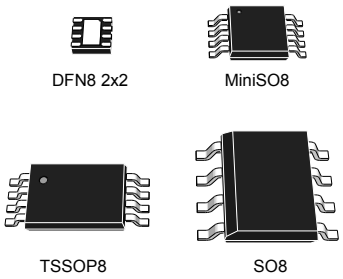
LM193, LM293
LM393, LM393W

Datasheet

Low-power, dual-voltage comparators



Features

- Wide single-supply voltage range or dual supplies: 2 V to 36 V or ±1 V to ±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: ±3 nA typ.
- Low input offset voltage: ±1 mV typ.
- Input common-mode voltage range includes ground
- Low output saturation voltage: 80 mV typ. (I_{sink} = 4 mA)
- Differential input voltage range equal to the supply voltage
- TTL, DTL, ECL, MOS, CMOS compatible outputs
- Available in DFN8 2x2, MiniSO8, TSSOP8, and SO8 packages
- LM393W and LM393AW with internal ESD protection: 2 kV HBM

Description

The LM193, LM293, and LM393 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.

The devices LM393W and LM393AW offer additional ESD robustness of 2 kV HBM on all pins.

1 Schematic diagram

Figure 1. **Schematic diagram (LM193, L293, LM393)**

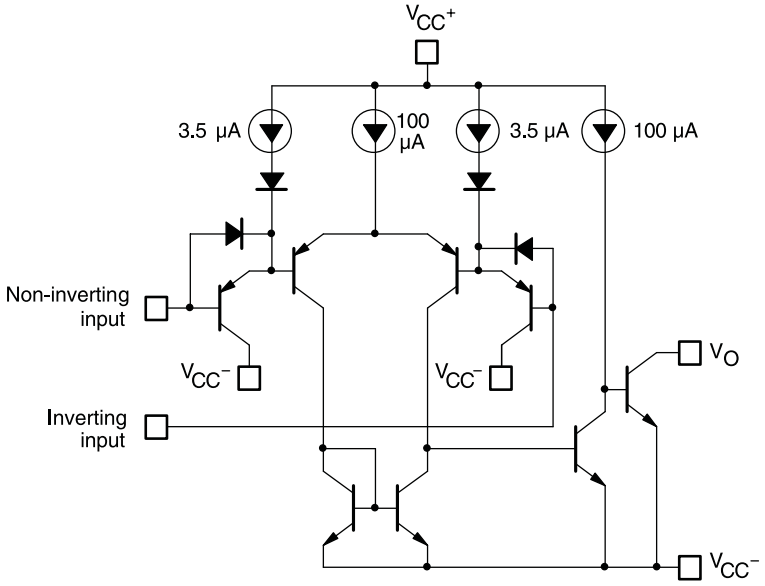
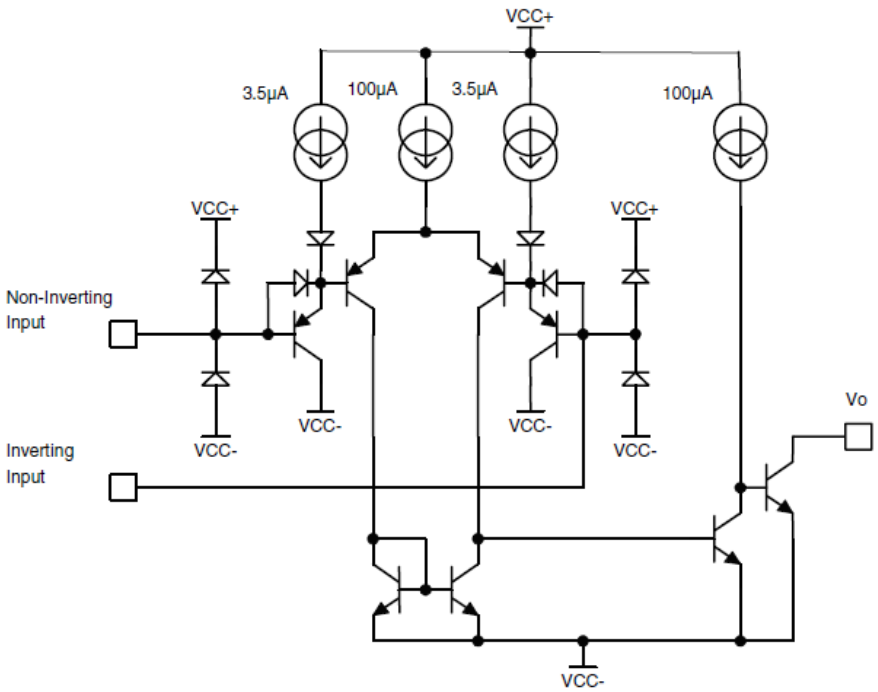
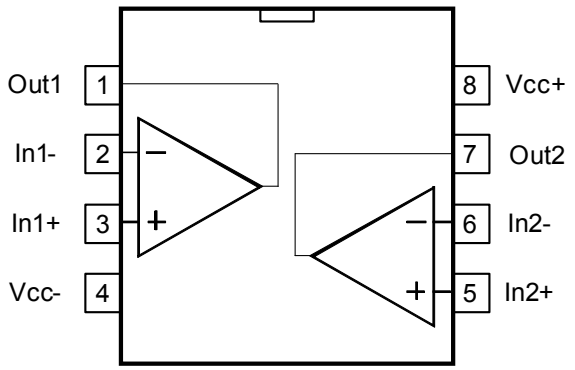


Figure 2. **Schematic diagram (LM393W)**



2 Package pin connections

Figure 3. **Pin connections (top view)**



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

3 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V_{CC}	Supply voltage		±18 or 36	V
V_{id}	Differential input voltage LM193, LM293, LM393 LM393W		±36 V_{cc}- -0.3 to V_{cc}+ +0.3	
V_{in}	Input voltage LM193, LM293, LM393 LM393W		-0.3 to 36 V_{cc}- -0.3 to V_{cc}+ +0.3	
	Output short-circuit to ground (1)		Infinite	
R_{thja}	Thermal resistance junction to ambient (2)	DFN8 2x2	57	°C/W
		MiniSO8	190	
		TSSOP8	120	
		SO8	125	
R_{thjc}	Thermal resistance junction to case (2)	DFN8 2x2	—	
		MiniSO8	39	
		TSSOP8	37	
		SO8	40	
T_j	Maximum junction temperature		150	°C
T_{stg}	Storage temperature range		-65 to 150	
ESD class (3) LM193, LM293, LM393	HBM: human body model (4)		H1B	
	MM: machine model (5)		M2	
	CDM: charged device model (6)		C5	
ESD class LM393W	HMB: human body model (7) MM: machine model CDM: charged device mode (8)		2000 200 1500	V

1. *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}+.*
2. *Short-circuits can cause excessive heating and destructive dissipation. Values are typical.*
3. *ESD class definition from AEC-Q100:*
4. *HBM class H1B: ESD voltage level from 500 V to 1000 V*
5. *MM class M2: ESD voltage level from 100 V to 200 V*
6. *CDM class C5: ESD voltage level greater than 1500 V.*
7. *JEDEC JESD22-A114F*
8. *JEDEC JESD22-101F*

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)	T_{amb} = 25 °C	0 to (V_{CC}^+) - 1.5	
		$T_{min} \leq T_{amb} \leq T_{max}$	0 to (V_{CC}^+) - 2	
T_{oper}	Operating free-air temperature range	LM193	-55 to 125	°C
		LM293, LM293A	-40 to 105	
		LM393, LM393A, LM393W	0 to 70	

4 Electrical characteristics

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

Symbol	Parameter	Condition	LM293A, LM393A			LM193, LM293, LM393, LM393W			Unit
			Min.	Typ.	Max.	Min	Typ.	Max.	
V_{io}	Input offset voltage (1)			1	2		1	5	mV
		$T_{min} \le T_{amb} \le T_{max}$			4			9	
I_{io}	Input offset current			3	25		3	50	nA
		$T_{min} \le T_{amb} \le T_{max}$			100			150	
I_{ib}	Input bias current (I^+ or I^-) (2)			20	100		20	250	
		$T_{min} \le T_{amb} \le T_{max}$			300			400	
A_{vd}	Large signal voltage gain	V_{CC} = 15 V, R_L = 15 kΩ, V_o = 1 V to 11 V	50	200		50	200		V/mV
I_{CC}	Supply current (all comparators)	V_{CC} = 5 V, no load		0.45	1		0.45	1	mA
		V_{CC} = 30 V, no load		0.6	2.5		0.6	2.5	
V_{id}	Differential input voltage (3)				V_{CC}^+			V_{CC}^+	
V_{OL}	Low-level output voltage	V_{id} = -1 V, I_{sink} = 4 mA		80	400		80	400	mV
		$T_{min} \le T_{amb} \le T_{max}$			700			700	
I_{OH}	High-level output current	$V_{CC} = V_o$ = 30 V, V_{id} = 1 V		0.1			0.1		nA
		$T_{min} \le T_{amb} \le T_{max}$			1			1	µA
I_{sink}	Output sink current	V_{id} = 1 V, V_o = 1.5 V	6	18		6	18		mA
t_{re}	Response time (4)	R_L = 5.1 kΩ connected to V_{CC}^+		1.3			1.3		µs
t_{rel}	Large signal response time	R_L = 5.1 kΩ connected to V_{CC}^+, e_I = TTL, $V_{(ref)}$ = 1.4 V		300			300		ns

1. *At output switch point, V_o = 1.4 V, R_s = 0 with V_{CC}^+ from 5 V to 30 V, and over the full common-mode range (0 V to (V_{CC}^+) - 1.5 V).*
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 -0.3 V (or 0.3 V below the negative power supply, if used).*
4. *The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals, 300 ns can be obtained.*

5 Electrical characteristic curves

Figure 4. Supply current vs. supply voltage

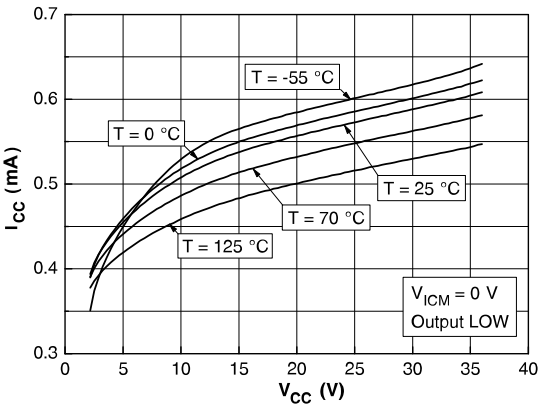


Figure 5. Input current vs. supply voltage

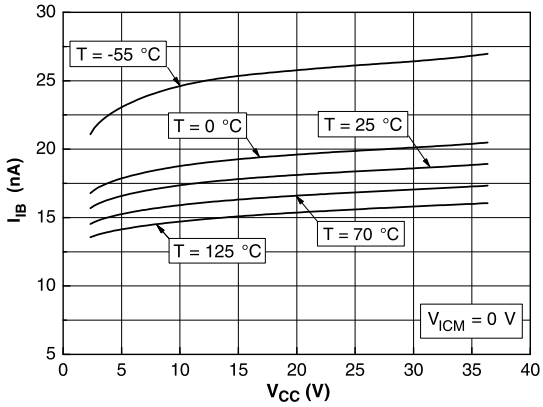


Figure 6. Output saturation voltage vs. output current

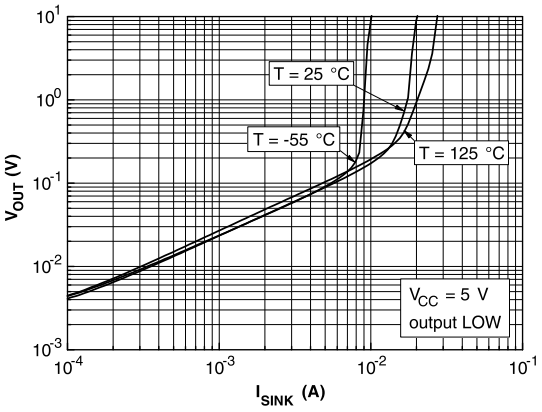


Figure 7. Response time for various input overdrives - negative transition

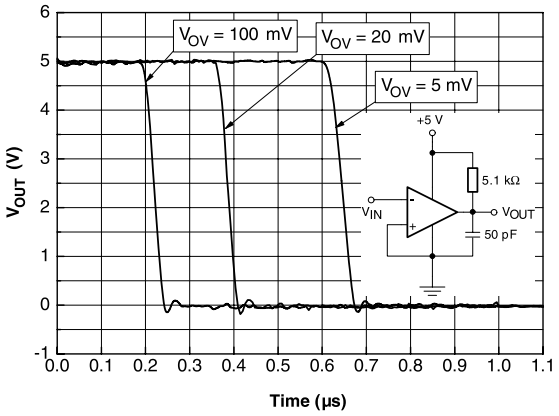
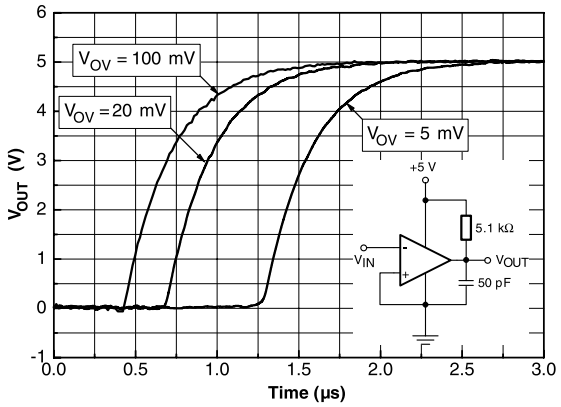


Figure 8. Response time for various input overdrives - positive transition



6 Typical applications

Figure 9. Basic comparator

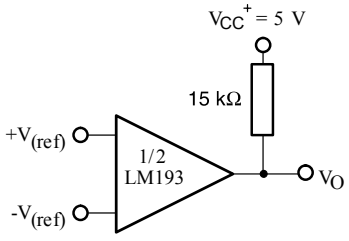


Figure 10. Driving TTL

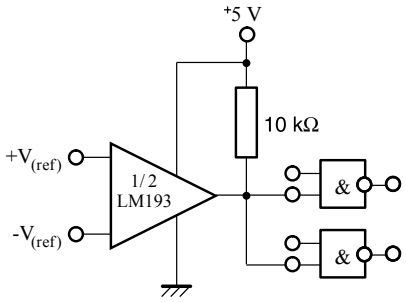


Figure 11. Low-frequency op amp (1)

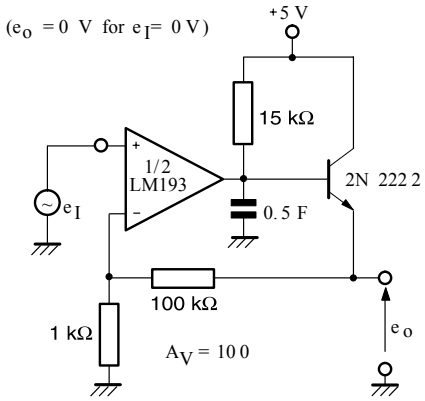


Figure 12. Driving CMOS

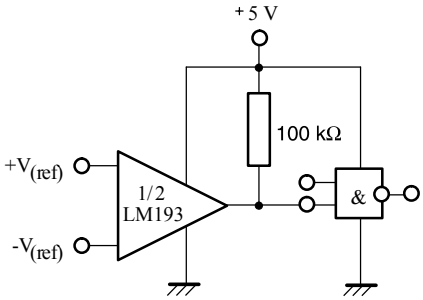


Figure 13. Low-frequency op amp (2)

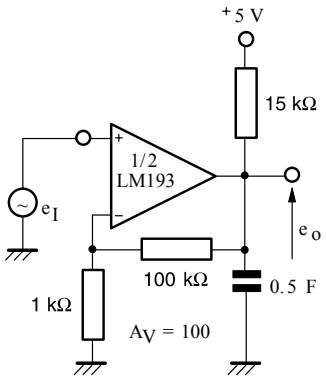


Figure 14. Transducer amplifier

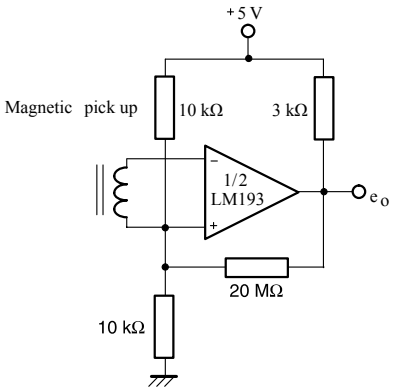


Figure 15. Low-frequency op amp with offset adjust

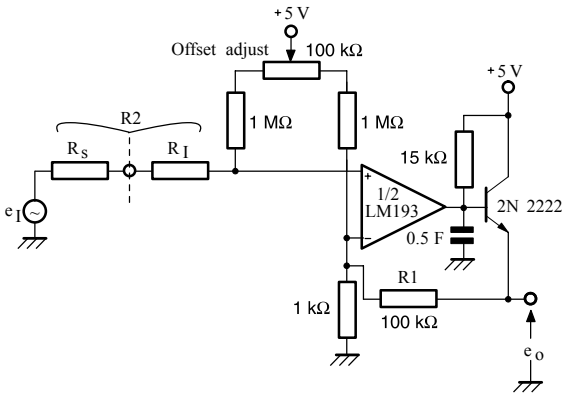


Figure 16. Zero crossing detector (single power supply)

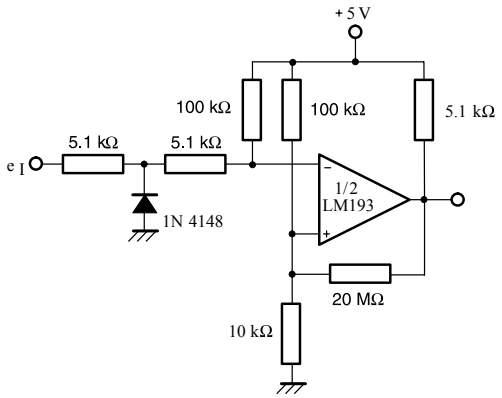


Figure 17. Limit comparator

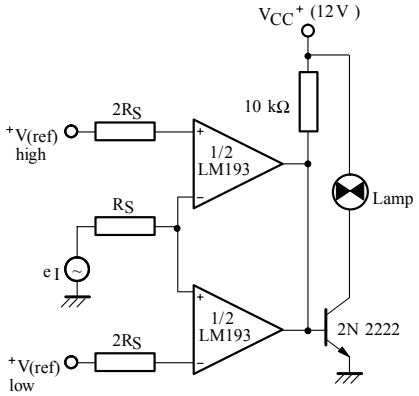


Figure 18. Crystal controlled comparator

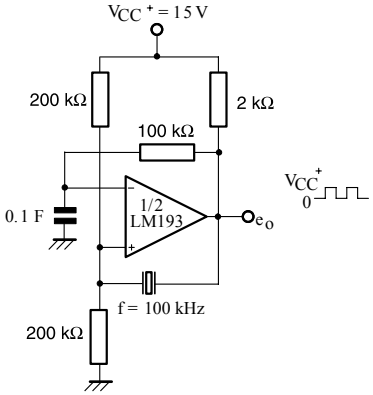


Figure 19. Split supply applications (zero crossing detector)

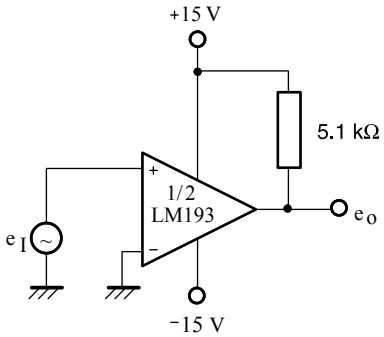


Figure 20. Comparator with a negative reference

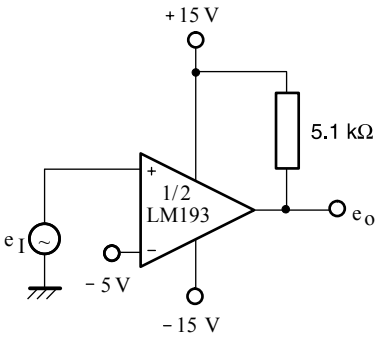
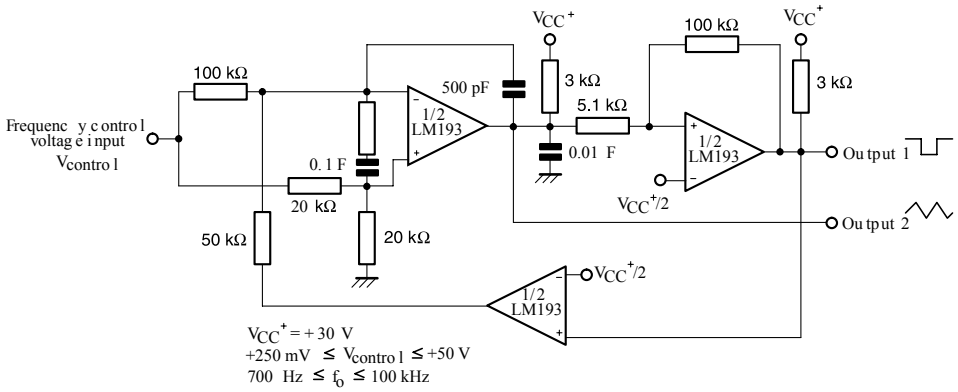


Figure 21. **Two-decade, high-frequency VCO**



7 Package information

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

7.1 DFN8 2 x 2 package information

Figure 22. DFN8 2 x 2 package outline

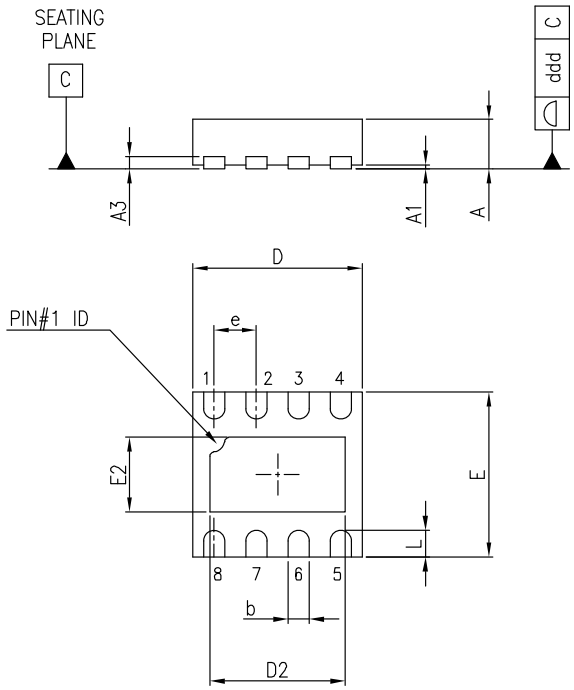
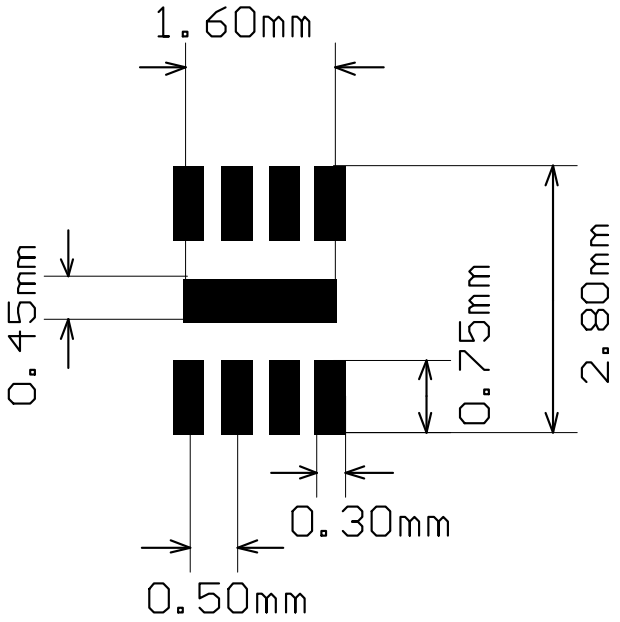


Table 4. DFN8 2 x 2 mechanical data

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	0.225	0.325	0.425	0.009	0.013	0.017
ddd			0.08			0.003

Figure 23. **DFN8 2 x 2 recommended footprint**



7.2 MiniSO8 package information

Figure 24. **MiniSO8 package outline**

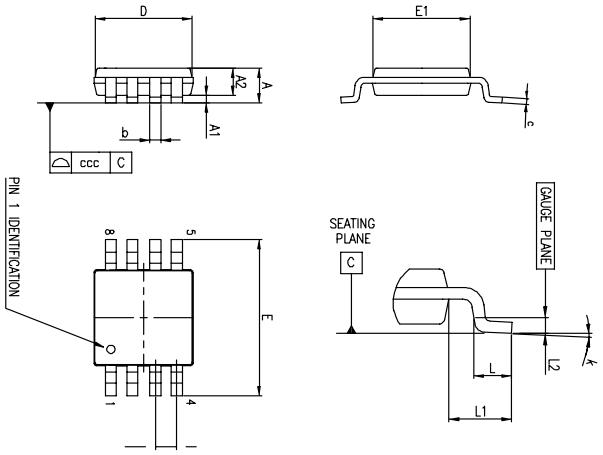


Table 5. **MiniSO8 package mechanical data**

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0		0.15	0		0.0006
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

7.3 TSSOP8 package information

Figure 25. **TSSOP8 package outline**

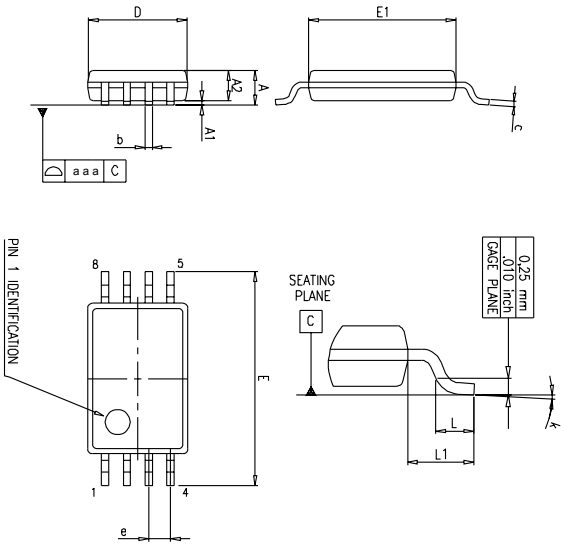


Table 6. **TSSOP8 package mechanical data**

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	

7.4 SO8 package information

Figure 26. **SO8 package outline**

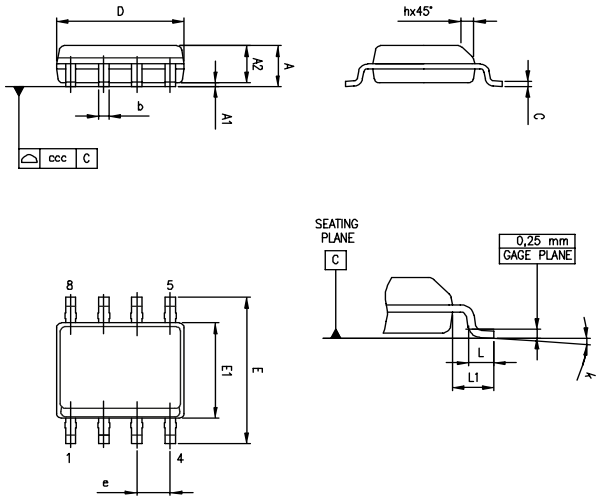


Table 7. **SO8 package mechanical data**

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	0°		8°	0°		8°
ccc			0.10			0.004

8 Ordering information

Table 8. **Ordering information**

Order code	Temperature range	Package	Packing	Marking
LM193DT	-55 °C to 125 °C	SO8	Tape and reel	193
LM193QT		DFN8 2x2		K57
LM293ADT	-40 °C to 105 °C	SO8		293A
LM293D			Tube	293
LM293DT			Tape and reel	
LM293PT		TSSOP8		
LM293ST		MiniSO8		K512
LM293QT		DFN8 2x2		K59
LM393ADT	0 °C to 70 °C	SO8		393A
LM393AWDT				393AW
LM393D			Tube	393
LM393DT			Tape and reel	
LM393WDT				393W
LM393PT		TSSOP8		393
LM393ST		MiniSO8		M393
LM393QT		DFN8 2x2		K5B

Revision history

Table 9. **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 Table 7: Ordering information on page 18.
02-Jul-2005	4	Modification on PPAP references - Errors on part numbers, see Table 7: Ordering information on page 18.
22-Nov-2005	5	Modification on Table 3 on page 6. LM293,A must be -40/+105°C instead of -40/+125°C.
16-Feb-2006	6	Unit error for V_{ol} parameter see Table 3 on page 6.
23-Aug-2007	7	Corrected error in DIP8 package information related to lead thickness, see Figure 21 on page 12. Added values for R_{thja} and R_{thjc}, and ESD parameters in Table 1: Absolute maximum ratings.
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 Figure 5.
22-Feb-2010	11	Deleted automotive grade order codes for LM293 and LM393.
22-Jun-2011	12	Updated typical performance curves. Updated typical values on Table 3 on page 6. Updated ESD parameters with ESD classes in Table 1: Absolute maximum ratings. Added DFN8 2x2mm package mechanical drawing. Added DFN8 2x2mm recommended footprint. Added DFN8 2x2mm order codes in Table 9.
27-Jun-2012	13	Updated Features (added package information), Description (added RPNs), Figure 1: Pin connections (top view) moved to page 3, added Contents, updated marking of the LM293QT device in Table 9, minor text corrections throughout document.
18-Jan-2013	14	Updated Table 8 (added dimensions in inches).
09-Feb-2016	15	Updated document layout. Removed DIP8 package. Section Features: removed “plastic micropackage” from the DFN8 2x2, MiniSO8, and SO8 silhouettes; removed “thin shrink small outline package” from the TSSOP8 silhouette. Figure 4. Figure 2: added footnote about the exposed pad of the DFN8 2x2. Table 4: updated “L” value Section 7.3 Table 6: “aaa” value is a typ. value not a max. value Section 7.4 Table 7: updated min. “k” millimeters value Table 8: removed following obsolete order codes: LM193AD, LM193D, LM193AN, LM193N, LM293AD, LM293AN, LM293N, LM393AD, LM393AN, LM393N; added footnote (not recommended for new design) to order code LM193ADT; replaced marking of LM393QT with “K5B” instead of “K5C”.
29-Aug-2022	16	Updated features and descripion on the cover page, Table 1, Figure 5, Section 8 . Added new Figure 3