$

As shown  $e_o = 101 (e_2 + e_1)$

Figure 24: Using symmetrical amplifiers to reduce input current

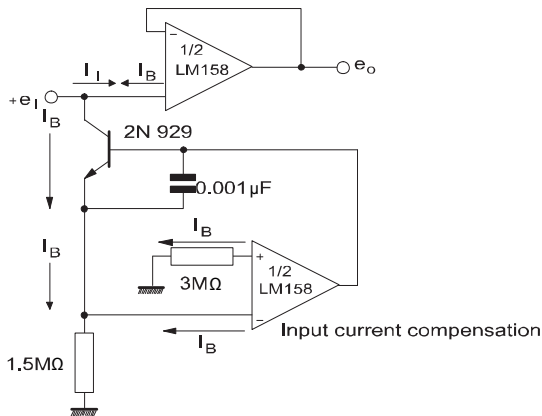


Figure 25: Low drift peak detector

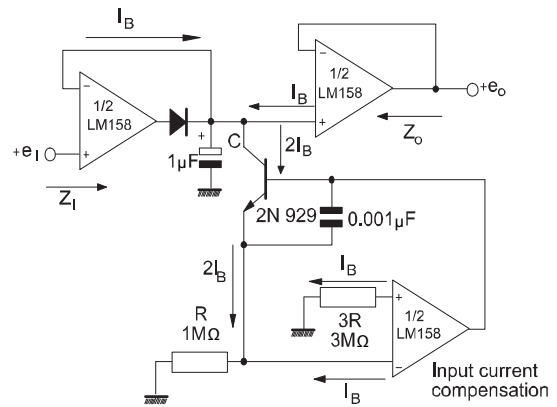
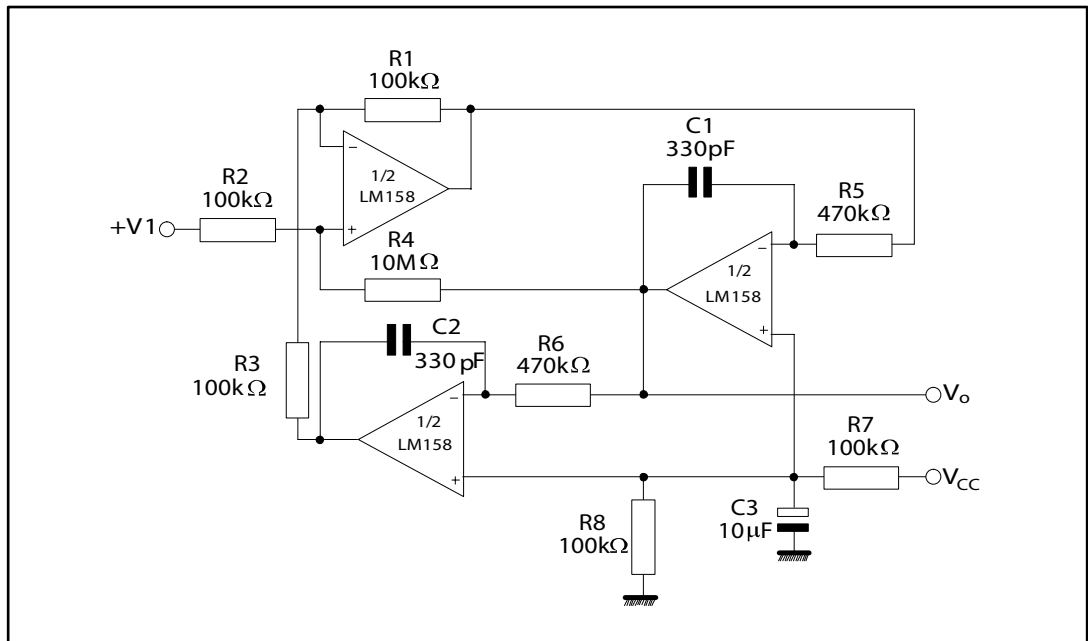


Figure 26: Active band-pass filter



## 6 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](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

## 6.1 SO8 package information

Figure 27: SO8 package mechanical drawing

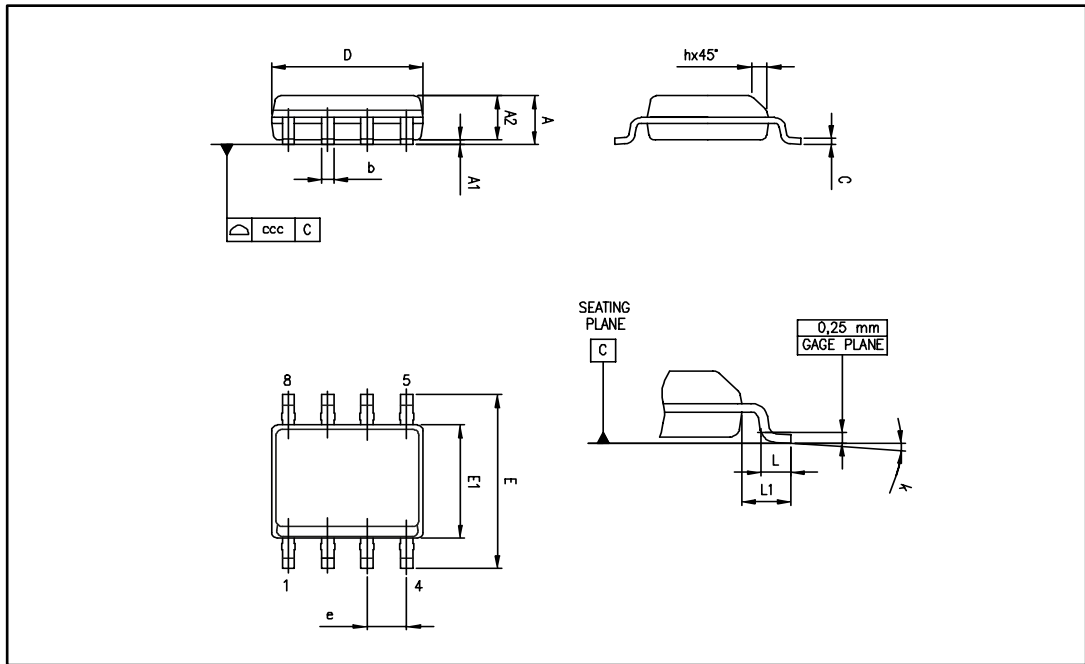


Table 4: SO8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
L1		1.04			0.040	
k	1°		8°	1°		8°
ccc			0.10			0.004

## 6.2 MiniSO8 package information

Figure 28: MiniSO8 package mechanical drawing

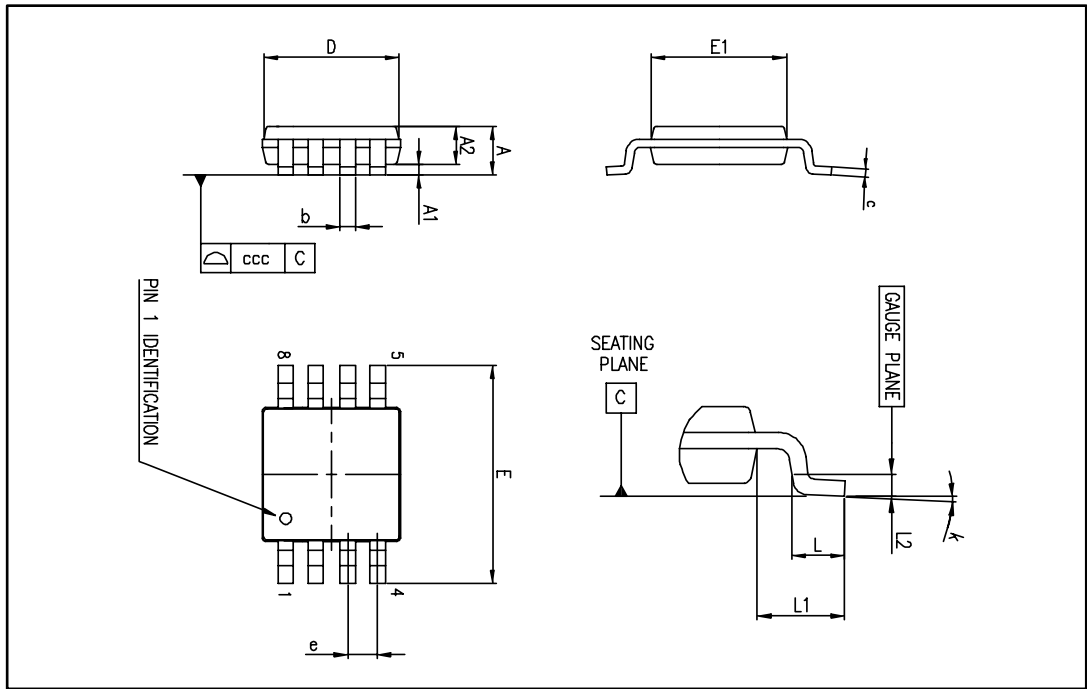


Table 5: MiniSO8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			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
c	0.08		0.23	0.003		0.009
D	2.80	3.00	3.20	0.11	0.118	0.126
E	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
e		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



### 6.3 DFN8 2 x 2 (NB) package information

Figure 29: DFN8 2 x 2 (NB) package mechanical drawing

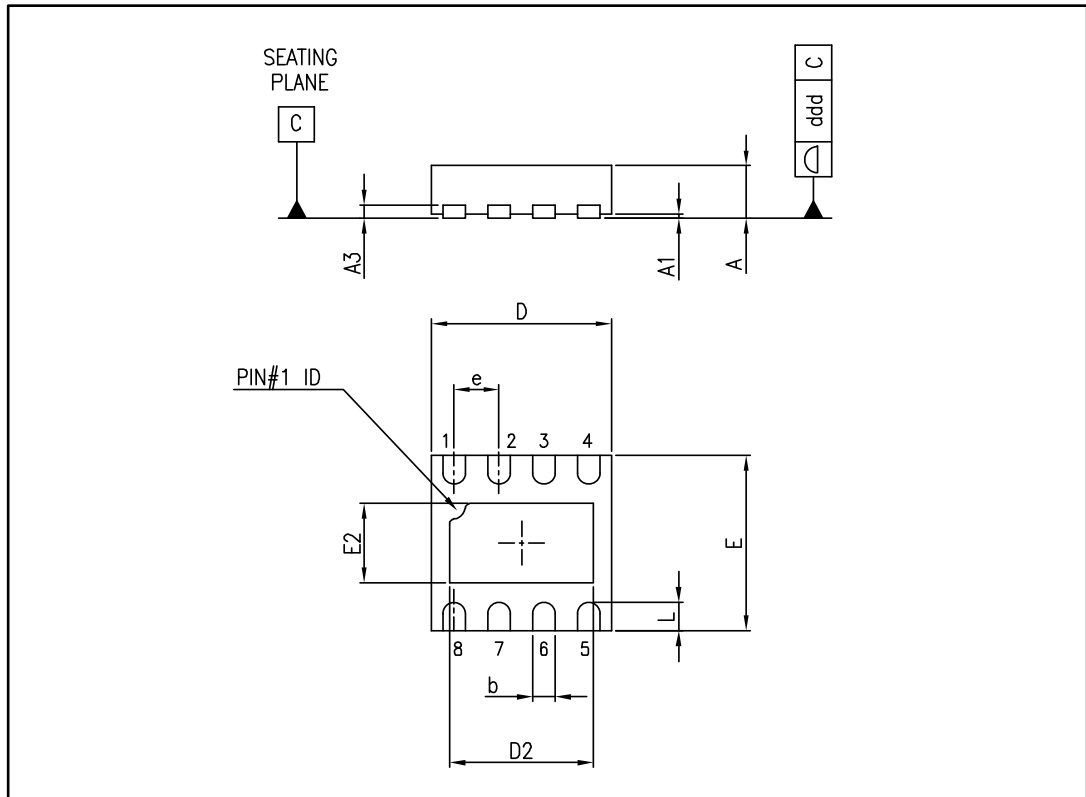
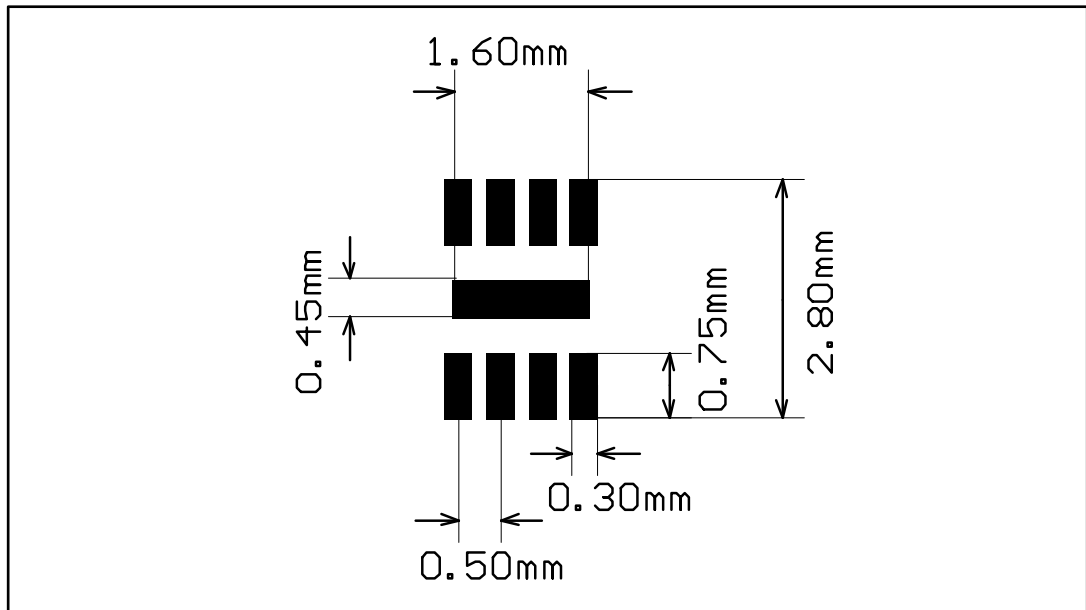


Table 6: DFN8 2 x 2 x 0.6 (NB) mm package mechanical data (pitch 0.5 mm)

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.51	0.55	0.60	0.020	0.022	0.024
A1			0.05			0.002
A3		0.15			0.006	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	1.85	2.00	2.15	0.073	0.079	0.085
D2	1.45	1.60	1.70	0.057	0.063	0.067
E	1.85	2.00	2.15	0.073	0.079	0.085
E2	0.75	0.90	1.00	0.030	0.035	0.039
e		0.50			0.020	
L			0.425			0.017
ddd			0.08			0.003

Figure 30: DFN8 2 x 2 (NB) footprint recommendation



## 6.4 TSSOP8 package information

Figure 31: TSSOP8 package mechanical drawing

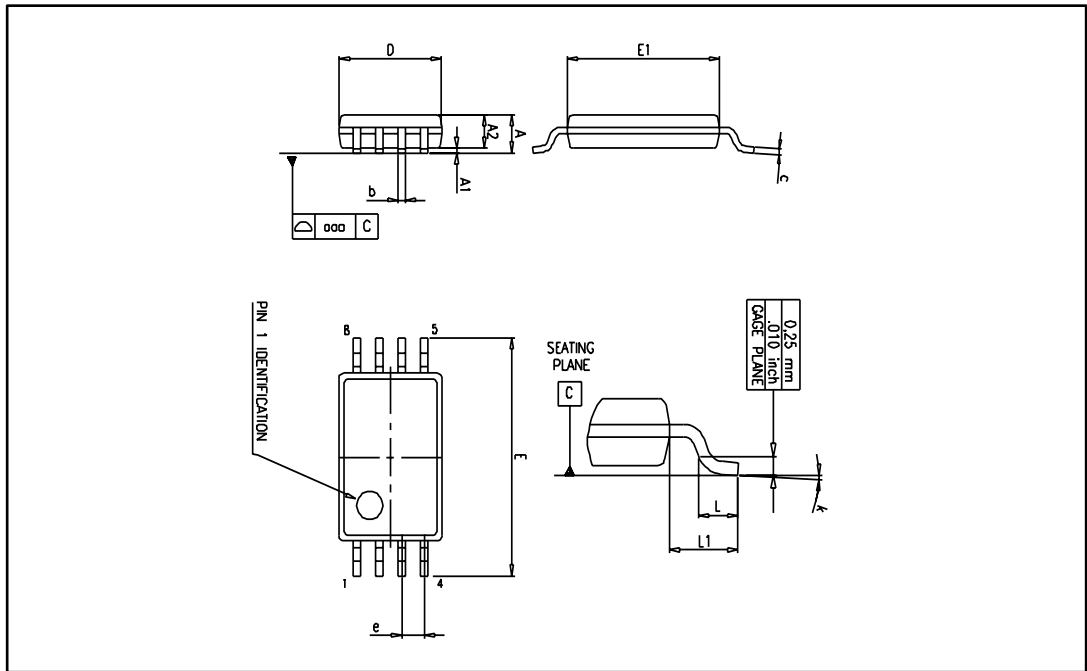


Table 7: TSSOP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
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		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
k	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	
aaa		0.1			0.004	

## 7 Ordering information

Table 8: Order codes

Order code	Temperature range	Package	Packaging	Marking
LM158QT	-55 °C, +125 °C	DFN8 2x2 (NB)	Tape and reel	K4A
LM158DT		SO8		158
LM258ADT	-40 °C, +105 °C	SO8		258A
LM258AYDT <sup>(1)</sup>		SO8 Automotive grade		258AY
LM258DT		SO8		258
LM258APT		TSSOP8		258A
LM258AST		MiniSO8		K408 K416
LM258ST				
LM258QT		DFN8 2x2 (NB)		K4C
LM358DT	0 °C, +70 °C	SO8		358
LM358YDT <sup>(1)</sup>		SO8 Automotive grade		358Y
LM358ADT		SO8		358A
LM358PT		TSSOP8		358
LM358APT				358A
LM358YPT <sup>(2)</sup>		TSSOP8 Automotive grade	358Y	
LM358AYPT <sup>(2)</sup>			358AY	
LM358ST		MiniSO8	K405	
LM358AST			K404	
LM358QT		DFN8 2x2 (NB)	K4E	

**Notes:**

<sup>(1)</sup> Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

<sup>(2)</sup> Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

## 8 Revision history

**Table 9: Document revision history**

Date	Revision	Changes
01-Jul-2003	1	First release.
02-Jan-2005	2	$R_{\theta ja}$ and $T_j$ parameters added in AMR <a href="#">Table 1: "Absolute maximum ratings"</a> .
01-Jul-2005	3	ESD protection inserted in <a href="#">Table 1: "Absolute maximum ratings"</a> .
05-Oct-2006	4	Added Figure 17: Phase margin vs. capacitive load.
30-Nov-2006	5	Added missing ordering information.
25-Apr-2007	6	Removed LM158A, LM258A and LM358A from document title. Corrected error in MiniSO-8 package data. L1 is 0.004 inch. Added automotive grade order codes in <a href="#">Section 7: "Ordering information"</a> .
12-Feb-2008	7	Corrected $V_{CC}$ max (30 V instead of 32 V) in operating conditions. Changed presentation of electrical characteristics table. Deleted $V_{opp}$ parameter in electrical characteristics table. Corrected miniSO-8 package information. Corrected temperature range for automotive grade order codes. Updated automotive grade footnotes in order codes table.
26-Aug-2008	8	Added limitations on input current in <a href="#">Table 1: "Absolute maximum ratings"</a> . Corrected title for <a href="#">Figure 11</a> . Added E and L1 parameters in <a href="#">Table 4: "SO8 package mechanical data"</a> . Changed <a href="#">Figure 31: "TSSOP8 package mechanical drawing"</a> .
02-Sep-2011	9	In <a href="#">Section 6: "Package information"</a> , added: <ul style="list-style-type: none"> <li>• DFN8 2 x 2 mm package mechanical drawing</li> <li>• DFN8 2 x 2 mm recommended footprint</li> <li>• DFN8 2 x 2 mm order codes.</li> </ul>
06-Apr-2012	10	Removed order codes LM158YD, LM258AYD, LM258YD and LM358YD from <a href="#">Table 8: "Order codes"</a> .
11-Jun-2013	11	<a href="#">Table 8: "Order codes"</a> : removed order codes LM158D, LM158YDT, LM258YDT, and LM258AD; added automotive grade qualification to order codes LM258ATDT and LM358YDT; updated marking for order codes LM158DT and LM258D/LM258DT; updated temperature range, packages, and packaging for several order codes.

Date	Revision	Changes
20-Jun-2014	12	Removed DIP8 package Corrected typos (W replaced with $\Omega$ , £ replaced with $\leq$ ) Updated <a href="#">Features</a> Added <a href="#">Related products</a> <a href="#">Table 3</a> : replaced $DV_{io}$ with $\Delta V_{io}/\Delta T$ and $DI_{io}$ with $\Delta I_{io}/\Delta T$ . Updated <a href="#">Table 7</a> for exposed pad dimensions <a href="#">Table 8: "Order codes"</a> : removed order codes LM258YPT and LM258AYPT; removed all order codes for devices with tube packing; added package code (NB) to DFN8 2x2 package.

**Please Read Carefully**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2014 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)