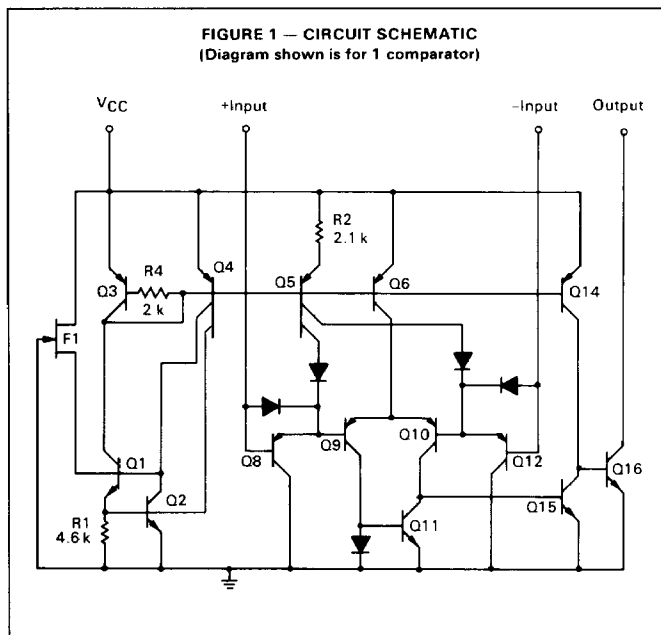


**SINGLE SUPPLY, LOW POWER, LOW OFFSET VOLTAGE
 DUAL COMPARATORS**

The LM193 series are dual independent precision voltage comparators capable of single- or split-supply operation. These devices are designed to permit a common mode range-to-ground level with single-supply operation. Input offset-voltage specifications as low as 2.0 mV make this device an excellent selection for many applications in consumer automotive, and industrial electronics.

- Wide Single-Supply Range — 2.0 Vdc to 36 Vdc
- Split-Supply Range — ± 1.0 Vdc to ± 18 Vdc
- Very Low Current Drain Independent of Supply Voltage — 0.4 mA
- Low Input Bias Current — 25 nA
- Low Input Offset Current — 5.0 nA
- Low Input Offset Voltage — 2.0 mV (max) LM193A/293A/393A
 — 5.0 mV (max) LM193/293/393
- Input Common Mode Range to Ground Level
- Differential Input Voltage Range Equal to Power Supply Voltage
- Output Voltage Compatible with DTL, ECL, TTL, MOS and CMOS Logic Levels

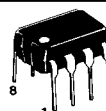
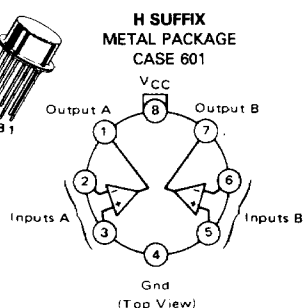
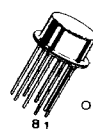
FIGURE 1 — CIRCUIT SCHEMATIC
 (Diagram shown is for 1 comparator)



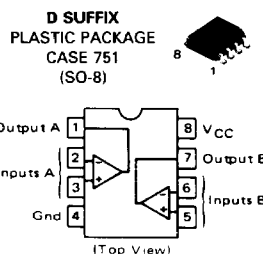
LM193 LM193A
LM293 LM293A
LM393 LM393A
LM2903

DUAL COMPARATORS

SILICON MONOLITHIC
 INTEGRATED CIRCUIT



N SUFFIX
 PLASTIC PACKAGE
 CASE 626



ORDERING INFORMATION

Device	Temperature Range	Package
LM193AH,H	-55 to +125°C	Metal Can
LM293AH,H	-25 to +85°C	Metal Can
LM293D		SO-8
LM393AH,H	0 to +70°C	Metal Can
LM393D		SO-8
LM393AN,N		Plastic DIP
LM2903D	-40 to +105°C	SO-8
LM2903N		Plastic DIP

LM193,A, LM293,A, LM393,A, LM2903

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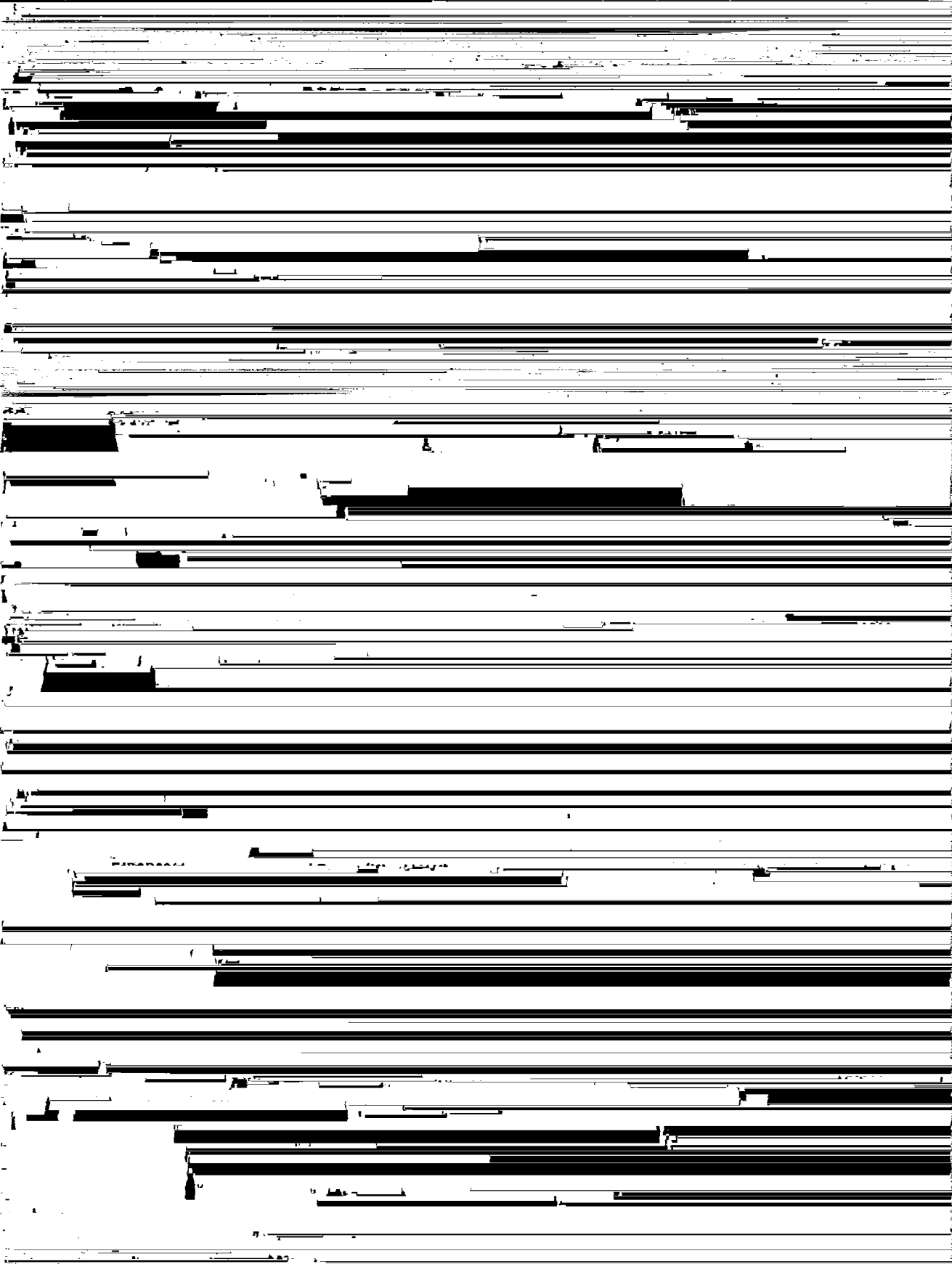
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V _{CC}	+36 or ±18	Vdc
Input Differential Voltage Range	V _{IDR}	36	Vdc
Input Common Mode Voltage Range	V _{ICR}	-0.3 to +36	Vdc
Input Current (2) (V _{in} < -0.3 Vdc)	I _{in}	50	mA
Output Short Circuit-to-Ground Output Sink Current (1)	I _{SC} I _{sink}	Continuous 20	mA
Power Dissipation @ T _A = 25°C			
Plastic DIP	P _D	570	mW
Derate above 25°C	1/R _{θJA}	5.7	mW/°C
Metal Can	P _D	830	mW
Derate above 25°C	1/R _{θJA}	6.64	mW/°C
Operating Ambient Temperature Range	T _A		°C
LM193, 193A		-55 to +125	
LM293, 293A		-25 to +85	
LM393, 393A		0 to +70	
LM2903		-40 to +105	
Maximum Operating Junction Temperature	T _{J(max)}		°C
LM393, 393A, 2903		125	
LM193, 193A, 293, 293A		150	
Storage Temperature Range	T _{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 Vdc; *T_{low} ≤ T_A ≤ T_{high} unless otherwise stated.)

Characteristic	Symbol	LM193A			LM293A, LM393A			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage (3) T _A = 25°C T _{low} ≤ T _A ≤ T _{high}	V _{IO}	—	±1.0	±2.0	—	±1.0	±2.0	mV
		—	—	4.0	—	—	4.0	
Input Offset Current T _A = 25°C T _{low} ≤ T _A ≤ T _{high}	I _{IO}	—	±3.0	±25	—	±5.0	±50	nA
		—	—	±100	—	—	±150	
Input Bias Current (4) T _A = 25°C T _{low} ≤ T _A ≤ T _{high}	I _{IB}	—	25	100	—	25	250	nA
		—	—	300	—	—	400	
Input Common Mode Voltage Range (5) T _A = 25°C T _{low} ≤ T _A ≤ T _{high}	V _{ICR}	0	—	V _{CC} - 1.5	0	—	V _{CC} - 1.5	Volts
		0	—	V _{CC} - 2.0	0	—	V _{CC} - 2.0	
Voltage Gain R _L ≥ 15 kΩ, V _{CC} = 15 Vdc, T _A = 25°C	A _{VOL}	50	200	—	50	200	—	V/mV
Large Signal Response Time V _{in} = TTL Logic Swing, V _{ref} = 1.4 Vdc V _{RL} = 5.0 Vdc, R _L = 5.1 kΩ, T _A = 25°C	—	—	300	—	—	300	—	ns
Response Time (5) V _{RL} = 5.0 Vdc, R _L = 5.1 kΩ, T _A = 25°C	t _{TLH}	—	1.3	—	—	1.3	—	μs
Input Differential Voltage (7) All V _{in} ≥ Gnd or V- Supply (if used)	V _{ID}	—	—	V _{CC}	—	—	V _{CC}	V
Output Sink Current V _{in} ≥ 1.0 Vdc, V _{in+} = 0 Vdc, V _O ≤ 1.5 Vdc T _A = 25°C	I _{sink}	6.0	16	—	6.0	16	—	mA
Output Saturation Voltage V _{in} ≥ 1.0 Vdc, V _{in+} = 0, I _{sink} ≤ 4.0 mA, T _A = 25°C T _{low} ≤ T _A ≤ T _{high}	V _{OL}	—	150	400	—	150	400	mV
		—	—	700	—	—	700	
Output Leakage Current V _{in} = 0 V, V _{in+} ≥ 1.0 Vdc, V _O = 5.0 Vdc, T _A = 25°C V _{in} = 0 V, V _{in+} ≥ 1.0 Vdc, V _O = 30 Vdc, T _{low} ≤ T _A ≤ T _{high}	I _{OL}	—	0.1	—	—	0.1	—	μA
		—	—	1.0	—	—	1.0	
Supply Current R _L = ∞ Both Comparators, T _A = 25°C R _L = ∞ Both Comparators, V _{CC} = 30 V	I _{CC}	—	0.4	1.0	—	0.4	1.0	mA
		—	1.0	2.5	—	1.0	2.5	

*LM193/193A — T_{low} = -55°C, T_{high} = +125°C
 LM293/293A — T_{low} = -25°C, T_{high} = +85°C
 LM393/393A — T_{low} = 0°C, T_{high} = +70°C
 LM2903 — T_{low} = -40°C, T_{high} = +105°C



LM193,A, LM293,A, LM393,A, LM2903

TYPICAL PERFORMANCE CHARACTERISTICS

LM193,A/293,A/393,A

FIGURE 2 — INPUT BIAS CURRENT versus POWER SUPPLY VOLTAGE

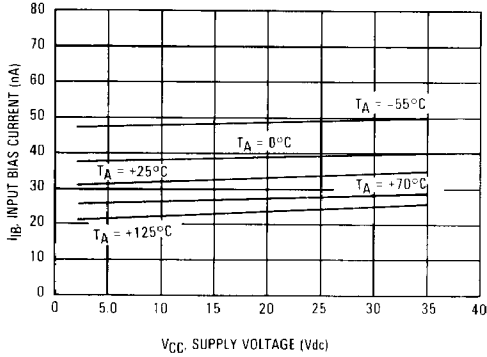


FIGURE 3 — OUTPUT SATURATION VOLTAGE versus OUTPUT SINK CURRENT

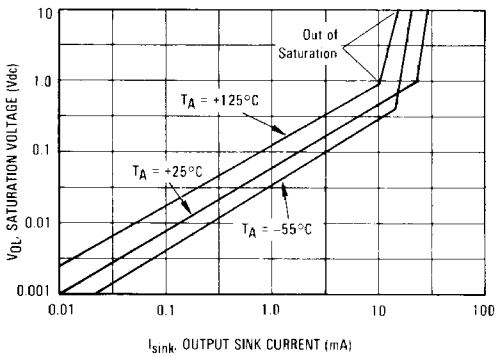
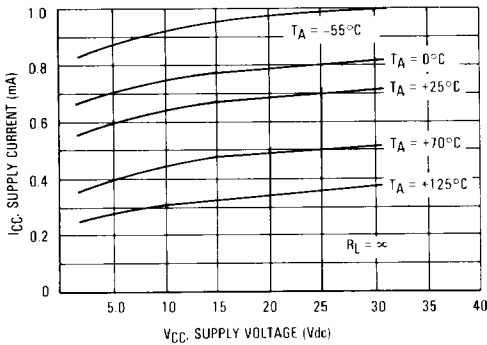


FIGURE 4 — POWER SUPPLY CURRENT versus POWER SUPPLY VOLTAGE



LM2903

FIGURE 5 — INPUT BIAS CURRENT versus POWER SUPPLY VOLTAGE

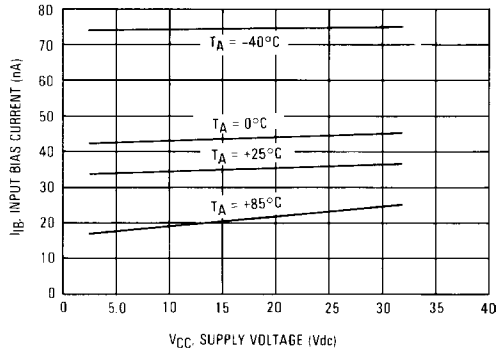


FIGURE 6 — OUTPUT SATURATION VOLTAGE versus OUTPUT SINK CURRENT

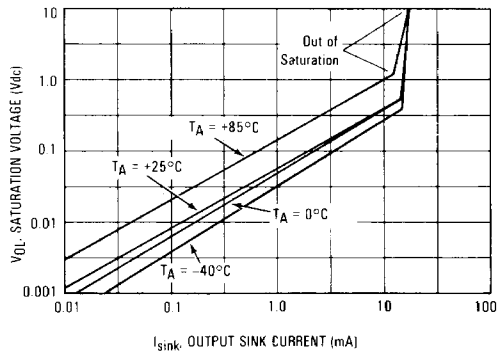
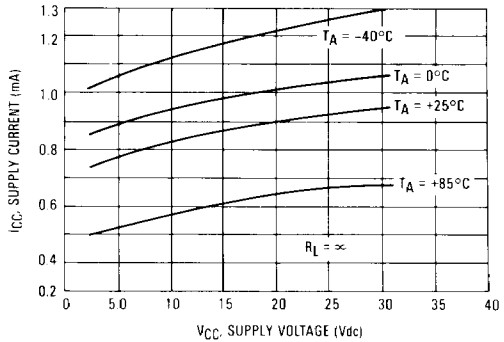


FIGURE 7 — POWER SUPPLY CURRENT versus POWER SUPPLY VOLTAGE



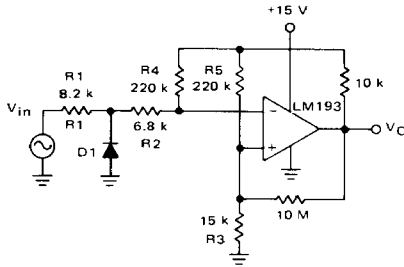
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APPLICATIONS INFORMATION

These dual comparators feature high gain, wide bandwidth characteristics. This gives the device oscillation tendencies if the outputs are capacitively coupled to the inputs via stray capacitance. This oscillation manifests itself during output transitions (V_{OL} to V_{OH}). To alleviate this situation input resistors $< 10\text{ k}\Omega$ should be used. The addition of positive feedback ($< 10\text{ mV}$) is also recommended.

It is good design practice to ground all unused pins. Differential input voltages may be larger than supply voltage without damaging the comparator's inputs. Voltages more negative than -0.3 V should not be used.

FIGURE 8 – ZERO CROSSING DETECTOR (Single Supply)

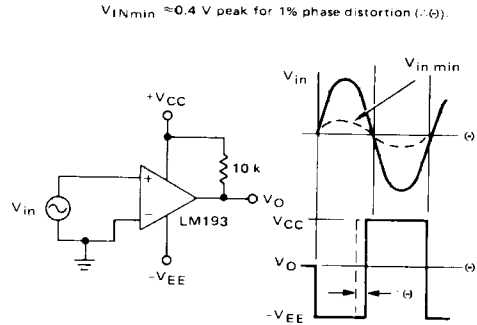


D1 prevents input from going negative by more than 0.6 V.

$$R1 + R2 = R3$$

$$R3 \leq \frac{R5}{10} \text{ for small error in zero crossing}$$

FIGURE 9 – ZERO CROSSING DETECTOR (Split Supplies)



$V_{INmin} \approx 0.4\text{ V}$ peak for 1% phase distortion ($-\theta$).

FIGURE 10 – FREE-RUNNING SQUARE-WAVE OSCILLATOR

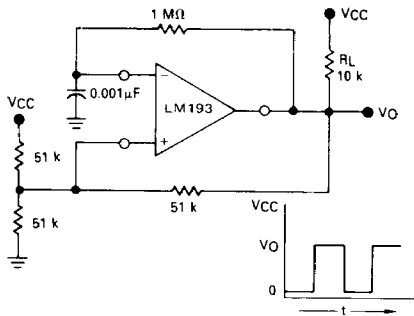
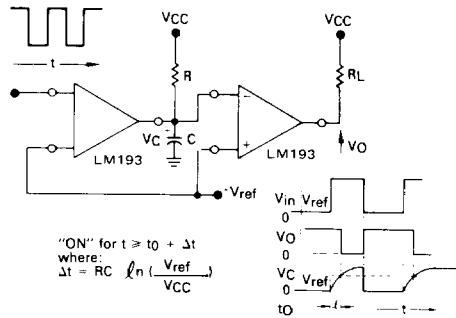
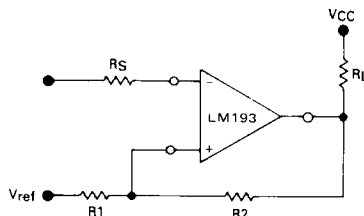


FIGURE 11 – TIME DELAY GENERATOR



"ON" for $t \geq t_0 + \Delta t$
where:
 $\Delta t = RC \ln \left(\frac{V_{ref}}{V_{CC}} \right)$

FIGURE 12 – COMPARATOR WITH HYSTERESIS



$$R_S = R1 \parallel R2$$

$$V_{th1} = V_{ref} + \frac{(V_{CC} - V_{ref}) R1}{R1 + R2 + R_L}$$

$$V_{th2} = V_{ref} - \frac{(V_{ref} - V_{Q Low}) R1}{R1 + R2 + R_L}$$