LM193JAN Low Power Low Offset Voltage Dual Comparators

Check for Samples: LM193JAN

FEATURES

- **Wide Supply**
  - **Voltage Range: 5.0V_{DC} to 36V_{DC}**
  - **Single or Dual Supplies: ±2.5V_{DC} to ±18V_{DC}**
- **Very Low Supply Current Drain (0.4 mA) — Independent of Supply Voltage**
- **Low Input Biasing Current: 25 nA typ**
- **Low Input Offset Current: ±3 nA typ**
- **Maximum Offset Voltage +5mV Max @ 25°C**
- **Input Common-Mode Voltage Range Includes Ground**
- **Differential Input Voltage Range Equal to the Power Supply Voltage**
- **Low Output Saturation Voltage,: 250 mV at 4 mA typ**
- **Output Voltage Compatible with TTL, DTL, ECL, MOS and CMOS Logic Systems**

ADVANTAGES

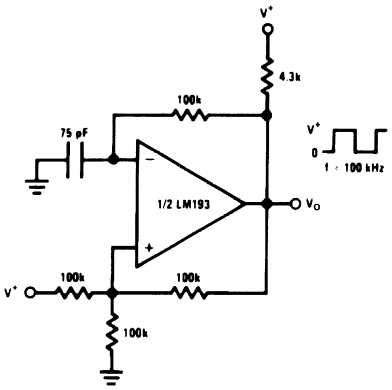
- **High Precision Comparators**
- **Reduced V_{OS} Drift Over Temperature**
- **Eliminates Need for Dual Supplies**
- **Allows Sensing Near Ground**
- **Compatible with all Forms of Logic**
- **Power Drain Suitable for Battery Operation**

DESCRIPTION

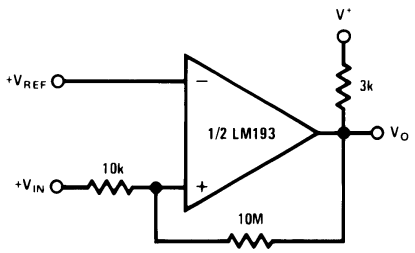
The LM193 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0 mV max for two comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible 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.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. 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.

Squarewave Oscillator



Non-Inverting Comparator with Hysteresis



Schematic and Connection Diagrams

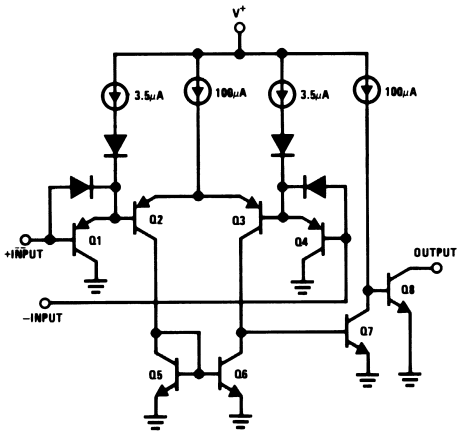


Figure 1. TO-99

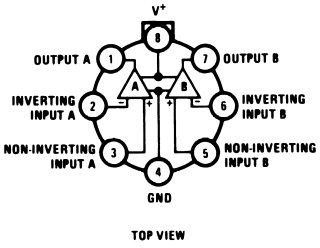
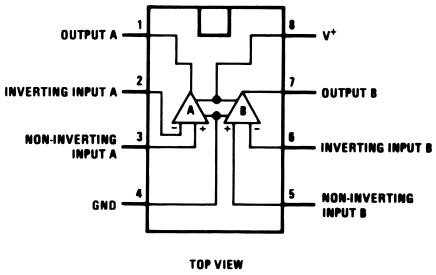


Figure 2. CDIP Package



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings(1)

Supply Voltage, V^+				$36V_{DC}$ or $\pm 18V_{DC}$
Differential Input Voltage(2)				36V
Output Voltage				36V
Input Voltage				$-0.3V_{DC}$ to $+36V_{DC}$
Input Current ($V_{IN} < -0.3V_{DC}$)(3)				50 mA
Power Dissipation(4)			CDIP	400 mW @ T_A = 125°C
			TO-99	330 mW @ T_A = 125°C
Maximum Junction Temperature (T_{Jmax})				175°C
Output Short-Circuit to Ground(5)				Continuous
Operating Temperature Range				$-55°C \le T_A \le +125°C$
Storage Temperature Range				$-65°C \le T_A \le +150°C$
Thermal Resistance	θ_{JA}	TO-99	Metal Can (Still Air)	174°C/W
			Metal Can (500LF/Min Air flow)	99°C/W
		CDIP	CERDIP (Still Air)	146°C/W
			CERDIP (500LF/Min Air flow)	85°C/W
	θ_{JC}	TO-99		44°C/W
		CDIP		33°C/W
Lead Temperature(Soldering, 10 seconds)				260°C
ESD Tolerance(6)				500V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

(2) 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 −0.3V (or 0.3V below the magnitude of the negative power supply, if used).

(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 $-0.3V_{DC}$.

(4) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower.

(5) Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 20 mA independent of the magnitude of V^+.

(6) Human body model, 1.5KΩ in series with 100pF.

Quality Conformance Inspection

Mil-Std-883, Method 5005 - Group A

Subgroup	Description	Temp°C
1	Static tests at	25
2	Static tests at	125
3	Static tests at	-55
4	Dynamic tests at	25
5	Dynamic tests at	125
6	Dynamic tests at	-55
7	Functional tests at	25
8A	Functional tests at	125
8B	Functional tests at	-55
9	Switching tests at	25
10	Switching tests at	125
11	Switching tests at	-55
12	Settling time at	25
13	Settling time at	125
14	Settling time at	-55

LM193JAN Electrical Characteristics
DC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{IO}	Input Offset Voltage	$+V_{CC}$ = 30V, $-V_{CC}$ = 0V, V_O = 15V		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -28V, V_O = -13V		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
		$+V_{CC}$ = 5V, $-V_{CC}$ = 0V, V_O = 1.4V		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -3V, V_O = -1.6V		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
I_{IO}	Input offset Current	$+V_{CC}$ = 30V, $-V_{CC}$ = 0V, V_O = 15V, R_S = 20KΩ	See(1)	-25	25	nA	1, 2
			See(1)	-75	75	nA	3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -28V, V_O = -13V, R_S = 20KΩ	See(1)	-25	25	nA	1, 2
			See(1)	-75	75	nA	3
		$+V_{CC}$ = 5V, $-V_{CC}$ = 0V, V_O = 1.4V, R_S = 20KΩ	See(1)	-25	25	nA	1, 2
			See(1)	-75	75	nA	3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -3V, V_O = -1.6V, R_S = 20KΩ	See(1)	-25	25	nA	1, 2
			See(1)	-75	75	nA	3
$\pm I_{IB}$	Input Bias Current	$+V_{CC}$ = 30V, $-V_{CC}$ = 0V, V_O = 15V, R_S = 20KΩ	See(1)	-100	+0.1	nA	1, 2
			See(1)	-200	+0.1	nA	3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -28V, V_O = -13V, R_S = 20KΩ	See(1)	-100	+0.1	nA	1, 2
			See(1)	-200	+0.1	nA	3
		$+V_{CC}$ = 5V, $-V_{CC}$ = 0V, V_O = 1.4V, R_S = 20KΩ	See(1)	-100	+0.1	nA	1, 2
			See(1)	-200	+0.1	nA	3
		$+V_{CC}$ = 2V, $-V_{CC}$ = -3V, V_O = -1.6V, R_S = 20KΩ	See(1)	-100	+0.1	nA	1, 2
			See(1)	-200	+0.1	nA	3

(1) S/S R_S = 20KΩ, tested with R_S = 100KΩ for better resolution

LM193JAN Electrical Characteristics
DC Parameters (continued)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
CMRR	Input Voltage Common Mode Rejection	2V ≤ $+V_{CC}$ ≤ 30V, -28V ≤ $-V_{CC}$ ≤ 0V, -13V ≤ V_O ≤ 15V		76		dB	1, 2, 3
		2V ≤ $+V_{CC}$ ≤ 5V, -3V ≤ $-V_{CC}$ ≤ 0V, -1.6V ≤ V_O ≤ 1.4V		70		dB	1, 2, 3
I_{CEX}	Output Leakage Current	$+V_{CC}$ = 30V, $-V_{CC}$ = 0V, V_O = +30V			1.0	µA	1, 2, 3
$+I_{IL}$	Input Leakage Current	$+V_{CC}$ = 36V, $-V_{CC}$ = 0V, $+V_I$ = 34V, $-V_I$ = 0V		-500	500	nA	1, 2, 3
$-I_{IL}$	Input Leakage Current	$+V_{CC}$ = 36V, $-V_{CC}$ = 0V, $+V_I$ = 0V, $-V_I$ = 34V		-500	500	nA	1, 2, 3
V_{OL}	Logical "0" Output Voltage	$+V_{CC}$ = 4.5V, $-V_{CC}$ = 0V, I_O = 4mA			0.4	V	1
					0.7	V	2, 3
		$+V_{CC}$ = 4.5V, $-V_{CC}$ = 0V, I_O = 8mA			1.5	V	1
					2.0	V	2, 3
I_{CC}	Power Supply Current	$+V_{CC}$ = 5V, $-V_{CC}$ = 0V, V_{ID} = 15mV			2.0	mA	1, 2
					3.0	mA	3
		$+V_{CC}$ = 30V, $-V_{CC}$ = 0V, V_{ID} = 15mV			3.0	mA	1, 2
					4.0	mA	3
Δ_{IO} / ΔT	Temperature Coefficient of Input Offset Voltage	25°C ≤ T_A ≤ +125°C	See (2)	-25	25	µV/°C	2
		-55°C ≤ T_A ≤ 25°C	See (2)	-25	25	µV/°C	3
ΔI_{IO} / ΔT	Temperature Coefficient of Input Offset Current	25°C ≤ T_A ≤ +125°C	See (2)	-300	300	pA/°C	2
		-55°C ≤ T_A ≤ 25°C	See (2)	-400	400	pA/°C	3
A_{VS}	Open Loop Voltage Gain	$+V_{CC}$ = 15V, $-V_{CC}$ = 0V, R_L = 15KΩ, 1V ≤ V_O ≤ 11V	See (3)	50		V/mV	4
			See (3)	25		V/mV	5, 6
V_{Lat}	Voltage Latch (Logical "1" Input)	$+V_{CC}$ = 5V, $-V_{CC}$ = 0V, V_I = 10V, I_O = 4mA			0.4	V	9

(2) Calculated parameter for ΔV_{IO} / ΔT and ΔI_{IO} / ΔT.
(3) K in datalog is equivalent to V/mV.

AC Parameters

The following conditions apply, unless otherwise specified. $+V_{CC}$ = 5V, $-V_{CC}$ = 0V

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
t_{RLH}	Response Time	V_I = 100mV, R_L = 5.1KΩ, V_{OD} = 5mV			5.0	µS	7, 8B
					7.0	µS	8A
		V_I = 100mV, R_L = 5.1KΩ, V_{OD} = 50mV			0.8	µS	7, 8B
					1.2	µS	8A
t_{RHL}	Response Time	V_I = 100mV, R_L = 5.1KΩ, V_{OD} = 5mV			2.5	µS	7, 8B
					3.0	µS	8A
		V_I = 100mV, R_L = 5.1KΩ, V_{OD} = 50mV			0.8	µS	7, 8B
					1.0	µS	8A
CS	Channel Separation	$+V_{CC}$ = 20V, $-V_{CC}$ = -10V, A to B		80		dB	7
		$+V_{CC}$ = 20V, $-V_{CC}$ = -10V, B to A		80		dB	7

Typical Performance Characteristics

Supply Current

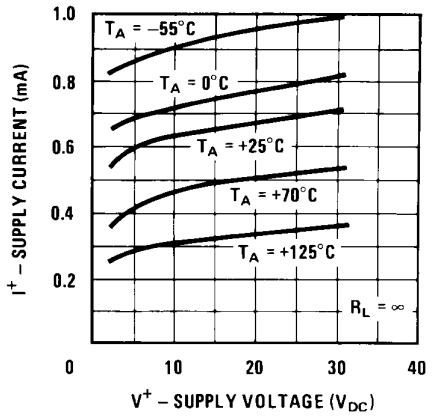


Figure 3.

Input Current

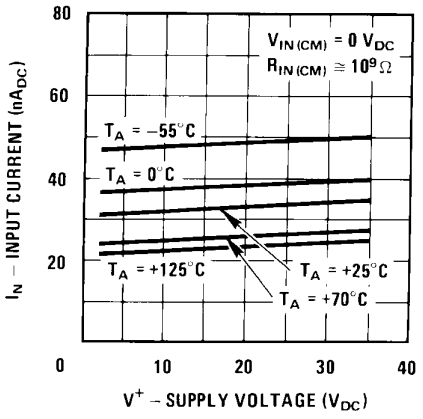


Figure 4.

Output Saturation Voltage

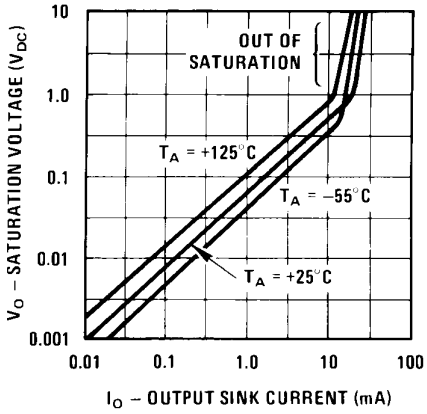


Figure 5.

Response Time for Various Input Overdrives—Negative Transition

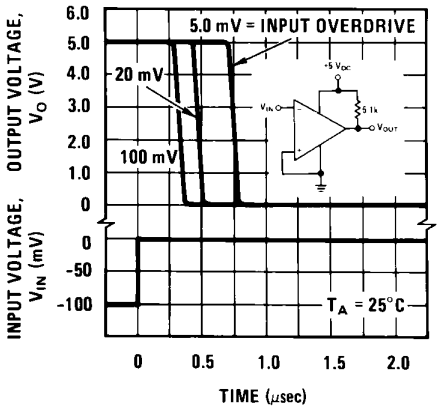


Figure 6.

Response Time for Various Input Overdrives—Positive Transition

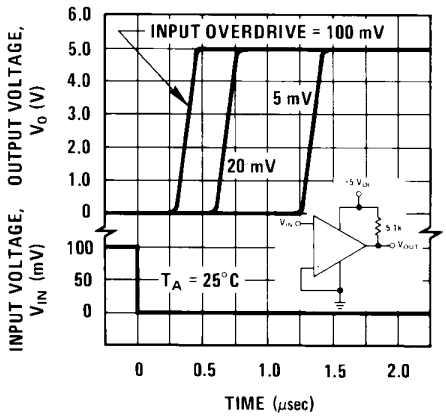


Figure 7.

APPLICATION HINTS

The LM193 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 change 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 < 10 kΩ 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 input pins of any unused comparators should be tied to the negative supply.

The bias network of the LM193 series establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from 2.0 V_{DC} to 30 V_{DC}.

It is usually unnecessary to use a bypass capacitor across the power supply line.

The differential input voltage may be larger than V^+ without damaging the device (1). Protection should be provided to prevent the input voltages from going negative more than −0.3 V_{DC} (at 25°C). An input clamp diode can be used as shown in the applications section.

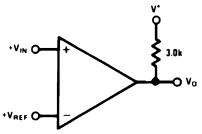
The output of the LM193 series is the uncommitted collector of a grounded-emitter NPN output transistor. Many collectors can be tied together to provide an output OR'ing function. An output pull-up resistor can be connected to any available power supply voltage within the permitted supply voltage range and there is no restriction on this voltage due to the magnitude of the voltage which is applied to the V^+ terminal of the LM193 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 β of this device. When the maximum current limit is reached (approximately 16mA), 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 60Ω r_{SAT} of the output transistor. The low offset voltage of the output transistor (1.0mV) allows the output to clamp essentially to ground level for small load currents.

(1) 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 −0.3V (or 0.3V below the magnitude of the negative power supply, if used).

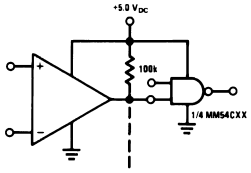
Typical Applications

(V^+=5.0 V_{DC})

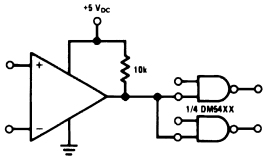
Basic Comparator



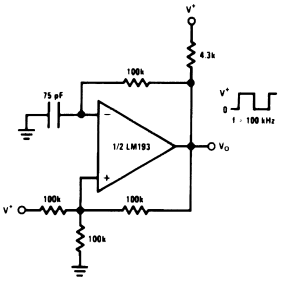
Driving CMOS



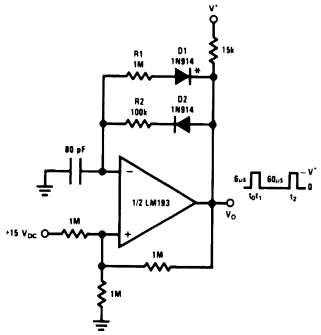
Driving TTL



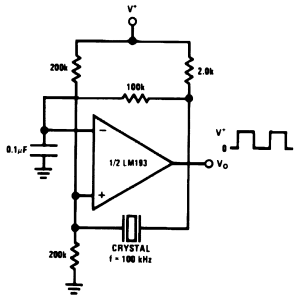
Squarewave Oscillator



Pulse Generator

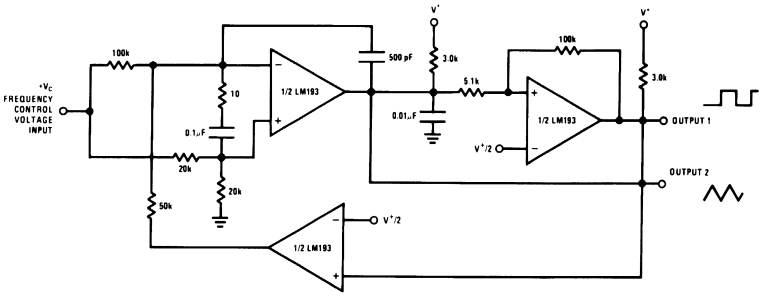


Crystal Controlled Oscillator



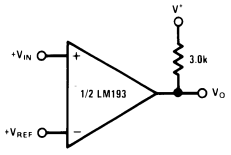
* For large ratios of R1/R2,
D1 can be omitted.

Figure 8. Two-Decade High Frequency VCO

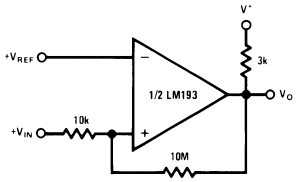


V^* = +30 V_{DC}
+250 mV_{DC} ≤ V_C ≤ +50 V_{DC}
700Hz ≤ f_0 ≤ 100kHz

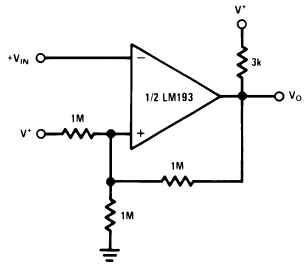
Basic Comparator



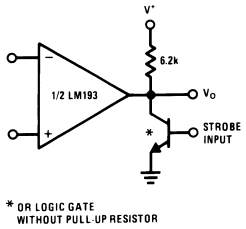
Non-Inverting Comparator with Hysteresis



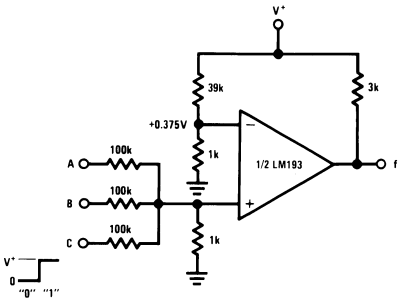
Inverting Comparator with Hysteresis



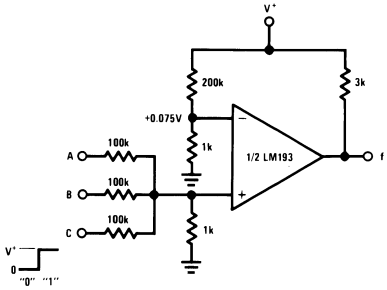
Output Strobing



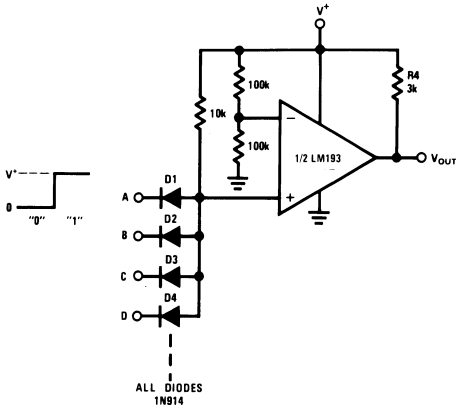
AND Gate



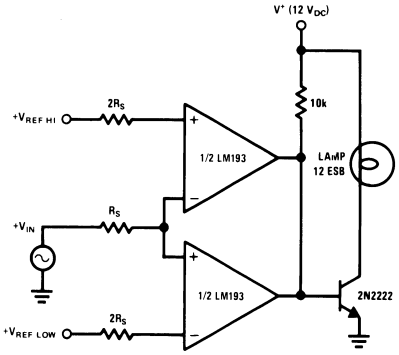
OR Gate



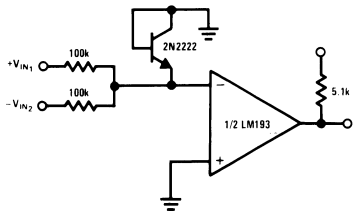
Large Fan-in AND Gate



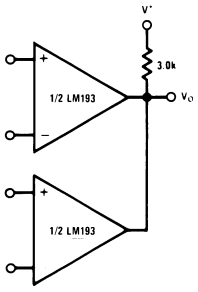
Limit Comparator



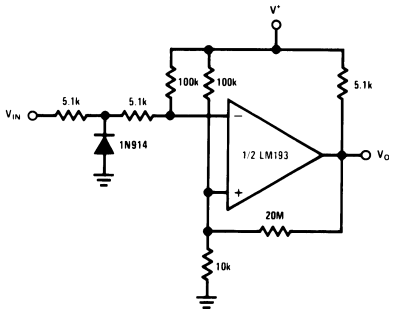
Comparing Input Voltages of Opposite Polarity



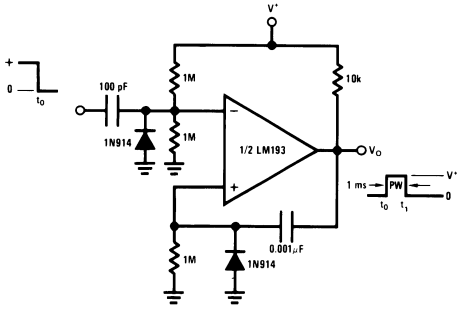
ORing the Outputs



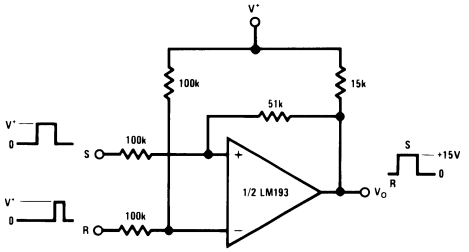
Zero Crossing Detector (Single Power Supply)



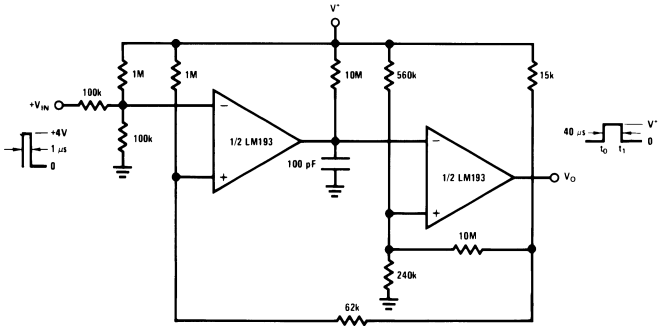
One-Shot Multivibrator



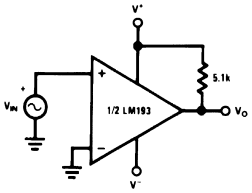
Bi-Stable Multivibrator



One-Shot Multivibrator with Input Lock Out



Zero Crossing Detector



Comparator With a Negative Reference

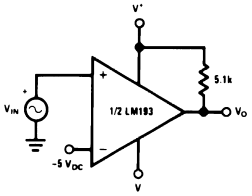
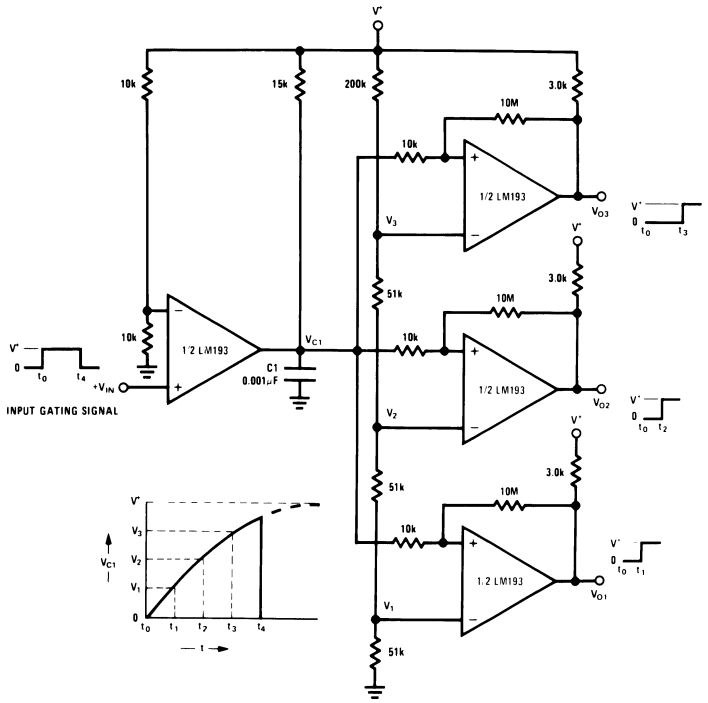


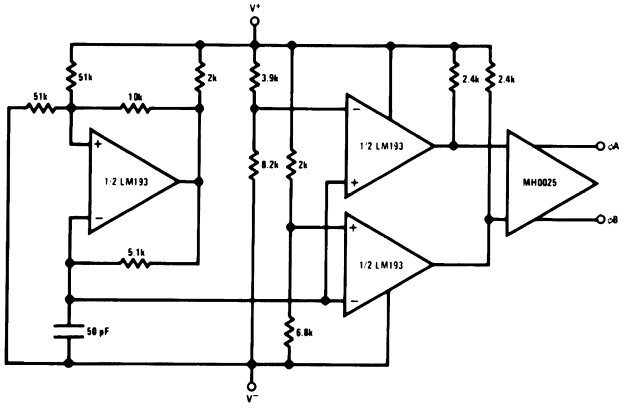
Figure 9. Time Delay Generator



Split-Supply Applications

(V^+=+15 V_{DC} and V^-=−15 V_{DC})

Figure 10. MOS Clock Driver



REVISION HISTORY SECTION

Date Released	Revision	Section	Originator	Changes
05/09/05	A	New Release. Corporate format	L. Lytle	1 MDS datasheets converted into one Corp. datasheet format. DC Drift table was deleted due to no JANS product offerings. MJLM193-X Rev 1A1 MDS will be archived.
03/26/2013	A	All Sections		Changed layout of National Data Sheet to TI format

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
JL193BGA	Active	Production	TO-99 (LMC) | 8	20 | JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	JL193BGA JM38510/11202BGA Q ACO JM38510/11202BGA Q >T
JL193BGA.A	Active	Production	TO-99 (LMC) | 8	20 | JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	JL193BGA JM38510/11202BGA Q ACO JM38510/11202BGA Q >T
JM38510/11202BGA	Active	Production	TO-99 (LMC) | 8	20 | JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	JL193BGA JM38510/11202BGA Q ACO JM38510/11202BGA Q >T
M38510/11202BGA	Active	Production	TO-99 (LMC) | 8	20 | JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	JL193BGA JM38510/11202BGA Q ACO JM38510/11202BGA Q >T

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

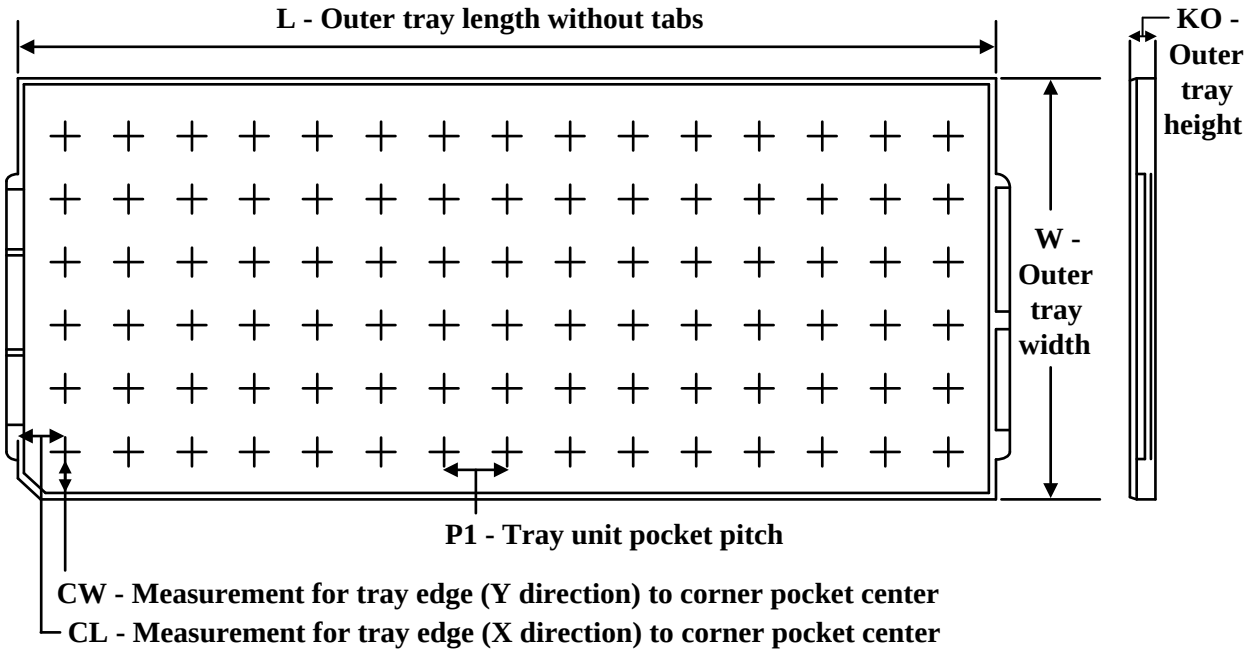
(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

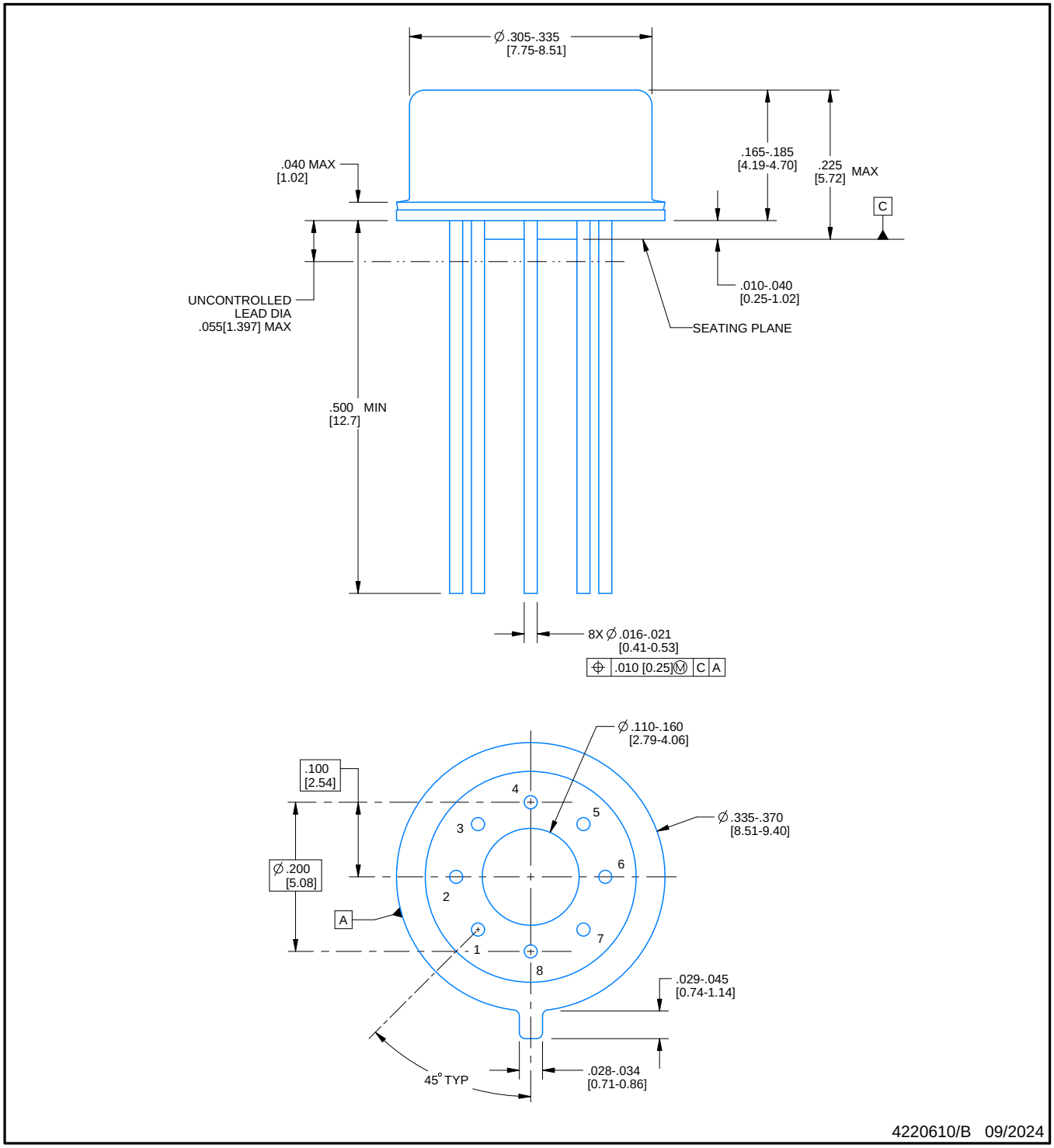
Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
JL193BGA	LMC	TO-CAN	8	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
JL193BGA.A	LMC	TO-CAN	8	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
JM38510/11202BGA	LMC	TO-CAN	8	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
M38510/11202BGA	LMC	TO-CAN	8	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54

PACKAGE OUTLINE

LMC0008A

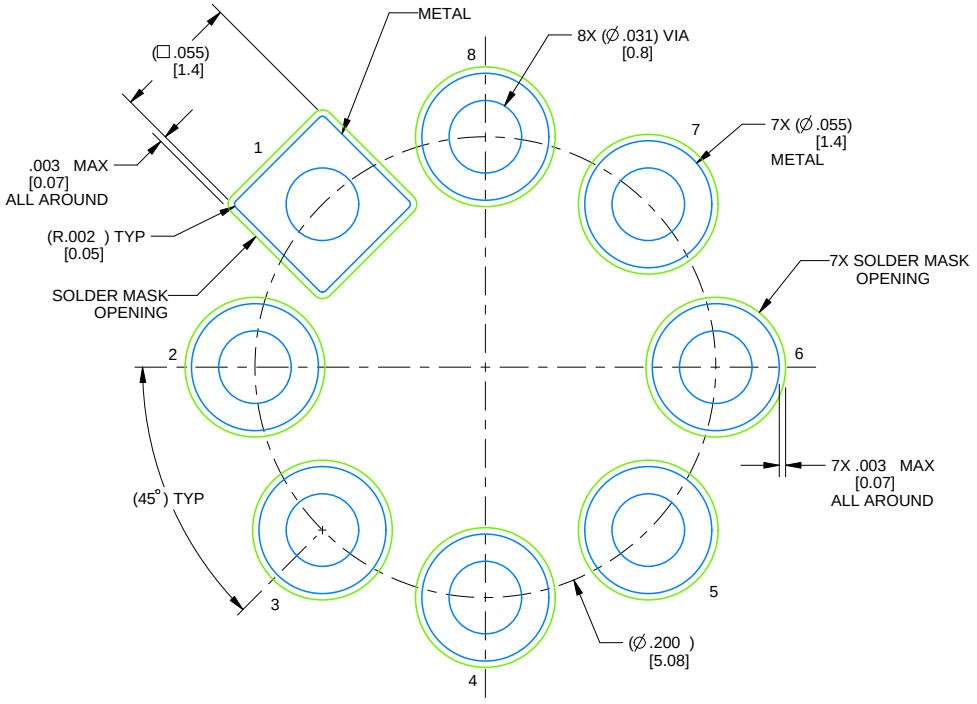
TO-CAN - 5.72 mm max height

TRANSISTOR OUTLINE



NOTES:

1. All linear dimensions are in inches [millimeters]. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Pin numbers shown for reference only. Numbers may not be marked on package.
4. Reference JEDEC registration MO-002/TO-99.



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 12X

4220610/B 09/2024

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