

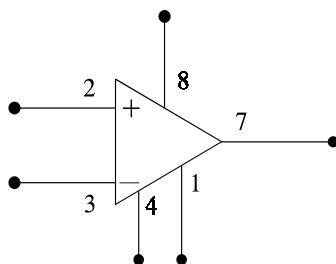
## High Performance Voltage Comparators

The HT111, HT211 and HT311 are voltage comparators that have input currents nearly a thousand times lower than devices like the LM106 or LM710. They are also designed to operate over a wider range of supply voltages: from standard  $\pm 15\text{V}$  op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50V at currents as high as 50 mA. Both the inputs and the outputs of the HT111, HT211 or the HT311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM106 and LM710 (200 ns response time vs 40 ns)

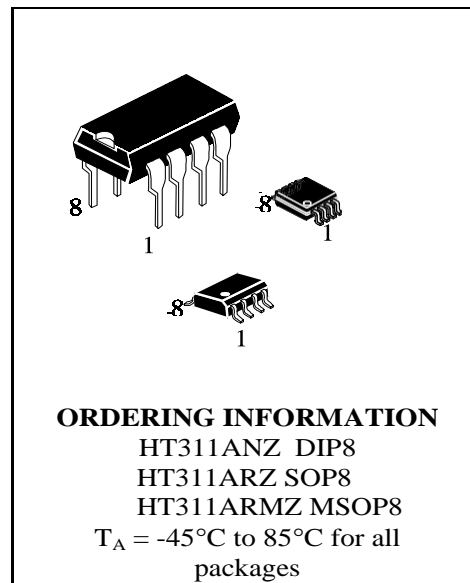
### Features

- n Operates from single 5V supply
- n Input current: 150 nA max. over temperature
- n Offset current: 20 nA max. over temperature
- n Differential input voltage range:  $\pm 30\text{V}$
- n Power consumption: 135 mW at  $\pm 15\text{V}$

### LOGIC DIAGRAM



Input polarity is reversed when GND pin is used as an output.



### PIN ASSIGNMENT

GND	1 ●	8	$V_{CC}$
Input	2	7	Output
Input	3	6	Balance/Strobe
$V_{EE}$	4	5	Balance

**MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_{CC} +  V_{EE} $	Total Supply Voltage	36	V
$V_O - V_{EE}$	Output to Negative Supply Voltage	40	V
$V_{EE}$	Ground to Negative Supply Voltage	30	V
$V_{ID}$	Input Differential Voltage	$\pm 30$	V
$V_{IN}$	Input Voltage (Note)	$\pm 15$	V
-	Voltage at Strobe Pin	$V_{CC}$ to $V_{CC} - 5$	V
$P_D$ $1/\theta_{JA}$	Power Dissipation and Thermal Characteristics Plastic Dual In-Line Packages Derate above $T_A = +25^\circ\text{C}$	625 5.0	mW mW/ $^\circ\text{C}$
$T_{J(\max)}$	Operating Junction Temperature	+150	$^\circ\text{C}$
Tstg	Storage Temperature Range	-60 to +150	$^\circ\text{C}$

Note: This rating applies for  $\pm 15$  volt supplies. The positive input voltage limit is 30 volts above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30 volts below the positive supply, whichever is less.

**RECOMMENDED OPERATING CONDITIONS**

Symbol	Parameter	Min	Max	Unit
$V_{CC} +  V_{EE} $	Total Supply Voltage		30	V
$T_A$	Operating Temperature, All Package Types	-45	+85	$^\circ\text{C}$

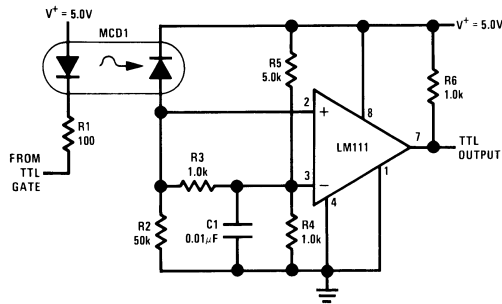
**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +15\text{ V}$ ,  $V_{EE} = -15\text{ V}$ ,  $T_A = +25^\circ\text{C}$  unless otherwise noted [Note 1])

Symbol	Parameter	Test Conditions	Guaranteed Limits		Unit
			Min	Max	
$V_{IO}$	Input Offset Voltage (Note 2)	$R_S \leq 50\text{ k}\Omega$ , $T_A = +25^\circ\text{C}$ $R_S \leq 50\text{ k}\Omega$ , $-45^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		7.5 10	mV
$I_{IO}$	Input Offset Current (Note 2)	$T_A = +25^\circ\text{C}$ $-45^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		50 100	nA
$I_{IB}$	Input Bias Current	$T_A = +25^\circ\text{C}$ $T_A = -45^\circ\text{C}$ $T_A = +85^\circ\text{C}$		250 375 500	nA
$A_V$	Voltage Gain		150000		
$t_{DLH}$	Propagation Delay Time			300	ns
$V_{DS}$	Saturation Voltage	$T_A = +25^\circ\text{C}$ $V_{ID} \leq -10\text{ mV}$ , $I_O = 50\text{ mA}$		1.5	V
$V_{IR}$	Input Voltage Range		-14.5	13.0	V
$I_{CC}$	Positive Supply Current			+7.5	mA
$I_{EE}$	Negative Supply Current			-5.0	mA

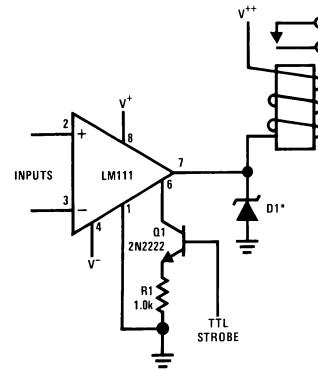
**NOTES:**

- Offset voltage, offset current and bias current specifications apply for a supply voltage range from a single 5.0 volt supply up to  $\pm 15$  volt supplies.
- The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1.0 mA load. Thus, these parameters define an error band and take into account the "worst case" effects of voltage gain and input impedance.

**Typical Applications** (Note 3) (Continued)

**Digital Transmission Isolator**


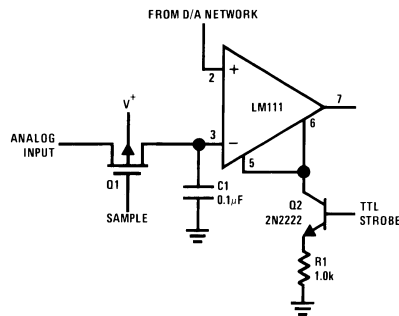
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**Relay Driver with Strobe**


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\*Absorbs inductive kickback of relay and protects IC from severe voltage transients on V<sup>+</sup> line.

**Note:** Do Not Ground Strobe Pin.

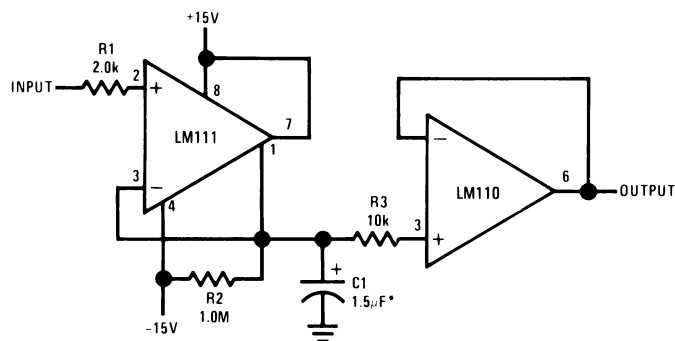
**Strobing off Both Input and Output Stages** (Note 2)


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**Note:** Do Not Ground Strobe Pin.

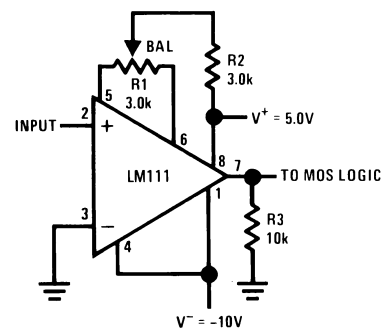
**Note 2:** Typical input current is 50 pA with inputs strobed off.

**Note 3:** Pin connections shown on schematic diagram and typical applications are for H08 metal can package.

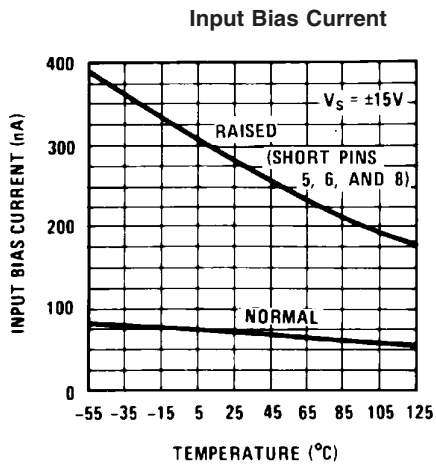
**Positive Peak Detector**


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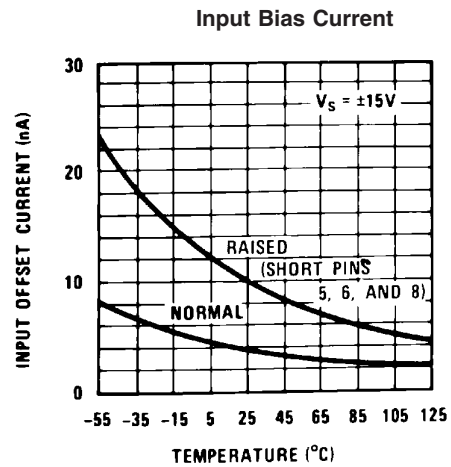
\*Solid tantalum

**Zero Crossing Detector Driving MOS Logic**


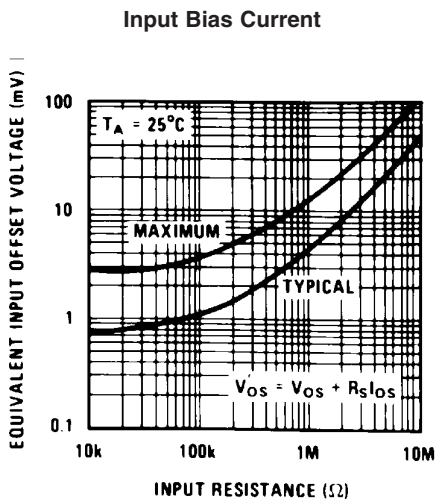
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**HT111/HT211 Typical Performance Characteristics**


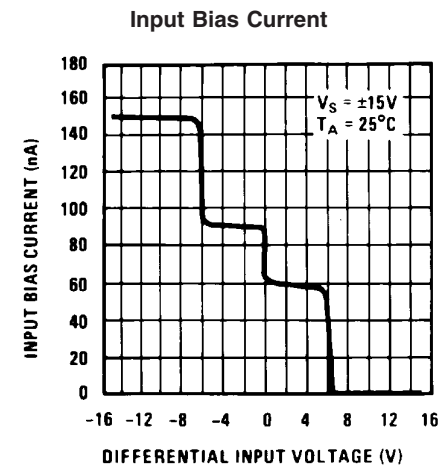
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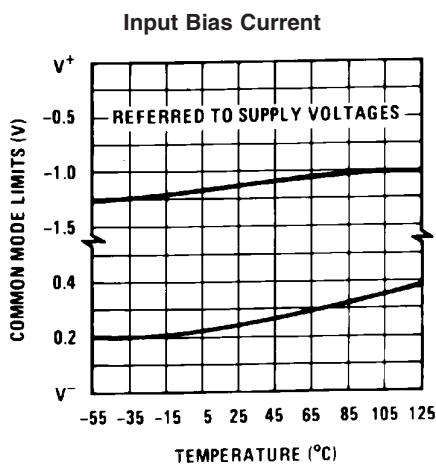
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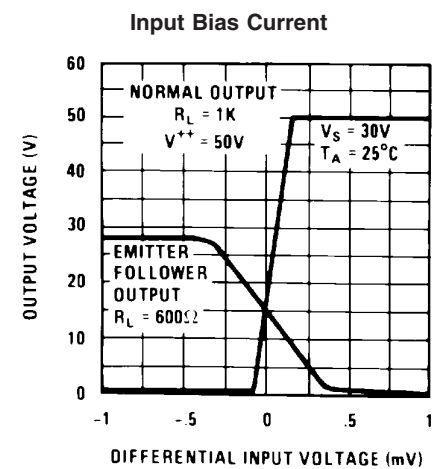
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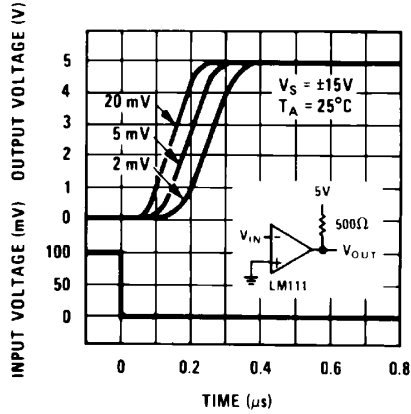
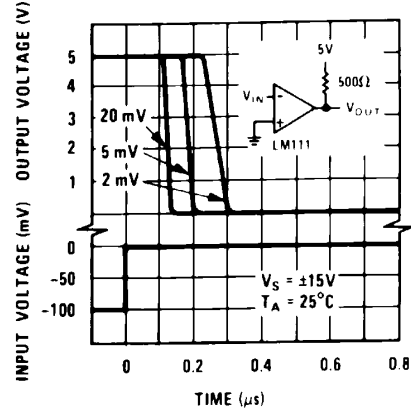
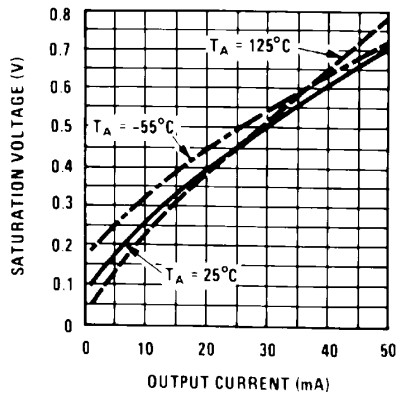
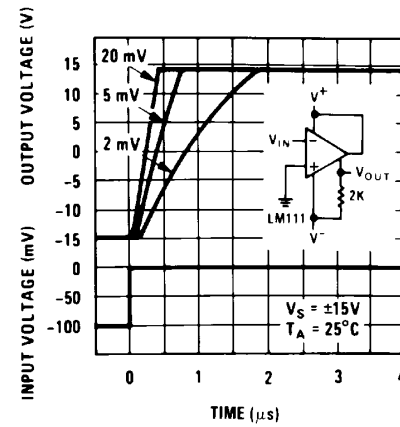
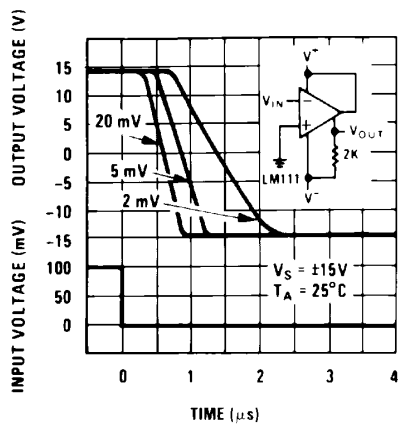
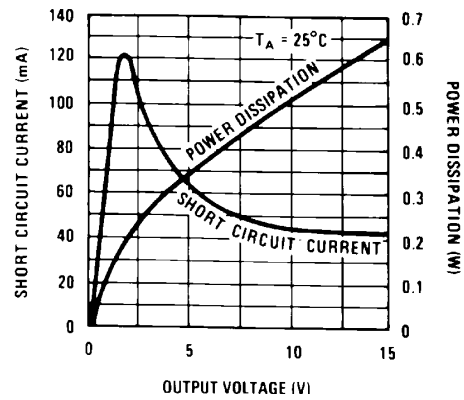
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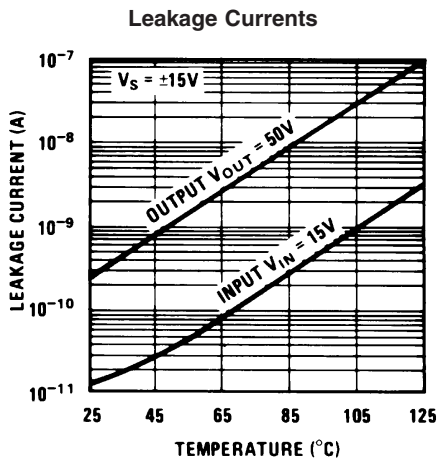
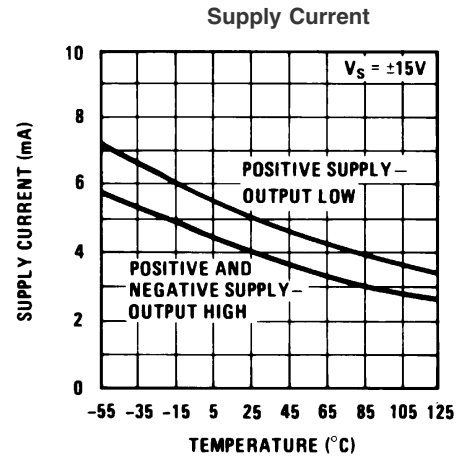
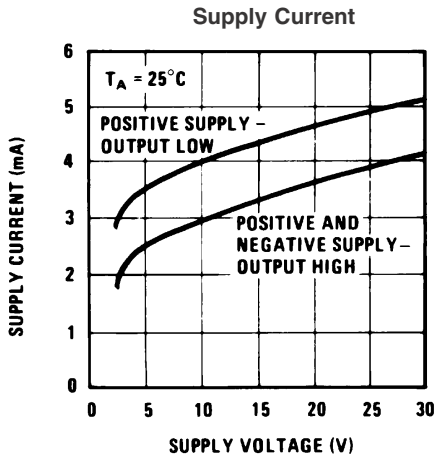
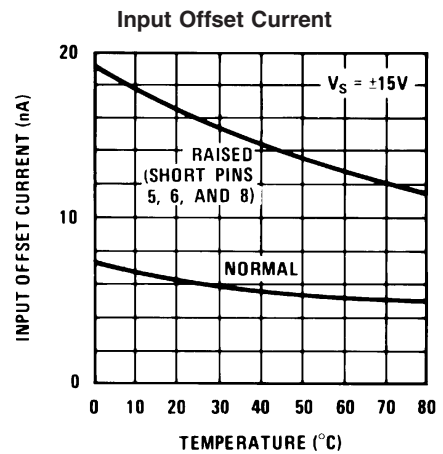
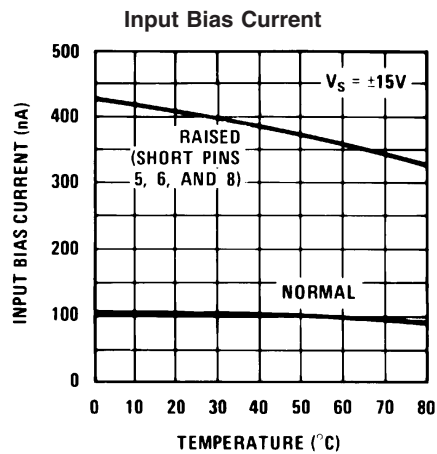


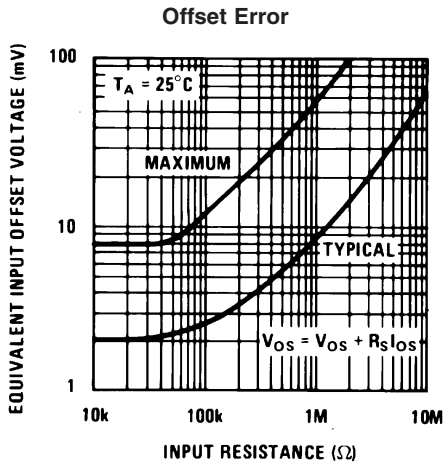
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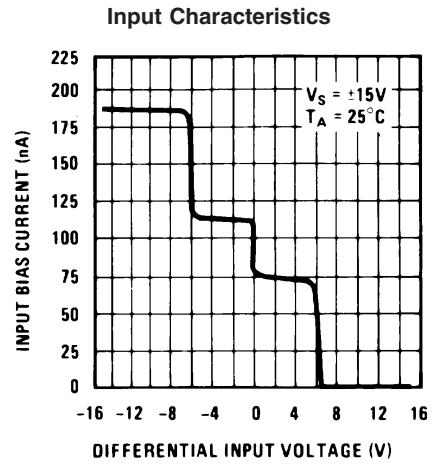
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**HT111/HT211 Typical Performance Characteristics (Continued)**
**Input Bias Current  
Input Overdrives**

**Input Bias Current  
Input Overdrives**

**Input Bias Current**

**Response Time for Various  
Input Overdrives**

**Response Time for Various  
Input Overdrives**

**Output Limiting Characteristics**


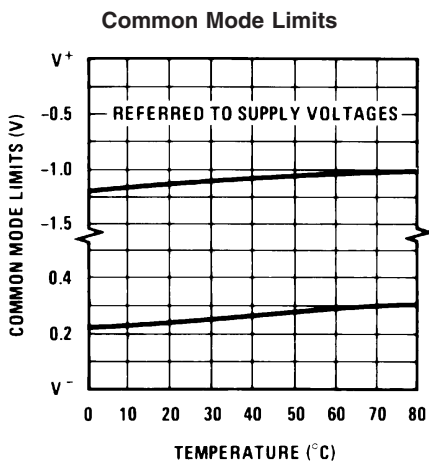
**HT111/HT211 Typical Performance Characteristics** (Continued)

**HT311 Typical Performance Characteristics**


**HT311 Typical Performance Characteristics** (Continued)


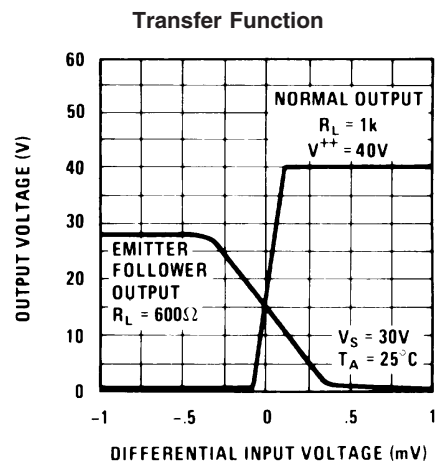
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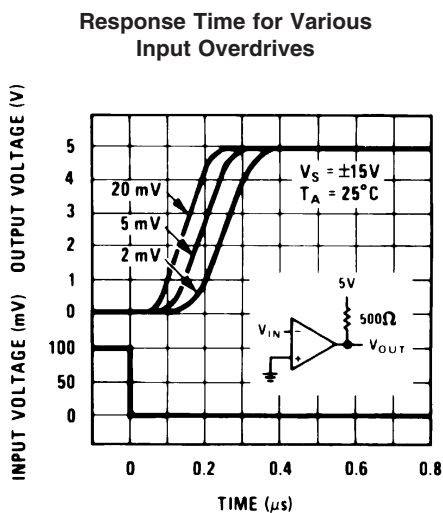
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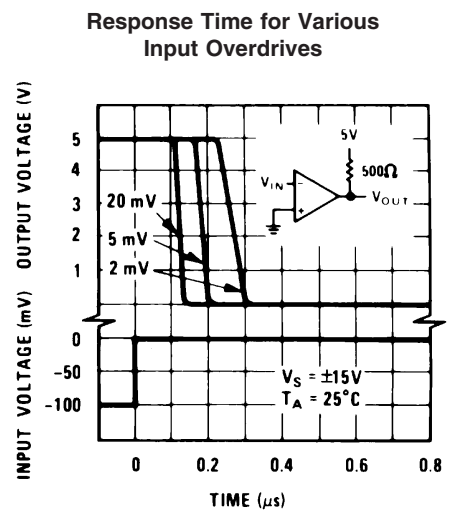
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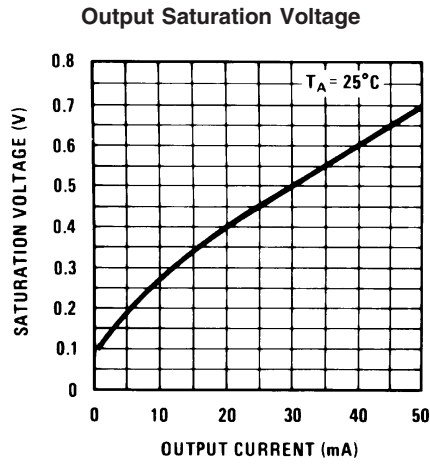
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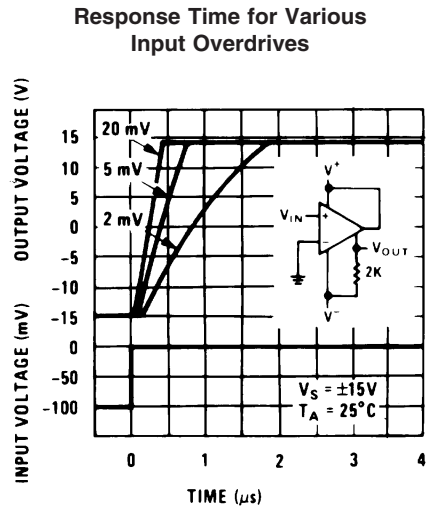
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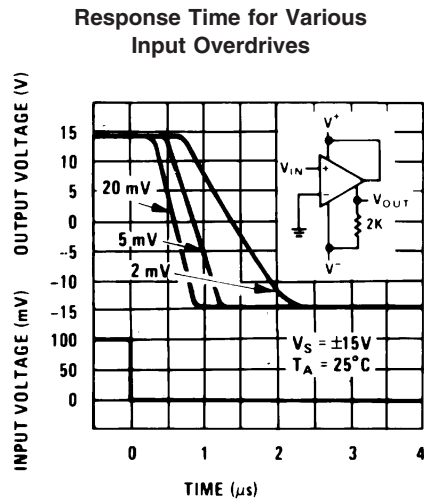
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**HT311 Typical Performance Characteristics** (Continued)


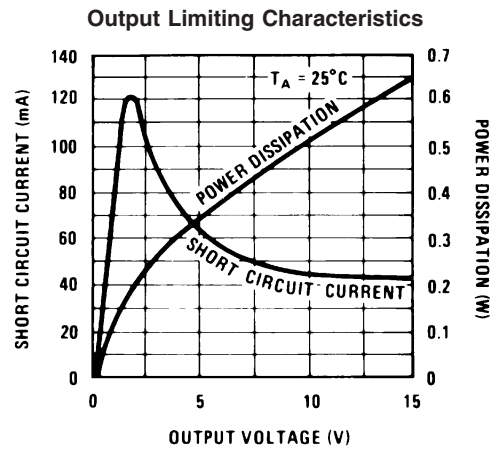
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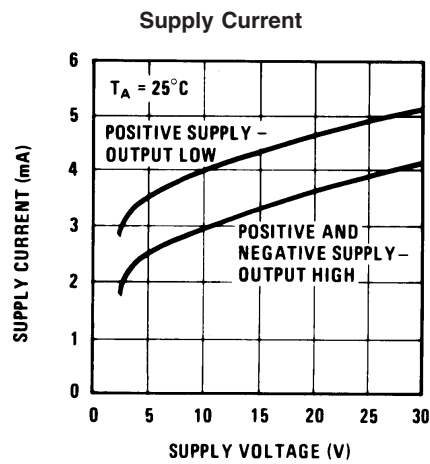
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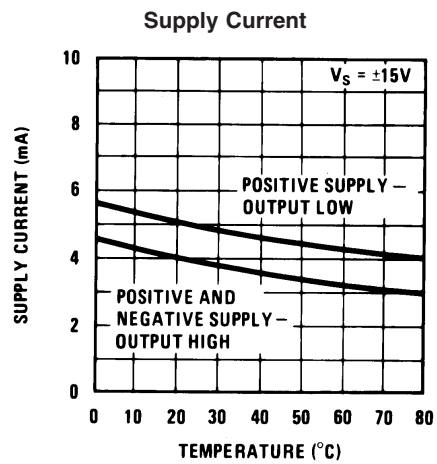
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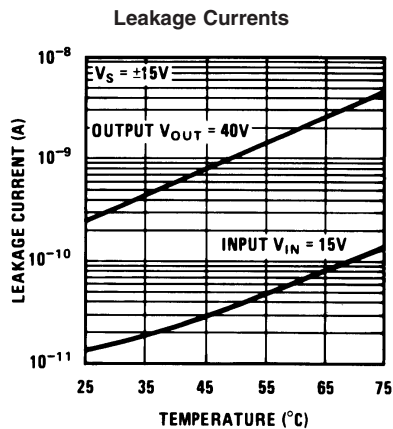


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**HT311 Typical Performance Characteristics** (Continued)


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## 8.0 Application Hints

### 8.1 CIRCUIT TECHNIQUES FOR AVOIDING OSCILLATIONS IN COMPARATOR APPLICATIONS

When a high-speed comparator such as the HT111 is used with fast input signals and low source impedances, the output response will normally be fast and stable, assuming that the power supplies have been bypassed (with 0.1  $\mu$ F disc capacitors), and that the output signal is routed well away from the inputs (pins 2 and 3) and also away from pins 5 and 6.

However, when the input signal is a voltage ramp or a slow sine wave, or if the signal source impedance is high (1 k $\Omega$  to 100 k $\Omega$ ), the comparator may burst into oscillation near the crossing-point. This is due to the high gain and wide bandwidth of comparators like the HT111. To avoid oscillation or instability in such a usage, several precautions are recommended, as shown in *Figure 1* below.

1. The trim pins (pins 5 and 6) act as unwanted auxiliary inputs. If these pins are not connected to a trim-pot, they should be shorted together. If they are connected to a trim-pot, a 0.01  $\mu$ F capacitor C1 between pins 5 and 6 will minimize the susceptibility to AC coupling. A smaller capacitor is used if pin 5 is used for positive feedback as in *Figure 1*.
2. Certain sources will produce a cleaner comparator output waveform if a 100 pF to 1000 pF capacitor C2 is connected directly across the input pins.
3. When the signal source is applied through a resistive network,  $R_S$ , it is usually advantageous to choose an  $R_S'$  of substantially the same value, both for DC and for dynamic (AC) considerations. Carbon, tin-oxide, and metal-film resistors have all been used successfully in comparator input circuitry. Inductive wirewound resistors are not suitable.
4. When comparator circuits use input resistors (eg. summing resistors), their value and placement are particularly important. In all cases the body of the resistor should be close to the device or socket. In other words there should be very little lead length or printed-circuit foil run between comparator and resistor to radiate or pick up signals. The same applies to capacitors, pots, etc. For example, if  $R_S=10$  k $\Omega$ , as little as 5 inches of

lead between the resistors and the input pins can result in oscillations that are very hard to damp. Twisting these input leads tightly is the only (second best) alternative to placing resistors close to the comparator.

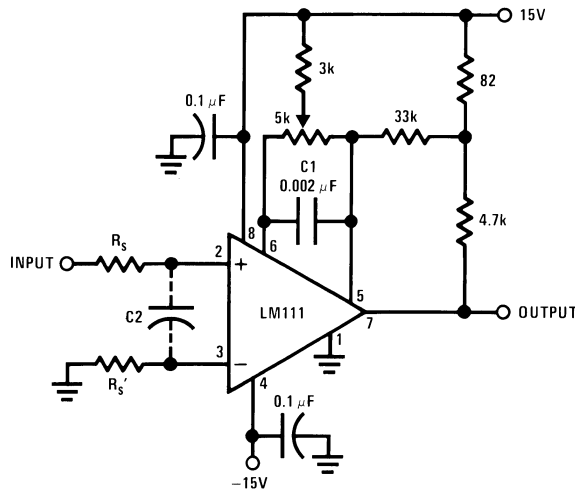
5. Since feedback to almost any pin of a comparator can result in oscillation, the printed-circuit layout should be engineered thoughtfully. Preferably there should be a groundplane under the HT111 circuitry, for example, one side of a double-layer circuit card. Ground foil (or, positive supply or negative supply foil) should extend between the output and the inputs, to act as a guard. The foil connections for the inputs should be as small and compact as possible, and should be essentially surrounded by ground foil on all sides, to guard against capacitive coupling from any high-level signals (such as the output). If pins 5 and 6 are not used, they should be shorted together. If they are connected to a trim-pot, the trim-pot should be located, at most, a few inches away from the HT111, and the 0.01  $\mu$ F capacitor should be installed. If this capacitor cannot be used, a shielding printed-circuit foil may be advisable between pins 6 and 7. The power supply bypass capacitors should be located within a couple inches of the HT111. (Some other comparators require the power-supply bypass to be located immediately adjacent to the comparator.)
6. It is a standard procedure to use hysteresis (positive feedback) around a comparator, to prevent oscillation, and to avoid excessive noise on the output because the comparator is a good amplifier for its own noise. In the circuit of *Figure 2*, the feedback from the output to the positive input will cause about 3 mV of hysteresis. However, if  $R_S$  is larger than 100 $\Omega$ , such as 50 k $\Omega$ , it would not be reasonable to simply increase the value of the positive feedback resistor above 510 k $\Omega$ . The circuit of *Figure 3* could be used, but it is rather awkward. See the notes in paragraph 7 below.

**Application Hints** (Continued)

7. When both inputs of the HT111 are connected to active signals, or if a high-impedance signal is driving the positive input of the HT111 so that positive feedback would be disruptive, the circuit of *Figure 1* is ideal. The positive feedback is to pin 5 (one of the offset adjustment pins). It is sufficient to cause 1 to 2 mV hysteresis and sharp transitions with input triangle waves from a few Hz to hundreds of kHz. The positive-feedback signal across the 82Ω resistor swings 240 mV below the posi-

tive supply. This signal is centered around the nominal voltage at pin 5, so this feedback does not add to the  $V_{OS}$  of the comparator. As much as 8 mV of  $V_{OS}$  can be trimmed out, using the 5 kΩ pot and 3 kΩ resistor as shown.

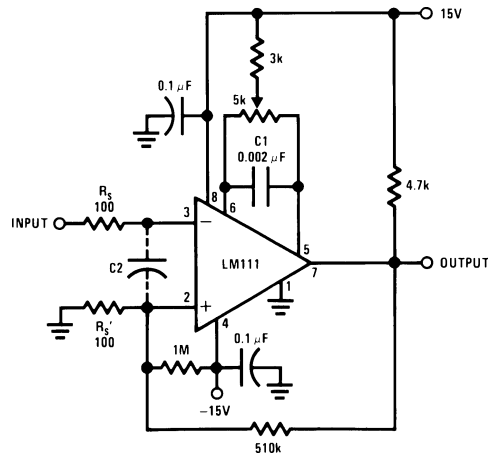
8. These application notes apply specifically to the HT111, HT211, HT311, and LF111 families of comparators, and are applicable to all high-speed comparators in general, (with the exception that not all comparators have trim pins).



Pin connections shown are for HT111H in the H08 hermetic package

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**FIGURE 1. Improved Positive Feedback**

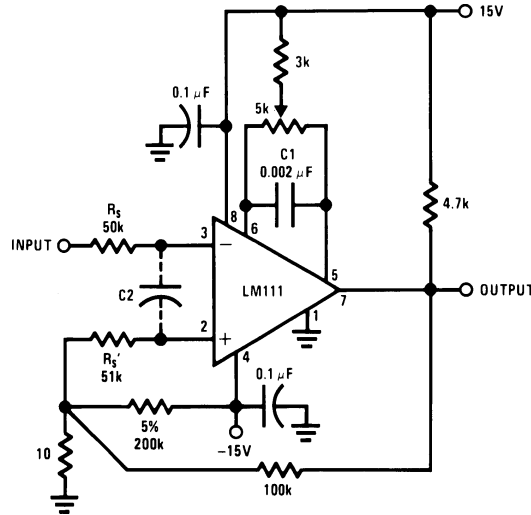


Pin connections shown are for HT111H in the H08 hermetic package

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**FIGURE 2. Conventional Positive Feedback**

**Application Hints** (Continued)

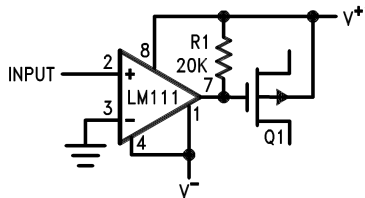


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FIGURE 3. Positive Feedback with High Source Resistance

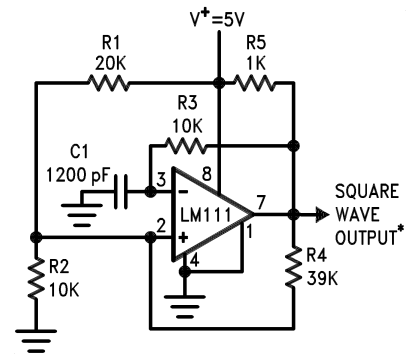
**Typical Applications** (Pin numbers refer to H08 package)

**Zero Crossing Detector Driving MOS Switch**



00570413

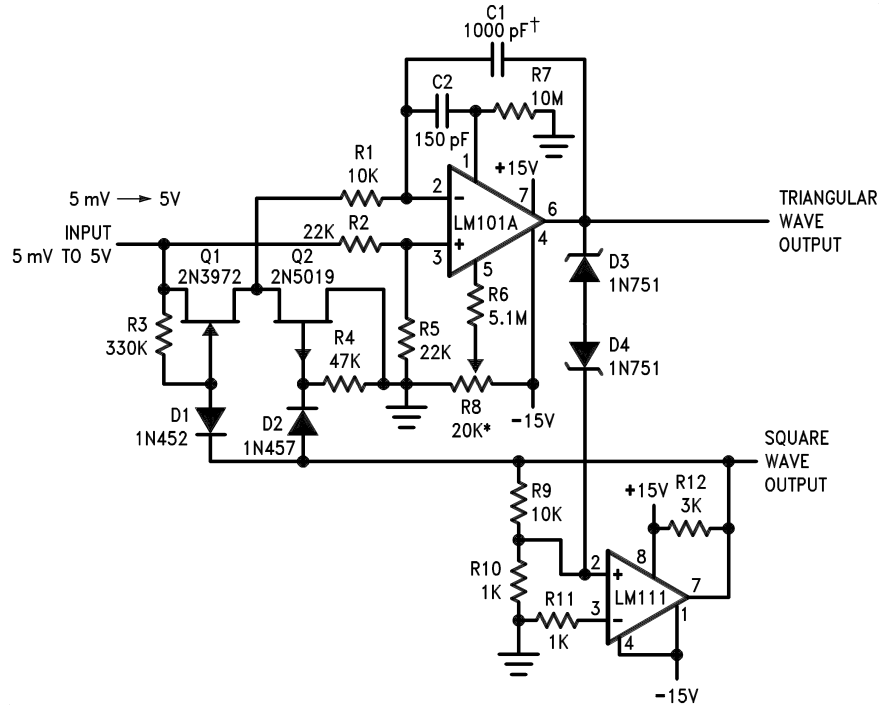
**100 kHz Free Running Multivibrator**



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\*TTL or DTL fanout of two

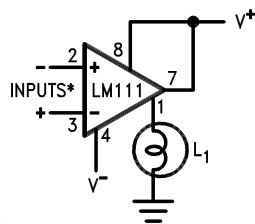
**Typical Applications** (Pin numbers refer to H08 package) (Continued)

**10 Hz to 10 kHz Voltage Controlled Oscillator**


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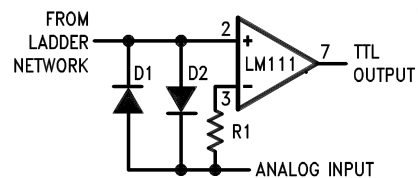
 \*Adjust for symmetrical square wave time when  $V_{IN} = 5 \text{ mV}$ 

†Minimum capacitance 20 pF Maximum frequency 50 kHz

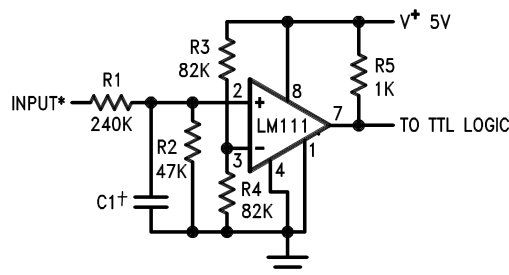
**Driving Ground-Referred Load**


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\*Input polarity is reversed when using pin 1 as output.

**Using Clamp Diodes to Improve Response**


00570417

**TTL Interface with High Level Logic**


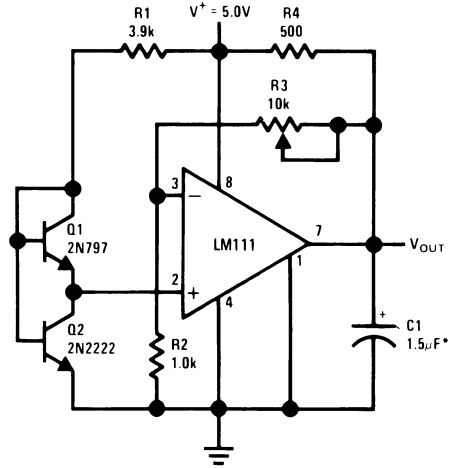
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\*Values shown are for a 0 to 30V logic swing and a 15V threshold.

†May be added to control speed and reduce susceptibility to noise spikes.

**Typical Applications** (Pin numbers refer to H08 package) (Continued)

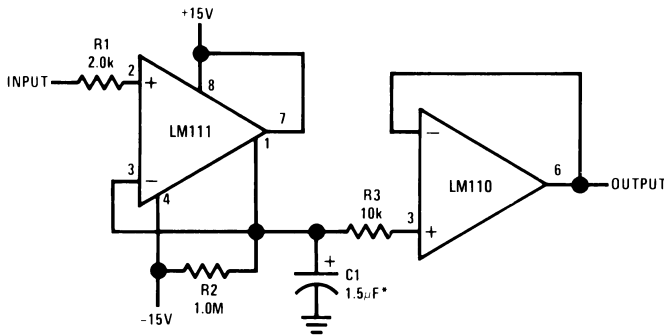
**Low Voltage Adjustable Reference Supply**



\*Solid tantalum

00570422

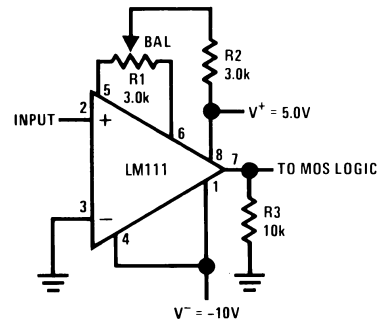
**Positive Peak Detector**



\*Solid tantalum

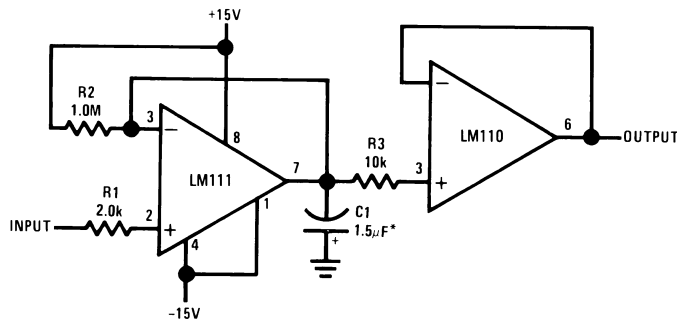
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**Zero Crossing Detector Driving MOS Logic**



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**Negative Peak Detector**

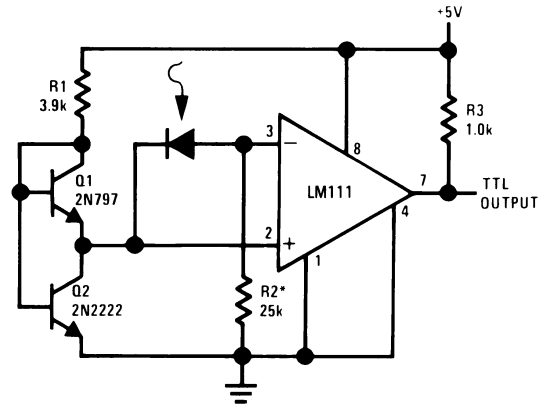


\*Solid tantalum

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**Typical Applications** (Pin numbers refer to H08 package) (Continued)

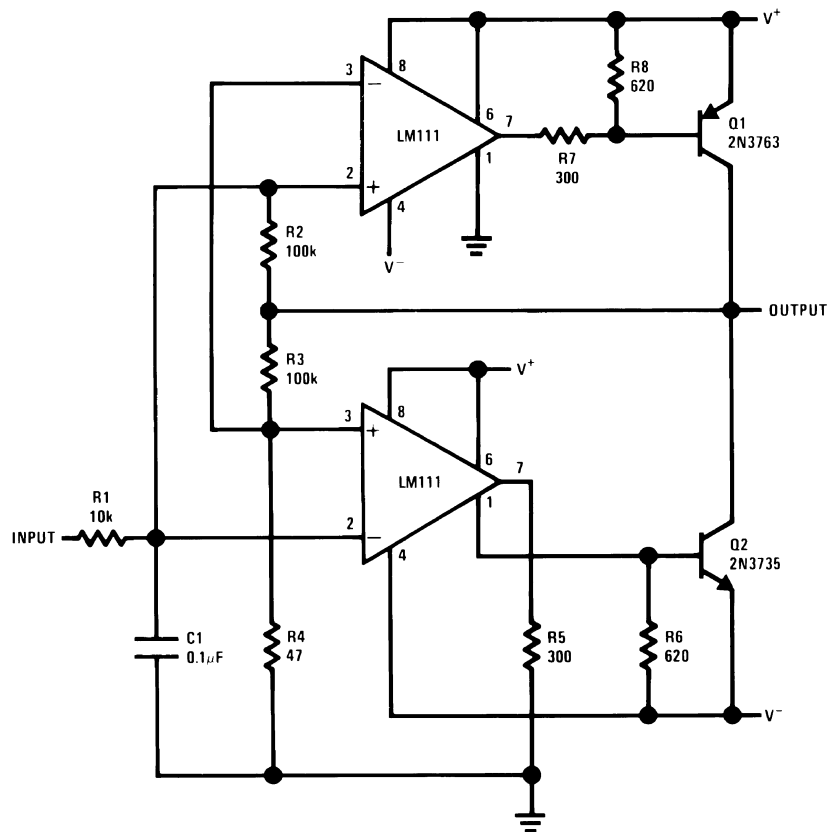
**Precision Photodiode Comparator**



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\*R2 sets the comparison level. At comparison, the photodiode has less than 5 mV across it, decreasing leakages by an order of magnitude.

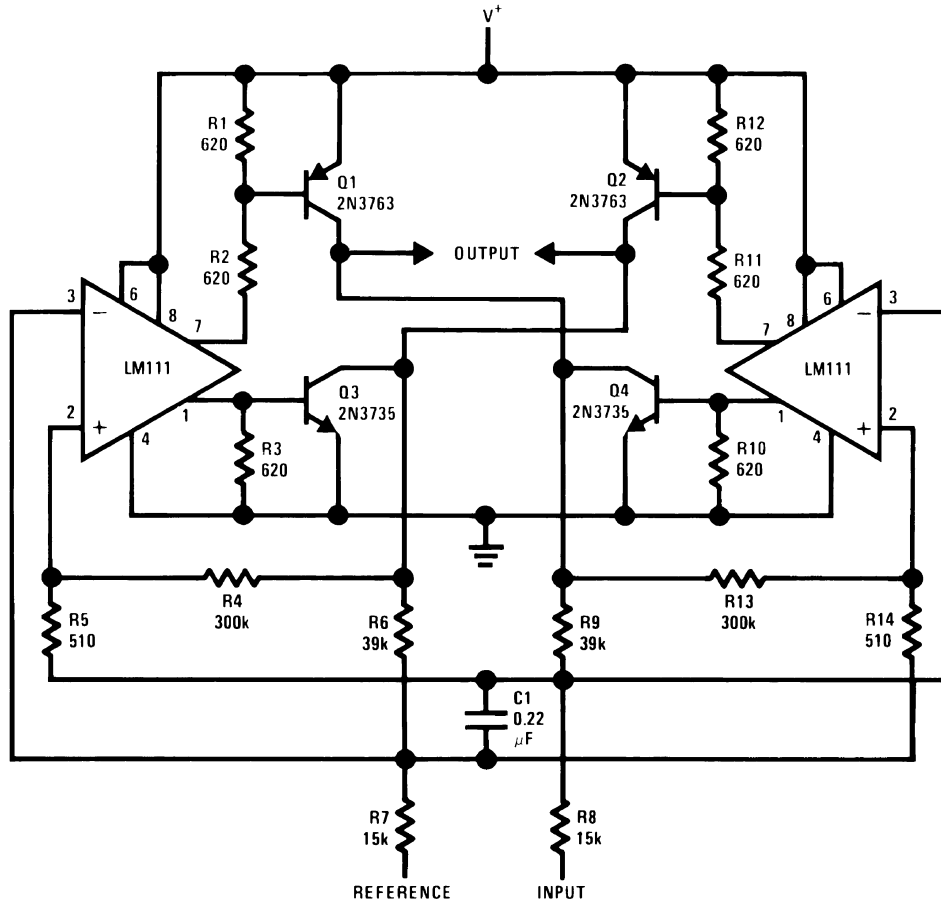
**Switching Power Amplifier**



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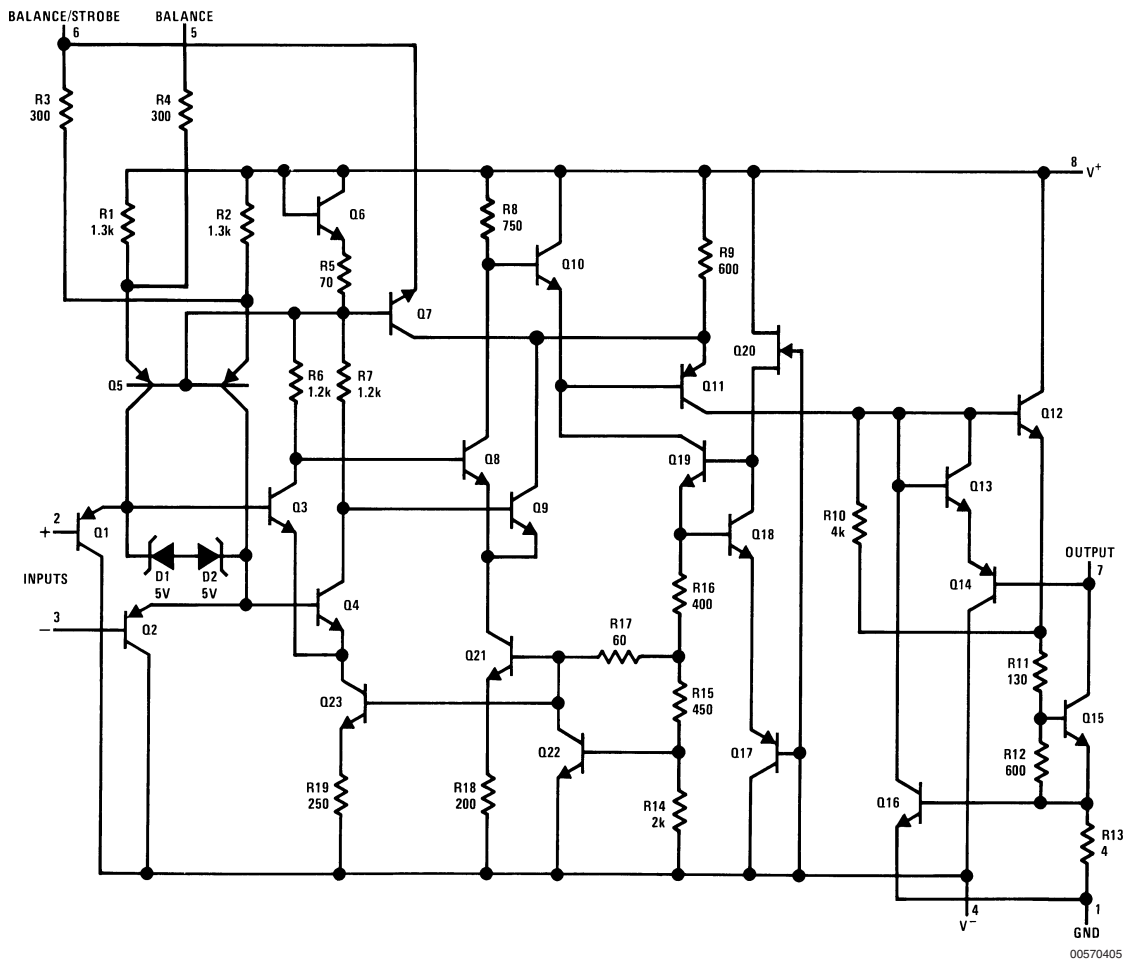
Typical Applications (Pin numbers refer to H08 package) (Continued)

Switching Power Amplifier



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**Schematic Diagram** (Note 20)



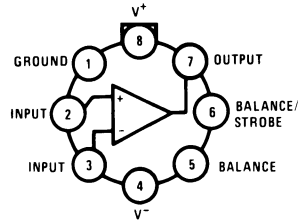
**Note 20:** Pin connections shown on schematic diagram are for H08 package.

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## Connection Diagrams

**Metal Can Package**



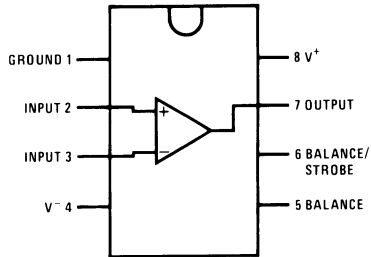
00570406

Note: Pin 4 connected to case

**Top View**

Order Number HT111H, HT111H/883(Note 21) , HT211H or HT311H

**Dual-In-Line Package**

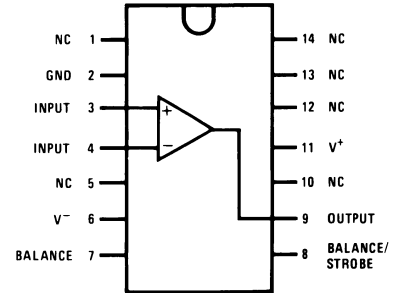


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**Top View**

Order Number HT111J-8, HT111J-8/883(Note 21), HT311 or HT311N

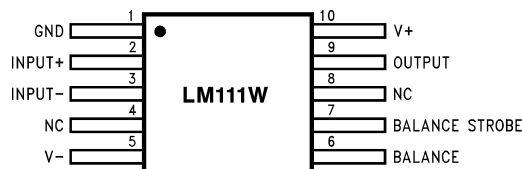
**Dual-In-Line Package**



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**Top View**

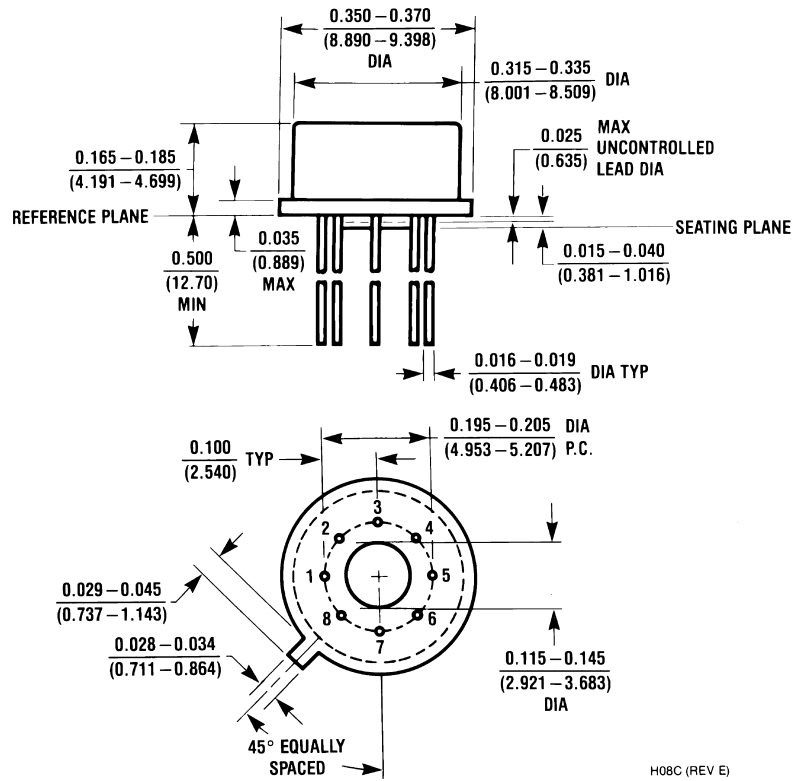
Order Number HT111J/883(Note 21)

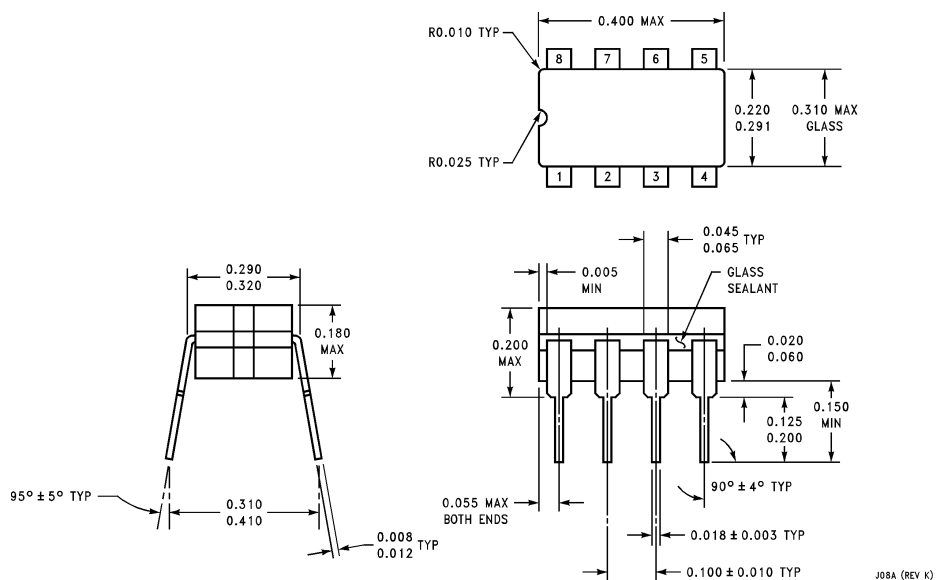


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Order Number HT111W/883(Note 21), HT111WG/883

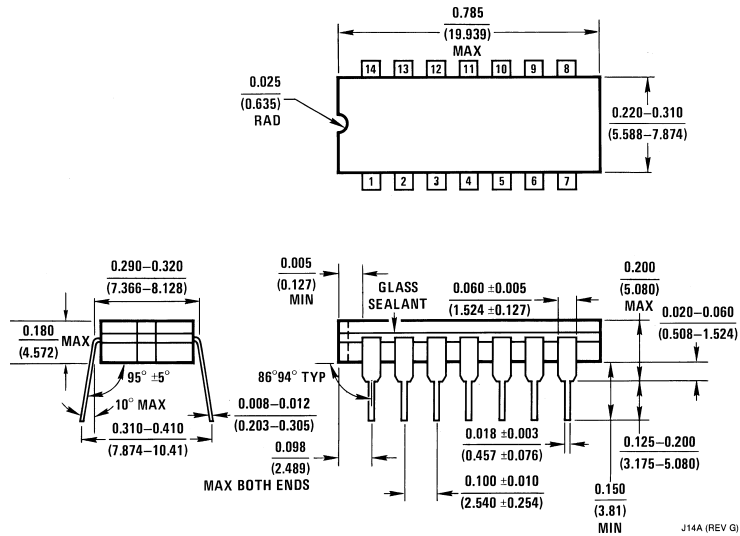
Note 21: Also available per JM38510/10304

**Physical Dimensions** inches (millimeters) unless otherwise noted

**Metal Can Package (H)**

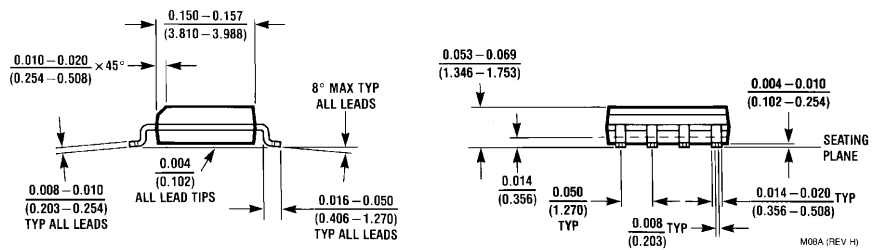
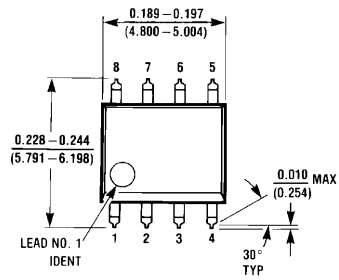
 Order Number HT111H, HT111H/883, HT211H or HT311H  
 NS Package Number H08C

**Cavity Dual-In-Line Package (J)**

 Order Number HT111J-8, HT111J-8/883  
 NS Package Number J08A

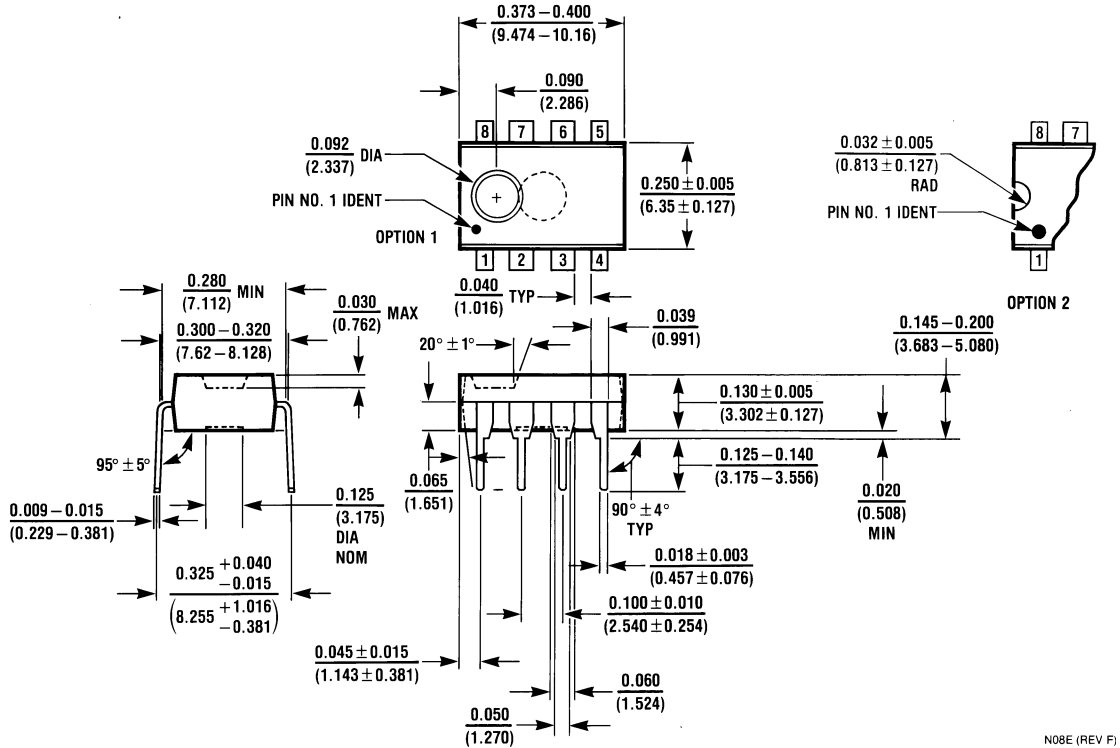
**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



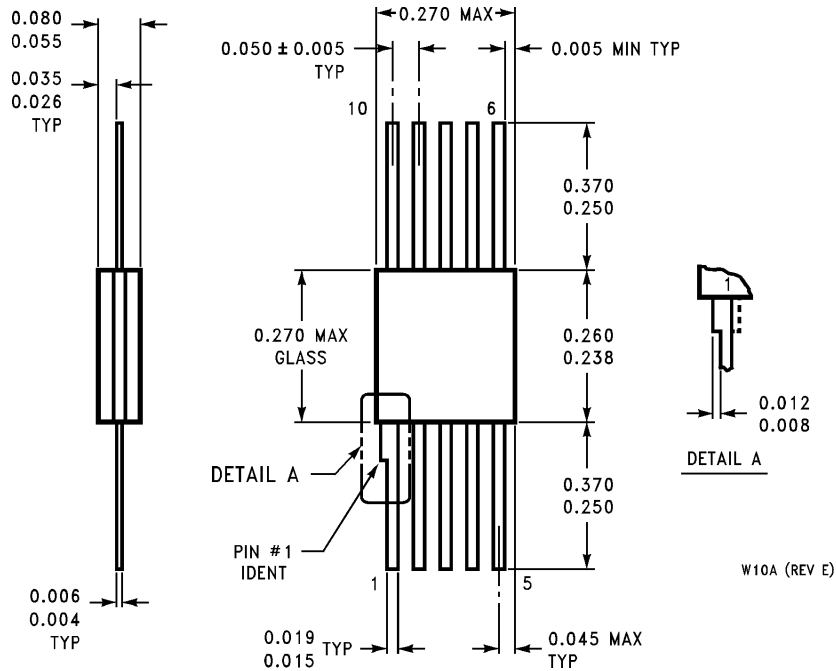
**Dual-In-Line Package (J)**  
Order Number HT111J/883



**Dual-In-Line Package (M)**  
Order Number HT311

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)

**Dual-In-Line Package (N)**  
**Order Number HT311N**

N08E (REV F)


**Order Number HT111W/883, HT111WG/883**

W10A (REV E)

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