

# DATA SHEET

**LM193A/293/A/393/A/2903**

Low power dual voltage comparator

Product data  
Supersedes data of 2002 Jan 22

2002 Jul 12

# Low power dual voltage comparator

# LM193A/293A/393A/2903

## DESCRIPTION

The LM193 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0 mV max. for two comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible, and the low power supply current drain is independent of the magnitude of the power supply voltage. 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 LM193 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM193 series will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.

## FEATURES

- Wide single supply voltage range  $2.0 V_{DC}$  to  $32 V_{DC}$ , or dual supplies  $\pm 1.0 V_{DC}$ , to  $\pm 16 V_{DC}$
- Very low supply current drain (0.8 mA) independent of supply voltage (2.0 mW/comparator at  $5.0 V_{DC}$ )
- Low input biasing current 25 nA
- Low input offset current  $\pm 5$  nA and offset voltage  $\pm 2$  mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output 250 mV at 4 mA saturation voltage
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems

## APPLICATIONS

- A/D converters
- Wide range VCO
- MOS clock generator
- High voltage logic gate
- Multivibrators

## PIN CONFIGURATION

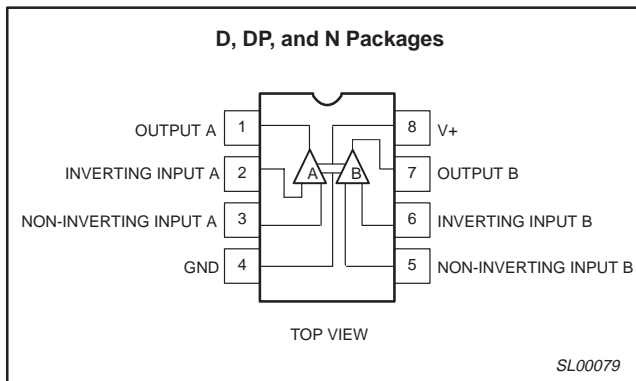


Figure 1. Pin configuration.

## EQUIVALENT CIRCUIT

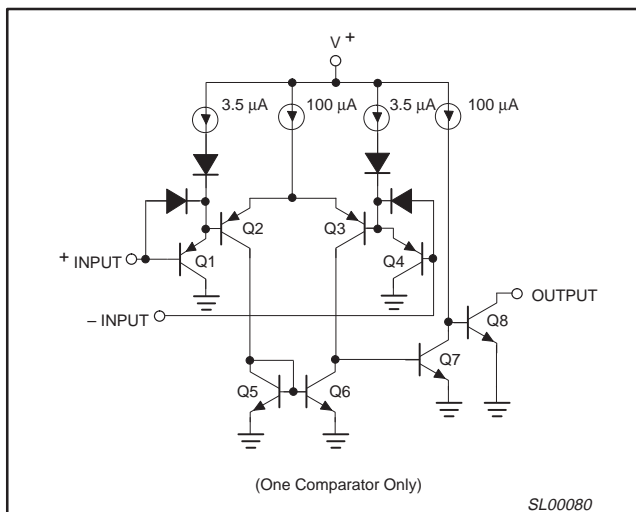


Figure 2. Equivalent circuit.

## ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Dual In-Line Package (DIP)	-55 °C to +125 °C	LM193AN	SOT97-1
8-Pin Plastic Small Outline (SO) Package	-25 °C to +85 °C	LM293D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	-25 °C to +85 °C	LM293N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	-25 °C to +85 °C	LM293AD	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	-25 °C to +85 °C	LM293AN	SOT97-1
8-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM393D	SOT96-1
8-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	0 °C to +70 °C	LM393DP	SOT505-1
8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM393N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM393AD	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM393AN	SOT97-1
8-Pin Plastic Small Outline (SO) Package	-40 °C to +125 °C	LM2903D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	-40 °C to +125 °C	LM2903N	SOT97-1
8-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	-40 °C to +125 °C	LM2903DP	SOT505-1

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

**ABSOLUTE MAXIMUM RATINGS**

SYMBOL	PARAMETER	RATING	UNIT
$V_{CC}$	Supply voltage	32 or $\pm 16$	$V_{DC}$
	Differential input voltage	32	$V_{DC}$
$V_{IN}$	Input voltage	-0.3 to +32	$V_{DC}$
$P_D$	Maximum power dissipation, $T_{amb} = 25\text{ }^\circ\text{C}$ (still-air) <sup>1</sup>		
	N package	1160	mW
	D package	780	mW
	DP package	714	mW
	Output short-circuit to ground <sup>2</sup>	Continuous	
$I_{IN}$	Input current ( $V_{IN} < -0.3 V_{DC}$ ) <sup>3</sup>	50	mA
$T_{amb}$	Operating temperature range		
	LM193A	-55 to +125	$^\circ\text{C}$
	LM293/293A	-25 to +85	$^\circ\text{C}$
	LM393/393A	0 to +70	$^\circ\text{C}$
	LM2903	-40 to +125	$^\circ\text{C}$
$T_{stg}$	Storage temperature range	-65 to +150	$^\circ\text{C}$
$T_{slid}$	Lead soldering temperature (10 sec max)	230	$^\circ\text{C}$

**NOTES:**

- Derate above 25  $^\circ\text{C}$ , at the following rates:  
N package at 9.3 mW/ $^\circ\text{C}$   
D package at 6.2 mW/ $^\circ\text{C}$   
DP package at 5.72 mW/ $^\circ\text{C}$
- Short circuits from the output to  $V_+$  can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of  $V_+$ .
- This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the comparators to go to the  $V_+$  voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than  $-0.3 V_{DC}$ .

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

## DC AND AC ELECTRICAL CHARACTERISTICS

$V_+ = 5 V_{DC}$ , LM193A:  $-55\text{ }^\circ\text{C} T_{amb} \leq +125\text{ }^\circ\text{C}$ , unless otherwise specified. LM293/293A:  $-25\text{ }^\circ\text{C} T_{amb} \leq +85\text{ }^\circ\text{C}$ , unless otherwise specified. LM393/393A:  $0\text{ }^\circ\text{C} T_{amb} \leq +70\text{ }^\circ\text{C}$ , unless otherwise specified. LM2903:  $-40\text{ }^\circ\text{C} T_{amb} \leq +125\text{ }^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LM193A			LM293A/393A			LM2903			UNIT
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OS}$	Input offset voltage <sup>2</sup>	$T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		$\pm 1.0$	$\pm 2.0$ $\pm 4.0$		$\pm 1.0$	$\pm 2.0$ $\pm 4.0$		$\pm 2.0$ $\pm 9$	$\pm 7.0$ $\pm 15$	mV mV
$V_{CM}$	Input common-mode voltage range <sup>3, 6</sup>	$T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.	0		$V_+ - 1.5$ $V_+ - 2.0$	0		$V_+ - 1.5$ $V_+ - 2.0$	0		$V_+ - 1.5$ $V_+ - 2.0$	V V
			0			0			0			
$V_{IDR}$	Differential input voltage <sup>1</sup>	Keep all $V_{IN} \geq 0 V_{DC}$ (or $V_-$ if needed)			$V_+$			$V_+$			$V_+$	V
$I_{BIAS}$	Input bias current <sup>4</sup>	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		25	100 300		25	250 400		25 200	250 500	nA nA
$I_{OS}$	Input offset current	$I_{IN(+)} - I_{IN(-)}$ $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		$\pm 3.0$	$\pm 25$ $\pm 100$		$\pm 5.0$	$\pm 50$ $\pm 150$		$\pm 5$ $\pm 50$	$\pm 50$ $\pm 200$	nA nA
$I_{OL}$	Output sink current	$V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $V_O \leq 1.5 V_{DC}$ $T_{amb} = 25\text{ }^\circ\text{C}$	6.0	16		6.0	16		6.0	16		mA
	Output leakage current	$V_O = 5 V_{DC}$ ; $T_{amb} = 25\text{ }^\circ\text{C}$ $V_{IN(+)} \geq 1 V_{DC}$ ; $V_{IN(-)} = 0$ ; $V_O = 30 V_{DC}$ ; Over temp.		0.1	1.0		0.1	1.0		0.1	1.0	nA $\mu\text{A}$
$I_{CC}$	Supply current	$R_L = \infty$ on both comparators; $T_{amb} = 25\text{ }^\circ\text{C}$		0.8	1		0.8	1		0.8	1	mA
				1	2.5		1	2.5		1	2.5	mA
$A_V$	Voltage gain	$R_L \geq 15\text{ k}\Omega$ ; $V_+ = 15 V_{DC}$ ; $T_{amb} = 25\text{ }^\circ\text{C}$	50	200		50	200		25	100		V/mV
$V_{OL}$	Saturation voltage	$V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $I_{SINK} \leq 4\text{ mA}$ $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		250	400 700		250	400 700		400	400 700	mV mV
$t_{LSR}$	Large-signal response time	$V_{IN} = \text{TTL logic swing}$ , $V_{REF} = 1.4 V_{DC}$ ; $V_{RL} = 5 V_{DC}$ ; $R_L = 5.1\text{ k}\Omega$ ; $T_{amb} = 25\text{ }^\circ\text{C}$		300			300			300		ns
$t_R$	Response time <sup>5</sup>	$V_{RL} = 5 V_{DC}$ ; $R_L = 5.1\text{ k}\Omega$ ; $T_{amb} = 25\text{ }^\circ\text{C}$		1.3			1.3			1.3		$\mu\text{s}$

## Low power dual voltage comparator

## LM193A/293/A/393/A/2903

**DC ELECTRICAL CHARACTERISTICS** (Continued)

$V_+ = 5 V_{DC}$ , LM193A:  $-55\text{ }^\circ\text{C} \leq T_{amb} \leq +125\text{ }^\circ\text{C}$ , unless otherwise specified. LM293/293A:  $-25\text{ }^\circ\text{C} \leq T_{amb} \leq +85\text{ }^\circ\text{C}$ , unless otherwise specified. LM393/393A:  $0\text{ }^\circ\text{C} \leq T_{amb} \leq +70\text{ }^\circ\text{C}$ , unless otherwise specified. LM2903:  $-40\text{ }^\circ\text{C} \leq T_{amb} \leq +125\text{ }^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LM293/393			UNIT
			Min	Typ	Max	
$V_{OS}$	Input offset voltage <sup>2</sup>	$T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		$\pm 2.0$	$\pm 5.0$ $\pm 9.0$	mV mV
$V_{CM}$	Input common-mode voltage range <sup>3, 6</sup>	$T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.	0 0		$V_+ - 1.5$ $V_+ - 2.0$	V V
$V_{IDR}$	Differential input voltage <sup>1</sup>	Keep all $V_{IN} \geq 0 V_{DC}$ (or $V_-$ if needed)			$V_+$	V
$I_{BIAS}$	Input bias current <sup>4</sup>	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		25	250 400	nA nA
$I_{OS}$	Input offset current	$I_{IN(+)} - I_{IN(-)}$ $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		$\pm 5.0$	$\pm 50$ $\pm 150$	nA nA
$I_{OL}$	Output sink current	$V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $V_O \leq 1.5 V_{DC}$ $T_{amb} = 25\text{ }^\circ\text{C}$	6.0	16		mA
	Output leakage current	$V_{IN(+)} \geq 1 V_{DC}$ ; $V_{IN(-)} = 0$ , $V_O = 5 V_{DC}$ ; $T_{amb} = 25\text{ }^\circ\text{C}$ $V_O = 30 V_{DC}$ ; over temp.		0.1	1.0	nA $\mu\text{A}$
$I_{CC}$	Supply current	$R_L = \infty$ on both comparators, $T_{amb} = 25\text{ }^\circ\text{C}$		0.8	1	mA
		$R_L = \infty$ on both comparators; $V_+ = 30\text{ V}$			2.5	mA
$A_V$	Voltage gain	$R_L \geq 15\text{ k}\Omega$ ; $V_+ = 15 V_{DC}$	50	200		V/mV
$V_{OL}$	Saturation voltage	$V_{IN(-)} \geq 1 V_{DC}$ ; $V_{IN(+)} = 0$ ; $I_{SINK} \leq 4\text{ mA}$ $T_{amb} = 25\text{ }^\circ\text{C}$ Over temp.		250	400 700	mV mV
$t_{LSR}$	Large signal response time	$V_{IN} = \text{TTL logic swing}$ , $V_{REF} = 1.4 V_{DC}$ ; $V_{RL} = 5 V_{DC}$ ; $R_L = 5.1\text{ k}\Omega$ ; $T_{amb} = 25\text{ }^\circ\text{C}$		300		ns
$t_R$	Response time <sup>5</sup>	$V_{RL} = 5 V_{DC}$ ; $R_L = 5.1\text{ k}\Omega$ $T_{amb} = 25\text{ }^\circ\text{C}$		1.3		$\mu\text{s}$

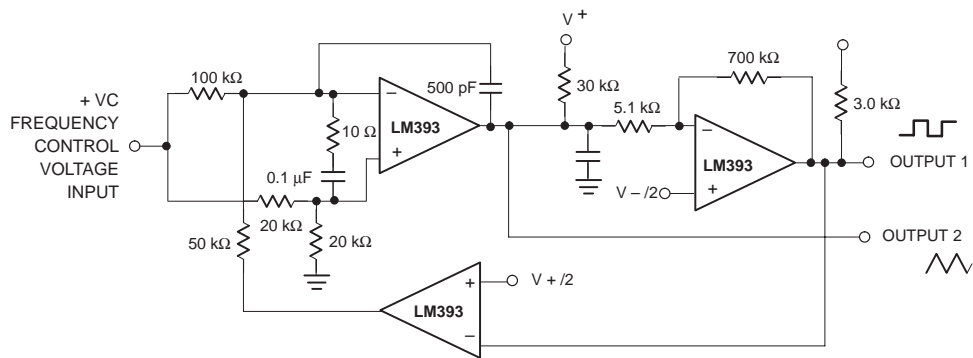
**NOTES:**

- Positive excursions of input voltage may exceed the power supply level by 17 V. 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  $-0.3 V_{DC}$  ( $V_{DC}$  below the magnitude of the negative power supply, if used).
- At output switch point,  $V_O \approx 1.4 V_{DC}$ ,  $R_S = 0\ \Omega$  with  $V_+$  from  $5 V_{DC}$  to  $30 V_{DC}$  and over the full input common-mode range ( $0 V_{DC}$  to  $V_+ - 1.5 V_{DC}$ ).
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_+ - 1.5\text{ V}$ , but either or both inputs can go to  $30 V_{DC}$  without damage.
- 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 change exists on the reference or input lines.
- The response time specified is for a 100 mV input step with a 5 mV overdrive.
- For input signals that exceed  $V_{CC}$ , only the over-driven comparator is affected. With a 5 V supply,  $V_{IN}$  should be limited to 25 V maximum, and a limiting resistor should be used on all inputs that might exceed the positive supply.

# Low power dual voltage comparator

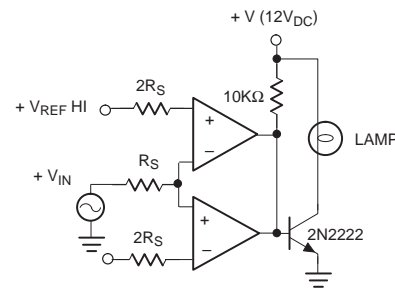
# LM193A/293/A/393/A/2903

## EQUIVALENT CIRCUIT

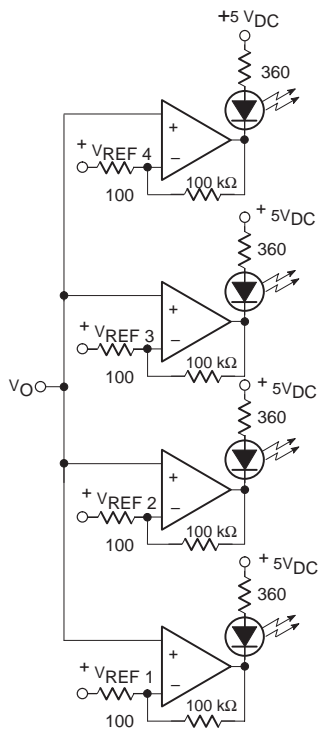


**NOTES:**  
 $V+ = 30 V_{DC}$   
 $+250 mV_{DC} \leq V_C = 50 V_{DC}$   
 $700H \leq f_O = 100 kHz$

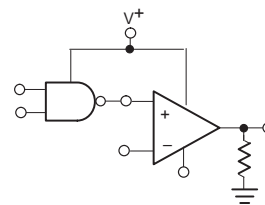
**Two-Decade High-Frequency VCO**



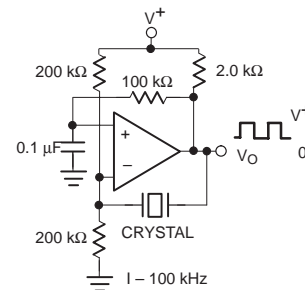
**Limit Comparator**



**Visible Voltage Indicator**



**TTL-to-MOS Logic Converter**



**Crystal-Controlled Oscillator**

**NOTE:**  
 Input of unused comparators should be grounded.

SL00081

**Figure 3. Equivalent circuit.**

Low power dual voltage comparator

LM193A/293/A/393/A/2903

TYPICAL PERFORMANCE CHARACTERISTICS

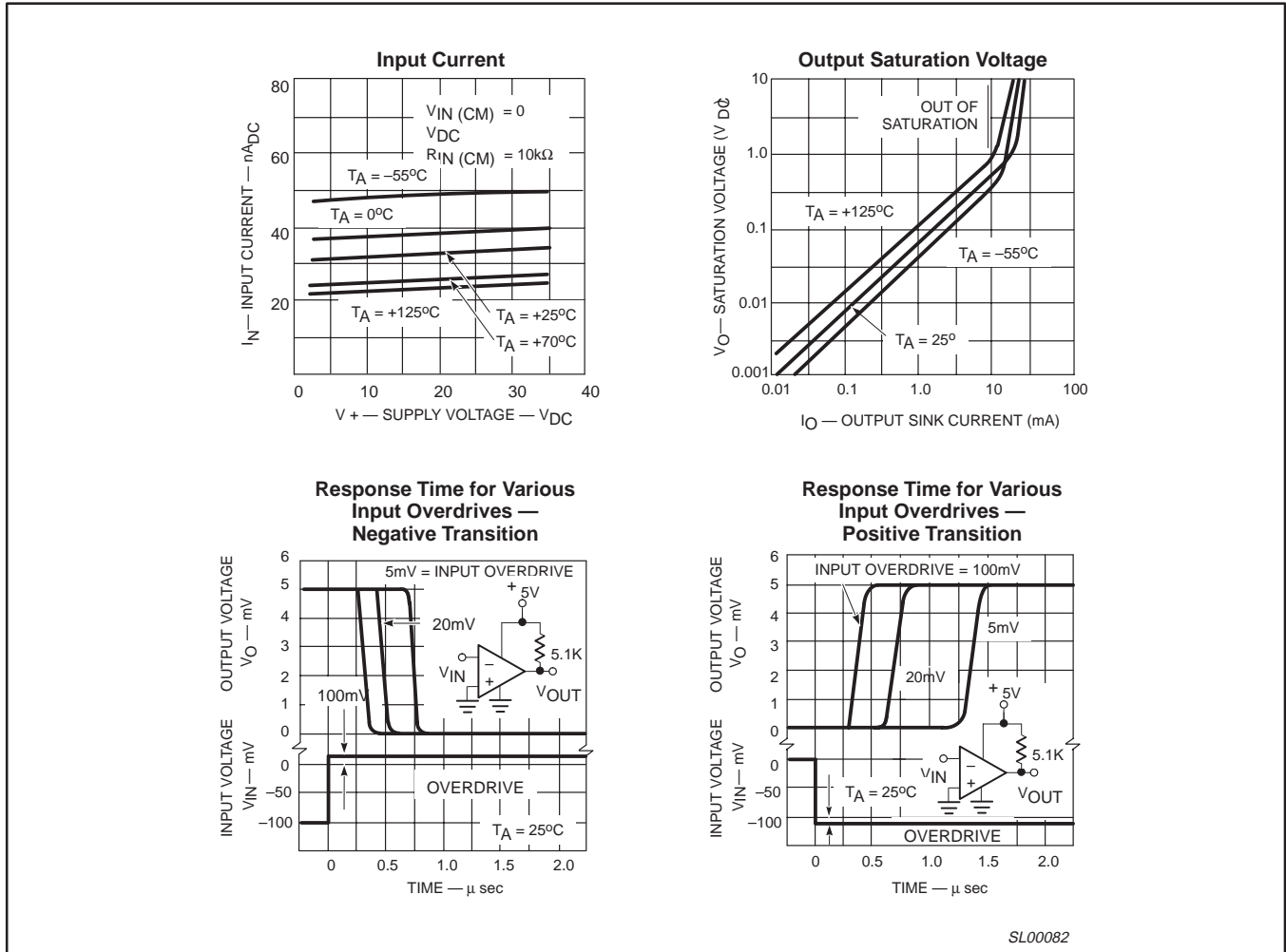


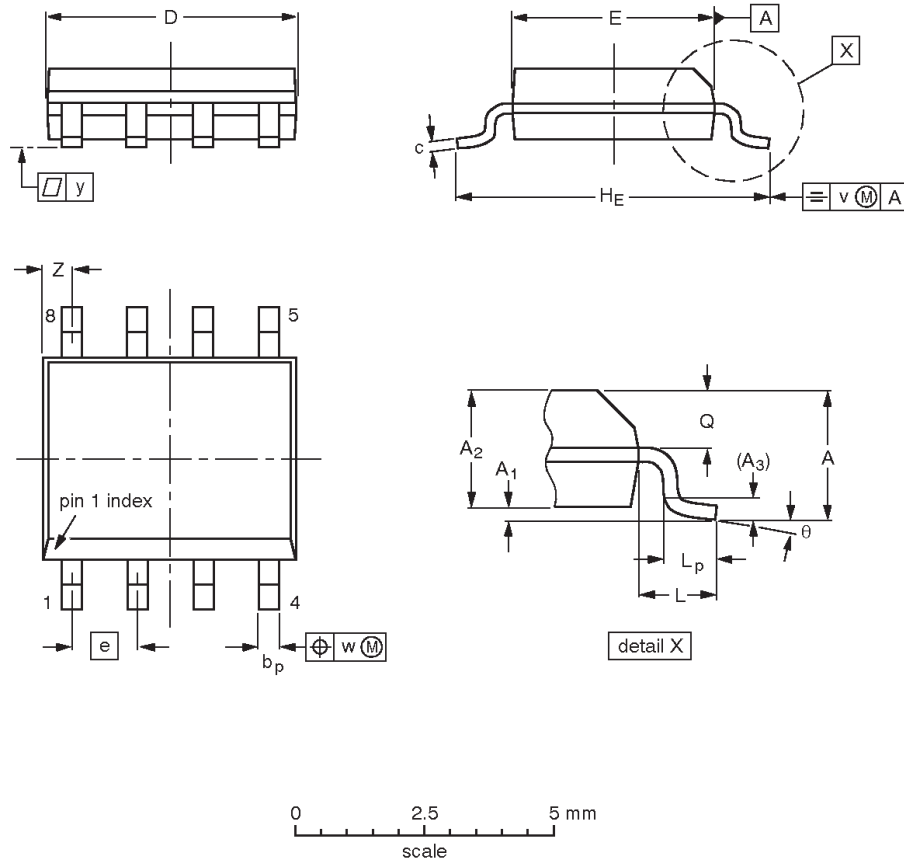
Figure 4. Typical performance characteristics.

# Low power dual voltage comparator

# LM193A/293/A/393/A/2903

**SO8:** plastic small outline package; 8 leads; body width 3.9 mm

**SOT96-1**



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	HE	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-1	076E03	MS-012				97-05-22 99-12-27

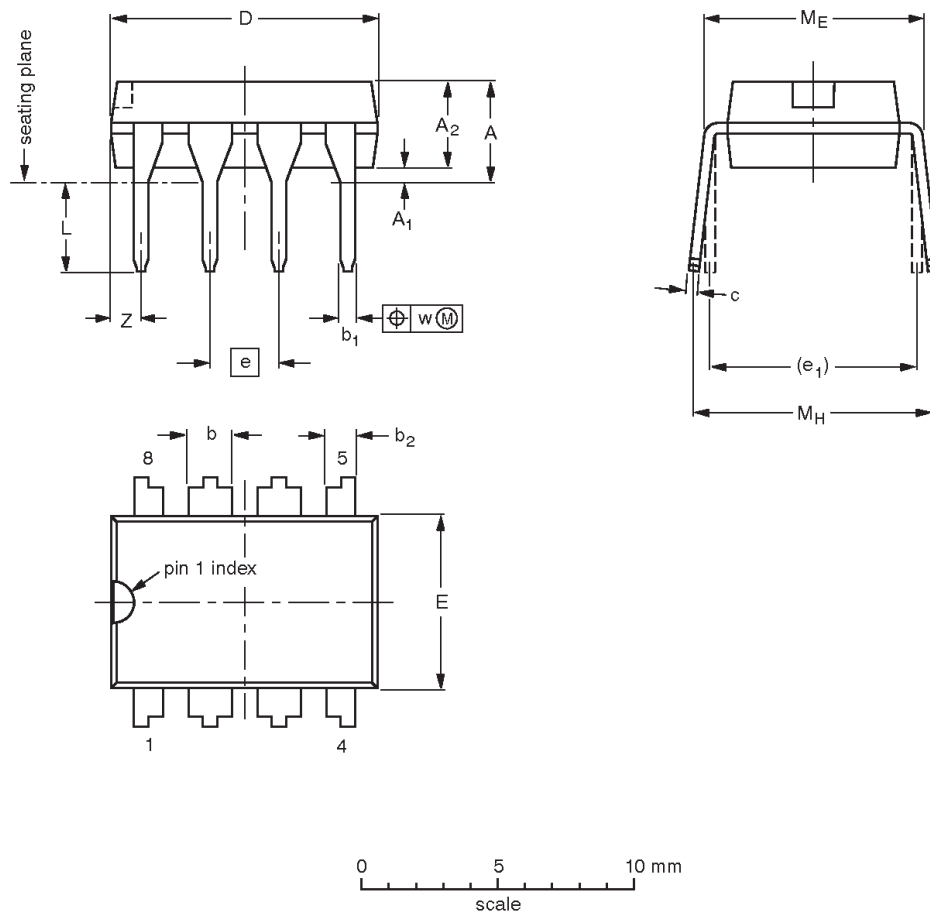


Low power dual voltage comparator

LM193A/293/A/393/A/2903

DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A <sub>1</sub> min.	A <sub>2</sub> max.	b	b <sub>1</sub>	b <sub>2</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	e <sub>1</sub>	L	M <sub>E</sub>	M <sub>H</sub>	w	Z <sup>(1)</sup> max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.020	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

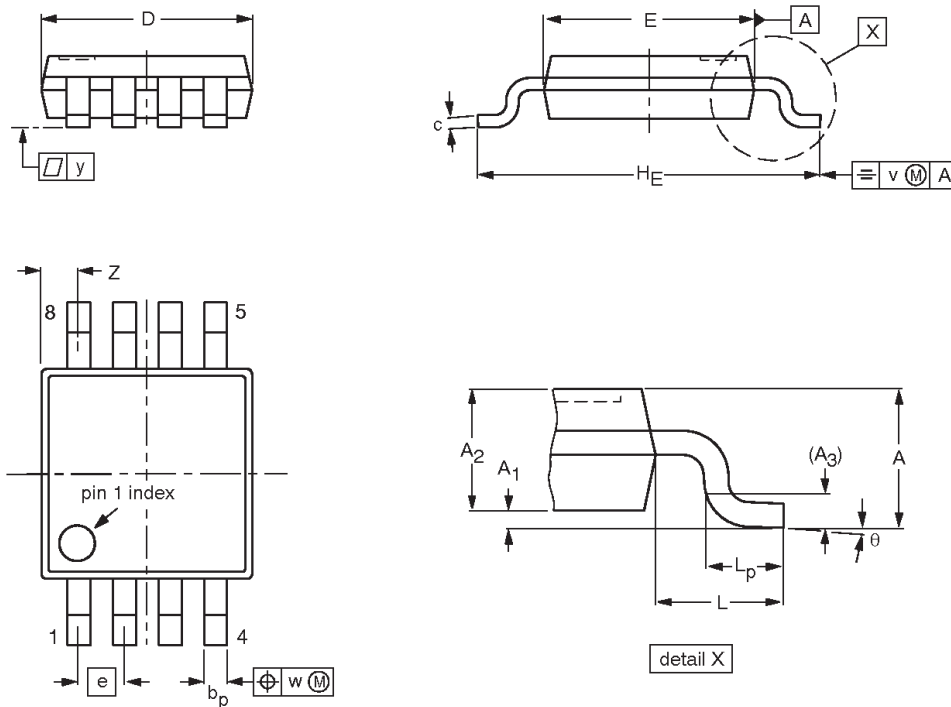
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001	SC-504-8			95-02-04 99-12-27

# Low power dual voltage comparator

# LM193A/293/A/393/A/2903

**TSSOP8:** plastic thin shrink small outline package; 8 leads; body width 3 mm

**SOT505-1**



**DIMENSIONS (mm are the original dimensions)**

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	v	w	y	Z <sup>(1)</sup>	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.45 0.25	0.28 0.15	3.10 2.90	3.10 2.90	0.65	5.10 4.70	0.94	0.70 0.40	0.1	0.1	0.1	0.70 0.35	6° 0°

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT505-1						99-04-09

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Low power dual voltage comparator

LM193A/293/A/393/A/2903

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**NOTES**

## Low power dual voltage comparator

LM193A/293/A/393/A/2903

## Data sheet status

Data sheet status <sup>[1]</sup>	Product status <sup>[2]</sup>	Definitions
Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
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