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# HA17901, HA17339 Series

## Quadruple Comparators

# HITACHI

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### Description

The HA17901 and HA17339 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

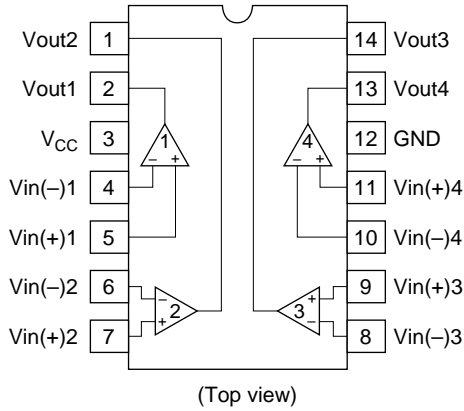
- Wide power-supply voltage range: 2 to 36V
- Extremely low current drain: 0.8mA
- Low input bias current: 25nA
- Low input offset current: 5nA
- Low input offset voltage: 2mV
- The common-mode input voltage range includes ground.
- Low output saturation voltage: 1mV (5 $\mu$ A), 70mV (1mA)
- Output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

# HA17901, HA17339 Series

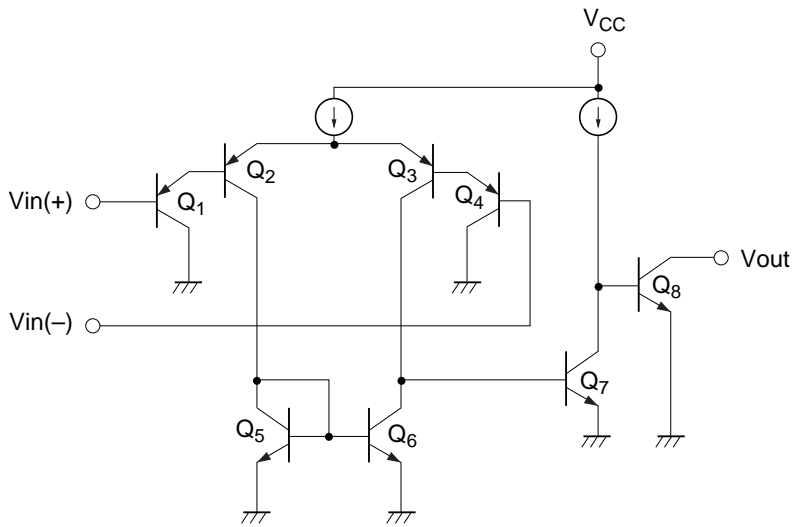
## Ordering Information

Type No.	Application	Package
HA17901PJ	Car use	DP-14
HA17901FPJ		FP-14DA
HA17901FPK		FP-14DA
HA17901P	Industrial use	DP-14
HA17901FP		FP-14DA
HA17339	Commercial use	DP-14
HA17339F		FP-14DA

## Pin Arrangement



Circuit Structure (1/4)



# HA17901, HA17339 Series

## Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	17901 P	17901 PJ	17901 FP	17901 FPJ	17901 FPK	17339	17339 F	Unit
Power-supply voltage	V <sub>CC</sub>	36	36	36	36	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 <sub>CC</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>	-0.3 to +V <sub>CC</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> *2	20	20	20	20	20	20	20	mA
Allowable power dissipation	P <sub>T</sub>	625*1	625*1	625*3	625*3	625*3	625*1	625*3	mW
Operating temperature	T <sub>opr</sub>	-20 to +75	-40 to +85	-20 to +75	-40 to +85	-40 to +125	-20 to +75	-20 to +75	°C
Storage temperature	T <sub>stg</sub>	-55 to +125	-55 to +125	-55 to +125	-55 to +125	-55 to +150	-55 to +125	-55 to +125	°C
Output pin voltage	V <sub>out</sub>	36	36	36	36	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** ( $V_{CC} = 5V$ ,  $T_a = 25^\circ C$ )

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	$V_{IO}$	—	2	7	mV	Output switching point: when $V_O = 1.4V$ , $R_S = 0\Omega$
Input bias current	$I_{IB}$	—	25	250	nA	$I_{IN(+)}$ or $I_{IN(-)}$
Input offset current	$I_{IO}$	—	5	50	nA	$I_{IN(+)} - I_{IN(-)}$
Common-mode input voltage* <sup>1</sup>	$V_{CM}$	0	—	$V_{CC} - 1.5$	V	
Supply current	$I_{CC}$	—	0.8	2	mA	$R_L = \infty$
Voltage Gain	$A_{VD}$	—	200	—	V/mV	$R_L = 15k\Omega$
Response time* <sup>2</sup>	$t_R$	—	1.3	—	$\mu s$	$V_{RL} = 5V$ , $R_L = 5.1k\Omega$
Output sink current	losink	6	16	—	mA	$V_{IN(-)} = 1V$ , $V_{IN(+)} = 0$ , $V_O \leq 1.5V$
Output saturation voltage	$V_O \text{ sat}$	—	200	400	mV	$V_{IN(-)} = 1V$ , $V_{IN(+)} = 0$ , losink = 3mA
Output leakage current	$I_{LO}$	—	0.1	—	nA	$V_{IN(+)} = 1V$ , $V_{IN(-)} = 0$ , $V_O = 5V$

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.

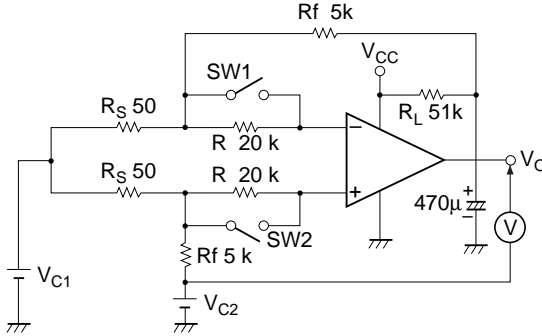
**Electrical Characteristics 2** ( $V_{CC} = 5V$ ,  $T_a = -41$  to  $+125^\circ C$ )

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	$V_{IO}$	—	—	7	mV	Output switching point: when $V_O = 1.4V$ , $R_S = 0\Omega$
Input offset current	$I_{IO}$	—	—	200	nA	$I_{IN(-)} - I_{IN(+)}$
Input bias current	$I_{IB}$	—	—	500	nA	
Common-mode input voltage* <sup>1</sup>	$V_{CM}$	0	—	$V_{CC} - 2.0$	V	
Output saturation voltage	$V_O \text{ sat}$	—	—	440	mV	$V_{IN(-)} \geq 1V$ , $V_{IN(+)} = 0$ , losink $\leq 4mA$
Output leakage current	$I_{LO}$	—	1.0	—	$\mu A$	$V_{IN(-)} = 0V$ , $V_{IN(+)} \geq 1V$ , $V_O = 30V$
Supply current	$I_{CC}$	—	—	4.0	mA	All comparators: $R_L = \infty$ , 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	$V_{O4}$

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

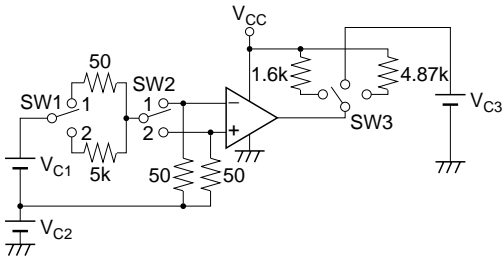
$$V_{C2} = 1.4V$$

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

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

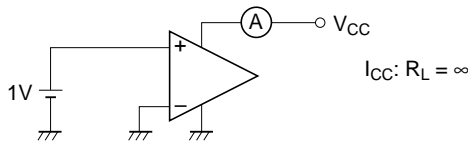
$$I_{IB} = \frac{|V_{O4} - V_{O3}|}{2 \cdot R(1 + R_f / R_S)} \quad (\text{nA})$$

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

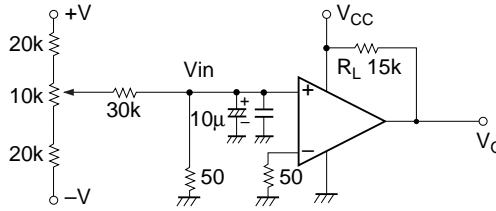


Item	$V_{C1}$	$V_{C2}$	$V_{C3}$	SW1	SW2	SW3	Unit
$V_{O \text{ sat}}$	2V	0V	—	1	1	1 at $V_{CC} = 5V$ 3 at $V_{CC} = 15V$	V
$I_{\text{osink}}$	2V	0V	1.5V	1	1	2	mA
$V_{CM}$	2V	-1 to $V_{CC}$	—	2	Switched between 1 and 2	3	V

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

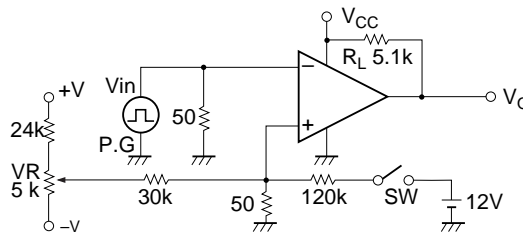


4. Voltage gain ( $A_{VD}$ ) test circuit ( $R_L = 15k\Omega$ )



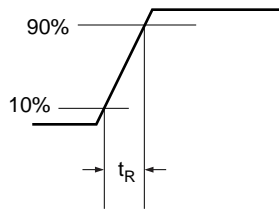
$$A_{VD} = 20 \log \frac{V_{O1} - V_{O2}}{V_{IN1} - V_{IN2}} \quad (\text{dB})$$

5. Response time ( $t_R$ ) test circuit



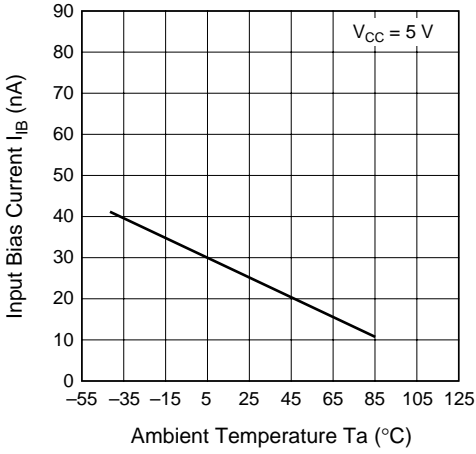
$t_R$ :  $R_L = 5.1k\Omega$ , a 100mV input step voltage that has a 5mV overdrive

- 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.

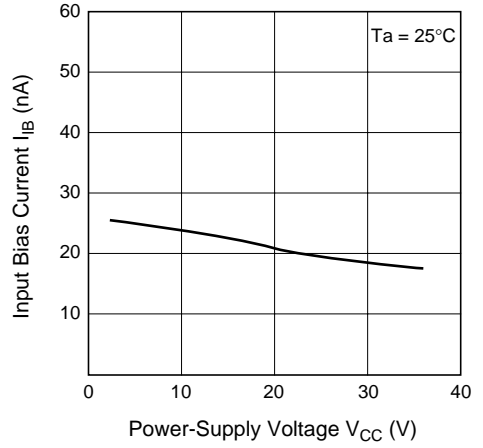


## Characteristics Curve

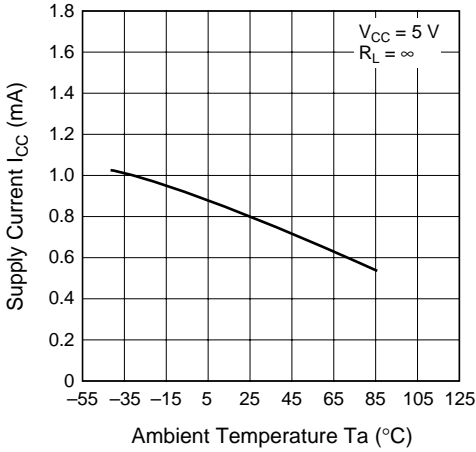
Input Bias Current vs.  
Ambient Temperature Characteristics



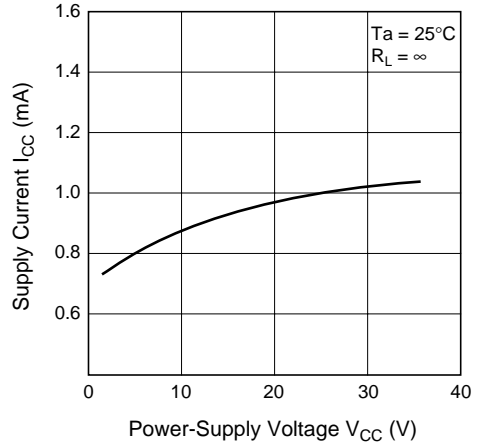
Input Bias Current vs.  
Power-Supply Voltage Characteristics



Supply Current vs.  
Ambient Temperature Characteristics

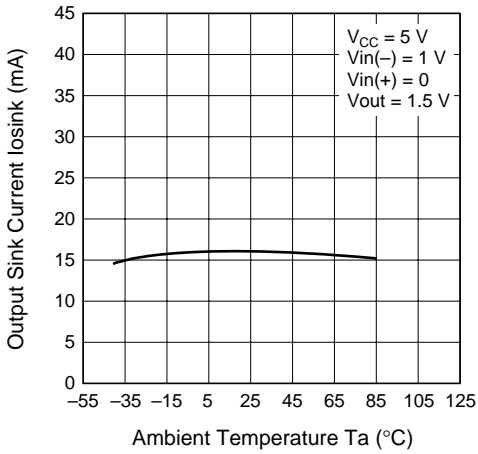


Supply Current vs.  
Power-Supply Voltage Characteristics

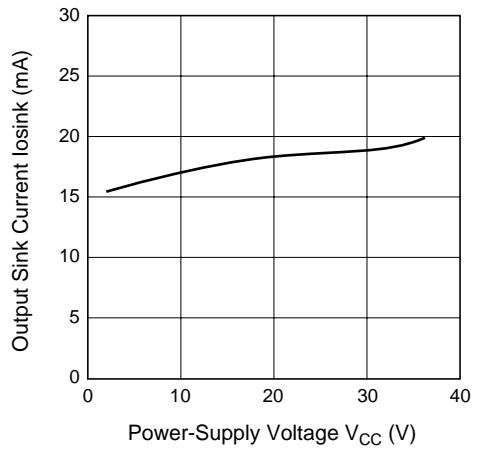




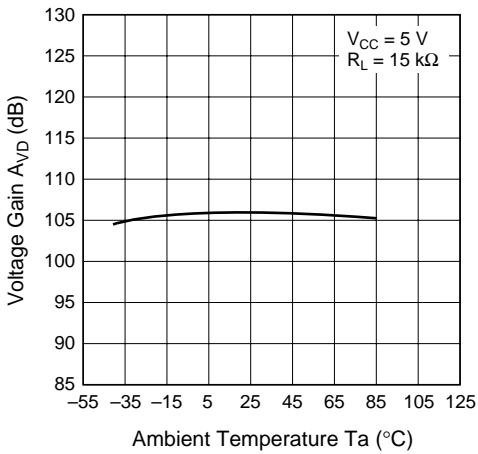
Output Sink Current vs. Ambient Temperature Characteristics



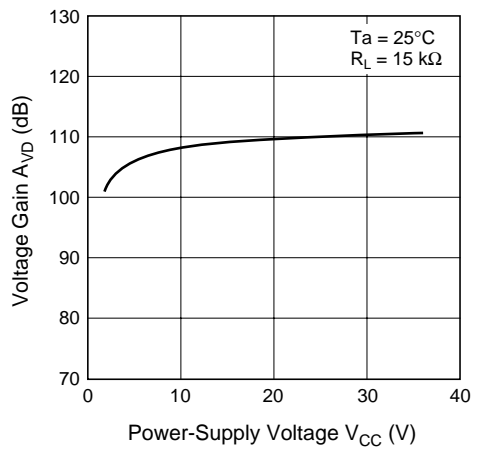
Output Sink Current vs. Power-Supply Voltage Characteristics



Voltage Gain vs. Ambient Temperature Characteristics



Voltage Gain vs. Power-Supply Voltage Characteristics



## 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.

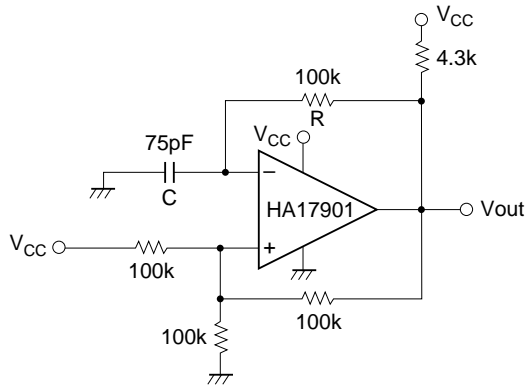
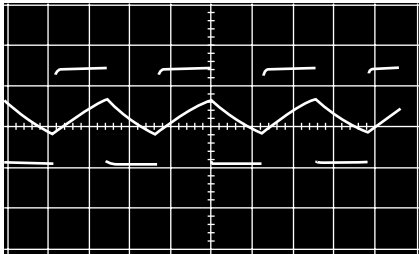
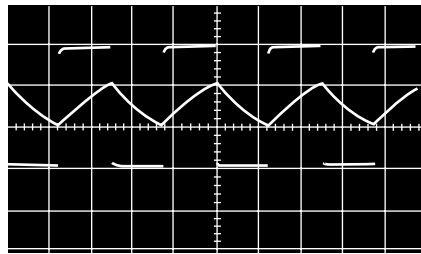


Figure 1 Square-Wave Oscillator



(1)

Horizontal: 2 V/div, Vertical: 5  $\mu$ s/div,  $V_{CC}$  = 5 V



(2)

Horizontal: 5 V/div, Vertical: 5  $\mu$ s/div,  $V_{CC}$  = 15 V

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.

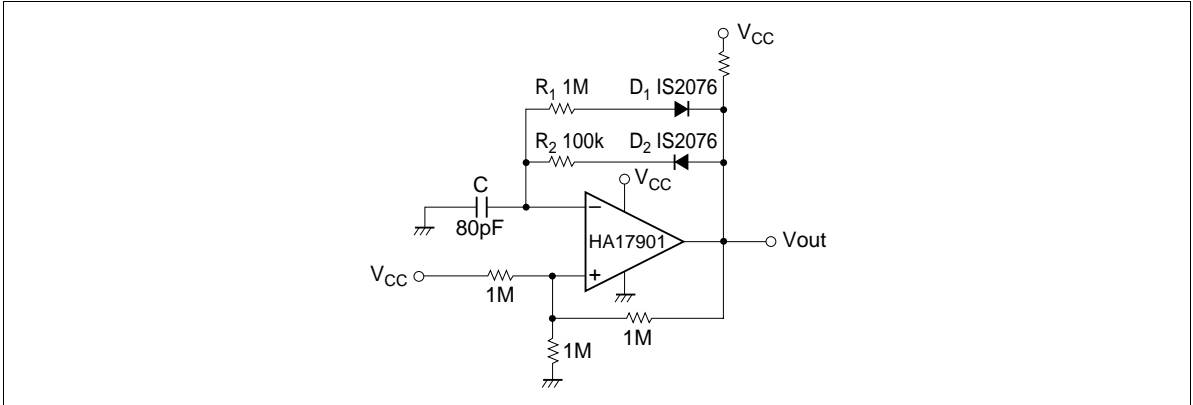


Figure 3 Pulse Generator

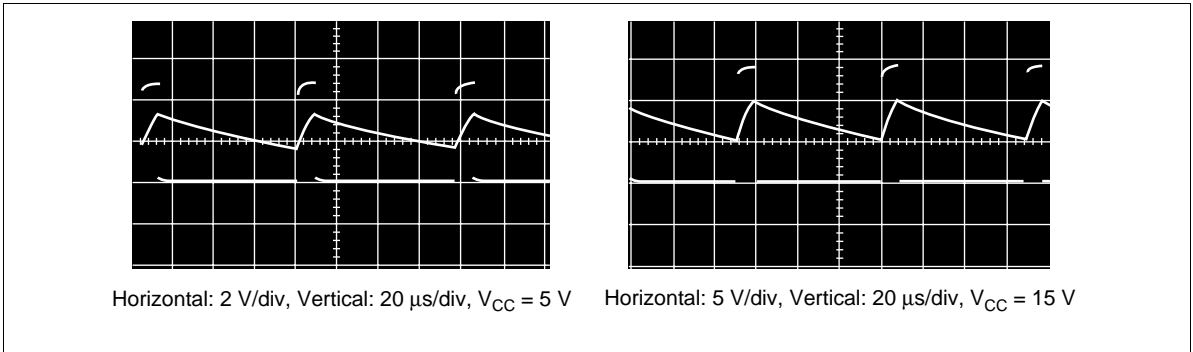
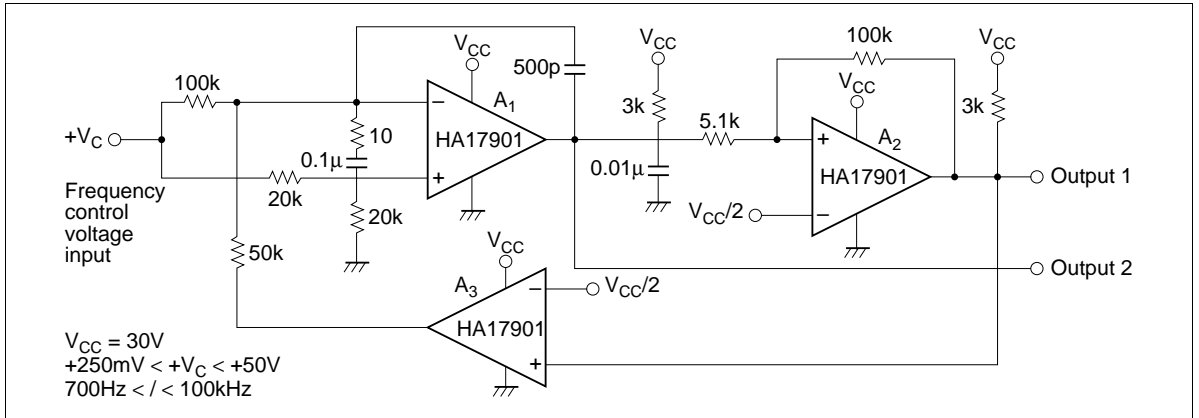


Figure 4 Operating Waveforms

3. Voltage Controlled Oscillator

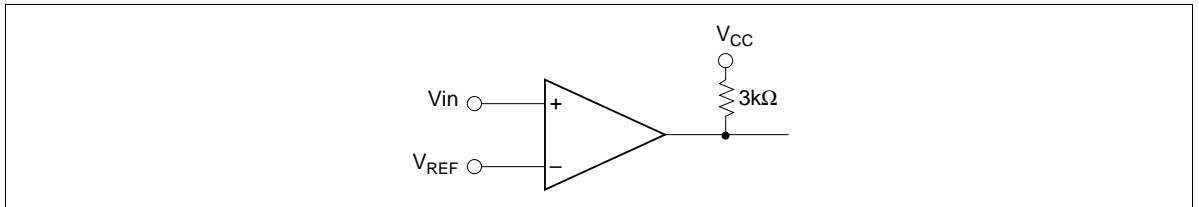
In the circuit in figure 5, comparator  $A_1$  operates as an integrator,  $A_2$  operates as a comparator with hysteresis, and  $A_3$  operates as the switch that controls the oscillator frequency. If the output  $V_{out1}$  is at the low level, the  $A_3$  output will go to the low level and the  $A_1$  inverting input will become a lower level than the  $A_1$  noninverting input. The  $A_1$  output will integrate this state and its output will increase towards the high level. When the output of the integrator  $A_1$  exceeds the level on the comparator  $A_2$  inverting input,  $A_2$  inverts to the high level and both the output  $V_{out1}$  and the  $A_3$  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  $A_1$  output level becomes lower than the level on the  $A_2$  noninverting input, the output  $V_{out1}$  is once again inverted to the low level. This operation generates a square wave on  $V_{out1}$  and a triangular wave on  $V_{out2}$ .



**Figure 5 Voltage Controlled Oscillator**

#### 4. Basic Comparator

The circuit shown in figure 6 is a basic comparator. When the input voltage V<sub>IN</sub> exceeds the reference voltage V<sub>REF</sub>, the output goes to the high level.



**Figure 6 Basic Comparator**

#### 5. Noninverting Comparator (with Hysteresis)

Assuming +V<sub>IN</sub> is 0V, when V<sub>REF</sub> is applied to the inverting input, the output will go to the low level (approximately 0V). If the voltage applied to +V<sub>IN</sub> is gradually increased, the output will go high when the value of the noninverting input, +V<sub>IN</sub> × R<sub>2</sub> / (R<sub>1</sub> + R<sub>2</sub>), exceeds +V<sub>REF</sub>. Next, if +V<sub>IN</sub> is gradually lowered, V<sub>out</sub> will be inverted to the low level once again when the value of the noninverting input, (V<sub>out</sub> - V<sub>IN</sub>) × R<sub>1</sub> / (R<sub>1</sub> + R<sub>2</sub>), becomes lower than V<sub>REF</sub>. With the circuit constants shown in figure 7, assuming V<sub>CC</sub> = 15V and +V<sub>REF</sub> = 6V, the following formula can be derived, i.e. +V<sub>IN</sub> × 10M / (5.1M + 10M) > 6V, and V<sub>out</sub> will invert from low to high when +V<sub>IN</sub> is > 9.06V.

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

(Assuming V<sub>out</sub> = 15V)

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

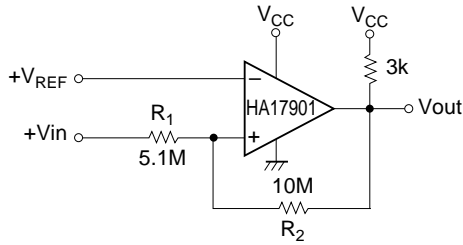


Figure 7 Noninverting Comparator

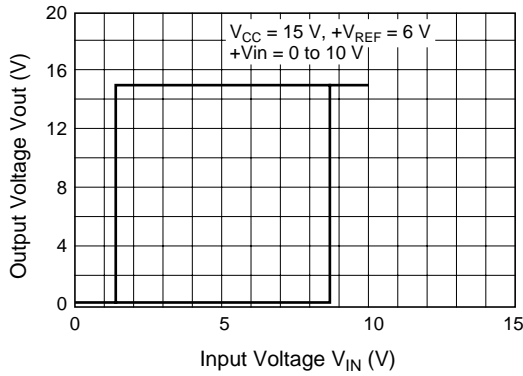


Figure 8 Noninverting Comparator I/O Transfer Characteristics

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.

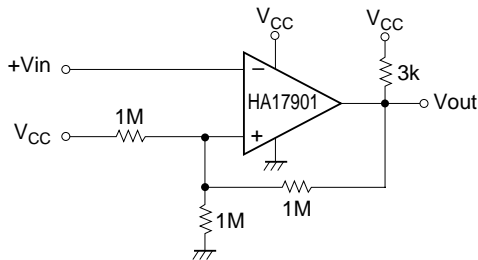
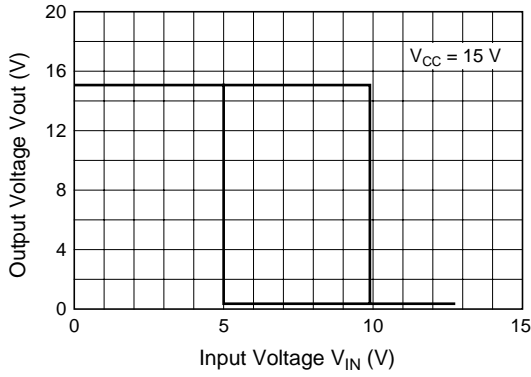


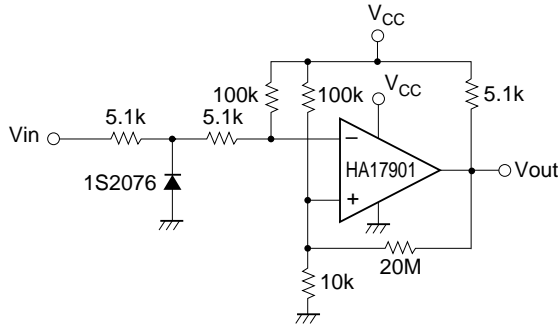
Figure 9 Inverting Comparator



**Figure 10 Inverting Comparator I/O Transfer Characteristics**

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

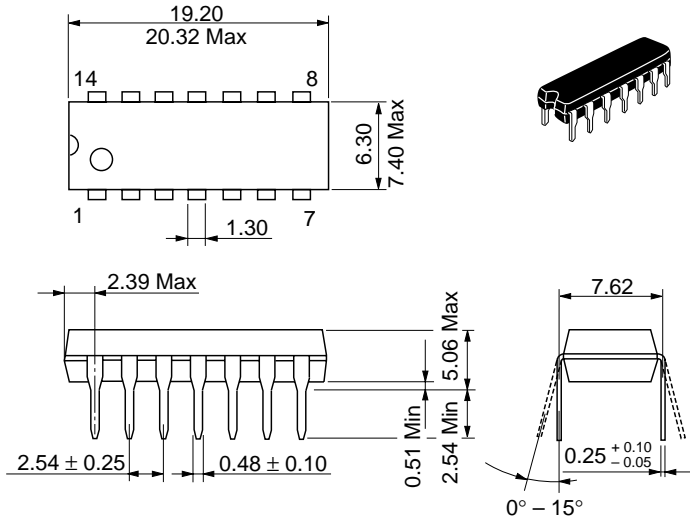
In this circuit, the noninverting input will essentially be held at the potential determined by dividing  $V_{CC}$  with  $100k\Omega$  and  $10k\Omega$  resistors. When  $V_{IN}$  is  $0V$  or higher, the output will be low, and when  $V_{IN}$  is negative,  $V_{out}$  will invert to the high level.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



**Figure 11 Zero-Cross Detector**

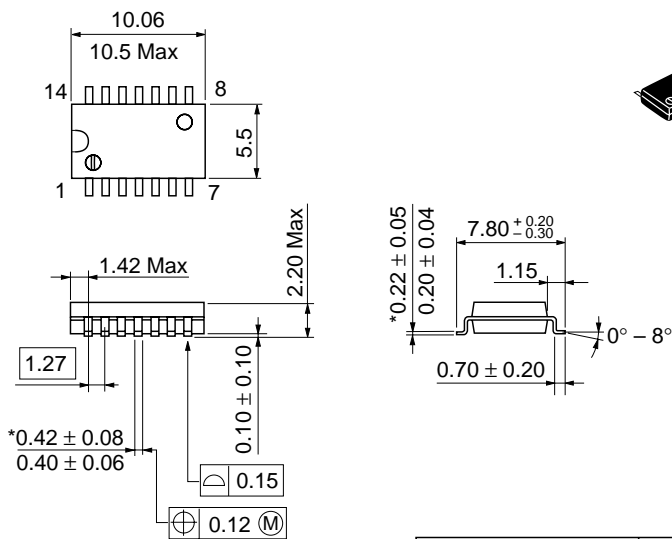
## Package Dimensions

Unit: mm



Hitachi Code	DP-14
JEDEC	Conforms
EIAJ	Conforms
Mass (reference value)	0.97 g

Unit: mm



\*Dimension including the plating thickness  
Base material dimension

Hitachi Code	FP-14DA
JEDEC	—
EIAJ	Conforms
Mass (reference value)	0.23 g

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