

# $\mu$ A 193/293/393/2903 Low-Power, Low-Offset Dual Comparators

Linear Products

### Description

The  $\mu$ A193 series consists of two independent precision voltage comparators designed specifically to operate from a single power supply. Operation from split power supplies is also possible and the low power supply current drain is independent of the supply voltage range. Darlington connected pnp input stage allows the input common-mode voltage to include ground.

- SINGLE SUPPLY OPERATION +2.0 V TO +36 V
- DUAL SUPPLY OPERATION  $\pm 1.0$  V TO  $\pm 18$  V
- ALLOW COMPARISON OF VOLTAGES NEAR GROUND POTENTIAL
- LOW CURRENT DRAIN 400  $\mu$ A TYP
- COMPATIBLE WITH ALL FORMS OF LOGIC
- LOW INPUT BIAS CURRENT 25 nA TYP
- LOW INPUT OFFSET CURRENT  $\pm 5$  nA TYP
- LOW OFFSET VOLTAGE  $\pm 2$  mV

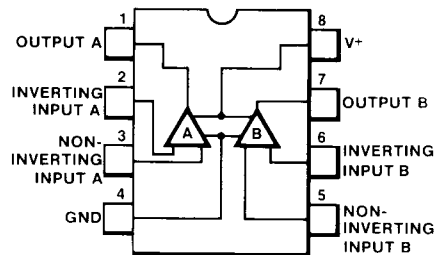
### Absolute Maximum Ratings

Supply Voltage, V+	36 V or $\pm 18$ V
Differential Input Voltage	36 V
Input Voltage Range	$-0.3$ V to +36 V
Power Dissipation (Note 1)	
9T, 6T	800 mW
Output Short-Circuit to GND, (Note 2)	Continuous
Input Current ( $V_{IN} < -0.3$ V, (Note 3))	50 mA
Operating Temperature Range	
$\mu$ A393, $\mu$ A393A	$0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$
$\mu$ A293, $\mu$ A293A	$-25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
$\mu$ A193, $\mu$ A193A	$-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
$\mu$ A2903	$-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
Storage Temperature Range	$-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Pin Temperature	
Hermetic DIP,	$300^{\circ}\text{C}$
Metal Package (Soldering 60 s)	
Molded DIP (Soldering, 10 s)	

### Notes

- For operating at high temperatures, the  $\mu$ A393/ $\mu$ A393A,  $\mu$ A2903 must be derated based on a  $125^{\circ}\text{C}$  maximum junction temperature and a thermal resistance of  $175^{\circ}\text{C}/\text{W}$  which applies for the device soldered in a printed circuit board, operating in a still air ambient. The  $\mu$ A193 and  $\mu$ A193A must be derated based on a  $150^{\circ}\text{C}$  maximum junction temperature. The low bias dissipation and the "ON-OFF" characteristic of the outputs keeps the chip dissipation very small ( $P_D \leq 100$  mW), provided the output transistors are allowed to saturate.
- Short circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent to the magnitude of V+.
- This input current will exist only 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 the 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 is negative, again returns to a value greater than  $-0.3$  V.

### Connection Diagram 8-Pin DIP

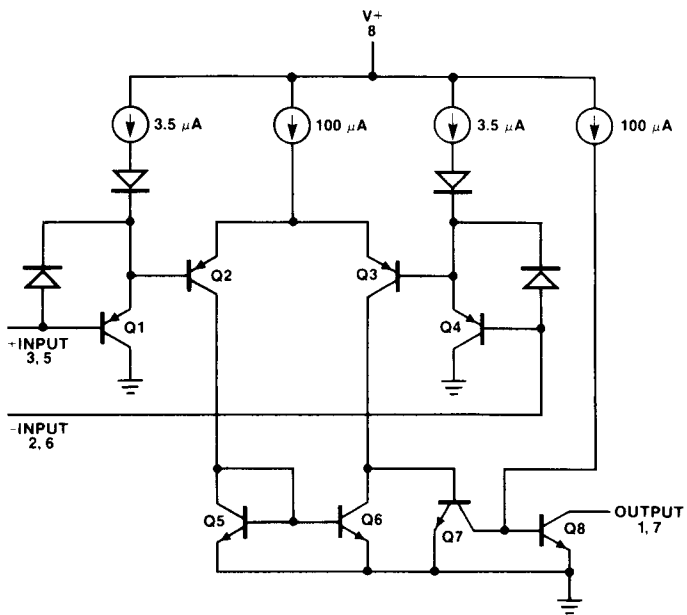


(Top View)

### Order Information

Type	Package	Code	Part No.
$\mu$ A193A	Ceramic DIP	6T	$\mu$ A193ARM
$\mu$ A193	Ceramic DIP	6T	$\mu$ A193RM
$\mu$ A293A	Ceramic DIP	6T	$\mu$ A293ARC
$\mu$ A293A	Molded DIP	9T	$\mu$ A293ATC
$\mu$ A293	Ceramic DIP	6T	$\mu$ A293RC
$\mu$ A293	Molded DIP	9T	$\mu$ A293TC
$\mu$ A393A	Ceramic DIP	6T	$\mu$ A393ARC
$\mu$ A393A	Molded DIP	9T	$\mu$ A393ATC
$\mu$ A393	Ceramic DIP	6T	$\mu$ A393RC
$\mu$ A393	Molded DIP	9T	$\mu$ A393TC
$\mu$ A2903	Ceramic DIP	6T	$\mu$ A2903RC
$\mu$ A2903	Molded DIP	9T	$\mu$ A2903TC

Circuit Schematic (1/2 of Circuit Shown)



μA193/A, μA293A, and μA393A

Electrical Characteristics V+ = 5 V (Note 4)

Characteristic	Condition	μA193A			μA293A, μA393A			μA193			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	T <sub>A</sub> = 25°C, (Note 9)		±1.0	±2.0		±1.0	±2.0		±2.0	±5.0	mV
Input Bias Current	I <sub>IN(+)</sub> or I <sub>IN(-)</sub> with Output in Linear Range, T <sub>A</sub> = 25°C, (Note 5)		25	100		25	250		25	100	nA
Input Offset Current	I <sub>IN(+)</sub> - I <sub>IN(-)</sub> , T <sub>A</sub> = 25°C		±5.0	±25		±5.0	±50		±5.0	±25	nA
Input Common-Mode Voltage Range	T <sub>A</sub> = 25°C, (Note 6)	0		V+ -1.5	0		V+ -1.5	0		V+ -1.5	V
Supply Current	R <sub>L</sub> = ∞ on all Comparators, T <sub>A</sub> = 25°C R <sub>L</sub> = ∞, V+ = 30 V, T <sub>A</sub> = 25°C		0.4 1.0	1.0 2.5		0.4 1.0	1.0 2.5		0.4 1.0	1.0 2.5	mA
Voltage Gain	R <sub>L</sub> ≥ 15 kΩ, V+ = 15 V (To Support Large V <sub>O</sub> Swing), T <sub>A</sub> = 25°C	50	200		50	200		50	200		V/mV
Large Signal Response Time	V <sub>IN</sub> = TTL Logic Swing, V <sub>REF</sub> = 1.4 V, V <sub>RL</sub> = 5.0 V, R <sub>L</sub> = 5.1 kΩ, T <sub>A</sub> = 25°C		300			300			300		ns
Response Time	V <sub>RL</sub> = 5.0 V, R <sub>L</sub> = 5.1 kΩ, T <sub>A</sub> = 25°C, (Note 7)		1.3			1.3			1.3		μs
Output Sink Current	V <sub>IN(-)</sub> ≥ 1.0 V, V <sub>IN(+)</sub> = 0, V <sub>O</sub> ≤ 1.5 V, T <sub>A</sub> = 25°C	6.0	16		6.0	16		6.0	16		mA
Saturation Voltage	V <sub>IN(-)</sub> ≥ 1.0 V, V <sub>IN(+)</sub> = 0, I <sub>sink</sub> ≤ 4.0 mA, T <sub>A</sub> = 25°C		250	400		250	400		250	400	mV
Output Leakage Current	V <sub>IN(+)</sub> ≥ 1.0 V, V <sub>IN(-)</sub> = 0, V <sub>O</sub> = 30 V, T <sub>A</sub> = 25°C			200			200			200	nA
Input Offset Voltage	(Note 9)			4.0			4.0			9.0	mV
Input Offset Current	I <sub>IN(+)</sub> - I <sub>IN(-)</sub>			±100			±150			±100	nA
Input Bias Current	I <sub>IN(+)</sub> or I <sub>IN(-)</sub> with Output in Linear Range			300			400			300	nA
Input Common-Mode Voltage Range		0		V+ -2.0	0		V+ -2.0	0		V+ -2.0	V
Saturation Voltage	V <sub>IN(-)</sub> ≥ 1.0 V, V <sub>IN(+)</sub> = 0, I <sub>sink</sub> ≤ 4 mA			700			700			700	mV
Output Leakage Current	V <sub>IN(+)</sub> ≥ 1.0 V, V <sub>IN(-)</sub> = 0, V <sub>O</sub> = 30 V			1.0			1.0			1.0	μA
Differential Input Voltage	Keep all V <sub>INs</sub> ≥ 0 V (or V-, if used), (Note 8)			V+			V+			V+	V

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Notes

- These specifications apply for V+ = 5.0 V and -55°C ≤ T<sub>A</sub> ≤ +125°C, unless otherwise stated. With the μA293/μA293A, all temperature specifications are limited to -25°C ≤ T<sub>A</sub> ≤ +85°C, the μA393/μA393A temperature specifications are limited to 0°C ≤ T<sub>A</sub> ≤ 70°C, and the μA2903 temperature range is -40°C ≤ T<sub>A</sub> ≤ +85°C.
- 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 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 V, but either or both inputs can go to +30 V without damage.
- The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained; see typical performance curves.

μA293, μA393 and μA2903

Electrical Characteristics  $V_+ = 5\text{ V}$  (Note 4)

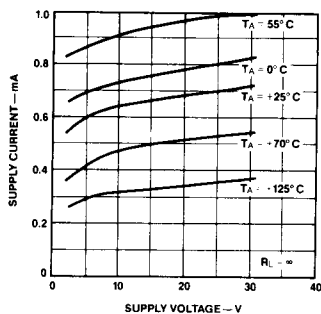
Characteristic	Condition	μA293, μA393			μA2903			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25^\circ\text{C}$ , (Note 9)		$\pm 2.0$	$\pm 5.0$		$\pm 2.0$	$\pm 7.0$	mV
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range, $T_A = 25^\circ\text{C}$ , (Note 5)		25	250		25	250	nA
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$ , $T_A = 25^\circ\text{C}$		$\pm 5.0$	$\pm 50$		$\pm 5.0$	$\pm 50$	nA
Input Common-Mode Voltage Range	$T_A = 25^\circ\text{C}$ , (Note 6)	0		$V_+ - 1.5$	0		$V_+ - 1.5$	V
Supply Current	$R_L = \infty$ on all Comparators, $T_A = 25^\circ\text{C}$ $R_L = \infty$ , $V_+ = 30\text{ V}$ , $T_A = 25^\circ\text{C}$		0.4 1.0	1.0 2.5		0.4 1.0	1.0 2.5	mA
Voltage Gain	$R_L \geq 15\text{ k}\Omega$ , $V_+ = 15\text{ V}$ (To Support Large $V_O$ Swing), $T_A = 25^\circ\text{C}$	50	200		25	100		V/mV
Large Signal Response Time	$V_{IN} = \text{TTL Logic Swing}$ , $V_{REF} = 1.4\text{ V}$ , $V_{RL} = 5.0\text{ V}$ , $R_L = 5.1\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$		300			300		ns
Response Time	$V_{RL} = 5.0\text{ V}$ , $R_L = 5.1\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$ , (Note 7)		1.3			1.3		$\mu\text{s}$
Output Sink Current	$V_{IN(-)} \geq 1.0\text{ V}$ , $V_{IN(+)} = 0$ , $V_O \leq 1.5\text{ V}$ , $T_A = 25^\circ\text{C}$	6.0	16		6.0	16		mA
Saturation Voltage	$V_{IN(-)} \geq 1.0\text{ V}$ , $V_{IN(+)} = 0$ , $I_{\text{sink}} \leq 4.0\text{ mA}$ , $T_A = 25^\circ\text{C}$		250	400		250	400	mV
Output Leakage Current	$V_{IN(+)} \geq 1.0\text{ V}$ , $V_{IN(-)} = 0$ , $V_O = 30\text{ V}$ , $T_A = 25^\circ\text{C}$			200			200	nA
Input Offset Voltage	(Note 9)			9.0		9.0	15	mV
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$			$\pm 150$		50	200	nA
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range			400		200	500	nA
Input Common-Mode Voltage Range		0		$V_+ - 2.0$	0		$V_+ - 2.0$	V
Saturation Voltage	$V_{IN(-)} \geq 1.0\text{ V}$ , $V_{IN(+)} = 0$ , $I_{\text{sink}} \leq 4\text{ mA}$			700		400	700	mV
Output Leakage Current	$V_{IN(+)} \geq 1.0\text{ V}$ , $V_{IN(-)} = 0$ , $V_O = 30\text{ V}$			1.0			1.0	$\mu\text{A}$
Differential Input Voltage	Keep all $V_{INs} \geq 0\text{ V}$ (or $V_-$ , if used), (Note 8)			$V_+$			$V_+$	V

Notes

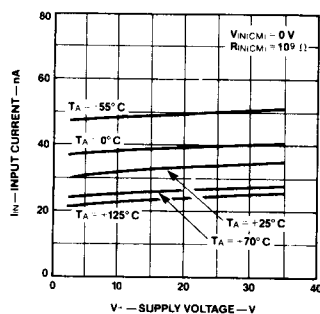
- Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, comparator will provide a proper output state. The low input voltage state must not be less than  $-0.3\text{ V}$  or  $0.3\text{ V}$  below the magnitude of the negative power supply, if used.
- At output switch point,  $V_O \cong 1.4\text{ V}$ ,  $R_S = 0\ \Omega$  with  $V_+$  from  $5\text{ V}$ ; and over the full input common-mode range ( $0\text{ V}$  to  $V_+ - 1.5\text{ V}$ ).
- For input signals that exceed  $V_{CC}$ , only the overdriven comparator is affected. With a  $5\text{ V}$  supply,  $V_{IN}$  should be limited to  $25\text{ V}$  max, and a limiting resistor should be used on all inputs that might exceed the positive supply.

Typical Performance Curves for  $\mu A193/293/393$

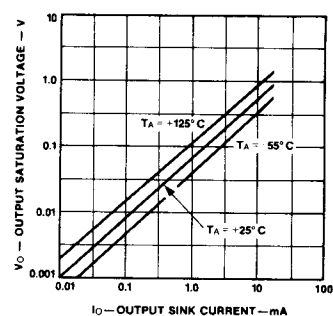
Supply Current



Input Current

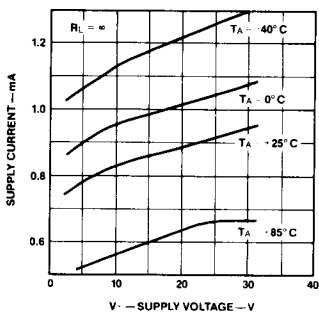


Output Saturation Voltage

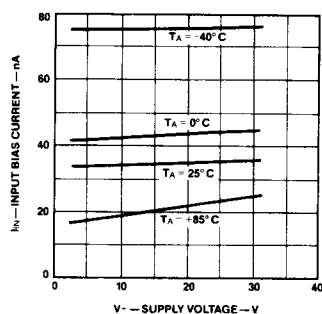


Typical Performance Curves for  $\mu A2903$

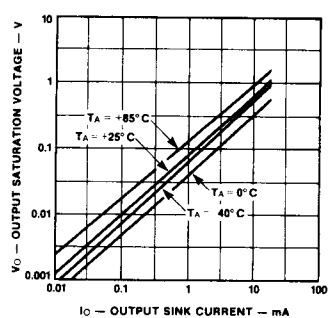
Supply Current



Input Current



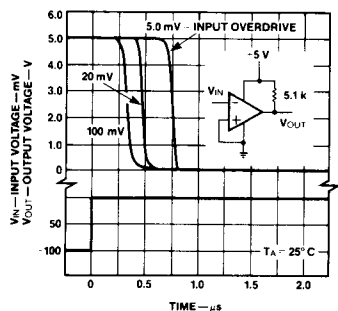
Output Saturation Voltage



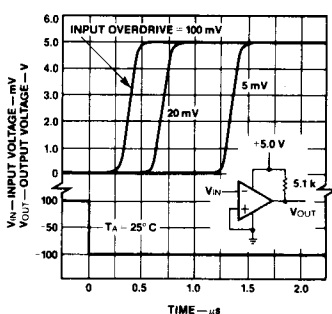
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Typical Performance Curves For All Devices

Response Time for Various Input Overdrives Negative Transition



Response Time for Various Input Overdrives Positive Transition



### Application Information

The  $\mu$ A193 series are high-gain, wide-bandwidth devices which, like most comparators, can easily oscillate if the output lead is inadvertently allowed to capacitively couple to the inputs via stray capacitance. This shows up only during the output voltage transition intervals as the comparator changes states. Power supply bypassing is not required to solve this problem. Standard pc board layout is helpful as it reduces stray input-output coupling. Reducing the input resistors to less than 10 k $\Omega$  reduces the feedback signal levels and finally, adding even a small amount (1.0 to 10 mV) of positive feedback (hysteresis) causes such a rapid transition that oscillations due to stray feedback are not possible. Simply socketing the IC and attaching resistors to the pins will cause input-output oscillations during the small transition intervals unless hysteresis is used. If the input signal is a pulse waveform, with relatively fast rise and fall times, hysteresis is not required. All pins of any unused comparators should be grounded.

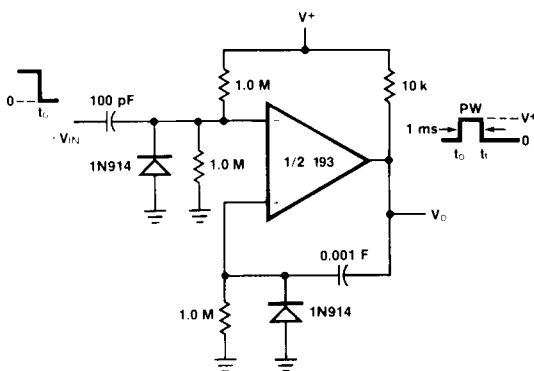
The bias network of the  $\mu$ A193 series establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from 2 V to 30 V. It is unnecessary to use a bypass capacitor across the power supply line.

The differential input voltage may be larger than  $V+$  without damaging the device. Protection should be provided to prevent the input voltages from going negative more than  $-0.3$  V (at 25°C). An input clamp diode can be used as shown in the applications section.

The output of the  $\mu$ A193 series is the uncommitted collector of a grounded-emitter npn output transistor. Many collectors can be tied together to provide an output ORing function. An output pull-up resistor can be connected to any available power supply voltage within the permitted supply voltage range and there is no restriction on this voltage due to the magnitude of the voltage which is applied to the  $V+$  terminal of the  $\mu$ A193 package. The output can also be used as a simple SPST switch to ground (when a pull-up resistor is not used). The amount of current which the output device can sink is limited by the drive available (which is independent of  $V+$ ) and the  $\beta$  of this device. When the maximum current limit is reached (approximately 16 mA), the output transistor will come out of saturation and the output voltage will rise very rapidly. The output saturation voltage is limited by the approximately 60  $\Omega$  saturation resistance of the output transistor. The low offset voltage of the output transistor (1 mV) allows the output to clamp essentially to ground level for small load currents.

### Typical Applications ( $V+ = 15$ V)

#### One-Shot Multivibrator



#### Bi-Stable Multivibrator

