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# HA17901 Series

## Quadruple Comparators

REJ03D0684-0100  
(Previous: ADE-204-047)  
Rev.1.00  
Jun 15, 2005

### Description

The HA17901 series products are comparators designed for use in power or control systems.

These IC operate from a single power-supply voltage over a wide range of voltages, and feature a reduced power-supply current since the power-supply voltage is determined independently.

These comparators have the unique characteristic of ground being included in the common-mode input voltage range, even when operating from a single-voltage power supply. These products have a wide range of applications, including limit comparators, simple A/D converters, pulse/square-wave/time delay generators, wide range VCO circuits, MOS clock timers, multivibrators, and high-voltage logic gates.

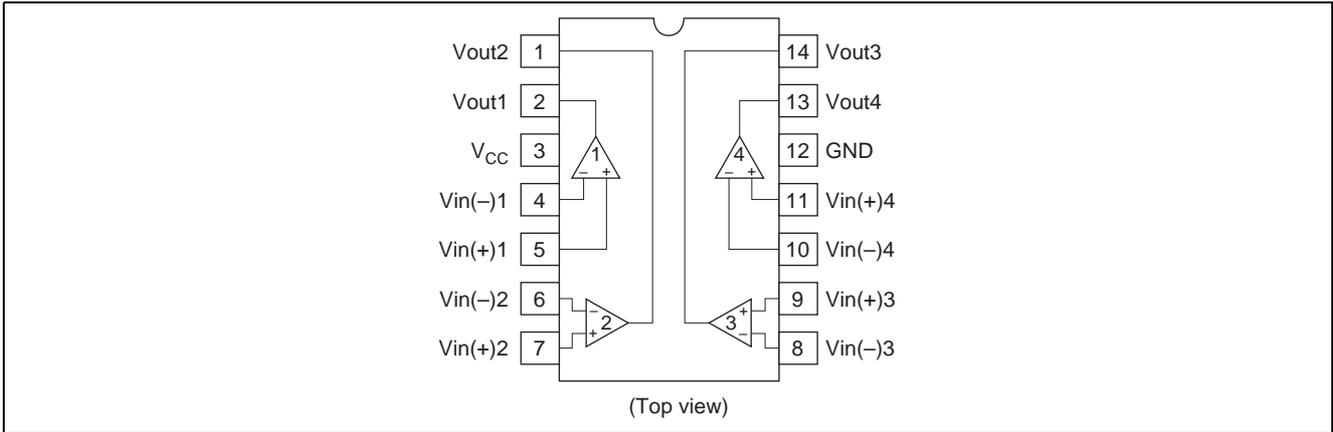
### Features

- Wide power-supply voltage range: 2 to 36V
- Extremely low current drain: 0.8mA
- Low input bias current: 25nA
- Low input offset current: 5nA
- Low input offset voltage: 2mV
- The common-mode input voltage range includes ground.
- Low output saturation voltage: 1mV (5 $\mu$ A), 70mV (1mA)
- Output voltages compatible with CMOS logic systems

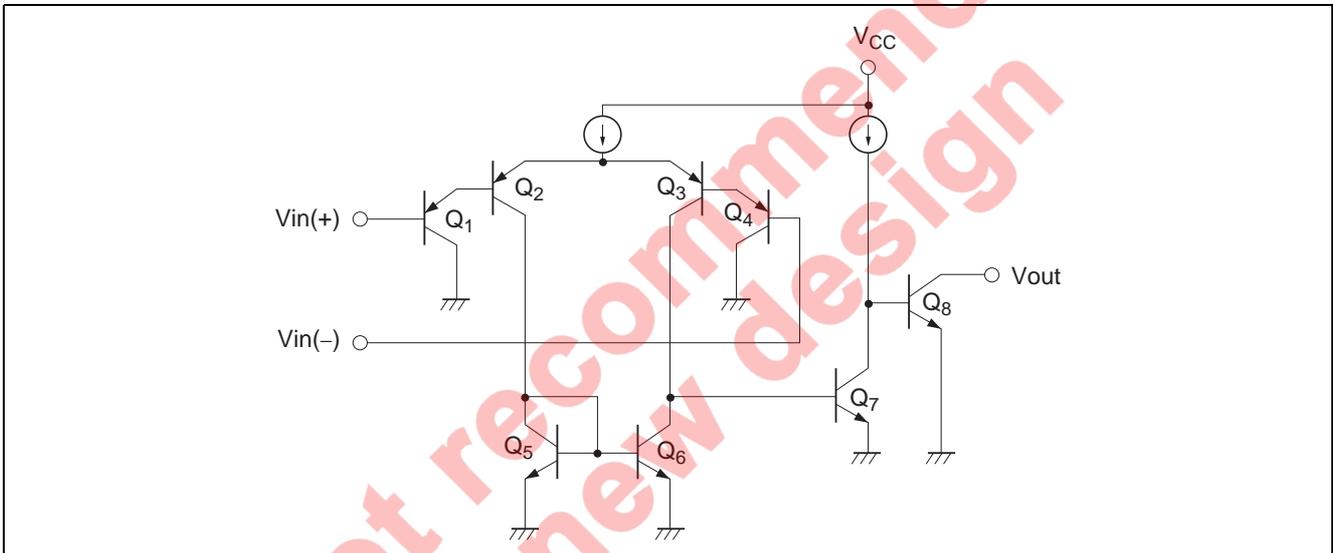
### Ordering Information

Type No.	Application	Package Code (Previous Code)
HA17901PJ	Car use	PRDP0014AB-A (DP-14)
HA17901FPJ		PRSP0014DF-B (FP-14DAV)
HA17901FPK		PRSP0014DF-B (FP-14DAV)

### Pin Arrangement



### Circuit Structure (1/4)



## Absolute Maximum Ratings

(Ta = 25°C)

Item	Symbol	17901PJ	17901FPJ	17901FPK	Unit
Power-supply voltage	V <sub>CC</sub>	36	36	36	V
Differential input voltage	V <sub>in(diff)</sub>	±V <sub>CC</sub>	±V <sub>CC</sub>	±V <sub>CC</sub>	V
Input voltage	V <sub>in</sub>	-0.3 to +V <sub>CC</sub>	-0.3 to +V <sub>CC</sub>	-0.3 to +V <sub>CC</sub>	V
Output current	I <sub>out</sub> * <sup>2</sup>	20	20	20	mA
Allowable power dissipation	P <sub>T</sub>	625* <sup>1</sup>	625* <sup>3</sup>	625* <sup>3</sup>	mW
Operating temperature	Topr	-40 to +85	-40 to +85	-40 to +125	°C
Storage temperature	Tstg	-55 to +125	-55 to +125	-55 to +150	°C
Output pin voltage	V <sub>out</sub>	36	36	36	V

- Notes: 1. These are the allowable values up to Ta = 50°C. Derate by 8.3mW/°C above that temperature.  
 2. These products can be destroyed if the output and V<sub>CC</sub> are shorted together. The maximum output current is the allowable value for continuous operation.  
 3. See notes of SOP Package Usage in Reliability section.

## Electrical Characteristics 1

(V<sub>CC</sub> = 5V, Ta = 25°C)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	V <sub>IO</sub>	—	2	7	mV	Output switching point: when V <sub>O</sub> = 1.4V, R <sub>S</sub> = 0Ω
Input bias current	I <sub>IB</sub>	—	25	250	nA	I <sub>IN(+)</sub> or I <sub>IN(-)</sub>
Input offset current	I <sub>IO</sub>	—	5	50	nA	I <sub>IN(+)</sub> - I <sub>IN(-)</sub>
Common-mode input voltage* <sup>1</sup>	V <sub>CM</sub>	0	—	V <sub>CC</sub> - 1.5	V	
Supply current	I <sub>CC</sub>	—	0.8	2	mA	R <sub>L</sub> = ∞
Voltage Gain	A <sub>VD</sub>	—	200	—	V/mV	R <sub>L</sub> = 15kΩ
Response time* <sup>2</sup>	t <sub>R</sub>	—	1.3	—	μs	V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1kΩ
Output sink current	I <sub>osink</sub>	6	16	—	mA	V <sub>IN(-)</sub> = 1V, V <sub>IN(+)</sub> = 0, V <sub>O</sub> ≤ 1.5V
Output saturation voltage	V <sub>O sat</sub>	—	200	400	mV	V <sub>IN(-)</sub> = 1V, V <sub>IN(+)</sub> = 0, I <sub>osink</sub> = 3mA
Output leakage current	I <sub>LO</sub>	—	0.1	—	nA	V <sub>IN(+)</sub> = 1V, V <sub>IN(-)</sub> = 0, V <sub>O</sub> = 5V

- Notes: 1. Voltages more negative than -0.3V are not allowed for the common-mode input voltage or for either one of the input signal voltages.  
 2. The stipulated response time is the value for a 100 mV input step voltage that has a 5mV overdrive.

## Electrical Characteristics 2

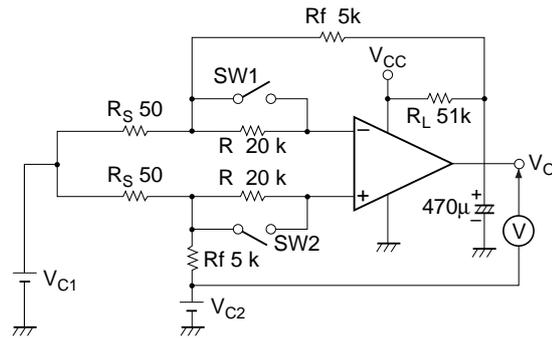
(V<sub>CC</sub> = 5V, Ta = -41 to +125°C)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	V <sub>IO</sub>	—	—	7	mV	Output switching point: when V <sub>O</sub> = 1.4V, R <sub>S</sub> = 0Ω
Input offset current	I <sub>IO</sub>	—	—	200	nA	I <sub>IN(-)</sub> - I <sub>IN(+)</sub>
Input bias current	I <sub>IB</sub>	—	—	500	nA	
Common-mode input voltage* <sup>1</sup>	V <sub>CM</sub>	0	—	V <sub>CC</sub> - 2.0	V	
Output saturation voltage	V <sub>O sat</sub>	—	—	440	mV	V <sub>IN(-)</sub> ≥ 1V, V <sub>IN(+)</sub> = 0, I <sub>osink</sub> ≤ 4mA
Output leakage current	I <sub>LO</sub>	—	1.0	—	μA	V <sub>IN(-)</sub> = 0V, V <sub>IN(+)</sub> ≥ 1V, V <sub>O</sub> = 30V
Supply current	I <sub>CC</sub>	—	—	4.0	mA	All comparators: R <sub>L</sub> = ∞, All channels ON

- Note: 1. Voltages more negative than -0.3V are not allowed for the common-mode input voltage or for either one of the input signal voltages.

**Test Circuits**

1. Input offset voltage ( $V_{IO}$ ), input offset current ( $I_{IO}$ ), and Input bias current ( $I_{IB}$ ) test circuit



SW1	SW2	Vout
On	On	$V_{O1}$
Off	Off	$V_{O2}$
On	Off	$V_{O3}$
Off	On	$V_{O4}$

$$V_{C1} = \frac{1}{2} V_{CC}$$

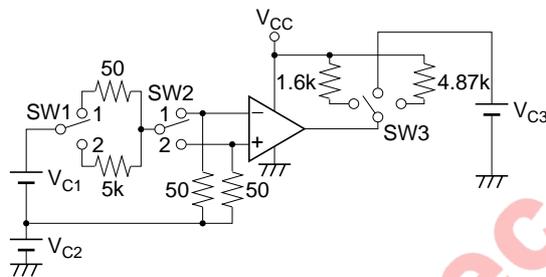
$$V_{C2} = 1.4V$$

$$V_{IO} = \frac{|V_{O1}|}{1 + R_f / R_S} \quad (\text{mV})$$

$$I_{IO} = \frac{|V_{O2} - V_{O1}|}{R(1 + R_f / R_S)} \quad (\text{nA})$$

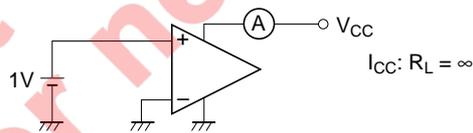
$$I_{IB} = \frac{|V_{O4} - V_{O3}|}{2 \cdot R(1 + R_f / R_S)} \quad (\text{nA})$$

2. Output saturation voltage ( $V_{O\text{ sat}}$ ) output sink current ( $I_{\text{osink}}$ ), and common-mode input voltage ( $V_{CM}$ ) test circuit

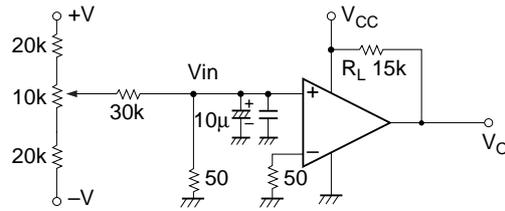


Item	$V_{C1}$	$V_{C2}$	$V_{C3}$	SW1	SW2	SW3	Unit
$V_{O\text{ sat}}$	2V	0V	—	1	1	1 at $V_{CC} = 5V$ 3 at $V_{CC} = 15V$	V
$I_{\text{osink}}$	2V	0V	1.5V	1	1	2	mA
$V_{CM}$	2V	-1 to $V_{CC}$	—	2	Switched between 1 and 2	3	V

3. Supply current ( $I_{CC}$ ) test circuit

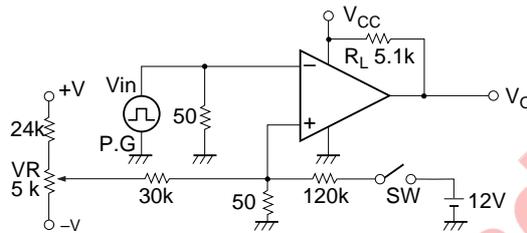


4. Voltage gain ( $A_{VD}$ ) test circuit ( $R_L = 15k\Omega$ )



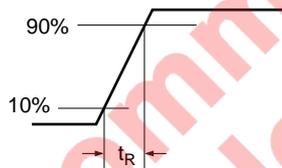
$$A_{VD} = 20 \log \frac{V_{O1} - V_{O2}}{V_{IN1} - V_{IN2}} \quad (\text{dB})$$

5. Response time ( $t_R$ ) test circuit



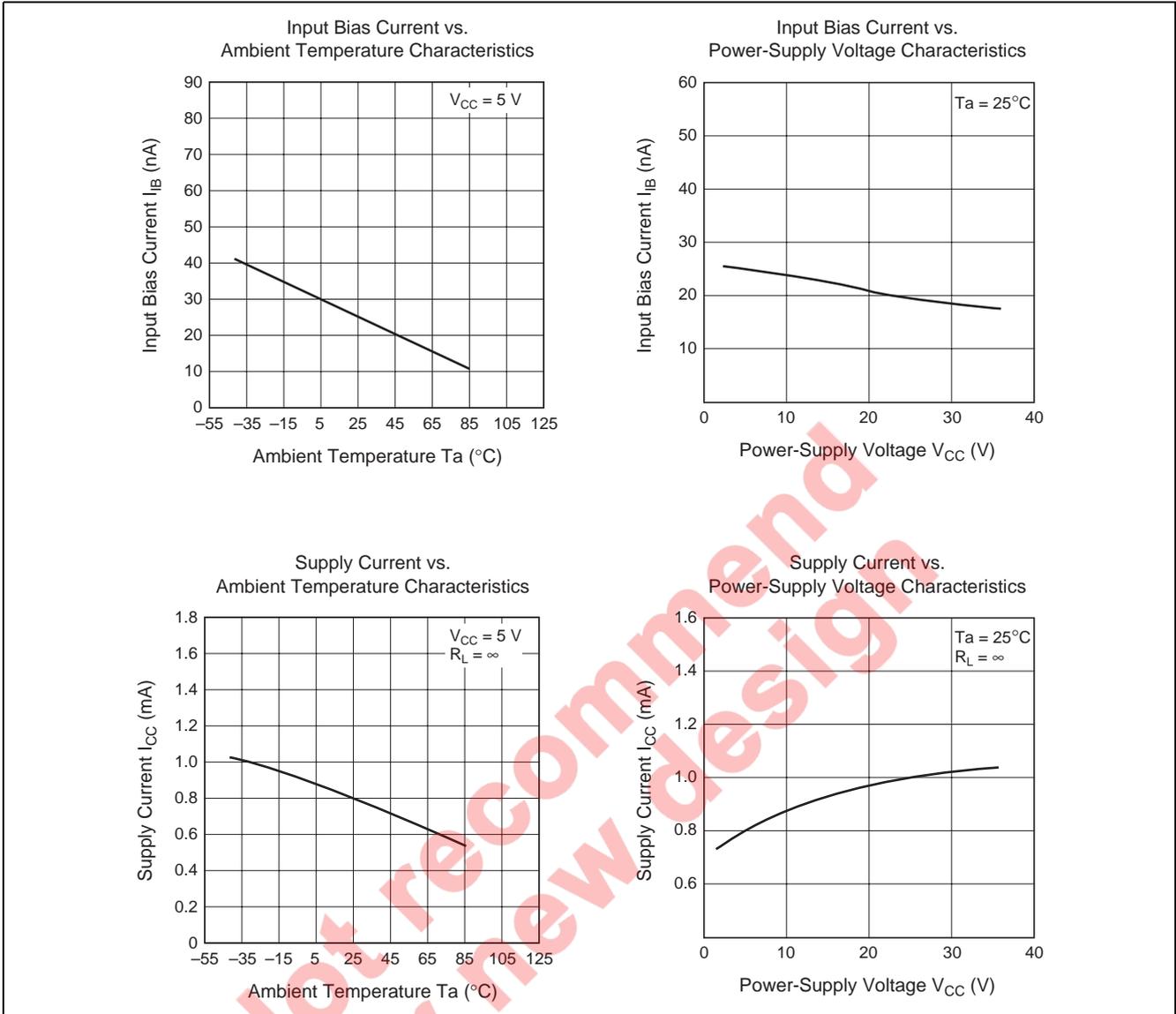
$t_R$ :  $R_L = 5.1k\Omega$ , a 100mV input step voltage that has a 5mV overdrive

- With  $V_{IN}$  not applied, set the switch SW to the off position and adjust  $V_R$  so that  $V_O$  is in the vicinity of 1.4V.
- Apply  $V_{IN}$  and turn the switch SW on.

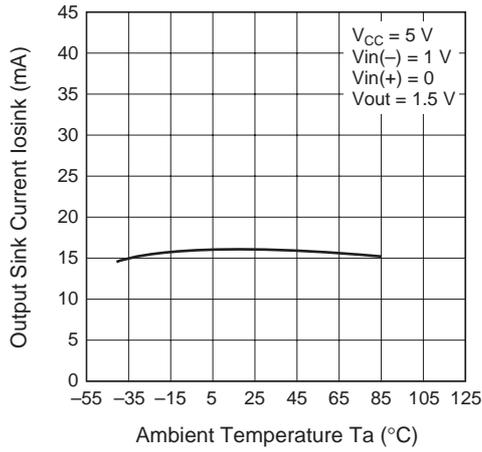


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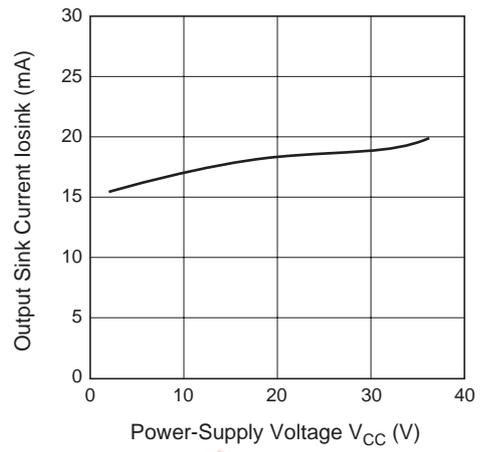
Characteristics Curve



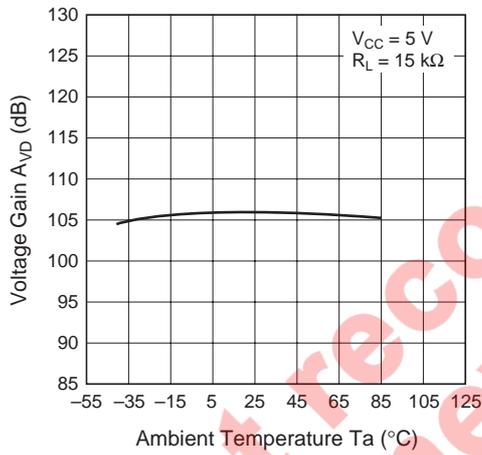
Output Sink Current vs. Ambient Temperature Characteristics



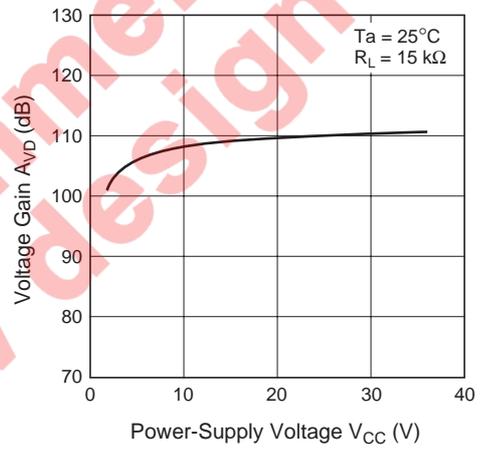
Output Sink Current vs. Power-Supply Voltage Characteristics



Voltage Gain vs. Ambient Temperature Characteristics



Voltage Gain vs. Power-Supply Voltage Characteristics



Not recommended for new design

## HA17901 Application Examples

The HA17901 houses four independent comparators in a single package, and operates over a wide voltage range at low power from a single-voltage power supply. Since the common-mode input voltage range starts at the ground potential, the HA17901 is particularly suited for single-voltage power supply applications. This section presents several sample HA17901 applications.

### HA17901 Application Notes

#### 1. Square-Wave Oscillator

The circuit shown in figure one has the same structure as a single-voltage power supply astable multivibrator. Figure 2 shows the waveforms generated by this circuit.

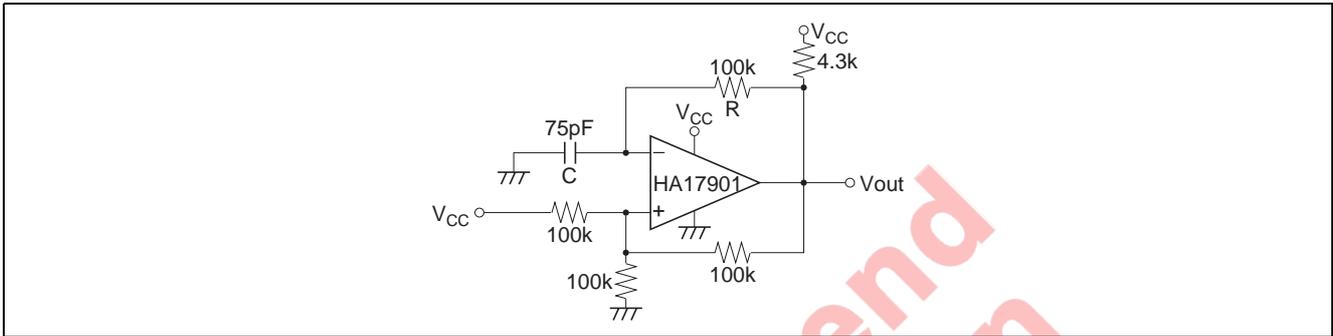


Figure 1 Square-Wave Oscillator

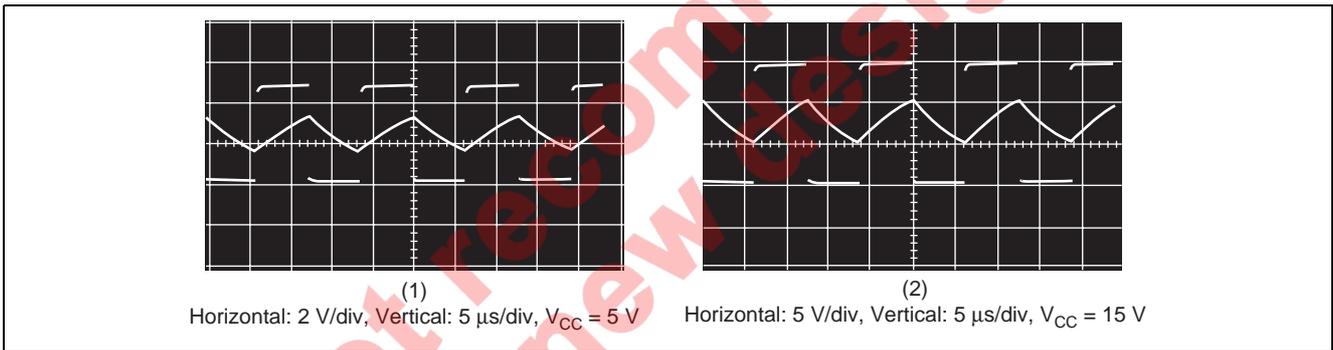


Figure 2 Operating Waveforms

2. Pulse Generator

The charge and discharge circuits in the circuit from figure 1 are separated by diodes in this circuit. (See figure 3.) This allows the pulse width and the duty cycle to be set independently. Figure 4 shows the waveforms generated by this circuit.

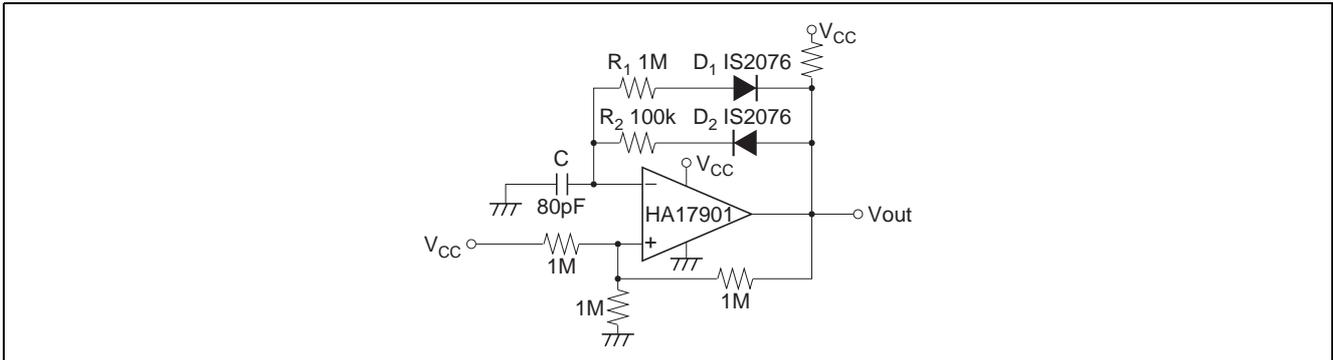


Figure 3 Pulse Generator

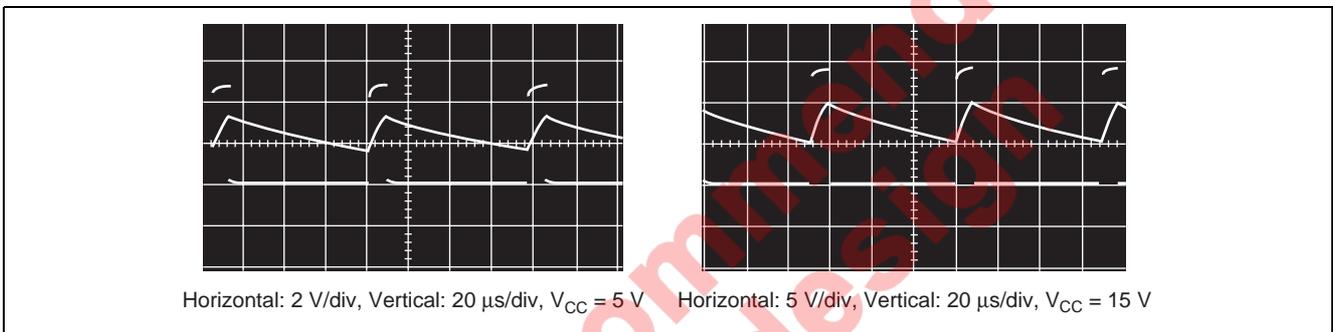


Figure 4 Operating Waveforms

3. Voltage Controlled Oscillator

In the circuit in figure 5, comparator A<sub>1</sub> operates as an integrator, A<sub>2</sub> operates as a comparator with hysteresis, and A<sub>3</sub> operates as the switch that controls the oscillator frequency. If the output Vout1 is at the low level, the A<sub>3</sub> output will go to the low level and the A<sub>1</sub> inverting input will become a lower level than the A<sub>1</sub> noninverting input. The A<sub>1</sub> output will integrate this state and its output will increase towards the high level. When the output of the integrator A<sub>1</sub> exceeds the level on the comparator A<sub>2</sub> inverting input, A<sub>2</sub> inverts to the high level and both the output Vout1 and the A<sub>3</sub> output go to the high level. This causes the integrator to integrate a negative state, resulting in its output decreasing towards the low level. Then, when the A<sub>1</sub> output level becomes lower than the level on the A<sub>2</sub> noninverting input, the output Vout1 is once again inverted to the low level. This operation generates a square wave on Vout1 and a triangular wave on Vout2.

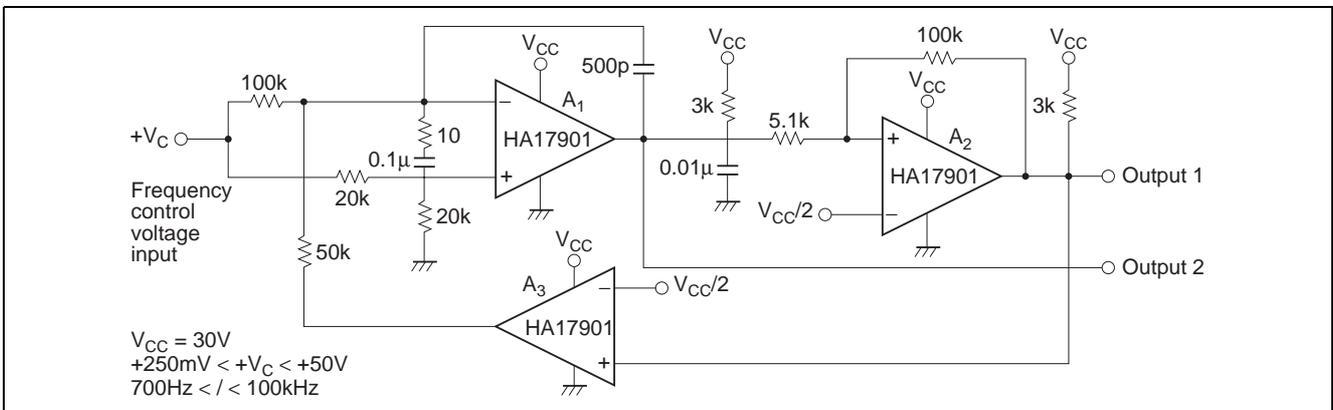


Figure 5 Voltage Controlled Oscillator

4. Basic Comparator

The circuit shown in figure 6 is a basic comparator. When the input voltage  $V_{IN}$  exceeds the reference voltage  $V_{REF}$ , the output goes to the high level.

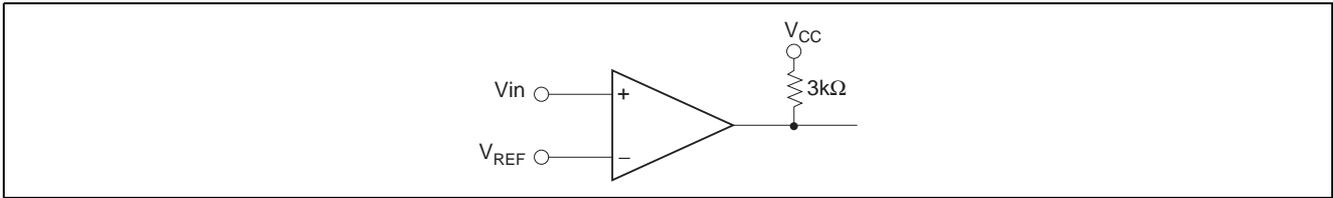


Figure 6 Basic Comparator

5. Noninverting Comparator (with Hysteresis)

Assuming  $+V_{IN}$  is 0V, when  $V_{REF}$  is applied to the inverting input, the output will go to the low level (approximately 0V). If the voltage applied to  $+V_{IN}$  is gradually increased, the output will go high when the value of the noninverting input,  $+V_{IN} \times R_2 / (R_1 + R_2)$ , exceeds  $+V_{REF}$ . Next, if  $+V_{IN}$  is gradually lowered,  $V_{out}$  will be inverted to the low level once again when the value of the noninverting input,  $(V_{out} - V_{IN}) \times R_1 / (R_1 + R_2)$ , becomes lower than  $V_{REF}$ . With the circuit constants shown in figure 7, assuming  $V_{CC} = 15V$  and  $+V_{REF} = 6V$ , the following formula can be derived, i.e.  $+V_{IN} \times 10M / (5.1M + 10M) > 6V$ , and  $V_{out}$  will invert from low to high when  $+V_{IN}$  is  $> 9.06V$ .

$$(V_{out} - V_{IN}) \times \frac{R_1}{R_1 + R_2} + V_{IN} < 6V$$

(Assuming  $V_{out} = 15V$ )

When  $+V_{IN}$  is lowered, the output will invert from high to low when  $+V_{IN} < 1.41V$ . Therefore this circuit has a hysteresis of 7.65V. Figure 8 shows the input characteristics.

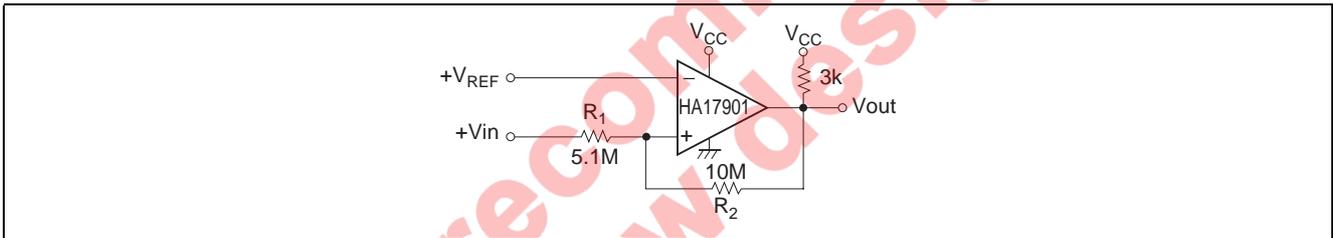


Figure 7 Noninverting Comparator

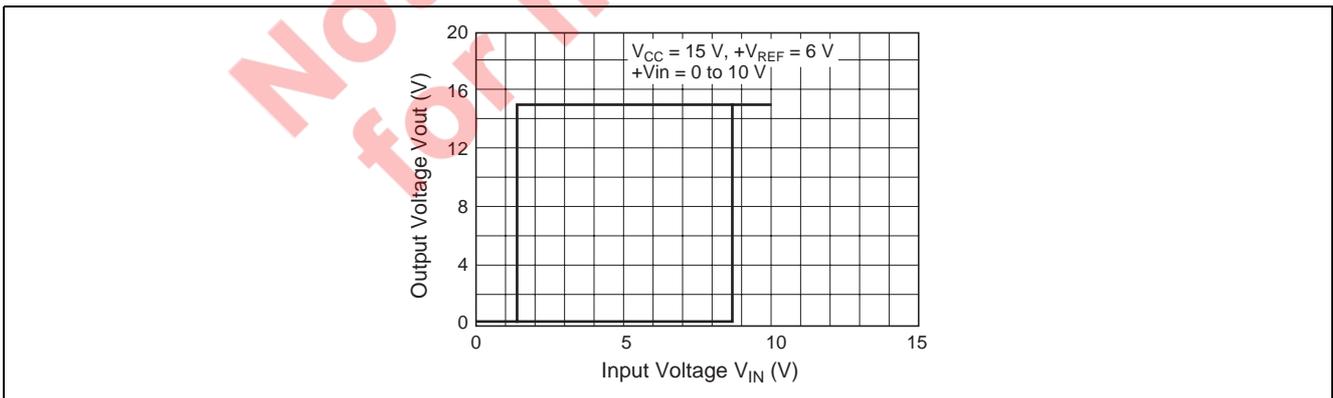


Figure 8 Noninverting Comparator I/O Transfer Characteristics

6. Inverting Comparator (with Hysteresis)

In this circuit, the output  $V_{out}$  inverts from high to low when  $+V_{IN} > (V_{CC} + V_{out})/3$ . Similarly, the output  $V_{out}$  inverts from low to high when  $+V_{IN} < V_{CC}/3$ . With the circuit constants shown in figure 9, assuming  $V_{CC} = 15V$  and  $V_{out} = 15V$ , this circuit will have a 5V hysteresis. Figure 10 shows the I/O characteristics for the circuit in figure 9.

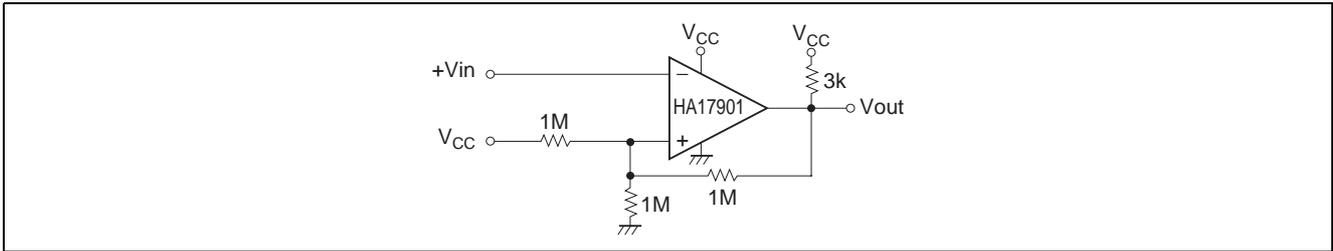


Figure 9 Inverting Comparator

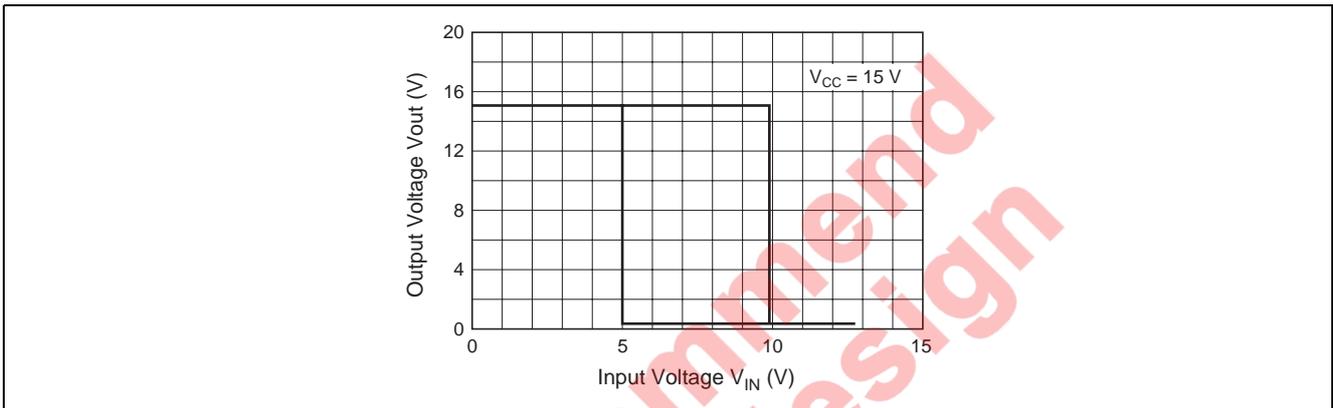


Figure 10 Inverting Comparator I/O Transfer Characteristics

7. Zero-Cross Detector (Single-Voltage Power Supply)

In this circuit, the noninverting input will essentially be held at the potential determined by dividing  $V_{CC}$  with  $100k\Omega$  and  $10k\Omega$  resistors. When  $V_{IN}$  is 0V or higher, the output will be low, and when  $V_{IN}$  is negative,  $V_{out}$  will invert to the high level. (See figure 11.)

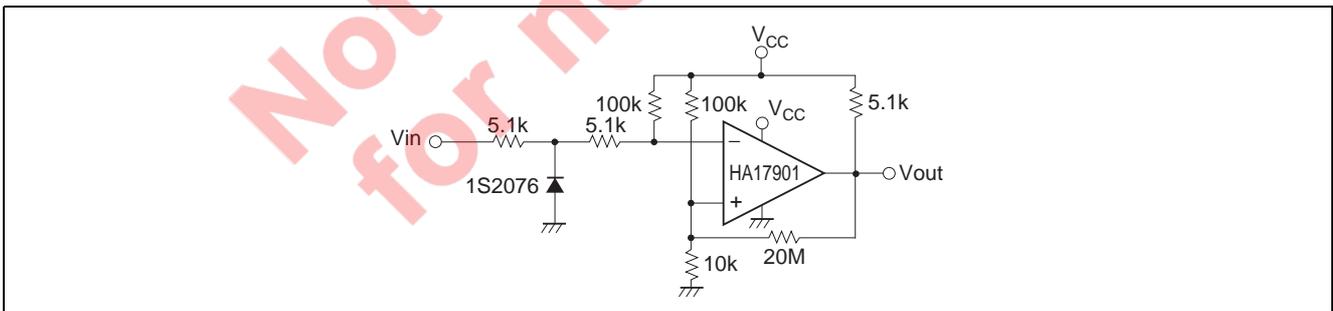
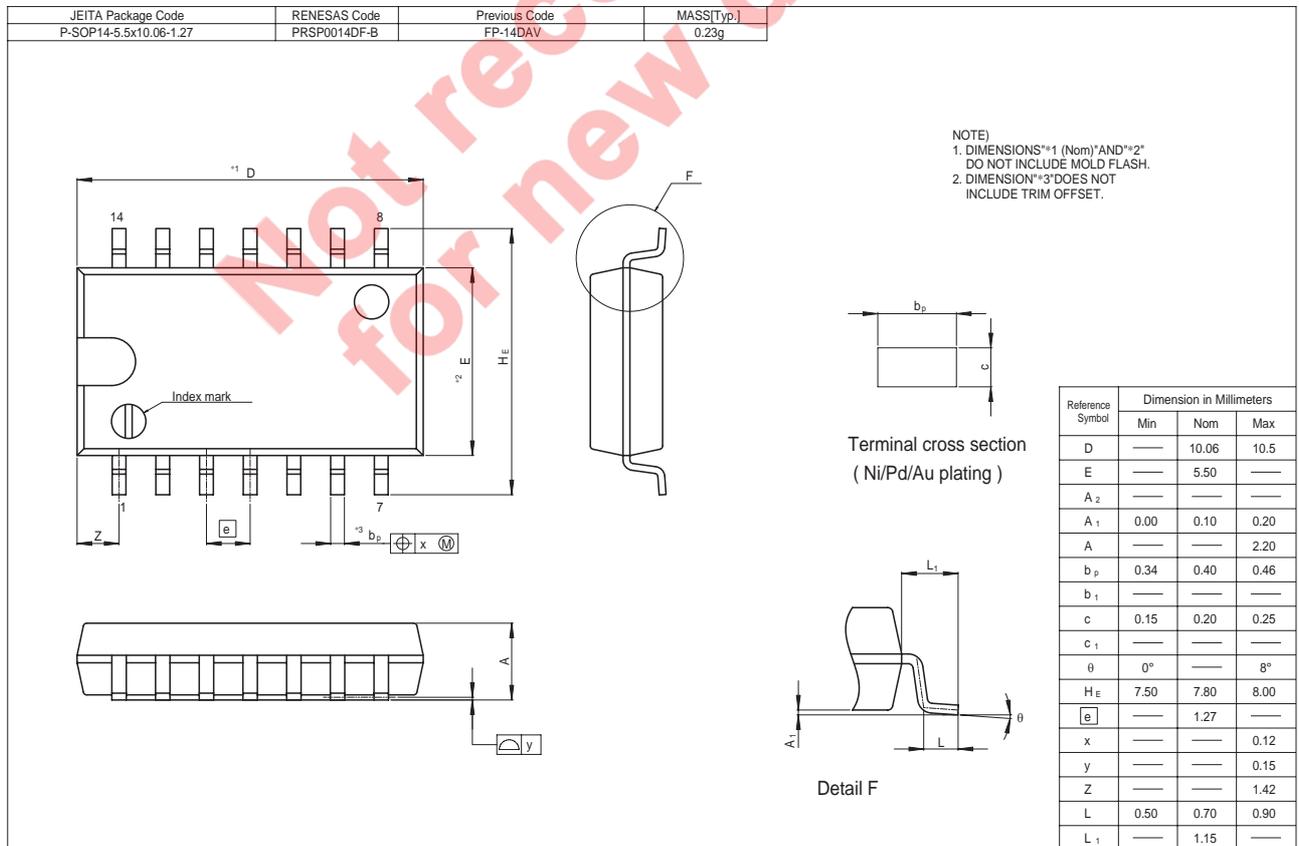
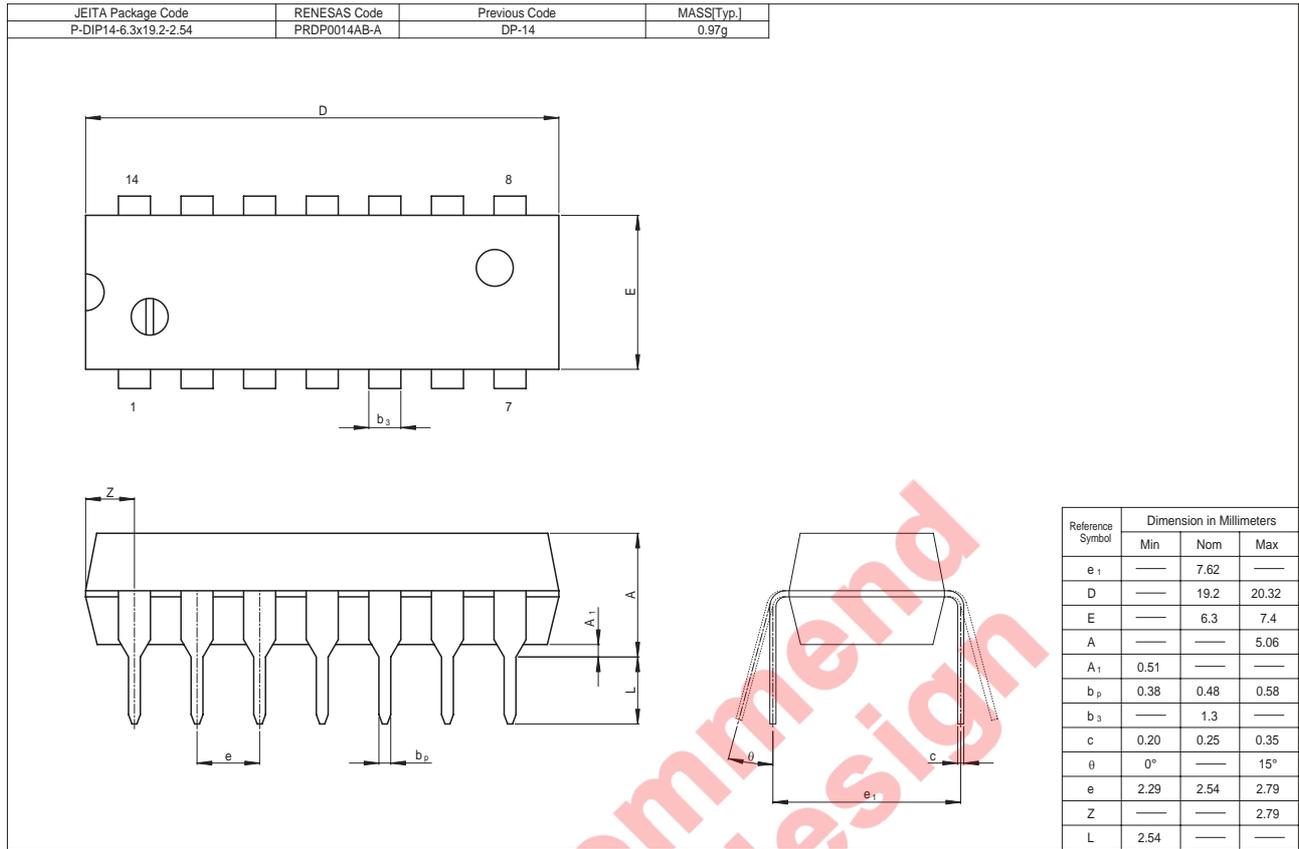


Figure 11 Zero-Cross Detector

Package Dimensions



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