LM2903EP Low Power Low Offset Voltage Dual Comparators

Check for Samples: LM2903EP

FEATURES

- **Wide supply**
  - **Voltage range: 2.0V to 36V**
  - **Single or dual supplies: ±1.0V to ±18V**
- **Very low supply current drain (0.4 mA) — independent of supply voltage**
- **Low input biasing current: 25 nA**
- **Low input offset current: ±5 nA**
- **Maximum offset voltage: ±3 mV**
- **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**
- **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 LM2903EP 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. This comparator also has 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 LM2903EP was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM2903EP will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.

ENHANCED PLASTIC

- Extended Temperature Performance of −40°C to +85°C
- Baseline Control - Single Fab & Assembly Site
- Process Change Notification (PCN)
- Qualification & Reliability Data
- Solder (PbSn) Lead Finish is standard
- Enhanced Diminishing Manufacturing Sources (DMS) Support

APPLICATIONS

- **Selected Military Applications**
- **Selected Avionics Applications**

Schematic and Connection Diagrams

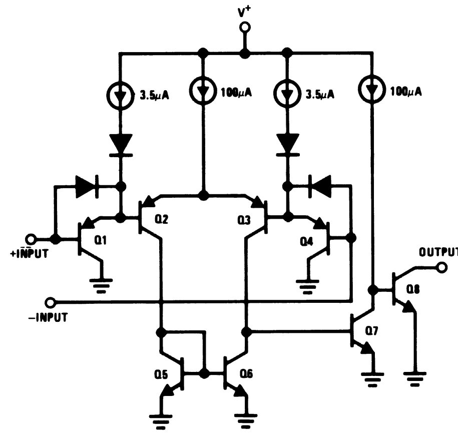


Figure 1. LM2903EP Schematic

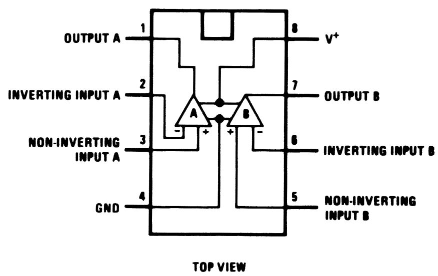


Figure 2. Dual-In-Line/SOIC Package

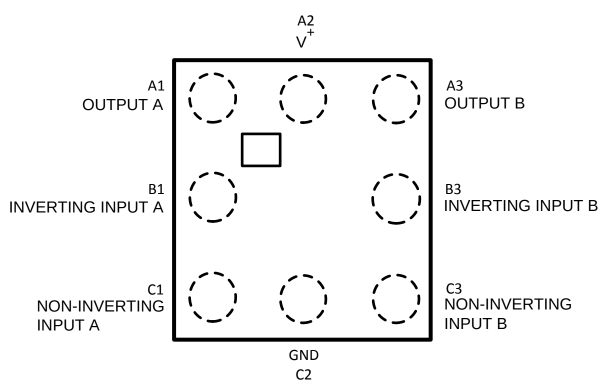


Figure 3. Micro SMD - Top View

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
Differential Input Voltage [2]			36V
Input Voltage			−0.3V to +36V
Input Current (V_{IN}<−0.3V) [3]			50 mA
Power Dissipation [4]	Molded DIP		780 mW
	Small Outline Package		510 mW
Output Short-Circuit to Ground [5]			Continuous
Operating Temperature Range			−40°C to +85°C
Storage Temperature Range			−65°C to +150°C
Soldering Information	Dual-In-Line Package	Soldering (10 seconds)	260°C
		Small Outline Package	215°C
		Vapor Phase (60 seconds)	
		Infrared (15 seconds)	220°C
ESD rating	(1.5 kΩ in series with 100 pF)		1300V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.

(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.

(4) For operating at high temperatures, the LM2903EP must be derated based on a 125°C maximum junction temperature and a thermal resistance of 170°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The low bias dissipation and the “ON-OFF” characteristic of the outputs keeps the chip dissipation very small (P_D≤100 mW), provided that the output transistors are allowed to saturate.

(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^+.

Electrical Characteristics [(1)(2)]

(V^+=5V, T_A = 25°C, unless otherwise stated)

Parameter	Conditions		LM2903 Min	Typ	Max	Units
Input Offset Voltage	[(3)]			2.0	7.0	mV
Input Bias Current	$I_{IN}(+)$ or $I_{IN}(-)$ with Output In			25	250	nA
	Linear Range, V_{CM} = 0V [(4)]					
Input Offset Current	$I_{IN}(+)-I_{IN}(-)$ V_{CM} = 0V			5.0	50	nA
Input Common Mode	V+ = 30V [(5)]		0		V+−1.5	V
Voltage Range						
Supply Current	R_L=∞	V^+=5V		0.4	1.0	mA
		V^+=36V		1	2.5	mA
Voltage Gain	R_L≥15 kΩ, V^+=15V		25	100		V/mV
	V_O = 1V to 11V					
Large Signal Response	V_{IN}=TTL Logic Swing, V_{REF}=1.4V			300		ns
Time	V_{RL}=5V, R_L=5.1 kΩ					
Response Time	V_{RL}=5V, R_L=5.1 kΩ [(6)]			1.5		µs
Output Sink Current	$V_{IN}(-)$=1V, $V_{IN}(+)$=0, V_O≤1.5V		6.0	16		mA
Saturation Voltage	$V_{IN}(-)$=1V, $V_{IN}(+)$=0, I_{SINK}≤4 mA			250	400	mV
Output Leakage Current	$V_{IN}(-)$=0, $V_{IN}(+)$=1V, V_O=5V			0.1		nA

(1) "Testing and other quality control techniques are used to the extent deemed necessary to ensure product performance over the specified temperature range. Product may not necessarily be tested across the full temperature range and all parameters may not necessarily be tested. In the absence of specific PARAMETRIC testing, product performance is assured by characterization and/or design."
(2) These specifications are limited to −40°C≤T_A≤+85°C.
(3) At output switch point, V_O≃1.4V, R_S=0Ω with V^+ from 5V to 30V; and over the full input common-mode range (0V to V^+−1.5V), at 25°C.
(4) 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.
(5) 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 at 25°C, but either or both inputs can go to 36V without damage, independent of the magnitude of V^+.
(6) 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 characteristics section.

Electrical Characteristics (1) (2)

(V+ = 5V)

Parameter	Conditions	LM2903			Units
		Min	Typ	Max	
Input Offset Voltage	(3)		9	15	mV
Input Offset Current	$I_{IN(+)}-I_{IN(-)}$, V_{CM}=0V		50	200	nA
Input Bias Current	I_{IN}(+) or I_{IN}(−) with Output in Linear Range, V_{CM}=0V (4)		200	500	nA
Input Common Mode Voltage Range	V^+=30V (5)	0		V^+−2.0	V
Saturation Voltage	V_{IN}(−)=1V, V_{IN}(+)=0, I_{SINK}≤4 mA		400	700	mV
Output Leakage Current	V_{IN}(−)=0, $V_{IN(+)}$=1V, V_O=30V			1.0	μA
Differential Input Voltage	Keep All V_{IN}'s≥0V (or V^-, if Used), (6)			36	V

(1) For operating at high temperatures, the LM2903EP must be derated based on a 125°C maximum junction temperature and a thermal resistance of 170°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The low bias dissipation and the “ON-OFF” characteristic of the outputs keeps the chip dissipation very small (P_D≤100 mW), provided that the output transistors are allowed to saturate.

(2) "Testing and other quality control techniques are used to the extent deemed necessary to ensure product performance over the specified temperature range. Product may not necessarily be tested across the full temperature range and all parameters may not necessarily be tested. In the absence of specific PARAMETRIC testing, product performance is assured by characterization and/or design."

(3) At output switch point, V_O≃1.4V, R_S=0Ω with V^+ from 5V to 30V; and over the full input common-mode range (0V to V^+−1.5V), at 25°C.

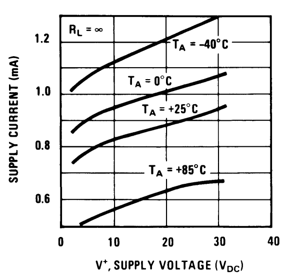
(4) The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

(5) 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 at 25°C, but either or both inputs can go to 36V without damage, independent of the magnitude of V^+.

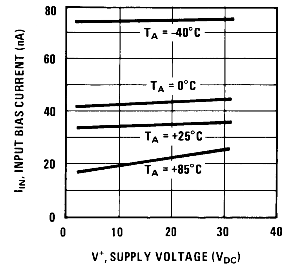
(6) Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than −0.3V (or 0.3V below the magnitude of the negative power supply, if used).

Typical Performance Characteristics

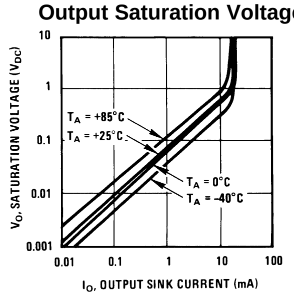
Supply Current



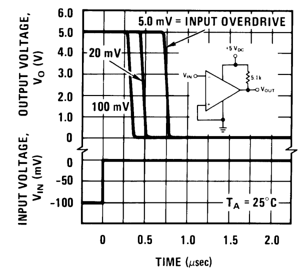
Input Current



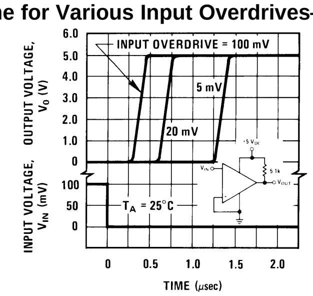
Output Saturation Voltage



Response Time for Various Input Overdrives—Negative Transition



Response Time for Various Input Overdrives—Positive Transition



Application Hints

The LM2903EP is a high gain, wide bandwidth device 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 LM2903EP 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.

(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).

The output of the LM2903EP 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 LM2903EP 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.

Typical Applications

(V^+=5.0 V_{DC}) (2)

Figure 4. Basic Comparator

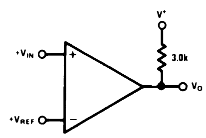


Figure 5. Driving CMOS

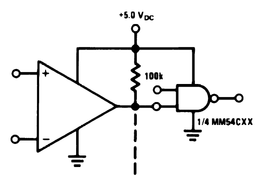


Figure 6. Driving TTL

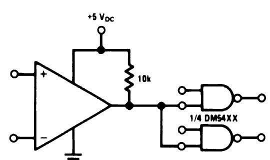
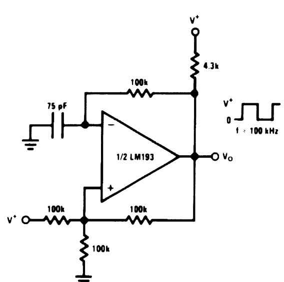


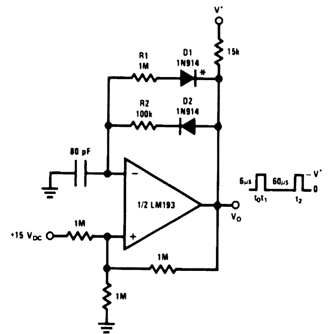
Figure 7. Squarewave Oscillator



(2) The LM193 within this data sheet's graphics is referenced because of it's a similarity to the LM2903, however is not offered in this data sheet.

(V^+=5.0 V_{DC}) (2)

Figure 8. Pulse Generator



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

Figure 9. Crystal Controlled Oscillator

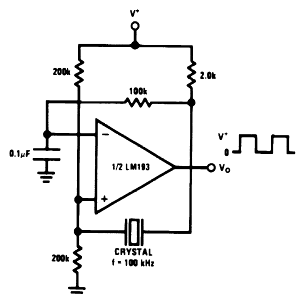
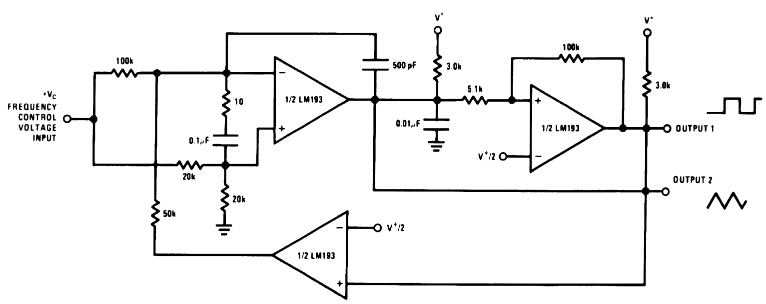
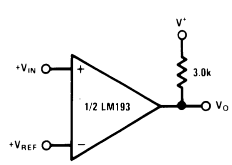


Figure 10. Two-Decade High Frequency VCO



$V^* = +30\ V_{DC}$
$+250\ mV_{DC} \le V_C \le +50\ V_{DC}$
$700Hz \le f_o \le 100kHz$

Figure 11. Basic Comparator



$(V^+=5.0\ V_{DC})$ [2]

Figure 12. Non-Inverting Comparator with Hysteresis

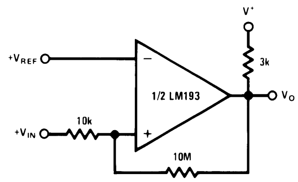


Figure 13. Inverting Comparator with Hysteresis

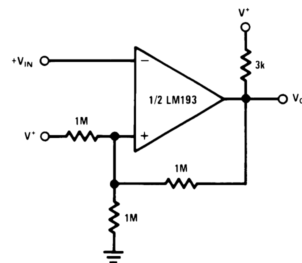


Figure 14. Output Strobing

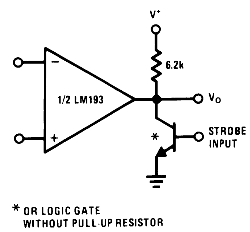


Figure 15. AND Gate

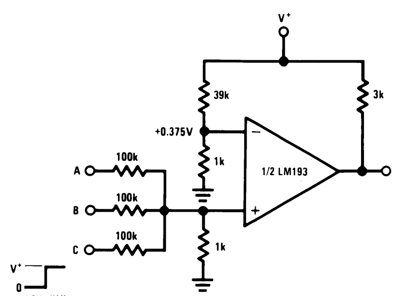
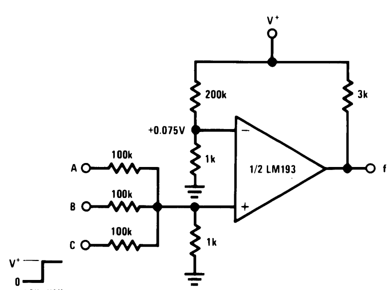


Figure 16. OR Gate



(V^{+}=5.0 V_{DC}) (2)

Figure 17. Large Fan-in AND Gate

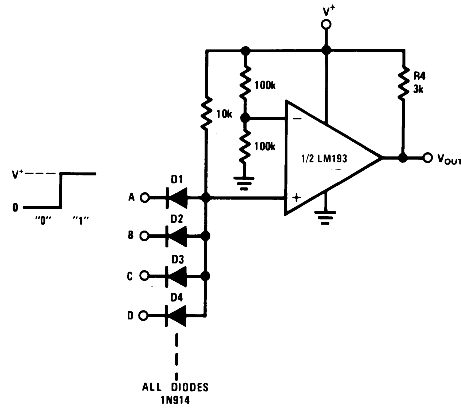


Figure 18. Limit Comparator

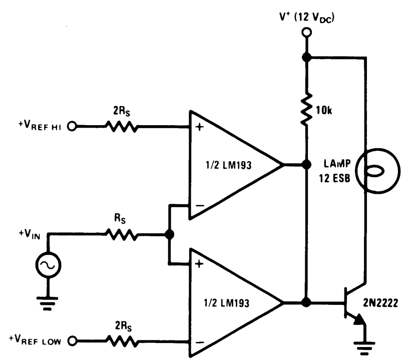


Figure 19. Comparing Input Voltages of Opposite Polarity

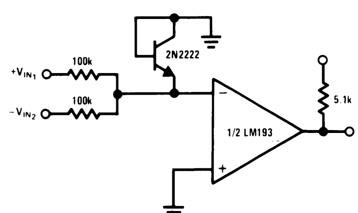
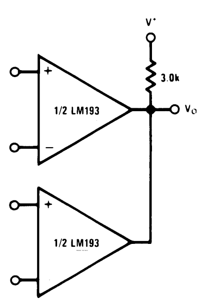


Figure 20. ORing the Outputs



(V^{+}=5.0 V_{DC}) (2)

Figure 21. Zero Crossing Detector (Single Power Supply)

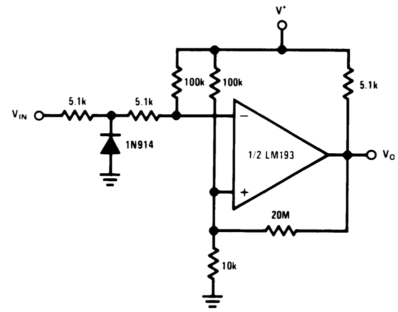


Figure 22. One-Shot Multivibrator

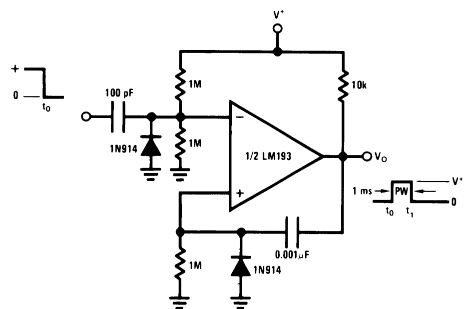


Figure 23. Bi-Stable Multivibrator

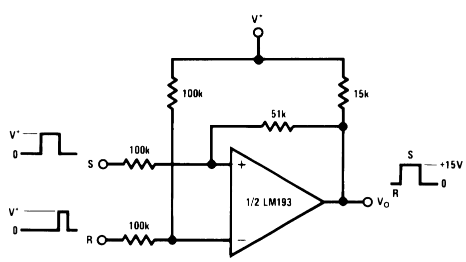
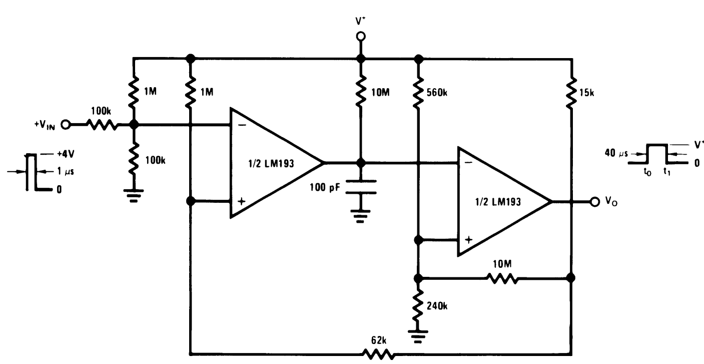


Figure 24. One-Shot Multivibrator with Input Lock Out



(V^{+}=5.0 V_{DC}) (2)

Figure 25. Zero Crossing Detector

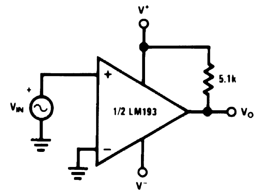


Figure 26. Comparator With a Negative Reference

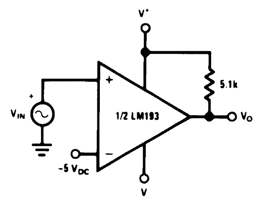
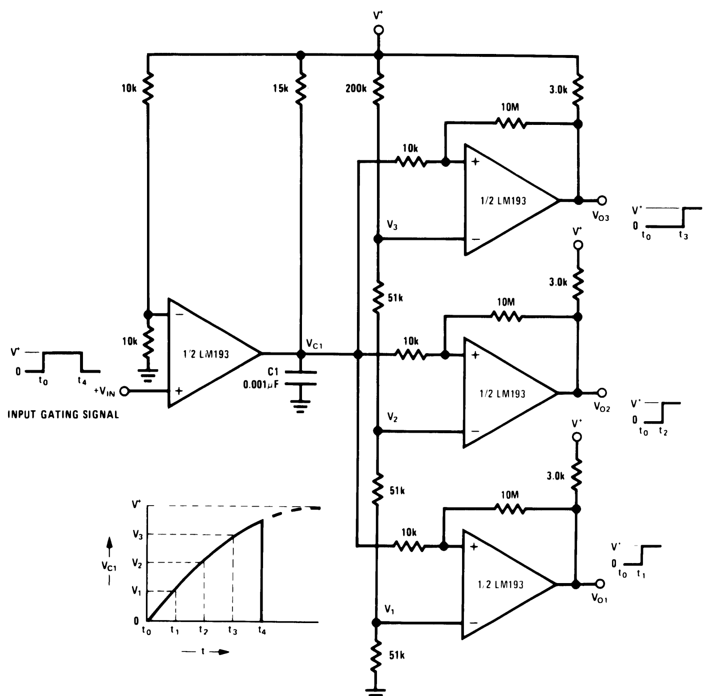


Figure 27. Time Delay Generator



Split-Supply Applications

(V^{+}=+15 V_{DC} and V^{-}=−15 V_{DC})

(V^{+}=+15 V_{DC} and V^{-}=−15 V_{DC})

Figure 28. MOS Clock Driver