LM139/A/239/A/339/A/2901-F,N • MC3302-N

DESCRIPTION

The LM139 series consists of four independent precision voltage comparators with an offset voltage specification as low as 2.0mV max for each comparator 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 LM139 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM139 series will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.

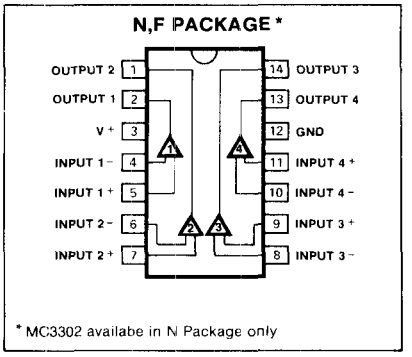
FEATURES

- **Wide single supply voltage range 2.0Vdc to 36Vdc or dual supplies ±1.0Vdc to ±18Vdc**
- **Very low supply current drain (0.8mA) independent of supply voltage (1.0mW/-comparator at 5.0Vdc)**
- **Low input biasing current 25nA**
- **Low input offset currrent ±5nA and offset voltage ±3mV**
- **Input common-mode voltage range includes ground**
- **Differential input voltage range equal to the power supply voltage.**
- **Low output 250mV at 4mA saturation voltage**
- **Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems.**

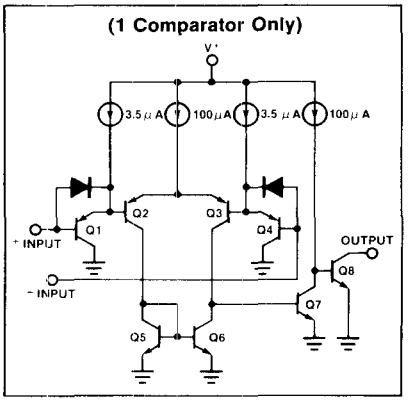
APPLICATIONS

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

PIN CONFIGURATION



EQUIVALENT CIRCUIT



ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
V_{CC} supply voltage	36 or ±18	Vdc
Differential input voltage	36	Vdc
Input voltage	-0.3 to +36	Vdc
Power dissipation[1]		
Molded DIP	570	mW
CERDIP	900	mW
Output short circuit to ground[2]	Continuous	
Input current (V_{IN} < -0.3Vdc)[3]	50	mA
Operating temperature range		
LM139/139A	-55 to +125	°C
LM239/239A	-25 to +85	°C
LM339/339A	0 to +70	°C
LM2901/MC3302	-40 to +85	°C
Storage temperature range	-65 to +150	°C
Lead temperature (soldering 10 sec.)	300	°C

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LM139/A/239/A/339/A/2901-F,N • MC3302-N

DC ELECTRICAL CHARACTERISTICS

V+ = 5Vdc, LM139A/LM139: $-55°C \leq T_A \leq 125°C$ unless otherwise specified
LM239: $-25°C \leq T_A \leq 85°C$ unless otherwise specified
LM339: $0°C \leq T_A \leq 70°C$ unless otherwise specified

PARAMETER	TEST CONDITIONS	LM139			LM239/339			LM139A			UNIT
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OS} Input offset voltage[5]	$T_A = 25°C$ Over temp.		±2.0	±5.0 9.0		±2.0	±5.0 9.0		±1.0	±2.0 4.0	mV
V_{CM} Input common mode voltage range[6]	$T_A = 25°C$ Over temp.	0 0		V+-1.5 V+-2.0	0 0		V+-15 V+-20	0 0		V+-1.5 V+-2.0	V
V_{IDR} Differential input voltage[4]	Keep all $V_{IN's} \geq$ 0Vdc (or V-if need)			V+			V+			V+	V
I_B Input bias current[7]	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range $T_A = 25°C$ Over temp.		25	100 300		25	250 400		25	100 300	nA
I_{OS} Input offset current	$I_{IN(+)} - I_{IN(-)}$ $T_A = 25°C$ Over temp.		±3.0	±25 ±100		±5.0	±50 ±150		±3.0	±25 ±100	nA nA
I_{OL} Output sink current	$V_{IN(-)} \geq$ 1Vdc, $V_{IN(+)} = 0$, $V_O \leq$ 1.5Vdc, $T_A = 25°C$	6.0	16		6.0	16		6.0	16		mA
I_{OH} Output leakage current	$V_{IN(+)} \geq$ 1Vdc, $V_{IN(-)} = 0$ V_O = 5Vdc, $T_A = 25°C$ V_O = 30Vdc, over temp.		0.1	 1.0		0.1	 1.0		0.1	 1.0	nA μA
I_{CC} Supply current[9]	$R_L = \infty$ on comparators, $T_A = 25°C$		0.8	2.0		0.8	2.0		0.8	2.0	mA
A_V Voltage gain	$R_L \geq 15k\Omega$, V+ = 15Vdc	50	200		50	200		50	200		V/mV
V_{OL} Saturation voltage	$V_{IN(-)} \geq$ 1Vdc, $V_{IN(+)} = 0$, $I_{SINK} \leq$ 4mA $T_A = 25°C$ Over temp.		250	400 700		250	400 700		250	400 700	mV
T_{LSR} Large signal response time	V_{IN} = TTL logic swing, V_{REF} = 1.4Vdc, V_{RL} = 5Vdc, $R_L = 5.1k\Omega$, $T_A = 25°C$		300			300			300		ns
T_R Response time[8]	V_{RL} = 5Vdc, $R_L = 5.1k\Omega$, $T_A = 25°C$		1.3			1.3			1.3		μs

LM139/A/239/A/339/A/2901-F,N • MC3302-N

DC ELECTRICAL CHARACTERTISICS

(Cont'd) V+ = 5Vdc, LM339A: 0°C ≤ T_A ≤ 70°C unless otherwise specified
LM239A: -25°C ≤ T_A ≤ 85°C unless otherwise specified
LM2901/LM3302: -40°C ≤ T_A ≤ 85°C unless otherwise specified

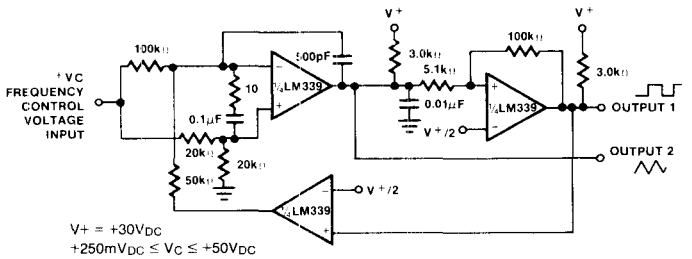
PARAMETER	TEST CONDITIONS	LM239A/339A			LM2901			MC3302			UNIT
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OS} Input offset voltage[5]	T_A = 25°C Over temp.		±1.0	±2.0 ±4.0		±2.0 ±9	±7.0 ±15		±3.0	±20 ±40	mV
V_{CM} Input common mode voltage range[6]	T_A = 25°C Over temp.	0 0		V+-1.5 V+-2.0	0 0		V+-1.5 V+-2.0			V+-1.5 V+-2.0	V
V_{IDR} Differential input voltage[4]	Keep all V_{IN}'s ≥ 0Vdc (or V- if need)			V+			V+			V+	V
I_B Input bias current[7]	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range T_A = 25°C Over temp.		25	250 400		25 200	250 500		25	500 1000	nA
I_{OS} Input offset current	$I_{IN(+)}$ - $I_{IN(-)}$ T_A = 25°C Over temp.		±5.0	±50 ±150		±5 ±50	±50 ±200		±5	±100 ±300	nA nA
I_{OL} Output sink current	$V_{IN(-)}$ ≥ 1Vdc, $V_{IN(+)}$ = 0, V_O ≤ 1.5Vdc, T_A = 25°C V_O = 800mV, Over temp.	6.0	16		6.0	16		2.0			mA
I_{OH} Output leakage current	$V_{IN(+)}$ ≥ 1Vdc, $V_{IN(-)}$ = 0 V_O = 5Vdc, T_A = 25°C V_O = 30Vdc, Over temp.		0.1	 1.0		0.1	 1.0		0.1	 1.0	nA μA
I_{CC} Supply current[9]	R_L = ∞ on comparators, V+ = 5Vdc T_A = 25°C V+ = 30V, T_A = 25°C		0.8	2.0		0.8 1.0	2.0 2.5		0.8	2.0	mA
A_V Voltage gain	R_L ≥ 15kΩ, V+ = 15Vdc	50	200		25	100		2	100		V/mV
V_{OL} Saturation voltage	$V_{IN(-)}$ ≥ 1Vdc, $V_{IN(+)}$ = 0, I_{SINK} ≤ 4mA T_A = 25°C Over temp. I_{SINK} = 2mA, V+ = 5V to 28V, T_A = 25°C		250	400 700		400	400 700		150	400 700	mV
T_{LSR} Large signal response time	V_{IN} = TTL logic swing, V_{REF} = 1.4Vdc, V_{RL} = 5Vdc, R_L = 5.1kΩ, T_A = 25°C		300			300			300		ns
T_R Response time[8]	V_{RL} = 5Vdc, R_L = 5.1kΩ, T_A = 25°C		1.3			1.3			1.3		μs

NOTES

1. For operating at high temperatures, the LM339/339A, LM2901 and MC3302 must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM139/139A/239/239A must be derated on a 150°C maximum junction temperature. The low power dissipation and the "On-Off" characteristics of the outputs keep the chip dissipation very small ($P_D \leq 100mW$), provided the output transistors are allowed to saturate.
2. Short circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of V+.
3. 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 -0.3Vdc.
4. 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 -0.3Vdc (or 0.3Vdc below the magnitude of the negative power supply, if used).
5. At output switch point, $V_O \cong 1.4Vdc$, $R_S = 0\Omega$ with V+ from 5Vdc to 30Vdc; and over the full input common-mode range (0Vdc to V+ -1.5Vdc).
6. The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V+ -1.5V, but either or both inputs can go to 30Vdc without damage.
7. 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.
8. The response time specified is for a 100mV input step with a 5mV overdrive. For larger overdrive signals, 300ns can be obtained, see typical performance characteristics section.
9. The MC3302 has supply current specified with a voltage range of 5 to 28 volts.

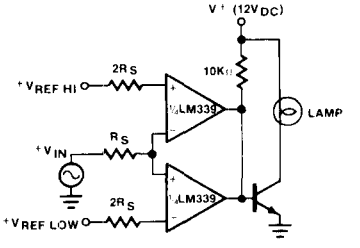
TYPICAL APPLICATIONS

TWO-DECADE HIGH-FREQUENCY VCO

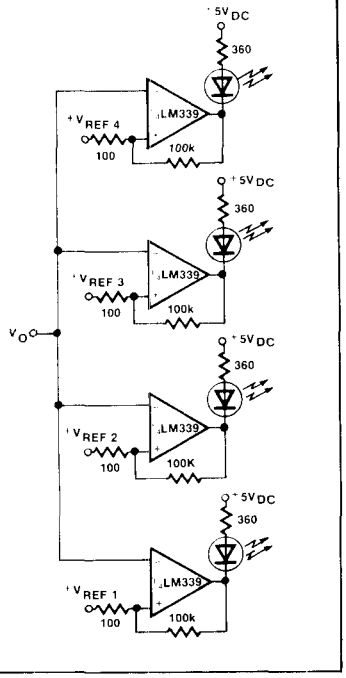


V+ = +30V_{DC}
+250m$V_{DC} \leq V_C \leq$ +50V_{DC}
700Hz $\leq f_O \leq$ 100kHz

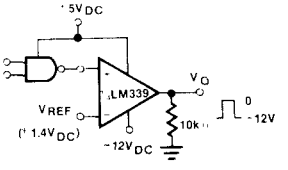
LIMIT COMPARATOR



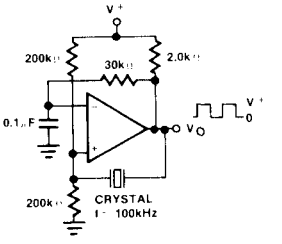
VISIBLE VOLTAGE INDICATOR



TTL TO MOS LOGIC CONVERTER

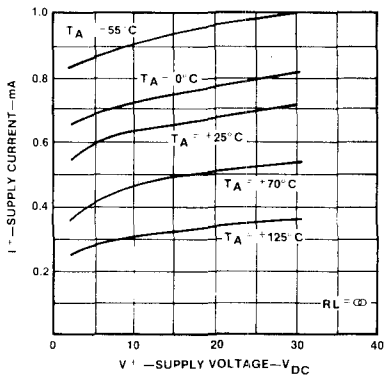


CRYSTAL CONTROLLED OSCILLATOR

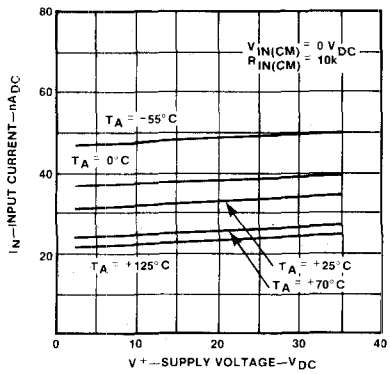


TYPICAL PERFORMANCE CHARACTERISTICS

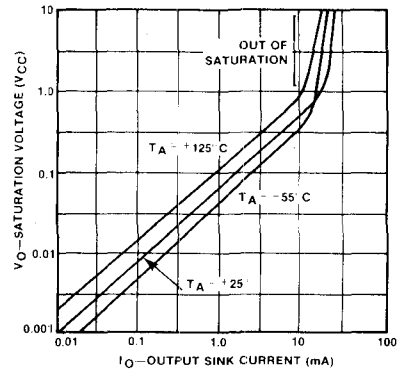
SUPPLY CURRENT



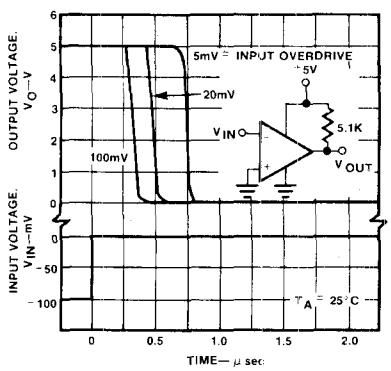
INPUT CURRENT



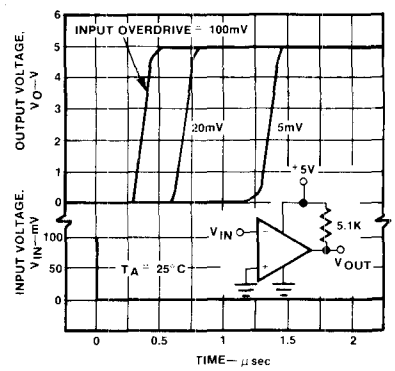
OUTPUT SATURATION VOLTAGE



RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES— NEGATIVE TRANSITION



RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES— POSITIVE TRANSITION



LM193/293/393/193A/293A/393A/2903-N,T

DESCRIPTION

The LM193 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0mV 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

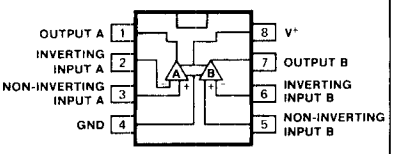
- **Wide single supply voltage range 2.0Vdc to 36Vdc or dual supplies ±1.0Vdc to ±18Vdc**
- **Very low supply current drain (0.8mA) independent of supply voltage (2.0mW/-comparator at 5.0Vdc)**
- **Low input biasing current 25nA**
- **Low input offset current ±5nA and offset voltage ±3mV**
- **Input common-mode voltage range includes ground**
- **Differential input voltage range equal to the power supply voltage.**
- **Low output 250mV at 4mA saturation voltage**
- **Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems.**

APPLICATIONS

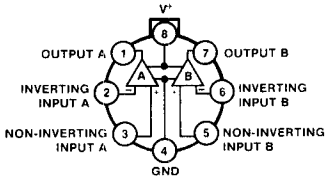
- **A/D converters**
- **Wide range VCO**
- **MOS clock generator**
- **High voltage logic gate**
- **Multivibrators**

PIN CONFIGURATIONS

N PACKAGE

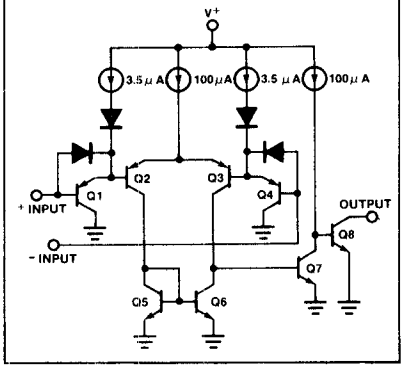


T PACKAGE



EQUIVALENT CIRCUIT

(One Comparator Only)



ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
V_{CC} supply voltage	36 or ±18	Vdc
Differential input voltage	36	Vdc
Input voltage	-0.3 to +36	Vdc
Power dissipation[1]		
Molded DIP	570	mW
Metal can	900	mW
Output short circuit to ground[2]	Continuous	
Input current (V_{IN} < -0.3Vdc)[3]	50	mA
Operating temperature range		
LM193/193A	-55 to +125	°C
LM293/293A	-25 to +85	°C
LM393/393A	0 to +70	°C
LM2903	-40 to +85	°C
Storage temperature range	-65 to +150	°C
Lead temperature (soldering 10 sec.)	300	°C

LM193/293/393/193A/293A/393A/2903-N,T

DC ELECTRICAL CHARACTERISTICS

V+ = 5Vdc, LM193/193A: $-55°C \leq T_A \leq +125°C$ unless otherwise specified.
LM293/293A: $-25°C \leq T_A \leq +85°C$ unless otherwise specified.
LM393/393A: $0°C \leq T_A \leq +70°C$ unless otherwise specified.
LM2903: $-40°C \leq T_A \leq +85°C$ unless otherwise specified.[7]

PARAMETER		TEST CONDITIONS	LM193A			LM293A/393A			LM2903			UNIT
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OS}	Input offset voltage[5]	$T_A = 25°C$ Over temp.		±1.0	±2.0 ±4.0		±1.0	±2.0 ±4.0		±2.0 ±9	±7.0 ±15	mV
V_{CM}	Input common mode voltage range[6,10]	$T_A = 25°C$ Over temp.	0 0		V+-1.5 V+-2.0	0 0		V+-1.5 V+-2.0	0 0		V+-1.5 V+-2.0	V
V_{IDR}	Differential input voltage[4]	Keep all $V_{IN's} \geq$ 0Vdc (or V-if need)			V+			V+			V+	V
I_B	Input bias current[8]	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range $T_A = 25°C$ Over temp.		25	100 300		25	250 400		25 200	250 500	nA
I_{OS}	Input offset current	$I_{IN(+)} - I_{IN(-)}$ $T_A = 25°C$ Over temp.		±3.0	±25 ±100		±5.0	±50 ±150		±5 ±50	±50 ±200	nA nA
I_{OL}	Output sink current	$V_{IN(-)} \geq$ 1Vdc, $V_{IN(+)} = 0$, $V_O \leq$ 1.5Vdc, $T_A = 25°C$	6.0	16		6.0	16		6.0	16		mA
I_{OH}	Output leakage current	$V_{IN(+)} \geq$ 1Vdc, $V_{IN(-)} = 0$ V_O = 30Vdc Over temp. V_O = 5Vdc, $T_A = 25°C$		0.1	1.0		0.1	1.0		0.1	1.0	µA na
I_{CC}	Supply current	$R_L = \infty$ on both comparators. $T_A = 25°C$ V+ = 30V, over temp.		0.8 1	1 2.5		0.8 1	1 2.5		0.8 1	1 2.5	mA
A_V	Voltage gain	$R_L \geq 15k\Omega$, V+ = 15Vdc	50	200		50	200		25	100		V/mV
V_{OL}	Saturation voltage	$V_{IN(-)} \geq$ 1Vdc, $V_{IN(+)} = 0$, $I_{SINK} \leq$ 4mA $T_A = 25°C$ Over temp.		250	400 700		250	400 700		400	400 700	mV
T_{LSR}	Large signal response time	V_{IN} = TTL logic swing, V_{REF} = 1.4Vdc, V_{RL} = 5Vdc, $R_L = 5.1k\Omega$, $T_A = 25°C$		300			300			300		ns
T_R	Response time[9]	V_{RL} = 5Vdc, $R_L = 5.1k\Omega$, $T_A = 25°C$		1.3			1.3			1.3		µs

LM193/293/393/193A/293A/393A/2903-N,T

DC ELECTRICAL CHARACTERISTICS (Cont'd) V+ = 5Vdc, LM193/193A: $-55°C \leq T_A \leq +125°C$ unless otherwise specified.
LM293/293A: $-25°C \leq T_A \leq +85°C$ unless otherwise specified.
LM393/393A: $0°C \leq T_A \leq +70°C$ unless otherwise specified.
LM2903: $-40°C \leq T_A \leq +85°C$ unless otherwise specified.[7]

PARAMETER		TEST CONDITIONS	LM193			LM293/393			UNIT
			Min	Typ	Max	Min	Typ	Max	
V_{OS}	Input offset voltage[5]	$T_A = 25°C$ Over temp.		±2.0	±5.0 ±9.0		±2.0	±5.0 ±9.0	mV
V_{CM}	Input common mode voltage range[6,10]	$T_A = 25°C$ Over temp.	0 0		V±-1.5 V±-2.0	0 0		V±-1.5 V±-2.0	V
V_{IDR}	Differential input voltage[4]	Keep all $V_{IN's} \geq 0Vdc$ (or V-if need)			V+			V+	V
I_B	Input bias current[8]	$I_{IN(+)}$ or $I_{IN(-)}$ with output in linear range $T_A = 25°C$ Over temp.		25	100 300		25	250 400	nA
I_{OS}	Input offset current	$I_{IN(+)} - I_{IN(-)}$ $T_A = 25°C$ Over temp.		±3.0	±25 ±100		±5.0	±50 ±150	nA nA
I_{OL}	Output sink current	$V_{IN(-)} \geq 1Vdc$, $V_{IN(+)} = 0$, $V_0 \leq 1.5Vdc$, $T_A = 25°C$	6.0	16		6.0	16		mA
I_{OH}	Output leakage current	$V_{IN(+)} \geq 1Vdc$, $V_{IN(-)} = 0$ $V_0 = 5Vdc$, $T_A = 25°C$ $V_0 = 30Vdc$, over temp.		0.1	 1.0		0.1	 1.0	nA μA
I_{CC}	Supply current	$R_L = \infty$ on both comparators $T_A = 25°C$ V+ = 30V, over temp.		0.8	1 2.5		0.8	1 2.5	mA
A_V	Voltage gain	$R_L \geq 15K\Omega$, V+ = 15Vdc	50	200		50	200		V/mV
V_{OL}	Saturation voltage	$V_{IN(-)} \geq 1Vdc$, $V_{IN(+)} = 0$, $I_{SINK} \leq 4mA$ $T_A = 25°C$ Over temp.		250	400 700		250	400 700	mV
T_{LSR}	Large signal response time	V_{IN} = TTL logic swing, $V_{REF} = 1.4Vdc$, $V_{RL} = 5Vdc$, $R_L = 5.1k\Omega$, $T_A = 25°C$		300			300		ns
T_R	Response time[9]	$V_{RL} = 5Vdc$, $R_L = 5.1k\Omega$, $T_A = 25°C$		1.3			1.3		μs

NOTES

1. For operating at high temperatures, the LM393/393A and LM2903 must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM193/193A/293/293A must be derated based on a 150°C maximum junction temperature. The low bias dissipation and the "On-Off" characteristics of the outputs keeps the chip dissipation very small ($P_D \leq 100mW$), provided the output transistors are allowed to saturate.
2. Short circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of V+.
3. 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 -0.3Vdc.
4. 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 -0.3Vdc (Vdc below the magnitude of the negative power supply, if used).
5. At output switch point, $V_0 = 1.4Vdc$, $R_S = 0\Omega$ with V+ from 5Vdc to 30Vdc; and over the full input common-mode range (0Vdc to V+ -1.5Vdc).
6. The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V+ -1.5V, but either or both inputs can go to 30Vdc without damage.
7. With the LM293/293A, all temperature specifications are limited to $-25°C \leq T_A \leq +85°C$ and the LM393/393A, all temperature specifications are limited to $0°C \leq T_A \leq +70°C$. The LM2903 is limited to $-40°C \leq T_A \leq 85°C$.
8. 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.
9. The response time specified is for a 100mV input step with a 5mV overdrive. For larger overdrive signals, 300ns can be obtained, see typical performance characteristics section.
10. For input signals that exceed V_{CC}, only the overdriven comparator is affected. With a 5V supply, V_{IN} should be limited to 25V max., and a limiting resistor should be used on all inputs that might exceed the positive supply.