



# LM193, LM293, LM393

## Low power dual voltage comparators

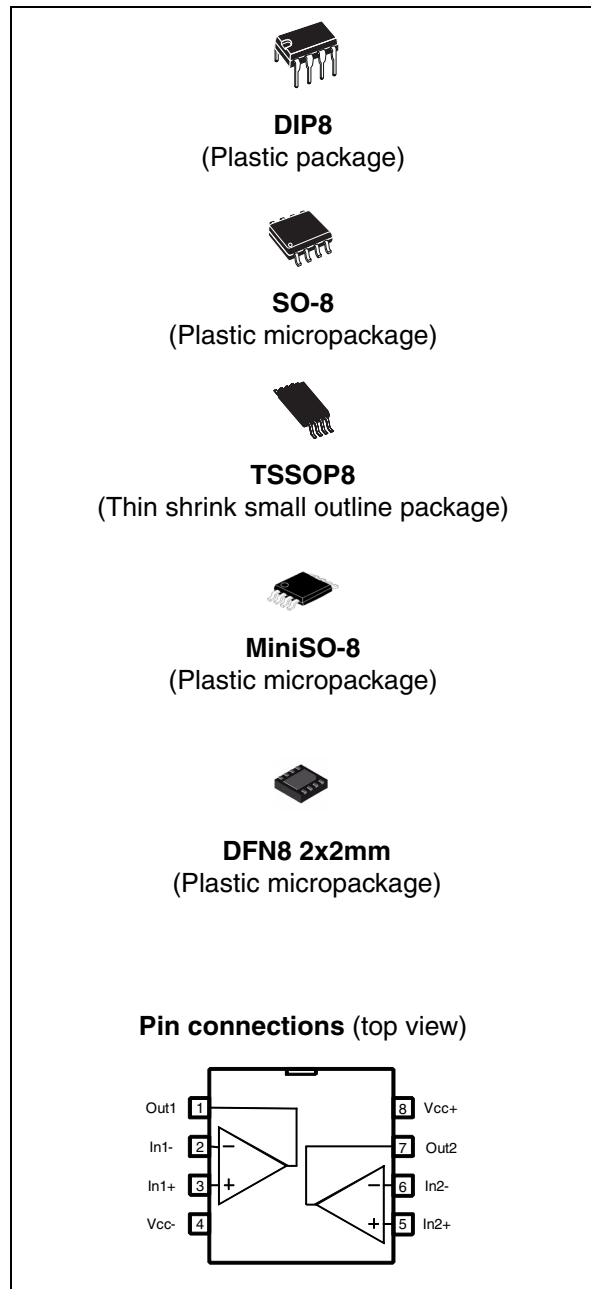
### Features

- Wide single-supply voltage range or dual supplies: +2 V to +36 V or  $\pm 1$  V to  $\pm 18$  V
- Very low supply current (0.45 mA) independent of supply voltage (1 mW/comparator at +5 V)
- Low input bias current: 20 nA typ.
- Low input offset current:  $\pm 3$  nA typ.
- Low input offset voltage:  $\pm 1$  mV typ.
- Input common-mode voltage range includes ground
- Low output saturation voltage: 80 mV typ. ( $I_{\text{sink}} = 4$  mA)
- Differential input voltage range equal to the supply voltage
- TTL, DTL, ECL, MOS, CMOS compatible outputs

### Description

These devices consist of two independent low voltage comparators designed specifically to operate from a single supply over a wide range of voltages. Operation from split power supplies is also possible.

These comparators also have a unique characteristic in that the input common-mode voltage range includes ground even though operated from a single power supply voltage.





## 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	$\pm 18$ or 36	V
$V_{id}$	Differential input voltage	$\pm 36$	V
$V_{in}$	Input voltage	-0.3 to +36	V
	Output short-circuit to ground <sup>(1)</sup>	Infinite	
$R_{thja}$	Thermal resistance junction to ambient <sup>(2)</sup>		°C/W
	SO-8	125	
	TSSOP8	120	
	DIP8	85	
	MiniSO-8 DFN8 2x2mm	190 57	
$R_{thjc}$	Thermal resistance junction to case <sup>(2)</sup>		°C/W
	SO-8	40	
	TSSOP8	37	
	DIP8	41	
	MiniSO-8	39	
$T_j$	Maximum junction temperature	150	°C
$T_{stg}$	Storage temperature range	-65 to +150	°C
ESD Class <sup>(3)</sup>	HBM: human body model	H1B	
	MM: machine model	M2	
	CDM: charged device model	C5	

- Short-circuits from the output to  $V_{CC}^+$  can cause excessive heating and potential destruction. The maximum output current is approximately 20 mA independent of the magnitude of  $V_{CC}^+$ .
- Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- ESD class definition from AEC-Q100:  
HBM class H1B: ESD voltage level from 500V to 1000V  
MM class M2: ESD voltage level from 100V to 200V  
CDM class C5: ESD voltage level greater than 1500V

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage ( $V_{CC}^+ - V_{CC}^-$ )	2 to 36	V
$V_{icm}$	Common mode input voltage range ( $V_{CC}^+ = 30$ V) <sup>(1)</sup> $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	0 to $V_{CC}^+ - 1.5$ 0 to $V_{CC}^+ - 2$	V
$T_{oper}$	Operating free-air temperature range LM193, LM193A LM293, LM293A LM393, LM393A	-55 to +125 -40 to +105 0 to +70	°C

- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The high end of the common-mode voltage range is  $V_{CC}^+ - 1.5$  V, but either or both inputs can go to +30 V without damage.

### 3 Electrical characteristics

Table 3.  $V_{CC}^+ = +5V$ ,  $V_{CC}^- = 0V$ ,  $T_{amb} = +25^\circ C$  (unless otherwise specified)

Symbol	Parameter	LM193A - LM293A LM393A			LM193- LM293 LM393			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{io}$	Input offset voltage <sup>(1)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		1	2 4		1	5 9	mV
$I_{io}$	Input offset current $T_{min} \leq T_{amb} \leq T_{max}$		3	25 100		3	50 150	nA
$I_{ib}$	Input bias current ( $I^+$ or $I^-$ ) <sup>(2)</sup> $T_{min} \leq T_{amb} \leq T_{max}$		20	100 300		20	250 400	nA
$A_{vd}$	Large signal voltage gain $V_{CC} = 15V$ , $R_L = 15k\Omega$ , $V_o = 1V$ to $11V$	50	200		50	200		V/mV
$I_{CC}$	Supply current (all comparators) $V_{CC} = +5V$ , no load $V_{CC} = +30V$ , no load		0.45 0.6	1 2.5		0.45 0.6	1 2.5	mA
$V_{id}$	Differential input voltage <sup>(3)</sup>			$V_{CC}^+$			$V_{CC}^+$	
$V_{OL}$	Low level output voltage $V_{id} = -1V$ , $I_{sink} = 4mA$ $T_{min} \leq T_{amb} \leq T_{max}$		80	400 700		80	400 700	mV
$I_{OH}$	High level output current $V_{CC} = V_o = 30V$ , $V_{id} = 1V$ $T_{min} \leq T_{amb} \leq T_{max}$		0.1	1		0.1	1	nA $\mu A$
$I_{sink}$	Output sink current $V_{id} = 1V$ , $V_o = 1.5V$	6	18		6	18		mA
$t_{re}$	Response time <sup>(4)</sup> $R_L = 5.1k\Omega$ connected to $V_{CC}^+$		1.3			1.3		$\mu s$
$t_{rel}$	Large signal response time $R_L = 5.1k\Omega$ connected to $V_{CC}^+$ $e_l = TTL, V_{(ref)} = +1.4v$		300			300		ns

1. At output switch point,  $V_o \approx 1.4V$ ,  $R_s = 0$  with  $V_{CC}^+$  from 5V to 30V, and over the full common-mode range (0V to  $V_{CC}^+ - 1.5V$ ).
2. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output, so no loading charge exists on the reference of input lines.
3. Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than  $-0.3V$  (or  $0.3V$  below the negative power supply, if used).
4. The response time specified is for a 100mV input step with 5mV overdrive. For larger overdrive signals 300ns can be obtained.

Figure 2. Supply current vs. supply voltage

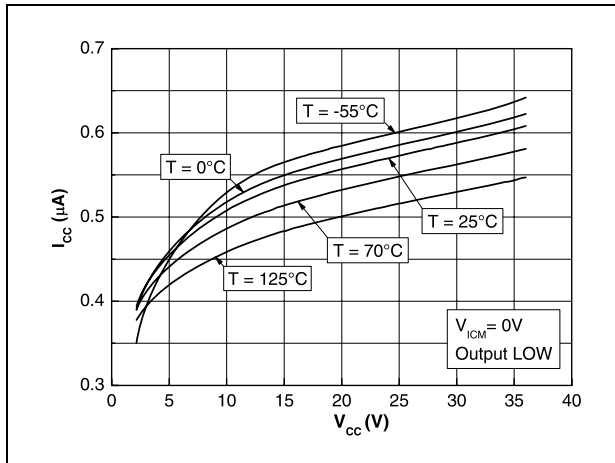


Figure 3. Input current vs. supply voltage

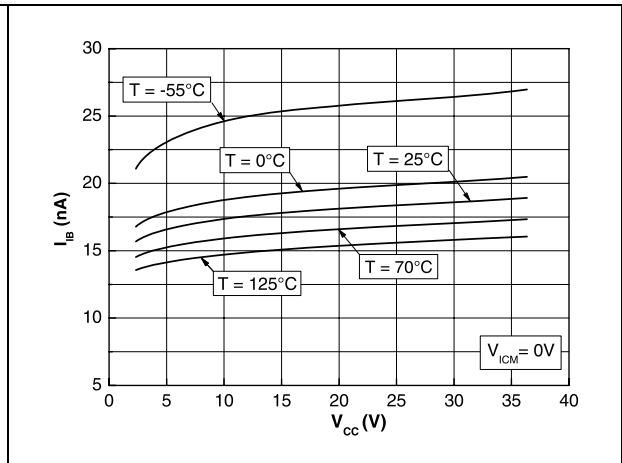


Figure 4. Output saturation voltage vs. output current

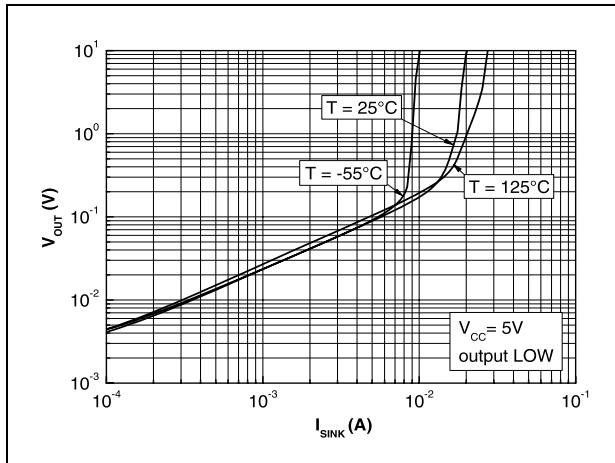


Figure 5. Response time for various input overdrives - negative transition

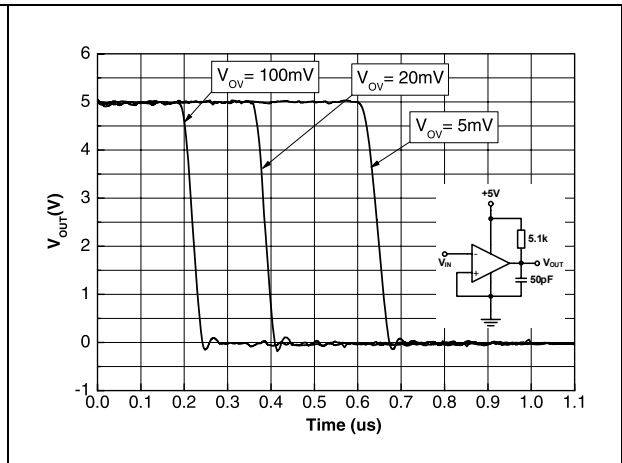
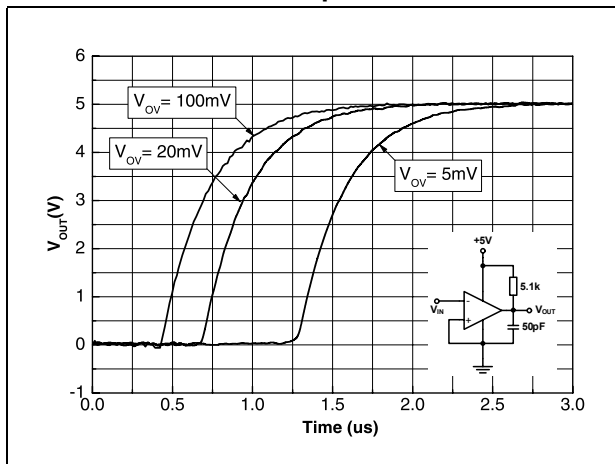


Figure 6. Response time for various input overdrives - positive transition



# 4 Typical applications

Figure 7. Basic comparator

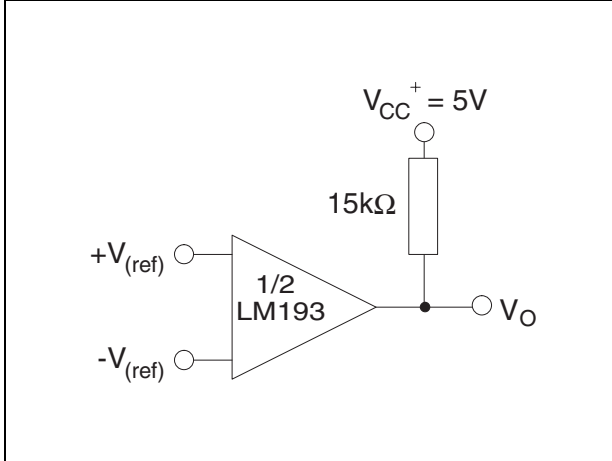


Figure 8. Driving TTL

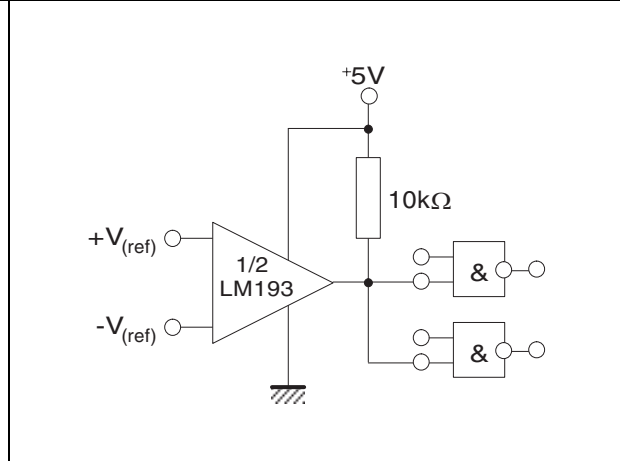


Figure 9. Low frequency op-amp

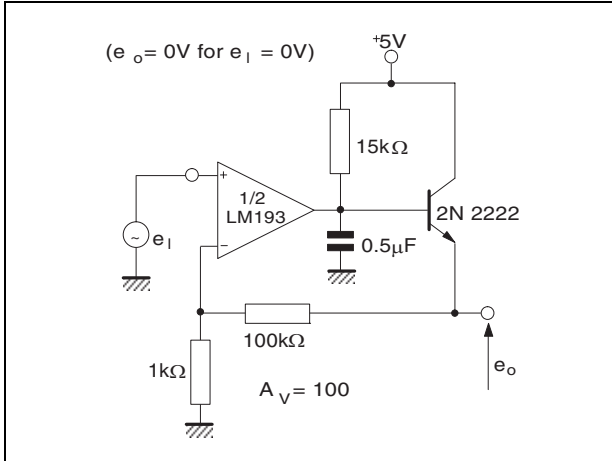


Figure 10. Driving CMOS

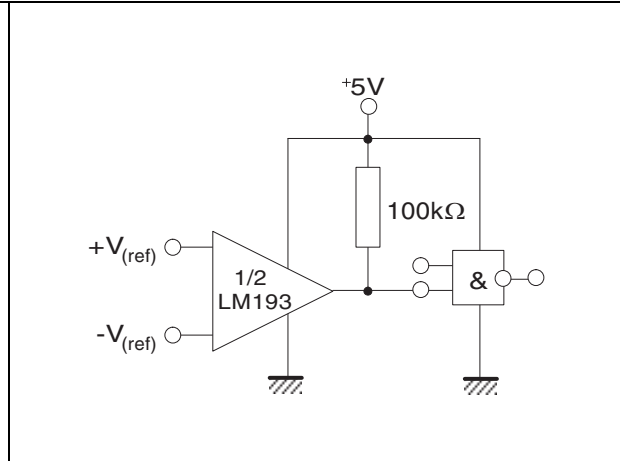


Figure 11. Low frequency op-amp

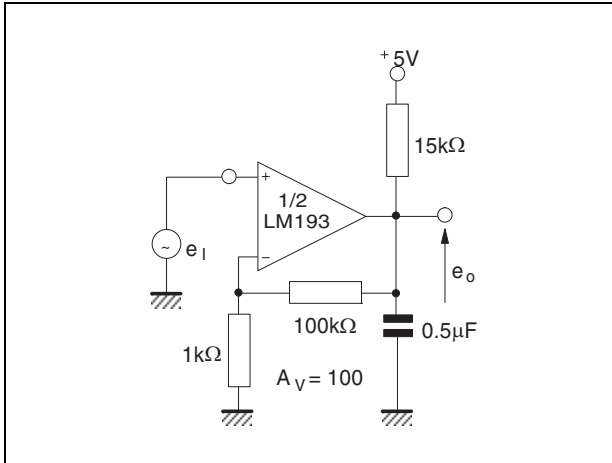


Figure 12. Transducer amplifier

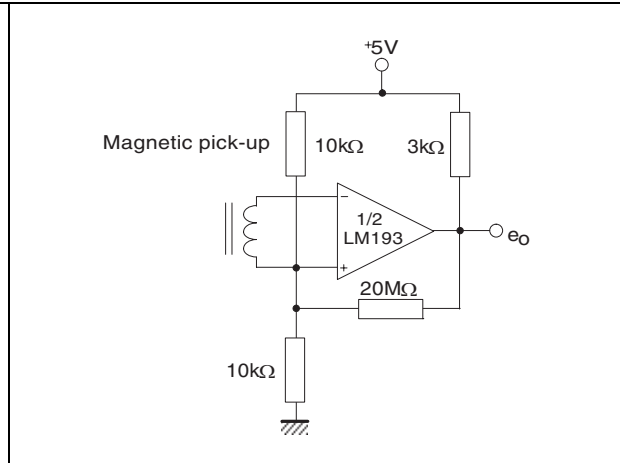


Figure 13. Low frequency op-amp with offset adjust

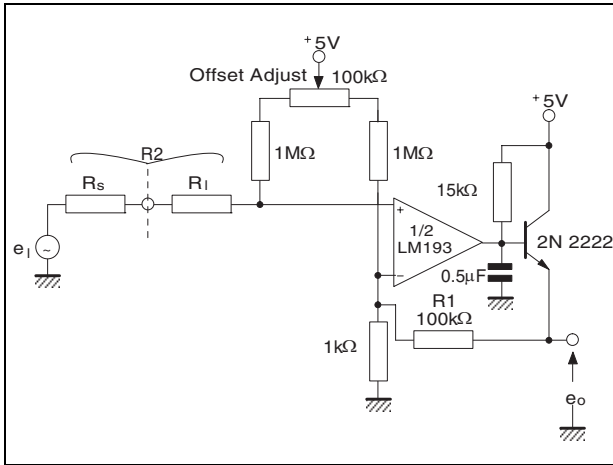


Figure 14. Zero crossing detector (single power supply)

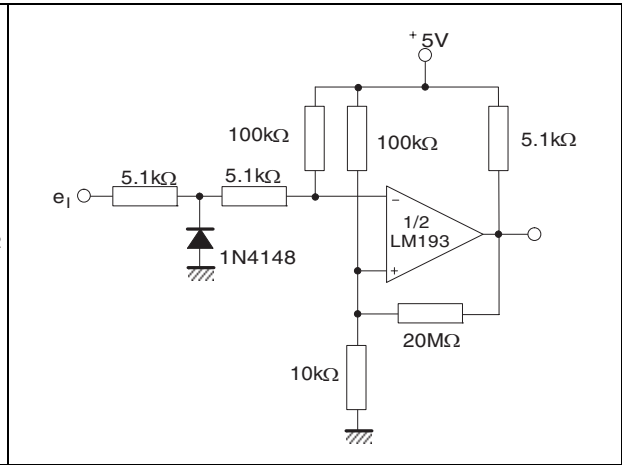


Figure 15. Limit comparator

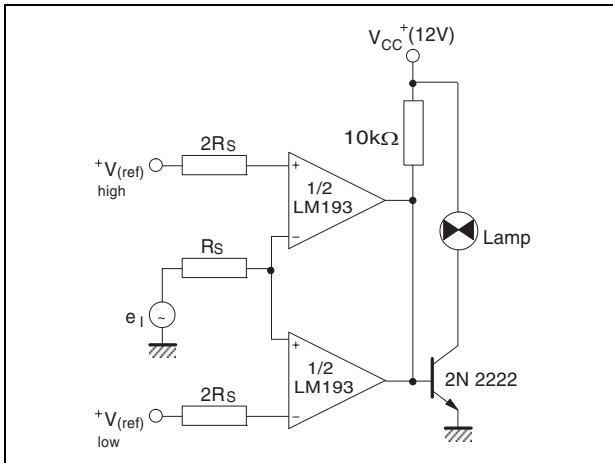


Figure 16. Crystal controlled oscillator

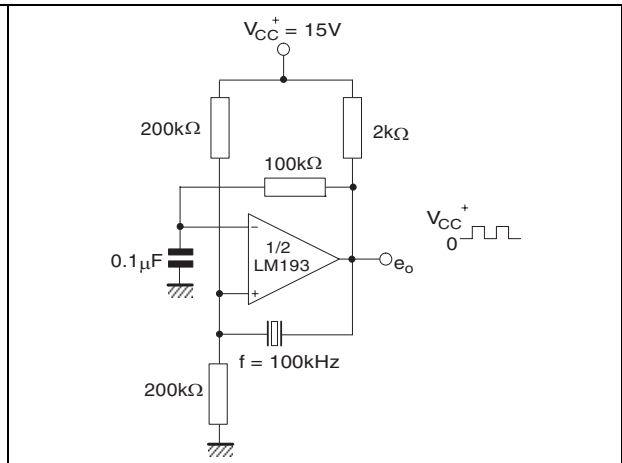


Figure 17. Split-supply applications - zero crossing detector

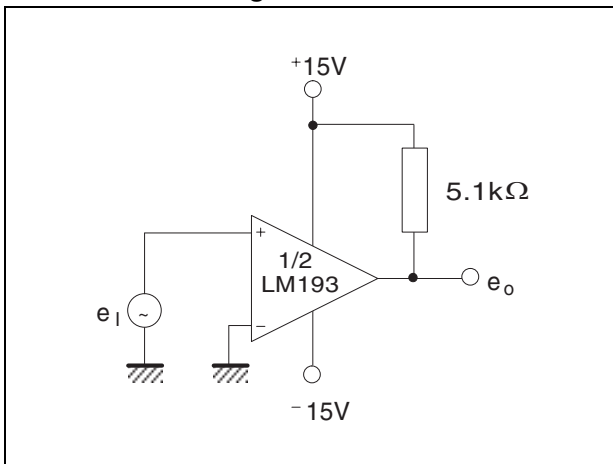


Figure 18. Comparator with a negative reference

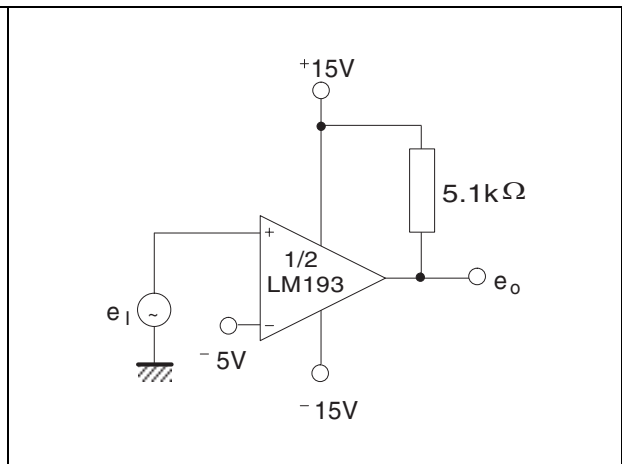
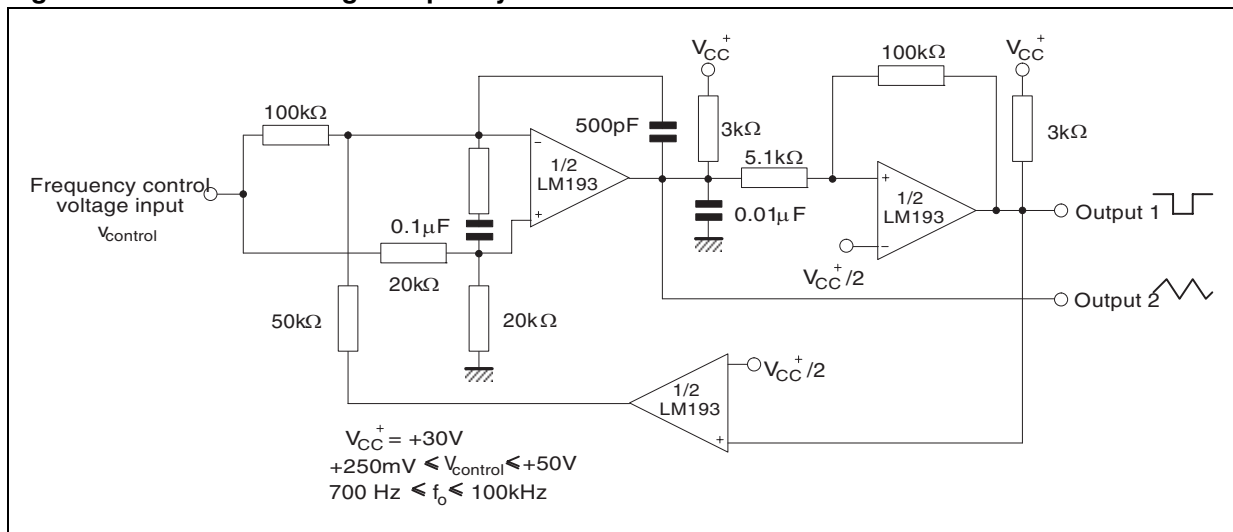


Figure 19. Two-decade high-frequency VCO





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

### 5.1 DIP8 package information

Figure 20. DIP8 package mechanical drawing

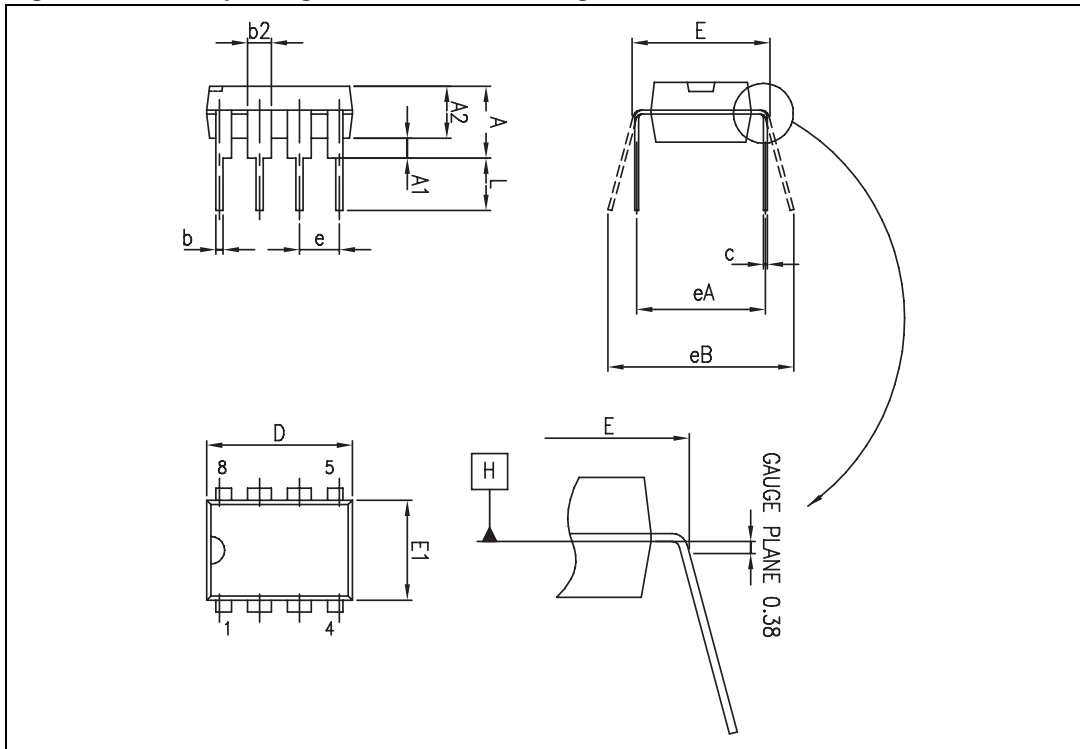


Table 4. DIP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.33			0.210
A1	0.38			0.015		
A2	2.92	3.30	4.95	0.115	0.130	0.195
b	0.36	0.46	0.56	0.014	0.018	0.022
b2	1.14	1.52	1.78	0.045	0.060	0.070
c	0.20	0.25	0.36	0.008	0.010	0.014
D	9.02	9.27	10.16	0.355	0.365	0.400
E	7.62	7.87	8.26	0.300	0.310	0.325
E1	6.10	6.35	7.11	0.240	0.250	0.280
e		2.54			0.100	
eA		7.62			0.300	
eB			10.92			0.430
L	2.92	3.30	3.81	0.115	0.130	0.150

## 5.2 SO-8 package information

Figure 21. SO-8 package mechanical drawing

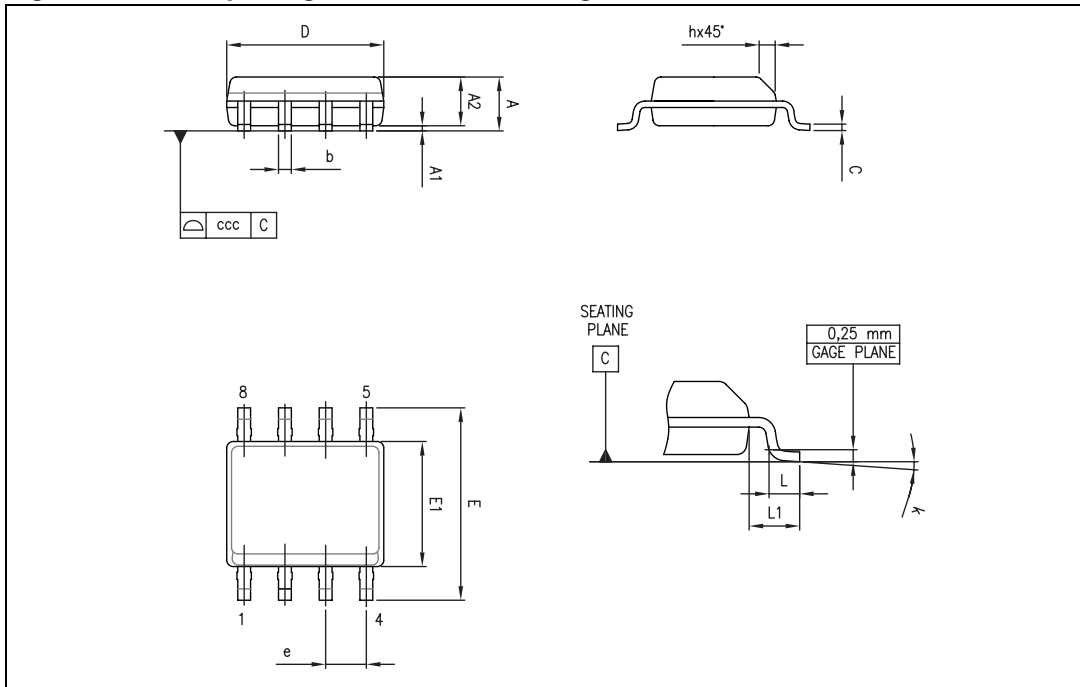


Table 5. SO-8 package mechanical data

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	0		8°	1°		8°
ccc			0.10			0.004

### 5.3 TSSOP8 package information

Figure 22. TSSOP8 package mechanical drawing

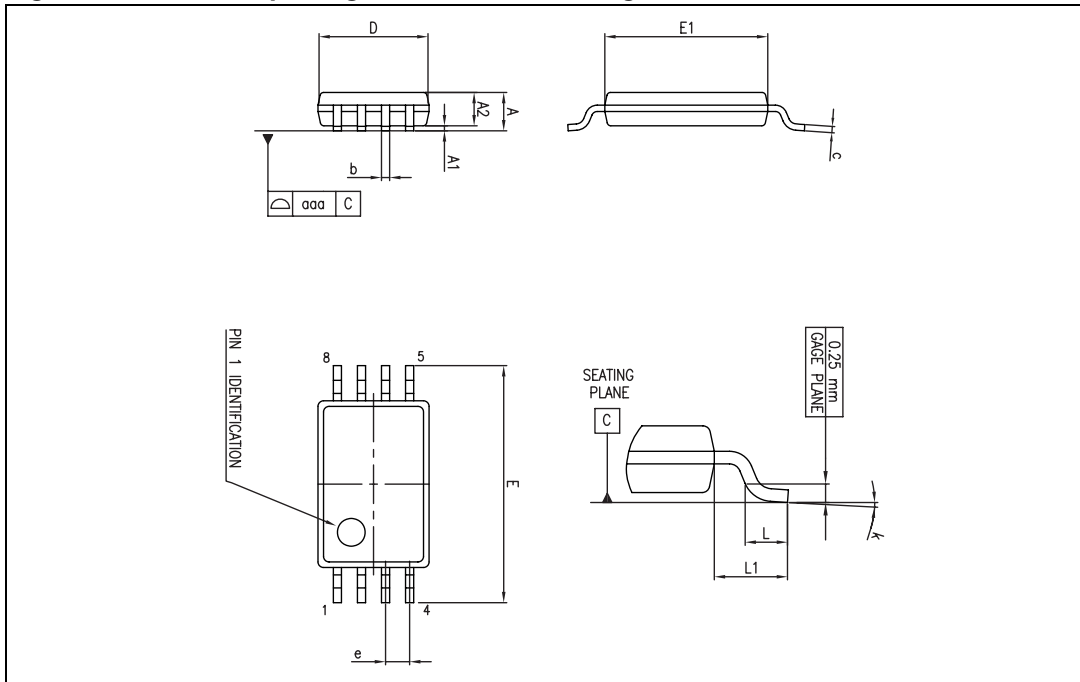


Table 6. TSSOP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002		0.006
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			0.10			0.004

### 5.4 MiniSO-8 package information

Figure 23. MiniSO-8 package mechanical drawing

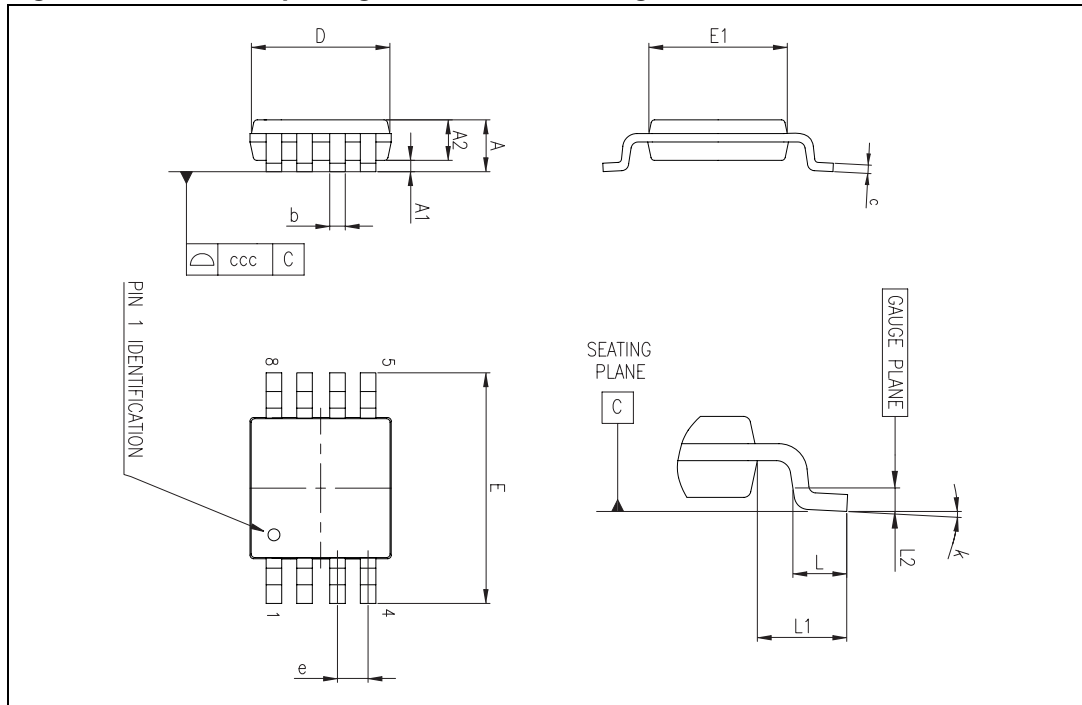


Table 7. MiniSO-8 package mechanical data

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 DFN8 2x2 package mechanical data

Figure 24. DFN8 2x2 package mechanical drawing

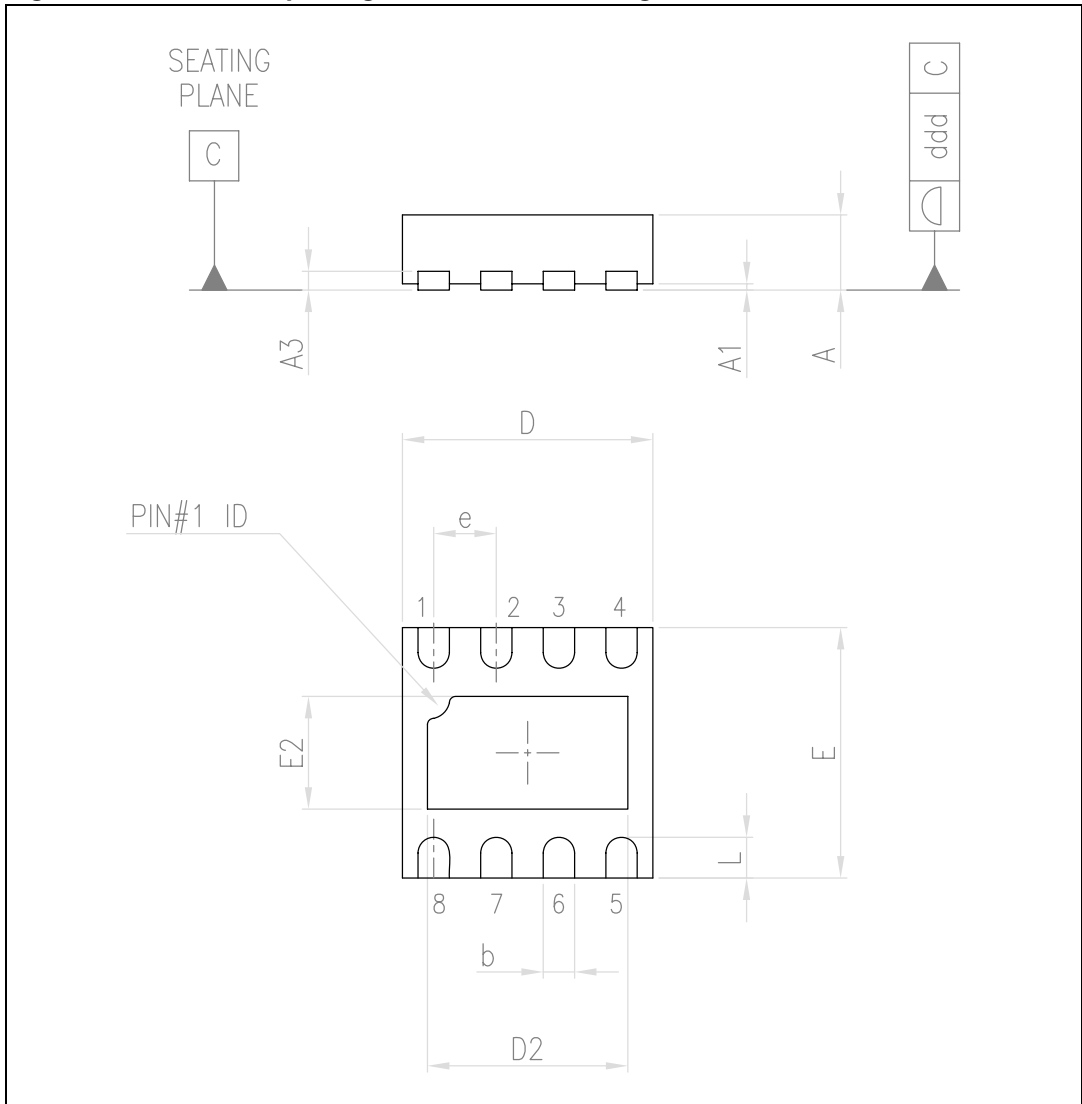
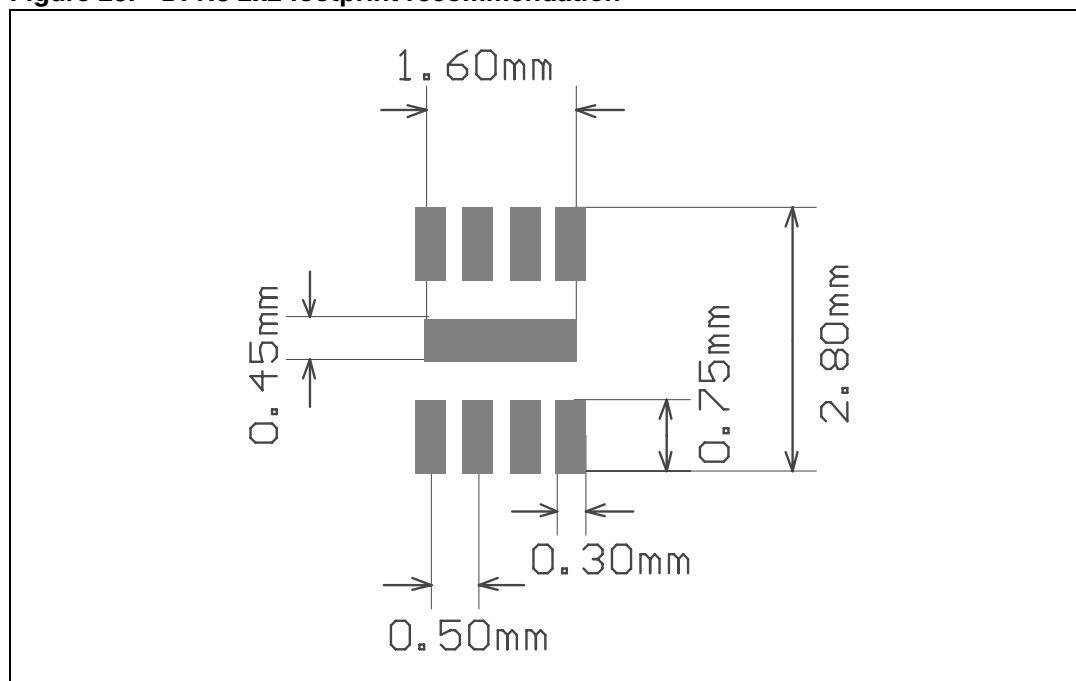


Table 8. DFN8 2x2x0.6 mm package mechanical data (pitch 0.5 mm)

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			0.50			0.020
ddd			0.08			0.003

Figure 25. DFN8 2x2 footprint recommendation



## 6 Ordering information

**Table 9. Order codes**

Order code	Temperature range	Package	Packing	Marking
LM193AD LM193ADT	-55°C, +125°C	SO-8	Tube or Tape & reel	193A
LM193D LM193DT				193
LM193AN		DIP8	Tube	LM193AN
LM193N				LM193N
LM293AD LM293ADT	-40°C, +105°C	SO-8	Tube or Tape & reel	293A
LM293D LM293DT				293
LM293AN		DIP8	Tube	LM293AN
LM293N				LM293N
LM293PT		TSSOP8	Tape & reel	293
LM293ST		MiniSO-8	Tape & reel	K512
LM293QT		DFN8 2x2	Tape & reel	K5A
LM393AD LM393ADT	0°C, +70°C	SO-8	Tube or Tape & reel	393A
LM393D LM393DT				393
LM393AN		DIP8	Tube	LM393AN
LM393N				LM393N
LM393PT		TSSOP8	Tape & reel	393
LM393ST		MiniSO-8	Tape & reel	M393
LM393QT		DFN8 2x2	Tape & reel	K5C



## 7 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
02-Jul-2002	1	First release.
02-Jan-2005	2	Class A of the product included in the datasheet.
02-May-2005	3	PPAP references inserted in the datasheet, see <a href="#">Table 6: Ordering information on page 16</a> .
02-Jul-2005	4	Modification on PPAP references - Errors on part numbers, see <a href="#">Table 6: Ordering information on page 16</a> .
22-Nov-2005	5	Modification on <a href="#">Table 3 on page 4</a> . LM293,A must be -40/+105°C instead of -40/+125°C.
16-Feb-2006	6	Unit error for $V_{OI}$ parameter see <a href="#">Table 3 on page 4</a> .
23-Aug-2007	7	Corrected error in DIP8 package information related to lead thickness, see <a href="#">Figure 20 on page 10</a> . Added values for $R_{thja}$ and $R_{thjc}$ , and ESD parameters in <a href="#">Table 1: Absolute maximum ratings</a> .
08-Nov-2007	8	Updated MiniSO-8 package information. Reformatted package information. Added automotive grade order codes.
19-Feb-2008	9	Corrected error in SO-8 package mechanical data: E dimension in drawing was marked with an F in table.
15-Dec-2008	10	Corrected heading in <a href="#">Figure 4</a> .
22-Feb-2010	11	Deleted automotive grade order codes for LM293 and LM393.
22-Jun-2011	12	Updated typical performance curves. Updated typical values in <a href="#">Table 3 on page 4</a> . Updated ESD parameters with ESD classes in <a href="#">Table 1: Absolute maximum ratings</a> . Added DFN8 2x2mm package mechanical drawing. Added DFN8 2x2mm recommended footprint. Added DFN8 2x2mm order codes in <a href="#">Table 9</a> .

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