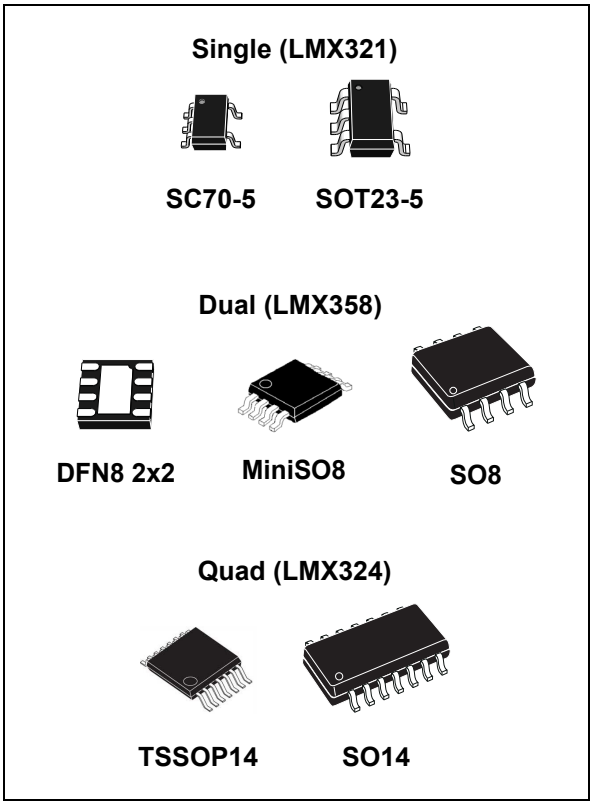
LMX321, LMX358, LMX324

General-purpose, low voltage rail-to-rail output operational amplifiers

Datasheet - production data



Features

- Low power consumption: 120 µA at 2.7 V
- Low supply voltage: 2.3 V - 5.5 V
- Rail-to-rail output swing
- Gain bandwidth product: 1.3 MHz
- Extended temperature range: -40 °C to 125 °C
- No crossover distortion
- No phase reversal
- Tiny packages

Related products

- See the TSV85x series for higher accuracy, stand-by options, and smaller packages

Applications

- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation

Description

The LMX3xx series is a set of single, dual, and quad low-voltage, general-purpose, operational amplifiers. These devices can operate from 2.3 V to 5.5 V with a typical current consumption of 120 µA per channel. The LMX3xx series offers a rail-to-rail output and an input common-mode voltage that includes ground.

The LMX3xx series also exhibits a 1.3 MHz gain bandwidth and they can drive capacitive loads. The devices are stable while operating at unity gain. They are offered with industry standard pinouts in tiny packages.

Table 1. Device summary

Reference	Single	Dual	Quad
LMX3xx	LMX321	LMX358	LMX324

This is information on a product in full production. www.st.com

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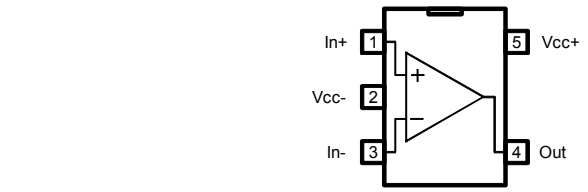
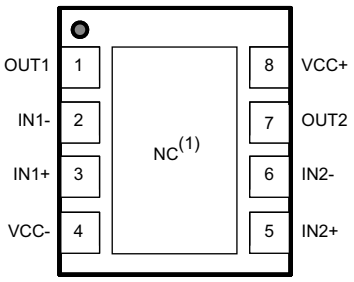
1 Package pin connections

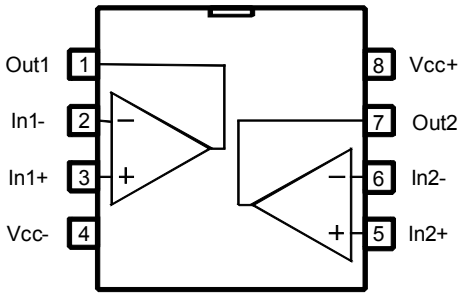
Figure 1. Pin connections for each package (top view)



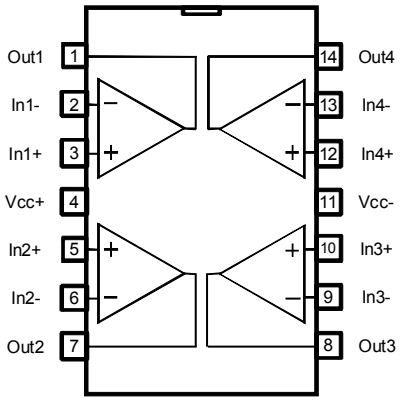
SC70-5/SOT23-5



DFN8 2x2



MiniSO8/SO8



TSSOP14/SO14

1. The exposed pad of the DFN8 2x2 can be connected to VCC- or left floating.

2 Absolute maximum ratings and operating conditions

Table 2. Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage(1)	6	V
V_{id}	Differential input voltage (2)	$\pm V_{CC}$	
V_{in}	Input pins (IN+ and IN- pins) voltage (3)	V_{cc-} - 0.3 to V_{cc+} + 0.3	
I_{in}	Input current (4)	10	mA
T_{stg}	Storage temperature	-65 to +150	°C
R_{thja}	Thermal resistance junction to ambient(5)(6)		°C/W
	SC70-5	205	
	SOT23-5	250	
	DFN8 2x2	57	
	MiniSO8	190	
	SO8	125	
	TSSOP14	100	
	SO14	105	
T_j	Maximum junction temperature	150	°C
ESD	HBM: human body model(7)	4000	V
	MM: machine model(8)	250	
	CDM: charged device model(9)	1300	
	Latch-up immunity	200	mA

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. V_{CC}-V_{in} must not exceed 6 V, V_{in} must not exceed 6 V.
4. 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_{th} are typical values.
7. Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
8. Machine model: a 200 pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating.
9. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 3. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.3 to 5.5	V
V_{icm}	Common mode input voltage range	V_{CC-} - 0.2 to V_{CC+} - 1	
T_{oper}	Operating free air temperature range	-40 to +125	°C

3 Electrical characteristics

Table 4. Electrical characteristics at V_{CC+} = 2.7 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage				4	mV
		-40 °C < T< 125 °C			6	
$\Delta V_{io}/\Delta T$	Input offset voltage drift(1)	-40 °C < T< 125 °C		1		µV/°C
I_{io}	Input offset current	V_{out} = V_{cc}/2		0.5	30	nA
		-40 °C < T< 125 °C			50	
I_{ib}	Input bias current	V_{out} = V_{cc}/2		27	60	
		-40 °C < T< 125 °C			110	
CMR	Common mode rejection ratio 20 log ($\Delta V_{icm}/\Delta V_{io}$)	Vic = 0 V to V_{cc}-1 V, V_{out} = V_{cc}/2	70	75		dB
		-40 °C < T< 125 °C	68			
A_{vd}	Large signal voltage gain	R_L = 10 kΩ, V_{out} = 0.5 V to (V_{cc}-0.5 V)	100	110		
		-40 °C < T< 125 °C	90			
		R_L = 2 kΩ, V_{out} = 0.5 V to (V_{cc}-0.5 V)	90	100		
		-40 °C < T< 125 °C	80			
V_{CC}-V_{OH}	High level output voltage	R_L = 10 kΩ,		10	100	mV
		-40 °C < T< 125 °C			200	
		R_L = 2 kΩ		40	300	
		-40 °C < T< 125 °C			400	
V_{OL}	Low level output voltage	R_L = 10 kΩ,		65	180	
		-40 °C < T< 125 °C			280	
		R_L = 2 kΩ,		120	300	
		-40 °C < T< 125 °C			400	
I_{out}	I_{sink}	V_{out} = V_{cc}, V_{id} = -1 V	15	26		mA
		-40 °C < T< 125 °C	15			
	I_{source}	V_{out} = 0 V, Vid = 1 V	15	21		
		-40 °C < T< 125 °C	12			
I_{CC}	Supply current (per channel)	No load, V_{out} = V_{CC}/2		120	180	µA
		-40 °C < T< 125 °C			180	

Table 4. Electrical characteristics at V_{CC+} = 2.7 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified) (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
AC performance						
GBP	Gain bandwidth product	R_L > 1 MΩ, C_L = 200 pF		1.3		MHz
F_u	Unity gain frequency			1		
Φ_m	Phase margin			60		degrees
G_m	Gain margin			10		dB
SR	Slew rate	R_L > 1 MΩ, C_L = 200 pF V_{out} = 0.5 V to V_{CC} - 0.5 V		0.6		V/µs
e_n	Equivalent input noise voltage	f = 1 kHz f = 10 kHz		31 20		$\frac{nV}{\sqrt{Hz}}$
i_n	Equivalent input noise current	f = 1 kHz		0.30		$\frac{pA}{\sqrt{Hz}}$
THD+N	Total harmonic distortion + noise	f_{in} = 1 kHz, A_{CL} = 1, R_L = 10 kΩ, V_{ICM} = V_{CC}/2, BW = 22 kHz, V_{out} = 1 Vpp		0.002		%

Table 5. Electrical characteristics at V_{CC+} = 5 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage				4	mV
		-40 °C < T< 125 °C			6	
$\Delta V_{io}/\Delta T$	Input offset voltage drift(1)	-40 °C < T< 125 °C		1		µV/°C
I_{io}	Input offset current	V_{out} = V_{cc}/2		0.5	30	nA
		-40 °C < T< 125 °C			50	
I_{ib}	Input bias current	V_{out} = V_{cc}/2		27	60	
		-40 °C < T< 125 °C			110	
CMR	Common mode rejection ratio 20 log ($\Delta V_{icm}/\Delta V_{io}$)	Vic = 0 V to V_{cc}-1V, V_{out} = V_{cc}/2	72	75		dB
		-40 °C < T< 125 °C	70			
SVR	Supply voltage rejection ratio 20 log ($\Delta V_{cc}/\Delta V_{io}$)	V_{cc} = 2.5 to 5 V	72	79		
		-40 °C < T< 125 °C	70			
A_{vd}	Large signal voltage gain	R_L = 10 kΩ, V_{out} = 0.5 V to (V_{CC} - 0.5 V)	100	110		
		-40 °C < T< 125 °C	90			
		R_L = 2 kΩ,	90	100		
		-40 °C < T< 125 °C	80			
V_{CC}-V_{OH}	High level output voltage	R_L = 10 kΩ		10	100	mV
		-40 °C < T< 125 °C			200	
		R_L = 2 kΩ,		40	300	
		-40 °C < T< 125 °C			400	
V_{OL}	Low level output voltage	R_L = 10 kΩ		65	180	
		-40 °C < T< 125 °C			280	
		R_L = 2 kΩ		120	300	
		-40 °C < T< 125 °C			400	
I_{out}	I_{sink}	V_{out} = V_{CC}, V_{id} = -1 V	35	43		mA
		-40 °C < T< 125 °C	25			
	I_{source}	V_{out} = 0 V, V_{id} = 1 V	60	70		
		-40 °C < T< 125 °C	50			
I_{CC}	Supply current (per channel)	No load, V_{out} = V_{CC}/2		130	180	µA
		-40 °C < T< 125 °C			180	

Table 5. Electrical characteristics at V_{CC+} = 5 V with V_{CC-} = 0 V, V_{icm} = V_{CC}/2, T_{amb} = 25° C, and R_L connected to V_{CC}/2 (unless otherwise specified) (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
AC performance						
GBP	Gain bandwidth product	R_L > 1 MΩ, C_L = 200 pF		1.3		MHz
F_u	Unity gain frequency			1		
Φ_m	Phase margin			60		degrees
G_m	Gain margin			10		dB
SR	Slew rate	R_L > 1 MΩ, C_L = 200 pF V_{out} = 0.5 V to V_{CC} - 0.5V		0.7		V/µs
e_n	Equivalent input noise voltage	f = 1 kHz f = 10 kHz		30 20		$\frac{nV}{\sqrt{Hz}}$
i_n	Equivalent input noise current	f = 1 kHz		0.30		$\frac{pA}{\sqrt{Hz}}$
THD+N	Total harmonic distortion + noise	f_{in} = 1 kHz, A_{CL} = 1, R_L = 10 kΩ, V_{ICM} = V_{CC}/2, BW = 22 kHz, V_{out} = 1 Vpp		0.002		%

1. See *Section 4.4: Input offset voltage drift over temperature*.

Figure 2. Supply current vs. supply voltage at $V_{icm} = V_{CC}/2$

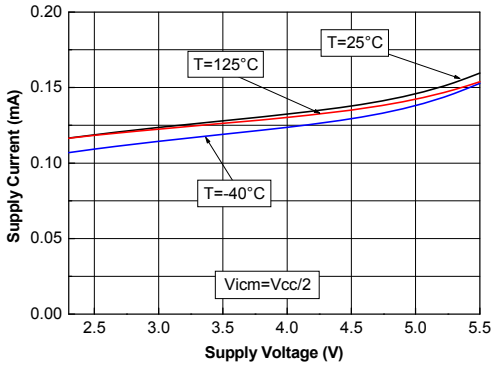


Figure 3. Vio distribution at V_{CC} = 5 V

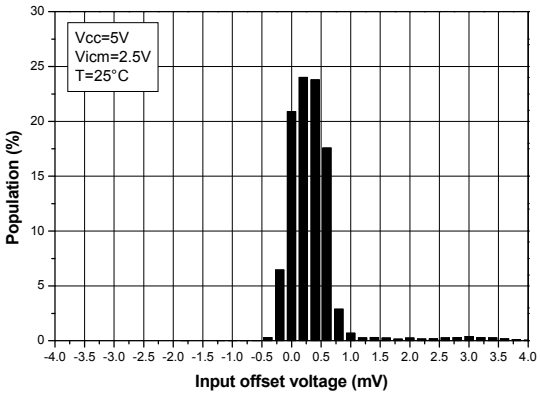


Figure 4. Input offset voltage vs. input common mode voltage at V_{CC} = 5 V

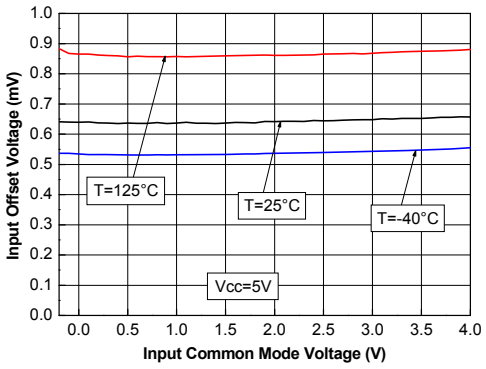


Figure 5. Output current vs. output voltage at V_{CC} = 2.7 V

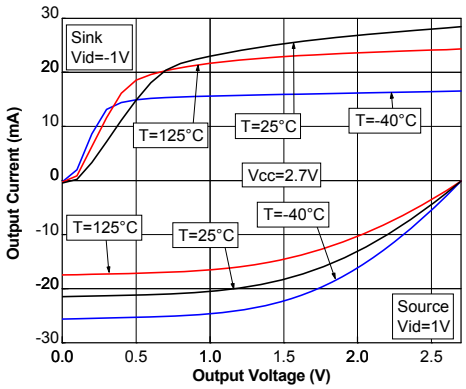


Figure 6. Output current vs. output voltage at V_{CC} = 5 V

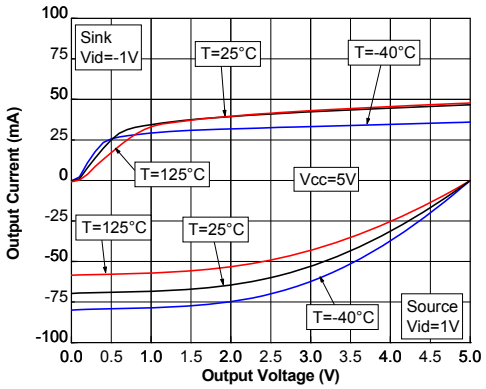


Figure 7. Output current vs. supply voltage at $V_{icm} = V_{CC}/2$

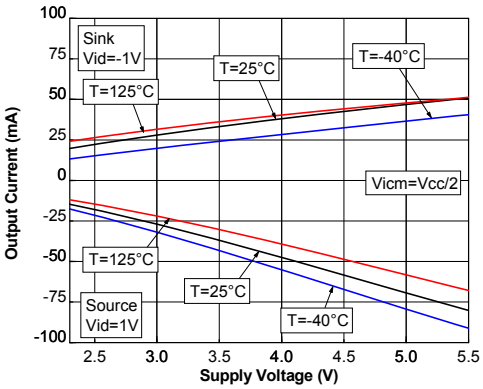


Figure 8. Voltage gain and phase with Cl = 100 pF

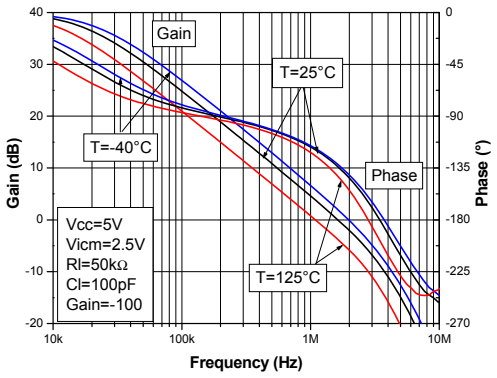


Figure 9. Voltage gain and phase with Cl = 200 pF

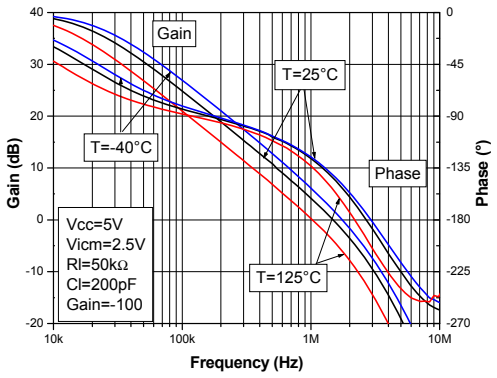


Figure 10. Gain margin vs. load capacitor at V_{CC} = 5 V

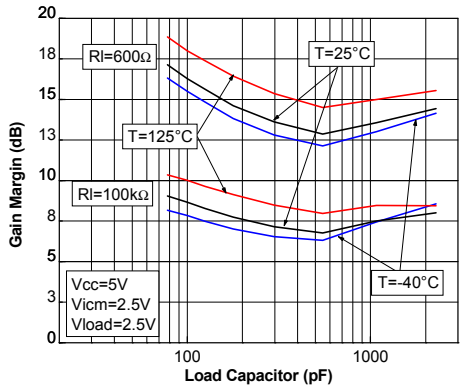


Figure 11. Phase margin vs. load capacitor at V_{CC} = 5 V

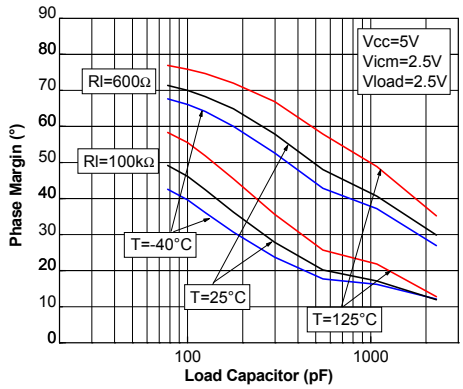


Figure 12. Closed-loop gain in voltage follower configuration for different capacitive loads

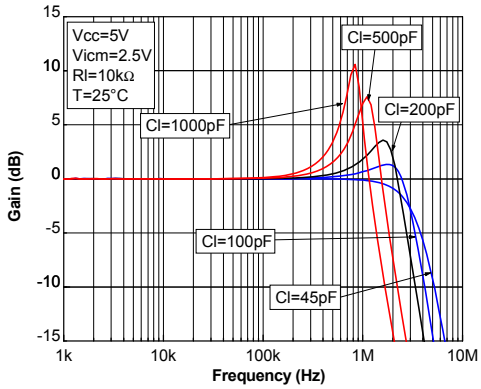


Figure 13. Phase margin vs. output current at V_{CC} = 5 V

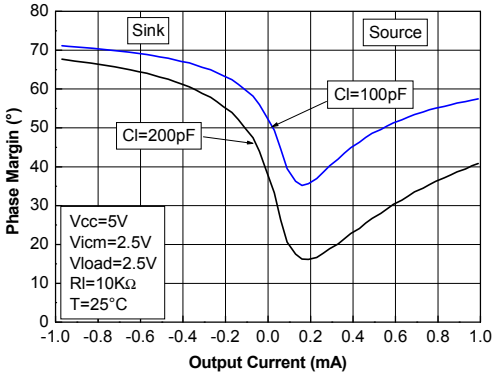


Figure 14. Positive and negative slew rate vs. supply voltage

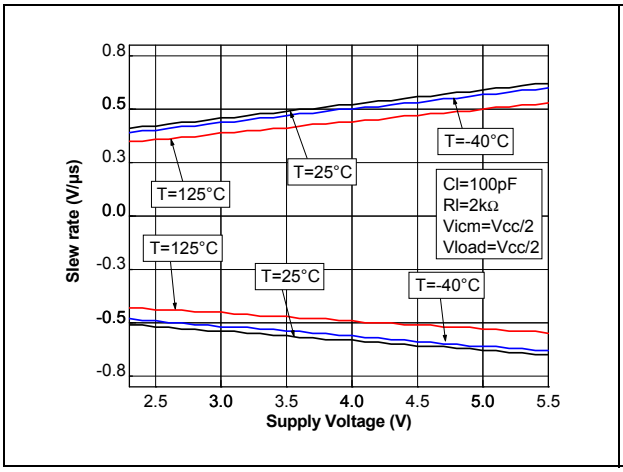


Figure 15. Positive slew rate at V_{CC} = 5 V with Cl = 100 pF

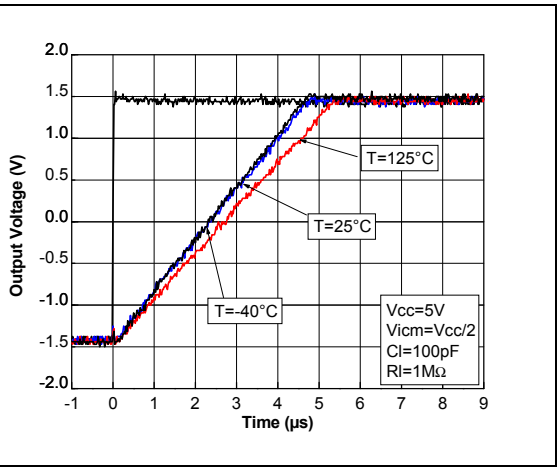


Figure 16. Negative slew rate at V_{CC} = 5 V with Cl = 100 pF

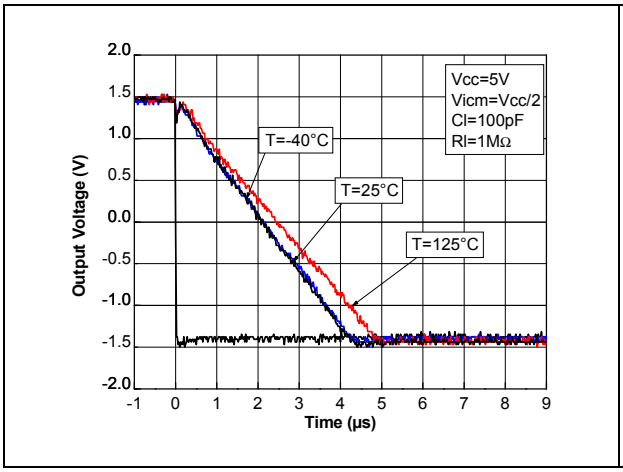


Figure 17. Noise vs. frequency

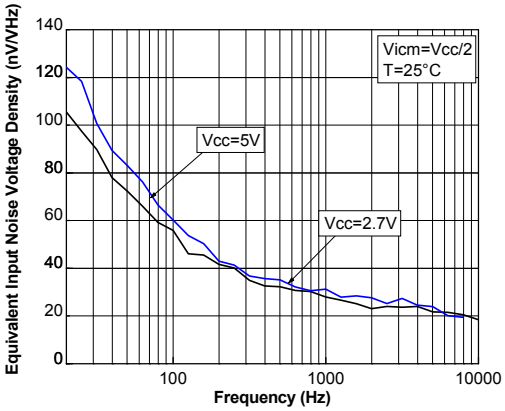


Figure 18. 0.1 Hz to 10 Hz noise at V_{CC} = 5 V

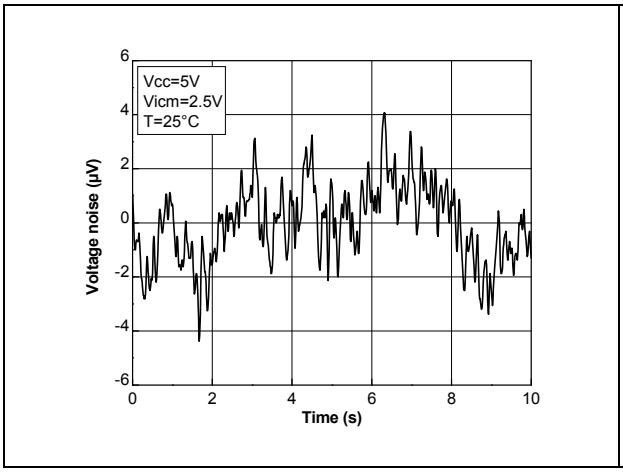


Figure 19. Distortion + noise vs. frequency

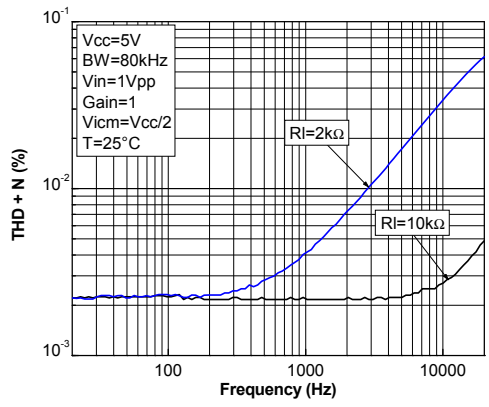
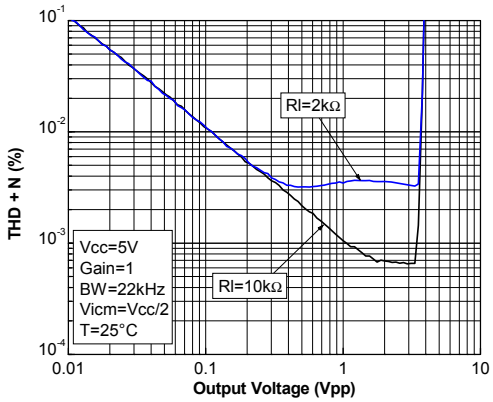


Figure 20. Distortion + noise vs. output voltage



4 Application information

4.1 Operating voltages

The LMX321, LMX358, and LMX324 can operate from 2.3 V to 5.5 V. The devices' parameters are fully specified for 2.7 V and 5 V power supplies. Additionally, the main specifications are guaranteed in extended temperature ranges from -40° C to +125° C.

4.2 Input common-mode range

The LMX321, LMX358, and LMX324 have an input common-mode range that includes ground. The input common-mode range is extended from V_{CC-} - 0.2 V to V_{CC+} - 1 V, with no output phase reversal.

4.3 Rail-to-rail output

The operational amplifiers' output levels can go close to the rails: to a maximum of 180 mV above and below the rail when connected to a 10 kΩ resistive load to $V_{CC}/2$.

4.4 Input offset voltage drift over temperature

The maximum input voltage drift over the temperature variation is defined in *Equation 1*.

Equation 1

$$\frac{\Delta Vio}{\Delta T} = \max\left|\frac{Vio(T) - Vio(25°C)}{T - 25°C}\right|$$

for $T_{min} < T < T_{max}$.

4.5 PCB layouts

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

4.6 Macromodel

Accurate macromodels of the LMX321, LMX358, and LMX324 are available on STMicroelectronics' web site at www.st.com. These models are a trade-off between accuracy and complexity (that is, time simulation) of the LMX321, LMX358, and LMX324 operational amplifiers. They emulate the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. They also help to validate a design approach and to select the right operational amplifier, *but they do not replace on-board measurements*.

5 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.

5.1 SC70-5 (or SOT323-5) package information

Figure 21. SC70-5 (or SOT323-5) package mechanical drawing

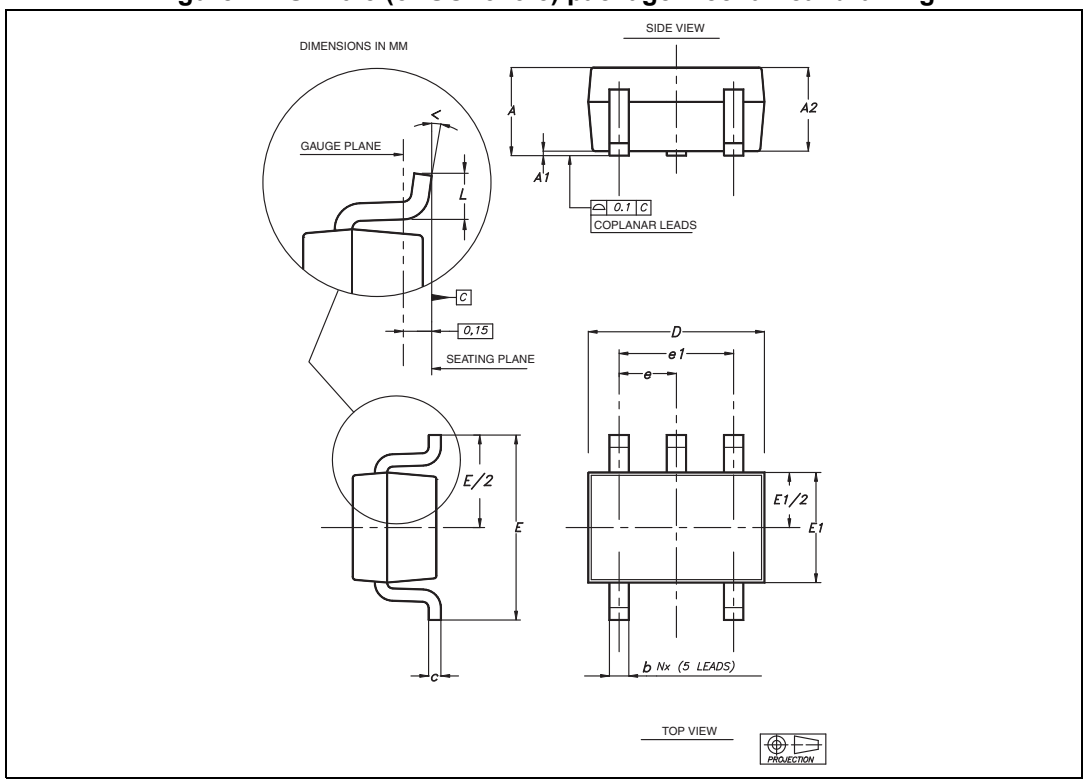


Table 6. SC70-5 (or SOT323-5) package mechanical data

Ref	Dimensions					
	Millimeters			Inches		
	Min	Typ	Max	Min	Typ	Max
A	0.80		1.10	0.032		0.043
A1			0.10			0.004
A2	0.80	0.90	1.00	0.032	0.035	0.039
b	0.15		0.30	0.006		0.012
c	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
e		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 SOT23-5 package information

Figure 22. SOT23-5 package mechanical drawing

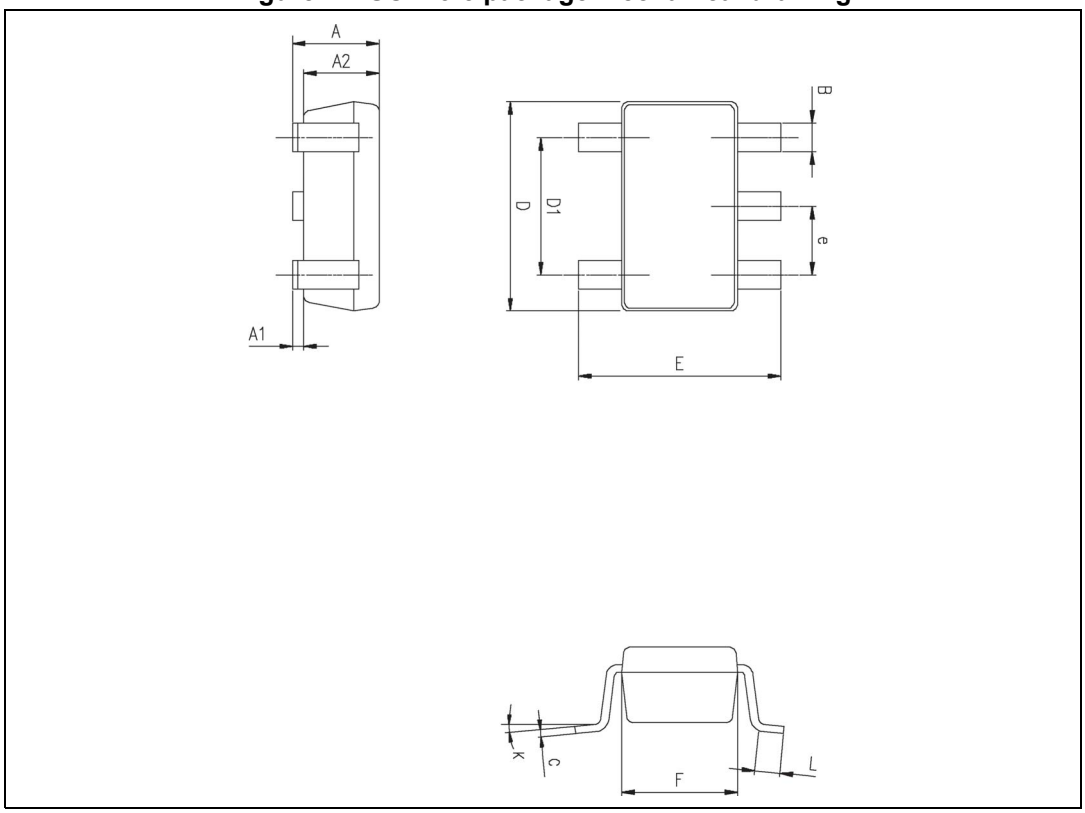


Table 7. SOT23-5 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1			0.15			0.006
A2	0.90	1.05	1.30	0.035	0.041	0.051
B	0.35	0.40	0.50	0.013	0.015	0.019
C	0.09	0.15	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.35	0.60	0.004	0.013	0.023
K	0 °		10 °	0 °		10 °

5.3 DFN8 2x2 package information

Figure 23. DFN8 2x2 package mechanical drawing

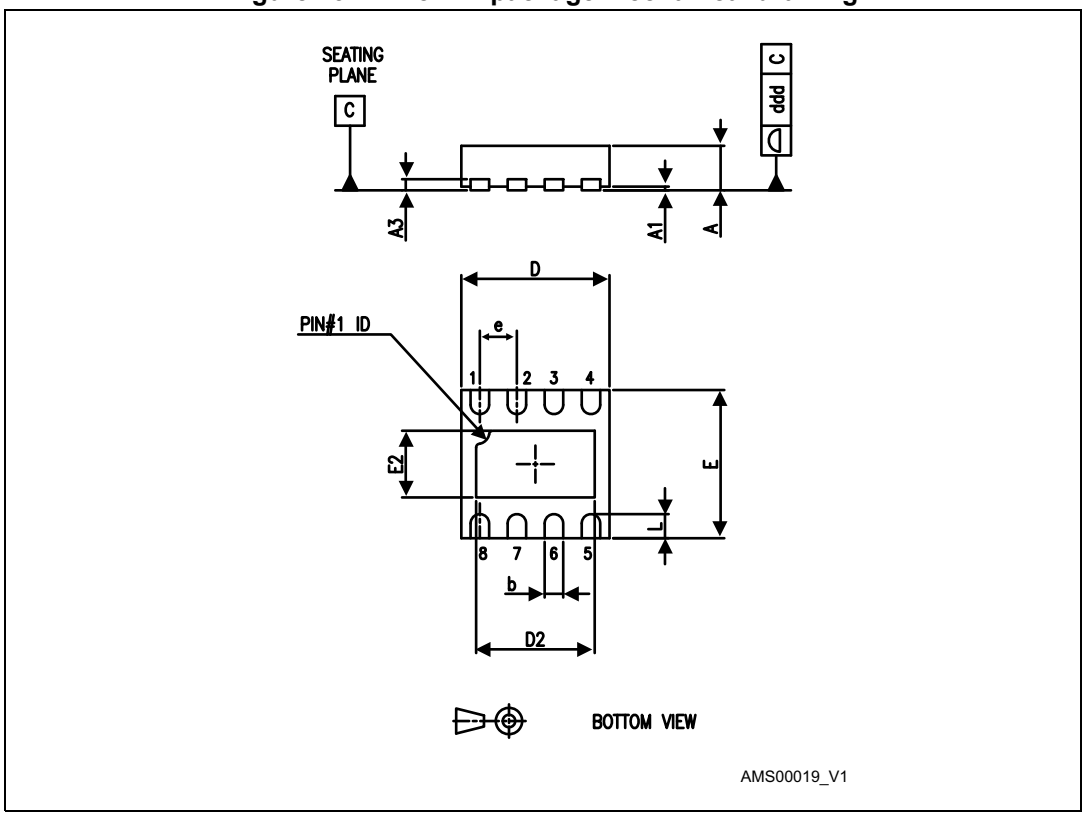
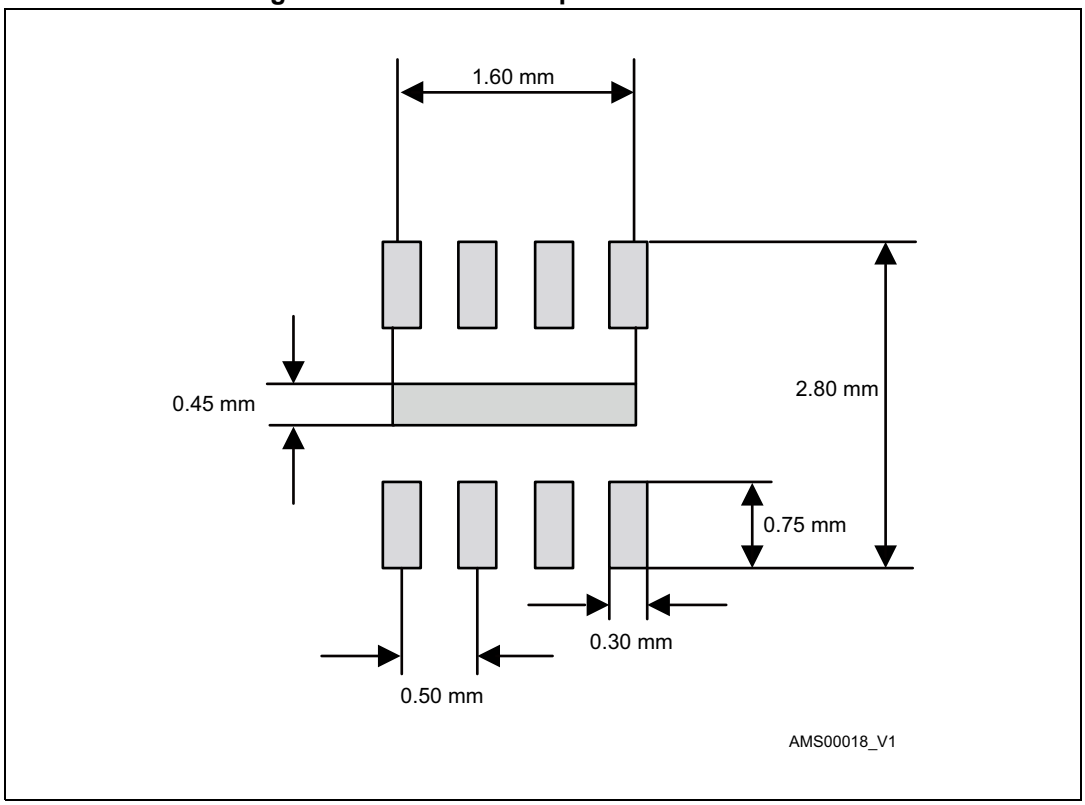


Figure 24. DFN8 2x2x0.6 mm package mechanical data (pitch 0.5 mm)

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 25. DFN8 2x2 footprint recommendation



5.4 MiniSO8 package information

Figure 26. MiniSO8 package mechanical drawing

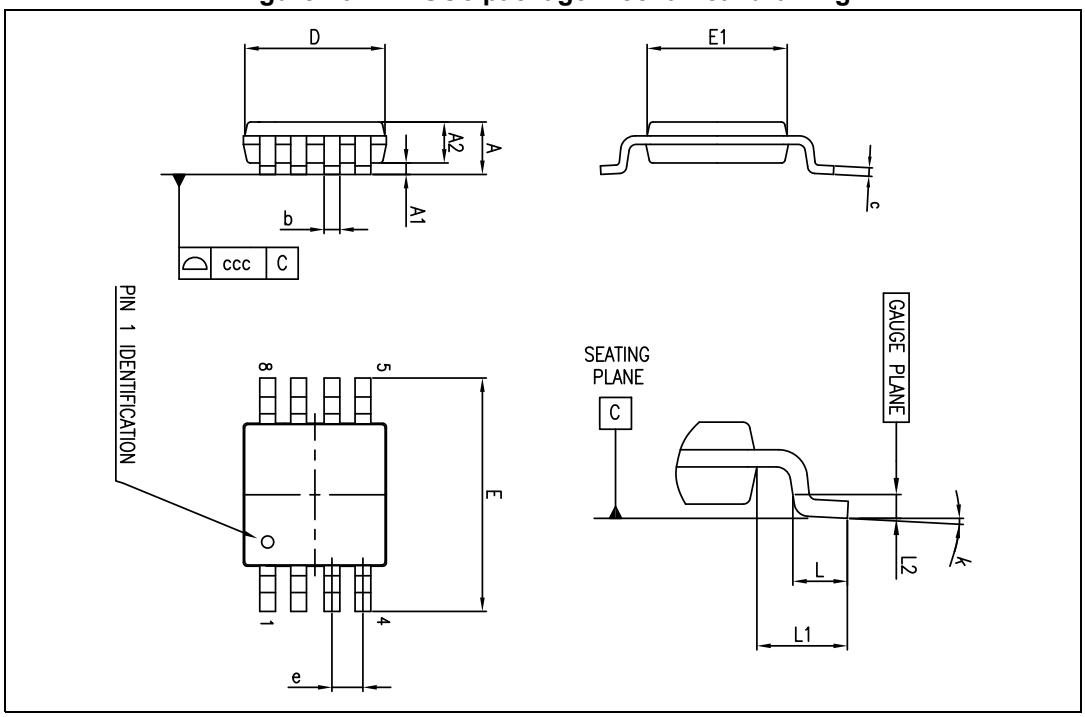


Table 8. MiniSO8 package mechanical data

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

5.5 SO8 package information

Figure 27. SO8 package mechanical drawing

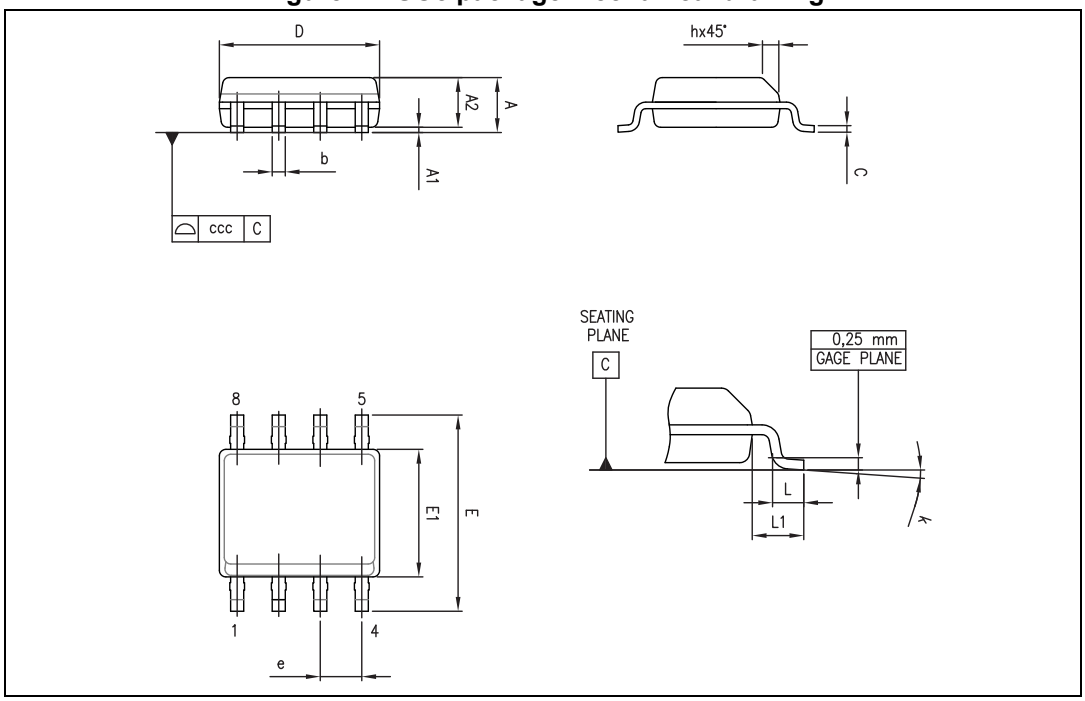


Table 9. SO8 package mechanical data

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

5.6 TSSOP14 package information

Figure 28. TSSOP14 package mechanical drawing

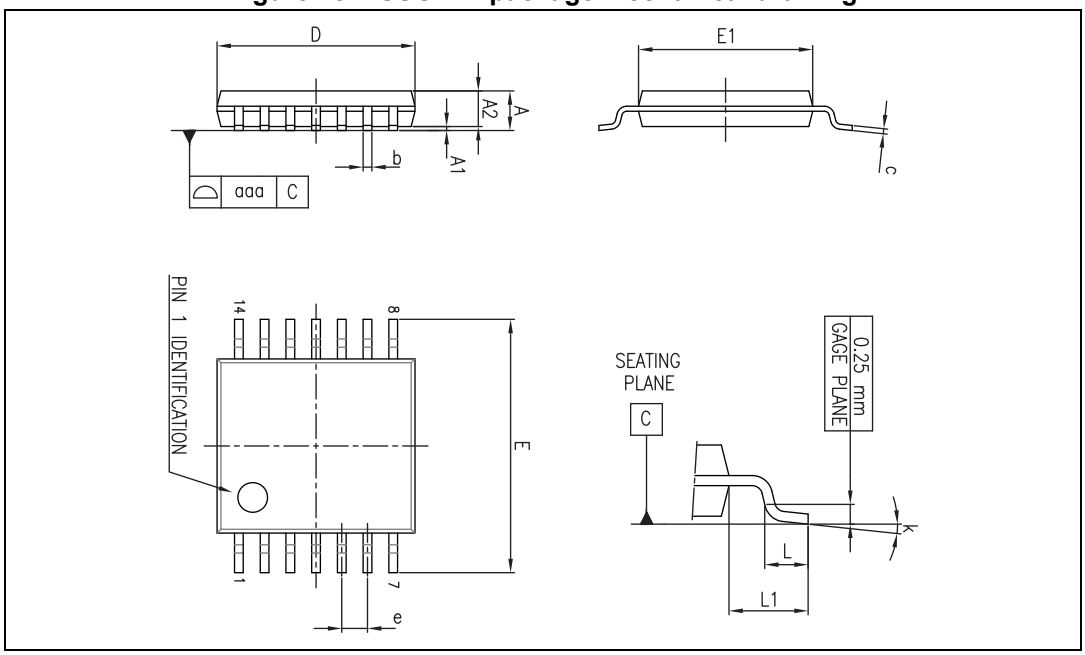


Table 10. TSSOP14 package mechanical data

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

5.7 SO14 package information

Figure 29. SO14 package mechanical drawing

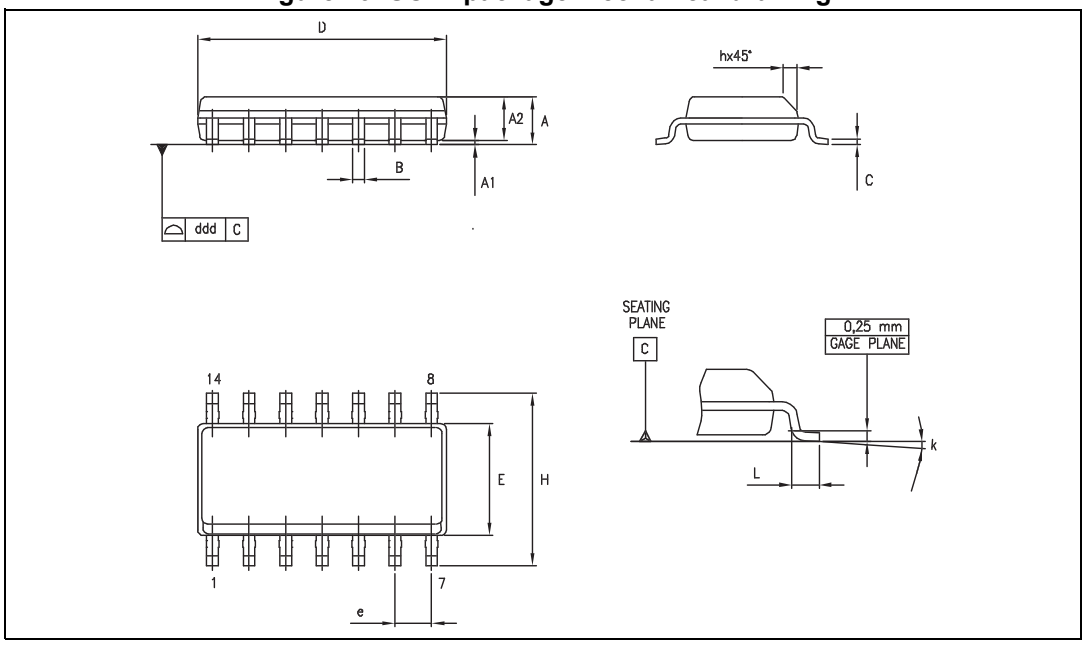


Table 11. SO14 package mechanical data

Dimensions						
Ref.	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 Ordering information

Table 12. Order codes

Order code	Temperature range	Package	Packing	Marking
LMX321ICT	-40° C to +125° C	SC70-5	Tape and reel	K21
LMX321ILT		SOT23-5		K430
LMX358IQ2T		DFN8 2x2		K21
LMX358IST		MiniSO8		K430
LMX358IDT		SO8		LMX358I
LMX324IPT		TSSOP14		LMX324I
LMX324IDT		SO14		LMX324I

7 Revision history

Table 13. Document revision history

Date	Revision	Changes
19-Mar-2012	1	Initial release.
06-Apr-2012	2	Document status promoted from Target Specification to Production Data.
07-May-2013	3	Added DFN8 2x2 silhouette, pinout, and package *Table 2: Absolute maximum ratings (AMR)*: added R_{thja} data for DFN8 2x2 package. *Table 12: Order codes*: added LMX358IQ2T order code.

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