National Semiconductor Corporation

PRELIMINARY

LP339 Ultra-Low Power Quad Comparator

General Description

The LP339 consists of four independent voltage comparators designed specifically to operate from a single power supply and draw typically 60 μA of power supply drain current over a wide range of power supply voltages. Operation from split supplies is also possible and the ultra-low power supply drain current is independent of the power supply voltage. These comparators also feature a common-mode range which includes ground, even when operated from a single supply.

Applications include limit comparators, simple analog-to-digital converters, pulse, square and time delay generators; VCO's; multivibrators; high voltage logic gates. The LP339 was specifically designed to interface with the CMOS logic family. The ultra-low supply current makes the LP339 valuable in battery powered applications.

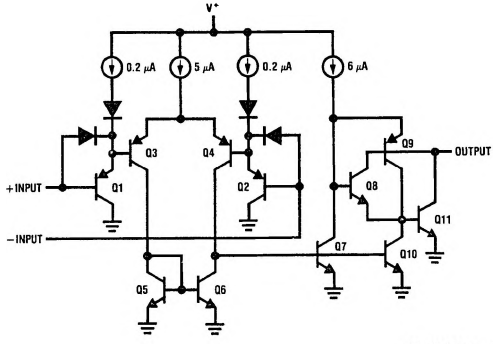
Advantages

- Ultra-low power supply drain suitable for battery applications
- Single supply operation
- Sensing at ground
- Compatible with CMOS logic family
- Pin-out identical to LM339

Features

- Ultra-low power supply current drain (60 μA)—independent of the supply voltage (75 μW/comparator at +5 V_{DC})
- Low input biasing current 3 nA
- Low input offset current ±0.5 nA
- Low input offset voltage ±2 mV
- Input common-mode voltage includes ground
- Output voltage compatible with MOS and CMOS logic
- High output sink current capability (30 mA at V_O = 2 V_{DC})
- Supply Input protected against reverse voltages

Schematic and Connection Diagrams



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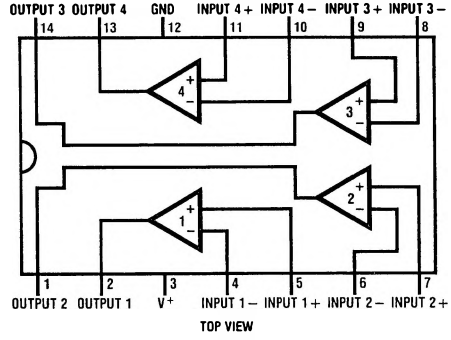

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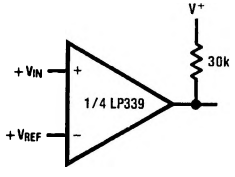
Order Number LP339M for S.O. Package
See NS Package Number M14A

Order Number LP339N for Dual-In-Line Package
See NS Package Number N14A

Typical Applications (V^+ = 5.0 V_{DC})

Basic Comparator



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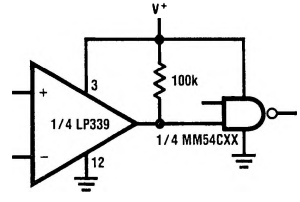
Driving CMOS



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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	36 V_{DC} or ±18 V_{DC}
Differential Input Voltage	±36 V_{DC}
Input Voltage	−0.3 V_{DC} to 36 V_{DC}
Power Dissipation (Note 1) Molded DIP	570 mW
Output Short Circuit to GND (Note 2)	Continuous
Input Current $V_{IN} < -0.3\ V_{DC}$ (Note 3)	50 mA
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−65° to +150°C
Soldering Information:	
Dual-In-Line Package (10 sec.)	+260°C
S.O. Package:	
Vapor Phase (60 sec.)	+215°C
Infrared (15 sec.)	+220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" (appendix D) for other methods of soldering surface mount devices.

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

Parameter	Conditions	Min	Typ	Max	Units
Input Offset Voltage	$T_A = 25°C$ (Note 9)		±2	±5	mV_{DC}
Input Bias Current	$I_{IN}(+)$ or $I_{IN}(-)$ with the Output in the Linear Range, $T_A = 25°C$ (Note 5)		2.5	25	nA_{DC}
Input Offset Current	$I_{IN}(+) - I_{IN}(-)$, $T_A = 25°C$		±0.5	±5	nA_{DC}
Input Common Mode Voltage Range	$T_A = 25°C$ (Note 6)	0		V+ −1.5	V_{DC}
Supply Current	R_L = Infinite on all Comparators, $T_A = 25°C$		60	100	μA_{DC}
Voltage Gain	V_O = 1 V_{DC} to 11 V_{DC}, $R_L = 15\ k\Omega$, $V+ = 15\ V_{DC}$, $T_A = 25°C$		500		V/mV
Large Signal Response Time	V_{IN} = TTL Logic Swing, $V_{REF} = 1.4\ V_{DC}$, $V_{RL} = 5\ V_{DC}$, $R_L = 5.1\ k\Omega$, $T_A = 25°C$		1.3		μSec
Response Time	$V_{RL} = 5\ V_{DC}$, $R_L = 5.1\ k\Omega$, $T_A = 25°C$ (Note 7)		8		μSec
Output Sink Current	$V_{IN}(-) = 1\ V_{DC}$, $V_{IN}(+) = 0$, $V_O = 2\ V_{DC}$, $T_A = 25°C$ (Note 11)	15	30		mA_{DC}
	$V_O = 0.4\ V_{DC}$	0.20	0.70		mA_{DC}
Output Leakage Current	$V_{IN}(+) = 1\ V_{DC}$, $V_{IN}(-) = 0$, $V_O = 5\ V_{DC}$, $T_A = 25°C$		0.1		nA_{DC}
Input Offset Voltage	(Note 9)			±9	mV_{DC}
Input Offset Current	$I_{IN}(+) - I_{IN}(-)$		±1	±15	nA_{DC}
Input Bias Current	$I_{IN}(+)$ or $I_{IN}(-)$ with Output in Linear Range		4	40	nA_{DC}
Input Common Mode Voltage Range	Single Supply	0		V+ −2.0	V_{DC}
Output Sink Current	$V_{IN}(-) = 1\ V_{DC}$, $V_{IN}(+) = 0$, $V_O = 2\ V_{DC}$	10			mA_{DC}
Output Leakage Current	$V_{IN}(+) = 1\ V_{DC}$, $V_{IN}(-) = 0$, $V_O = 30\ V_{DC}$			1.0	μA_{DC}
Differential Input Voltage	All V_{IN}'s ≥ 0 V_{DC} (or V− on split supplies) (Note 8)			36	V_{DC}

Note 1: For elevated temperature operation, T_j max is 125°C for the LP339. θ_{ja} (junction to ambient) is 175°C/W for the LP339N and 120°C/W for the LP339M when either device is soldered in a printed circuit board in a still air environment. 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.

Note 2: Short circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 50 mA.

Note 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 clamp diodes. 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 voltage of the comparators to go to the V+ voltage level (or to ground for a large input 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 $-0.3\ V_{DC}$ ($T_A = 25°C$).

Note 4: These specifications apply for $V+ = 5V_{DC}$ and $0°C \leq T_A \leq 70°$ C, unless otherwise stated. The temperature extremes are guaranteed but not 100% production tested. These parameters are not used to calculate outgoing AQL.

Note 5: 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 the input lines as long as the common-mode range is not exceeded.

Note 6: The input common-mode voltage or either input 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 ($T_A = 25°C$), but either or both inputs can go to 30 V_{DC} without damage.

Note 7: The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 1.3 μs can be obtained. See Typical Performance Characteristics section.

Electrical Characteristics ($V+ = 5\ V_{DC}$, Note 4) (Continued)

Note 8: 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 $-0.3\ V_{DC}$ (or 0.3 V_{DC} below the magnitude of the negative power supply, if used) at $T_A = 25°C$.

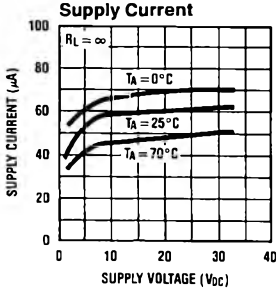
Note 9: At output switch point, $V_O = 1.4V$, $R_S = 0\Omega$ with $V+$ from 5 V_{DC}; and over the full input common-mode range (0 V_{DC} to $V+ - 1.5\ V_{DC}$).

Note 10: For input signals that exceed $V+$, only the overdriven comparator is affected. With a 5V supply, V_{IN} should be limited to 25V maximum, and a limiting resistor should be used on all inputs that might exceed the positive supply.

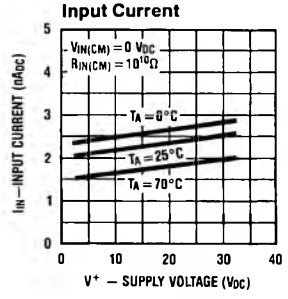
Note 11: The output sink current is a function of the output voltage. The LP339 has a bi-modal output section which allows it to sink large currents via a Darlington connection at output voltages greater than approximately 1.5 V_{DC} and sink lower currents below this point. (See typical characteristics section and applications section).

Typical Performance Characteristics

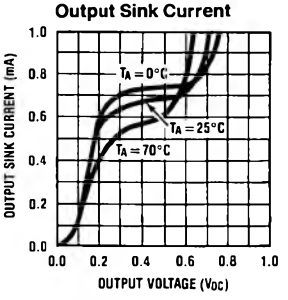
Supply Current



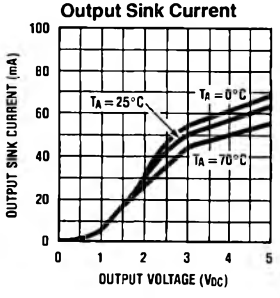
Input Current



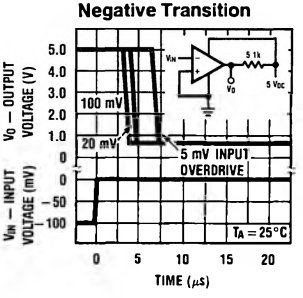
Output Sink Current



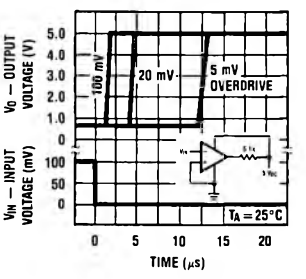
Output Sink Current



Response Times for Various Input Overdrives — Negative Transition



Response Times for Various Input Overdrives — Positive Transition



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Application Hints

All pins of any unused comparators should be grounded.

The bias network of the LP339 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from 2 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. 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 application section.

The output section of the LP339 has two distinct modes of operation-a Darlington mode and a grounded emitter mode. This unique drive circuit permits the LP339 to sink 30 mA at $V_O = 2\ V_{DC}$ (Darlington mode) and 700 μA at $V_O = 0.4\ V_{DC}$ (grounded emitter mode). *Figure 1* is a simplified schematic diagram of the LP339 output section.

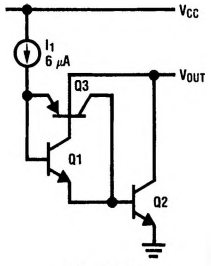

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FIGURE 1

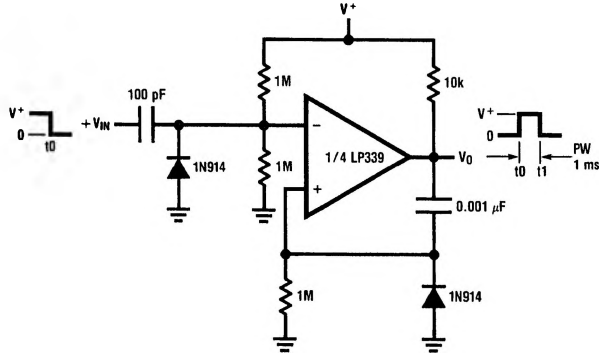
Notice that the output section is configured in a Darlington connection (ignoring Q3). Therefore, if the output voltage is held high enough ($V_O \geq 1\ V_{DC}$), Q1 is not saturated and the output current is limited only by the product of the betas of Q1, Q2 and I1 (and the 60Ω R_{SAT} of Q2). The LP339 is thus capable of driving LED's, relays, etc. in this mode while maintaining an ultra-low power supply current of typically 60 μA.

If transistor Q3 were omitted, and the output voltage allowed to drop below about 0.8 V_{DC}, transistor Q1 would saturate and the output current would drop to zero. The circuit would, therefore, be unable to 'pull' low current loads down to ground (or the negative supply, if used). Transistor Q3 has been included to bypass transistor Q1 under these conditions and apply the current I1 directly to the base of Q2. The output sink current is now approximately I1 times the beta of Q2 (700 μA at $V_O = 0.4\ V_{DC}$). The output of the LP339 exhibits a bi-modal characteristic with a smooth transition between modes. (See Output Sink Current graphs in Typical Performance Characteristics section.)

It is also important to note that in both cases the output is an uncommitted collector. Therefore, 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 power 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 LP339 package.

Typical Applications ($V^+ = 15\ V_{DC}$)

One-Shot Multivibrator



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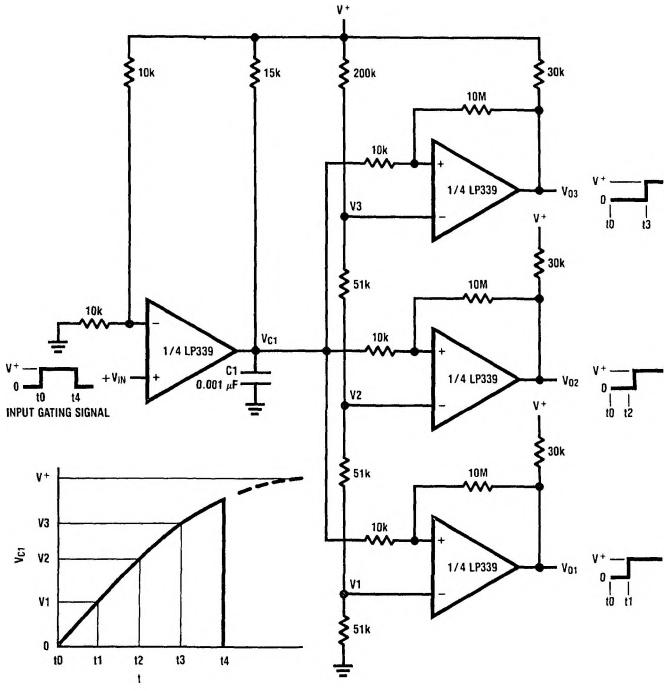
Typical Applications ($V^+ = 15\ V_{DC}$)

Time Delay Generator



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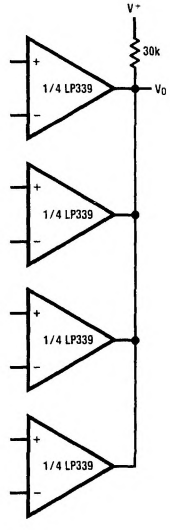
ORing the Outputs



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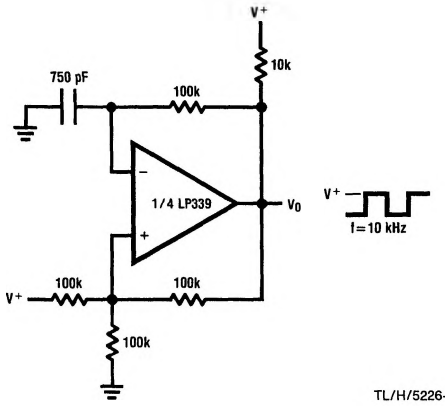
Typical Applications (Continued) ($V^+ = 15\ V_{DC}$)

Squarewave Oscillator



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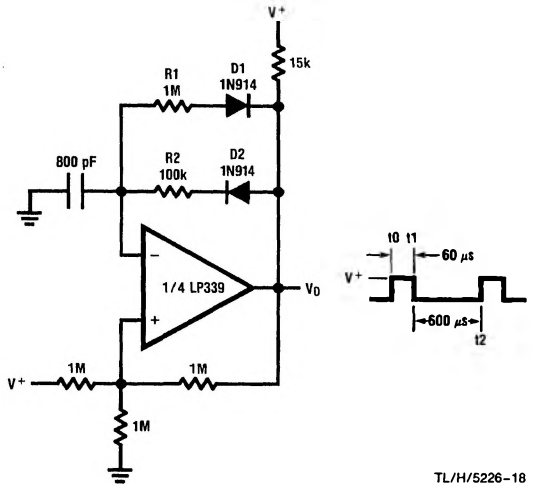
Pulse Generator



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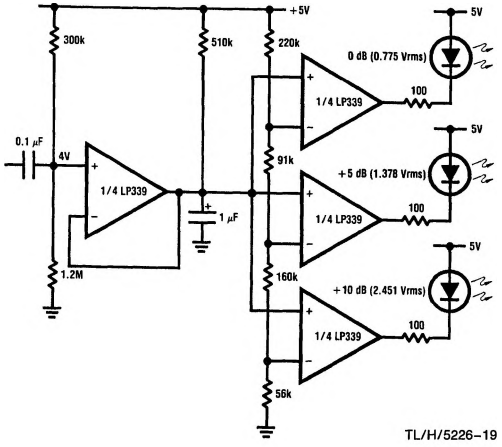
Three Level Audio Peak Indicator



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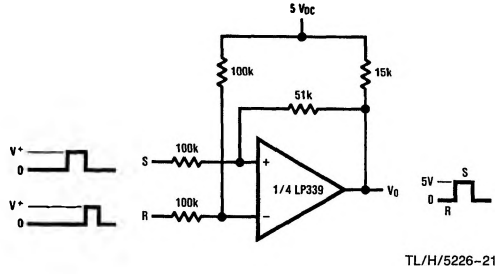
Bi-Stable Multivibrator



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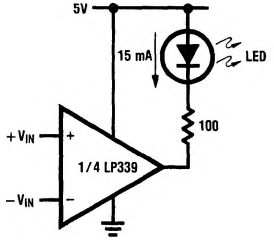
LED Driver



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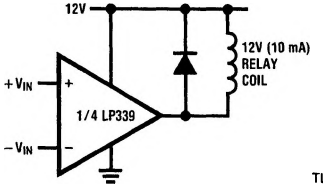
Relay Driver



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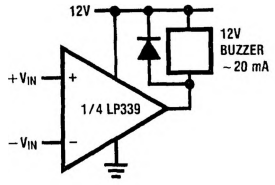
Typical Applications (Continued) (Single Supply)

Buzzer Driver



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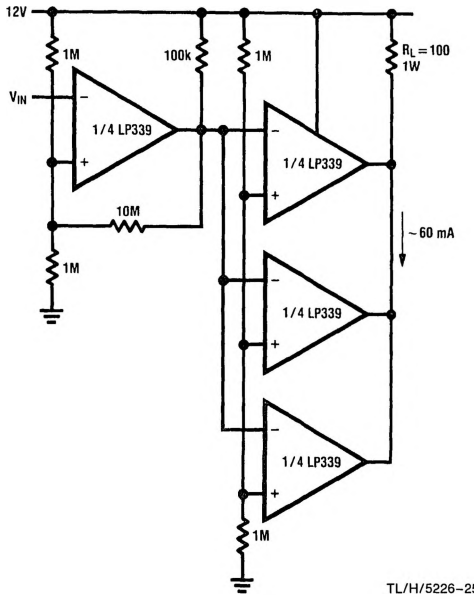
Comparator With 60 mA Sink Capability



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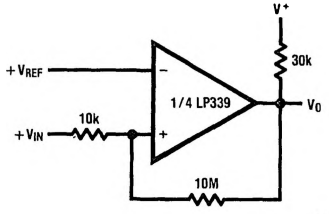
Non-Inverting Comparator with Hysteresis



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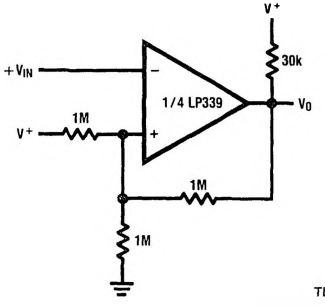
Inverting Comparator with Hysteresis



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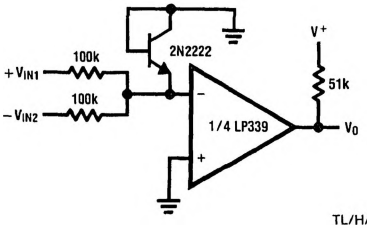
Comparing Input Voltages of Opposite Polarity



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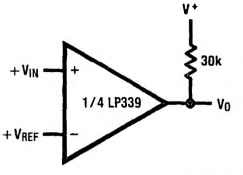
Basic Comparator



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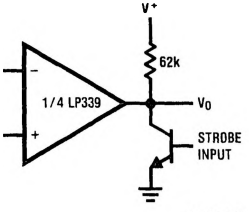
Output Strobing



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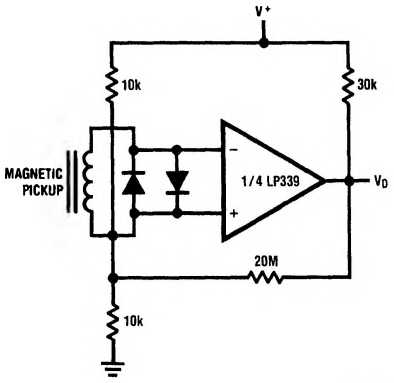
Typical Applications (Continued) (Single Supply)

Transducer Amplifier



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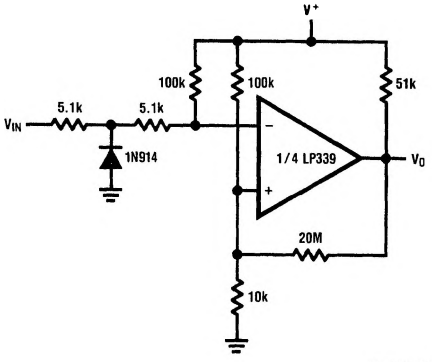
Zero Crossing Detector (Single Power Supply)



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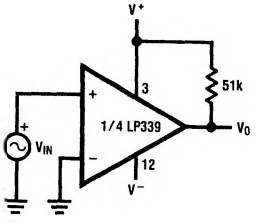
Split-Supply Applications
Zero Crossing Detector



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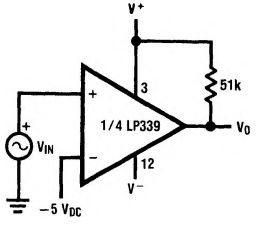
Comparator With a Negative Reference



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