# HA17901, HA17339 Series

Quadruple Comparators

HITACHI

## 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

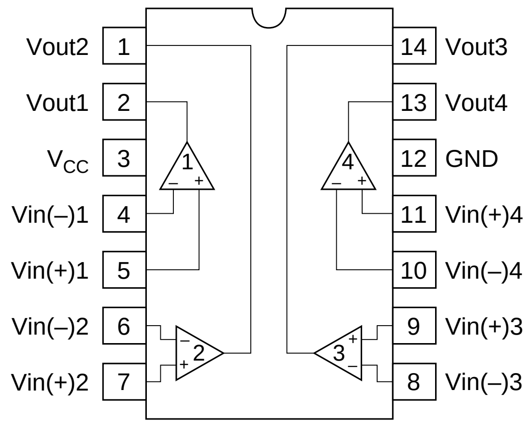
- Wide power-supply voltage range: 2 to 36V
- Extremely low current drain: 0.8mA
- Low input bias current: 25nA
- Low input offset current: 5nA
- Low input offset voltage: 2mV
- The common-mode input voltage range includes ground.
- Low output saturation voltage: 1mV (5µA), 70mV (1mA)
- Output voltages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

Hitachi semiconductor

## Ordering Information

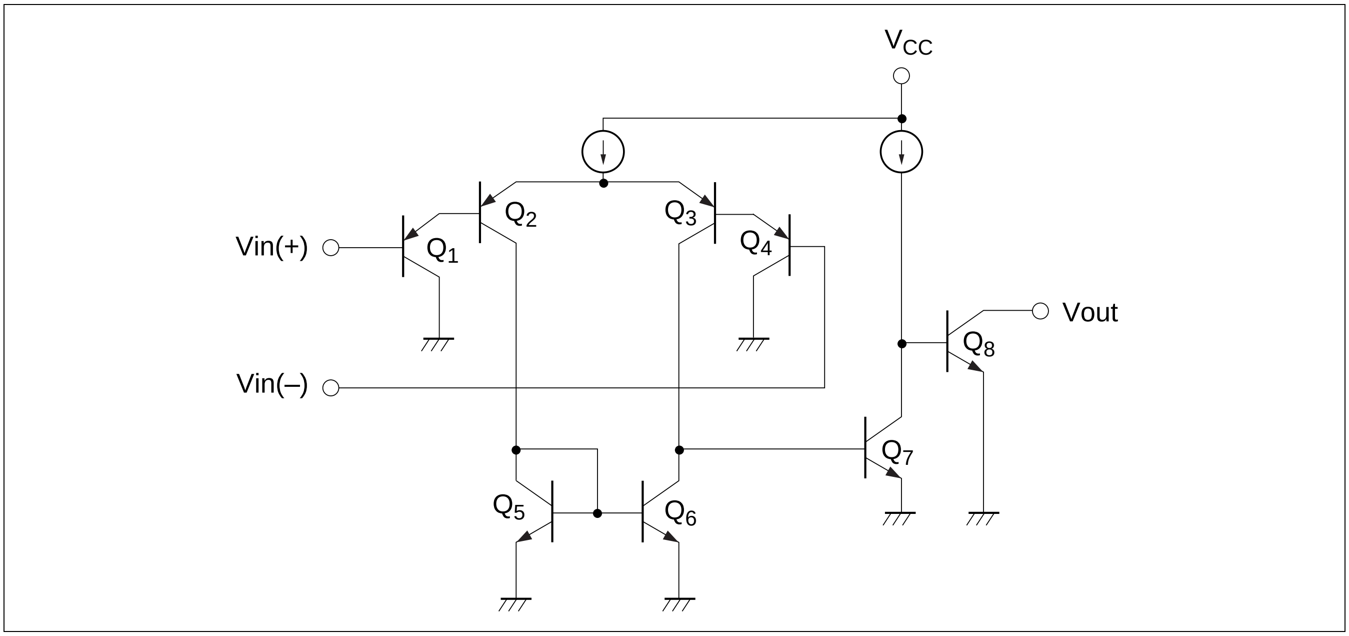
| Type No. | Application | Package |
|---|---|---|
| HA17901PJ | Car use | DP-14 |
| HA17901FPJ | | FP-14DA |
| HA17901FPK | | FP-14DA |
| HA17901P | Industrial use | DP-14 |
| HA17901FP | | FP-14DA |
| HA17339 | Commercial use | DP-14 |
| HA17339F | | FP-14DA |

## Pin Arrangement



(Top view)

## **Circuit Structure** (1/4)



## 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 | $V_{CC}$ | 36 | 36 | 36 | 36 | 36 | 36 | 36 | V |
| Differential input voltage | Vin(diff) | $\pm V_{CC}$ | $\pm V_{CC}$ | $\pm V_{CC}$ | $\pm V_{CC}$ | $\pm V_{CC}$ | $\pm V_{CC}$ | $\pm V_{CC}$ | V |
| Input voltage | Vin | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | –0.3 to $+V_{CC}$ | V |
| Output current | Iout*[2] | 20 | 20 | 20 | 20 | 20 | 20 | 20 | mA |
| Allowable power dissipation | $P_T$ | 625*[1] | 625*[1] | 625*[3] | 625*[3] | 625*[3] | 625*[1] | 625*[3] | mW |
| Operating temperature | Topr | –20 to +75 | –40 to +85 | –20 to +75 | –40 to +85 | –40 to +125 | –20 to +75 | –20 to +75 | °C |
| Storage temperature | Tstg | –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 | Vout | 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 $V_{CC}$ 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, Ta = 25°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, $R_S$ = 0Ω |
| 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*[1] | $V_{CM}$ | 0 | — | $V_{CC}$ – 1.5 | V | |
| Supply current | $I_{CC}$ | — | 0.8 | 2 | mA | $R_L$ = ∞ |
| Voltage Gain | $A_{VD}$ | — | 200 | — | V/mV | $R_L$ = 15kΩ |
| Response time*[2] | $t_R$ | — | 1.3 | — | µs | $V_{RL}$ = 5V, $R_L$ = 5.1kΩ |
| Output sink current | Iosink | 6 | 16 | — | mA | $V_{IN(–)}$ = 1V, $V_{IN(+)}$ = 0, $V_O$ ≤ 1.5V |
| Output saturation voltage | $V_O$ sat | — | 200 | 400 | mV | $V_{IN(–)}$ = 1V, $V_{IN(+)}$ = 0, Iosink = 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.

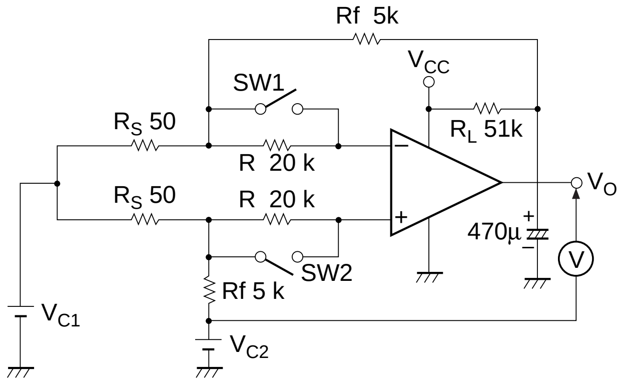
## Electrical Characteristics 2 ($V_{CC}$ = 5V, Ta = – 41 to + 125°C)

| Item | Symbol | Min | Typ | Max | Unit | Test Condition |
|---|---|---|---|---|---|---|
| Input offset voltage | $V_{IO}$ | — | — | 7 | mV | Output switching point: when $V_O$ = 1.4V, $R_S$ = 0Ω |
| Input offset current | $I_{IO}$ | — | — | 200 | nA | $I_{IN(-)}$ – $I_{IN(+)}$ |
| Input bias current | $I_{IB}$ | — | — | 500 | nA | |
| Common-mode input voltage*[1] | $V_{CM}$ | 0 | — | $V_{CC}$ – 2.0 | V | |
| Output saturation voltage | $V_{O\ sat}$ | — | — | 440 | mV | $V_{IN(–)}$ ≥ 1V, $V_{IN(+)}$ = 0, Iosink ≤ 4mA |
| Output leakage current | $I_{LO}$ | — | 1.0 | — | µA | $V_{IN(–)}$ = 0V, $V_{IN(+)}$ ≥ 1V, $V_O$ = 30V |
| Supply current | $I_{CC}$ | — | — | 4.0 | mA | All comparators: $R_L$ = ∞, 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 | $V_{O4}$ |

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

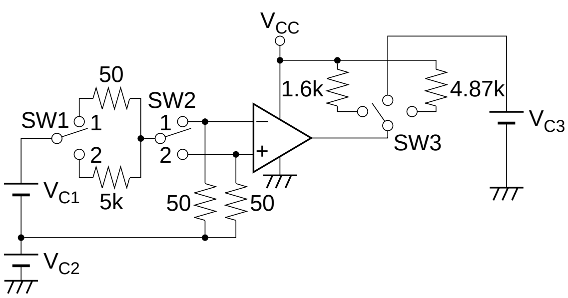
$V_{C2} = 1.4V$

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

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

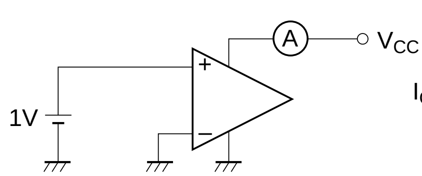
$$I_{IB} = \frac{|V_{O4} - V_{O3}|}{2 \cdot R(1 + Rf / R_S)} \quad (nA)$$

2. Output saturation voltage ($V_O$ sat) output sink current (Iosink), and common-mode input voltage ($V_{CM}$) test circuit



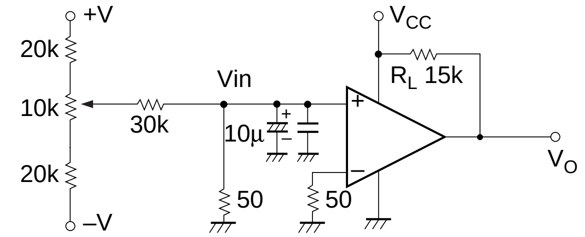

| Item | $V_{C1}$ | $V_{C2}$ | $V_{C3}$ | SW1 | SW2 | SW3 | Unit |
|---|---|---|---|---|---|---|---|
| $V_O$sat | 2V | 0V | — | 1 | 1 | 1 at $V_{CC}$ = 5V<br>3 at $V_{CC}$ = 15V | V |
| Iosink | 2V | 0V | 1.5V | 1 | 1 | 2 | mA |
| $V_{CM}$ | 2V | –1 to $V_{CC}$ | — | 2 | Switched between 1 and 2 | 3 | V |

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



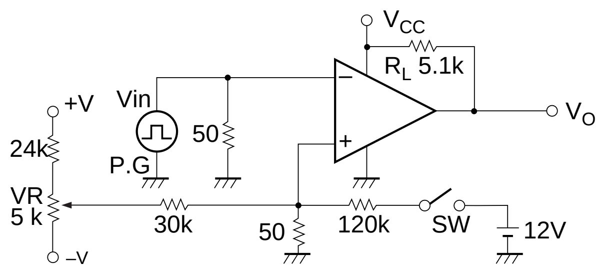

$I_{CC}$: $R_L = \infty$

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



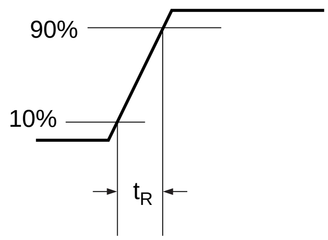

$$A_{VD} = 20 \log \frac{V_{O1} - V_{O2}}{V_{IN1} - V_{IN2}} \quad (dB)$$

5. Response time ($t_R$) test circuit



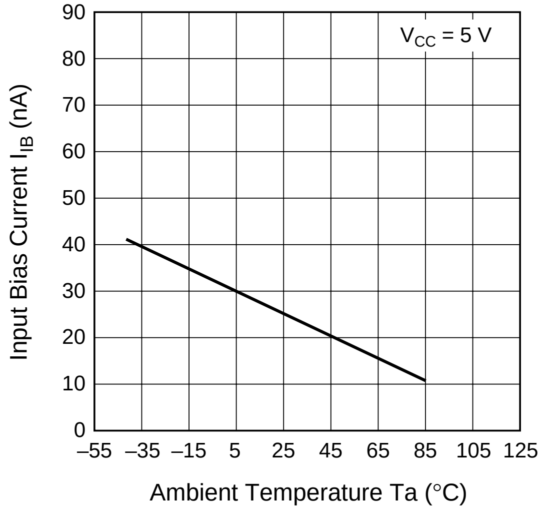

$t_R$: $R_L$ = 5.1kΩ, a 100mV input step voltage that has a 5mV overdrive

- 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.

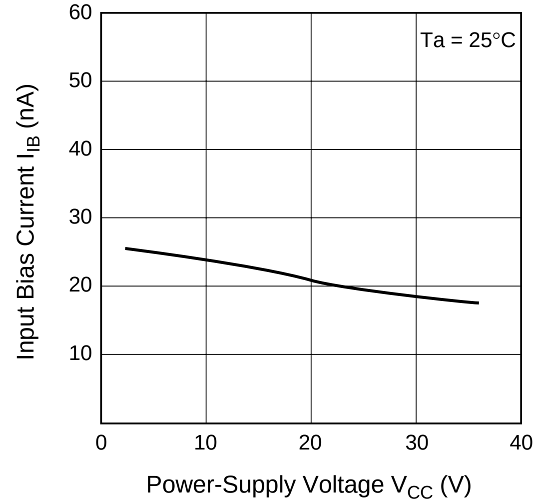


## Characteristics Curve

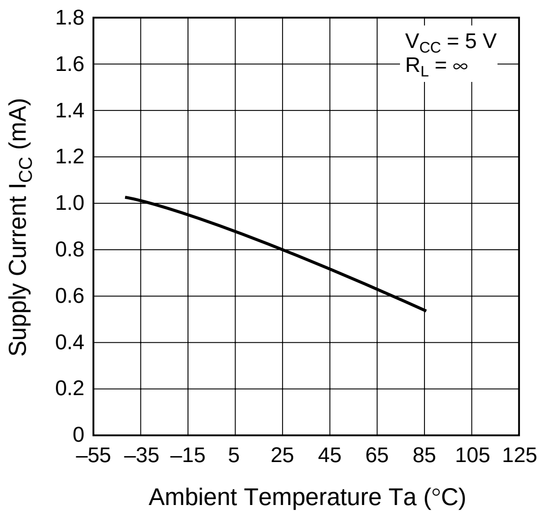
Input Bias Current vs.
Ambient Temperature Characteristics



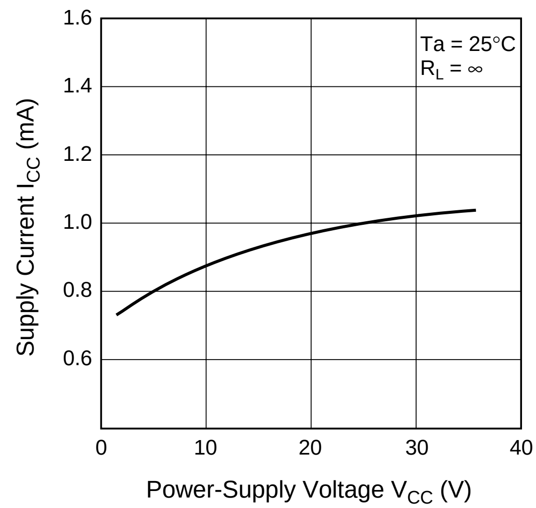

Input Bias Current vs.
Power-Supply Voltage Characteristics

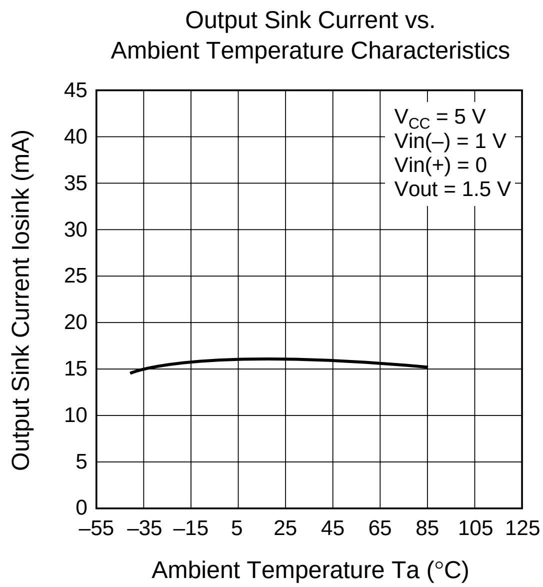


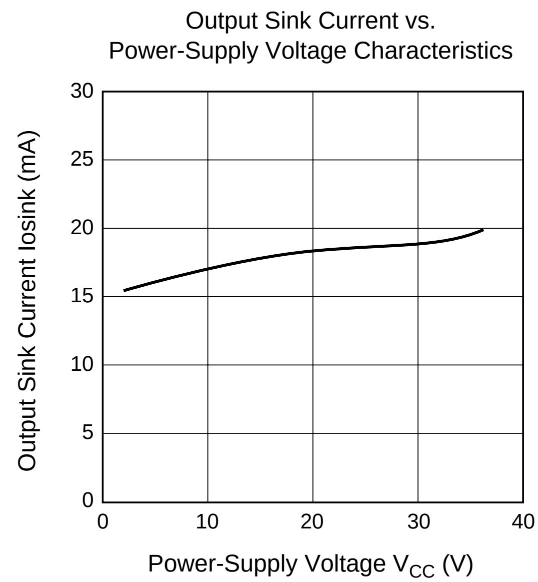

Supply Current vs.
Ambient Temperature Characteristics

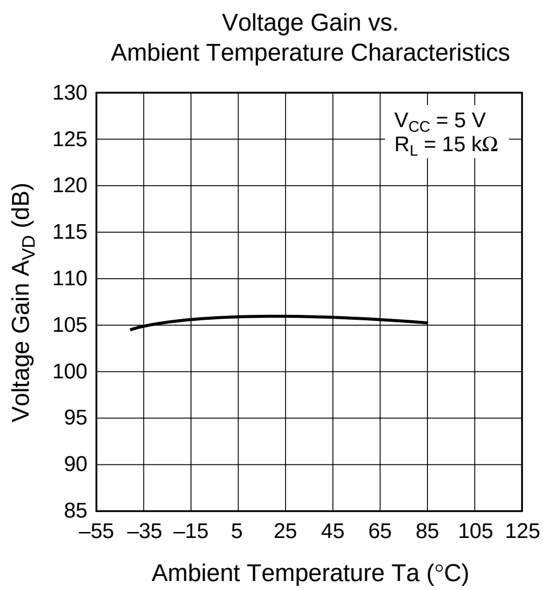


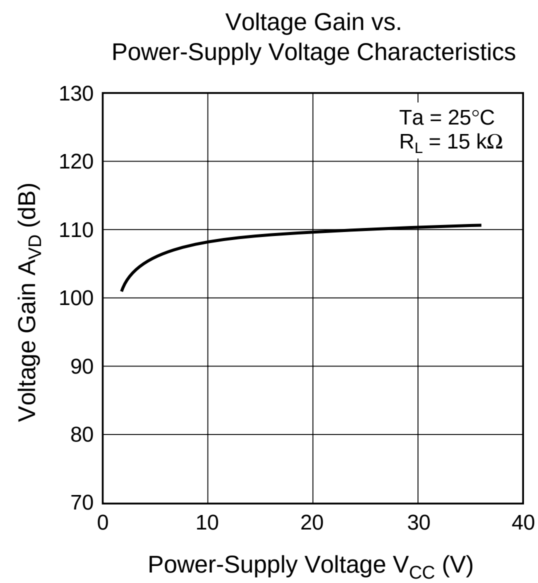

Supply Current vs.
Power-Supply Voltage Characteristics




Output Sink Current vs.
Ambient Temperature Characteristics
Output Sink Current Iosink (mA)
45
40
35
30
25
20
15
10
5
0
–55 –35 –15 5 25 45 65 85 105 125
Ambient Temperature Ta (°C)
VCC = 5 V
Vin(–) = 1 V
Vin(+) = 0
Vout = 1.5 V


Output Sink Current vs.
Power-Supply Voltage Characteristics
Output Sink Current Iosink (mA)
30
25
20
15
10
5
0
0 10 20 30 40
Power-Supply Voltage VCC (V)


Voltage Gain vs.
Ambient Temperature Characteristics
Voltage Gain AVD (dB)
130
125
120
115
110
105
100
95
90
85
–55 –35 –15 5 25 45 65 85 105 125
Ambient Temperature Ta (°C)
VCC = 5 V
RL = 15 kΩ


Voltage Gain vs.
Power-Supply Voltage Characteristics
Voltage Gain AVD (dB)
130
120
110
100
90
80
70
0 10 20 30 40
Power-Supply Voltage VCC (V)
Ta = 25°C
RL = 15 kΩ

## 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.

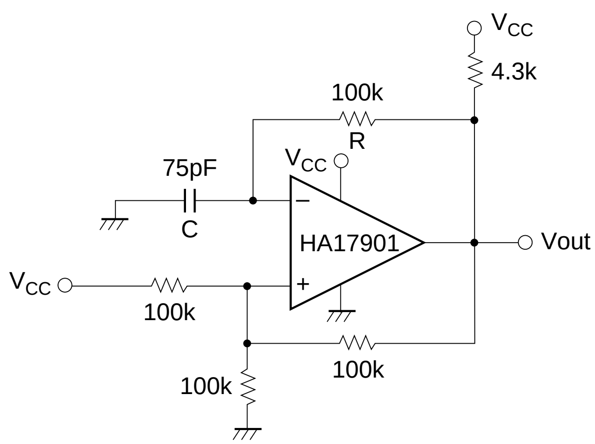
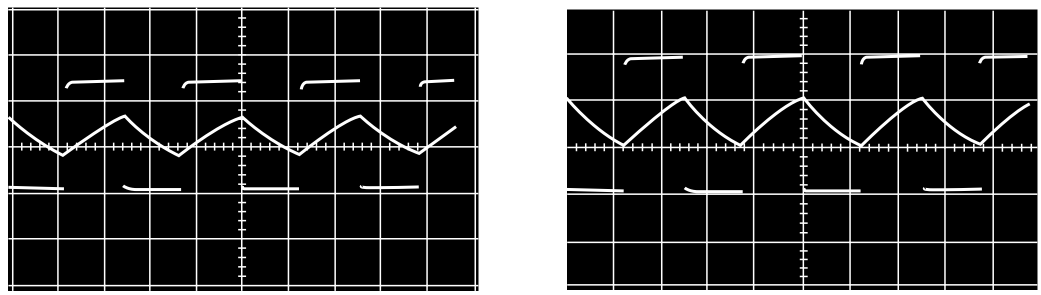



**Figure 1 Square-Wave Oscillator**



(1)
Horizontal: 2 V/div, Vertical: 5 µs/div, $V_{CC}$ = 5 V

(2)
Horizontal: 5 V/div, Vertical: 5 µs/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.

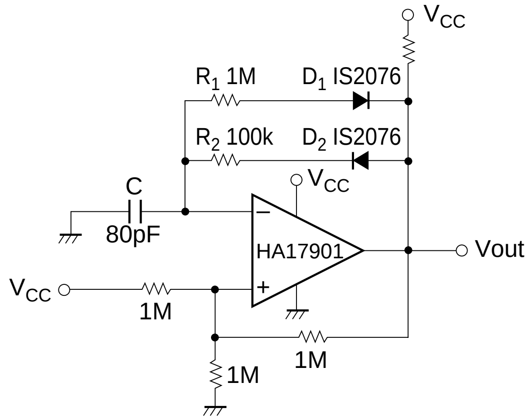
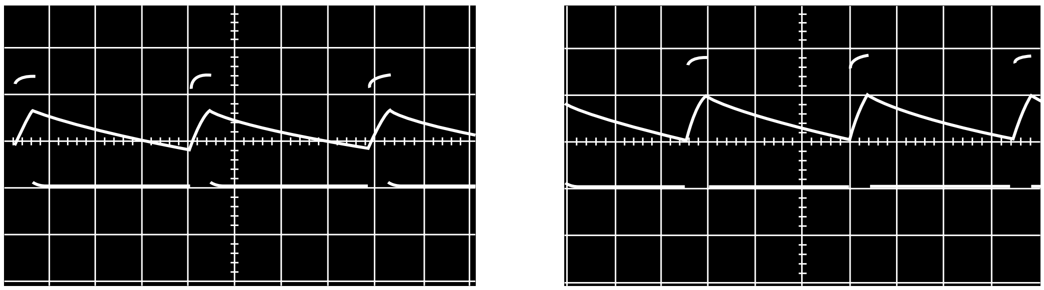



**Figure 3 Pulse Generator**



Horizontal: 2 V/div, Vertical: 20 µs/div, $V_{CC}$ = 5 V    Horizontal: 5 V/div, Vertical: 20 µs/div, $V_{CC}$ = 15 V

**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 Vout1 is at the low level, the $A_3$ output will go to the low level and the A1 inverting input will become a lower level than the A1 noninverting input. The A1 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 Vout1 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 Vout1 is once again inverted to the low level. This operation generates a square wave on Vout1 and a triangular wave on Vout2.

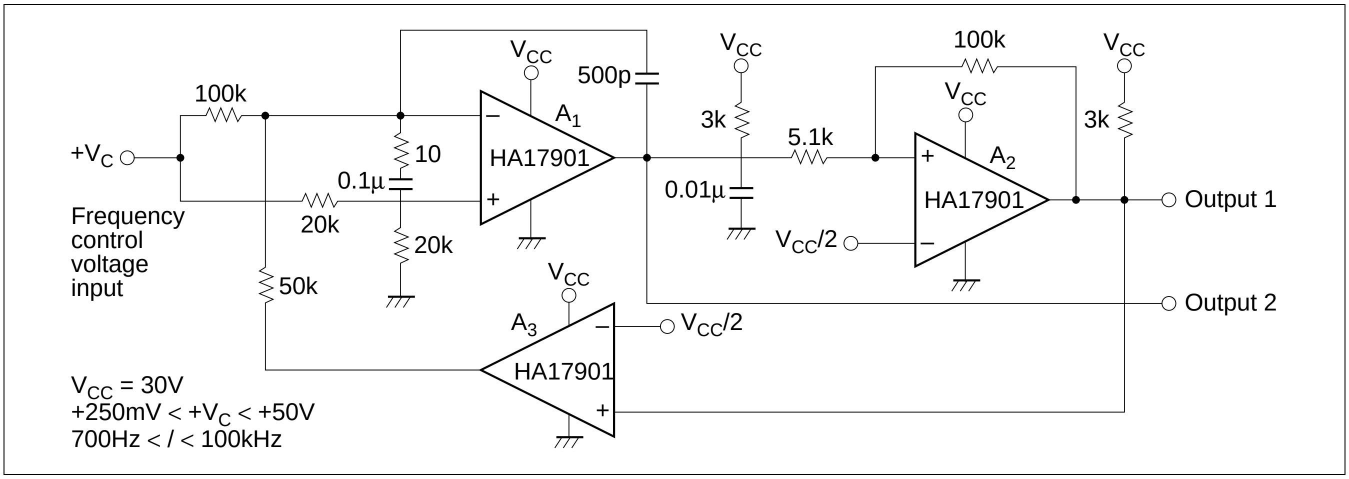



**Figure 5 Voltage Controlled Oscillator**

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.

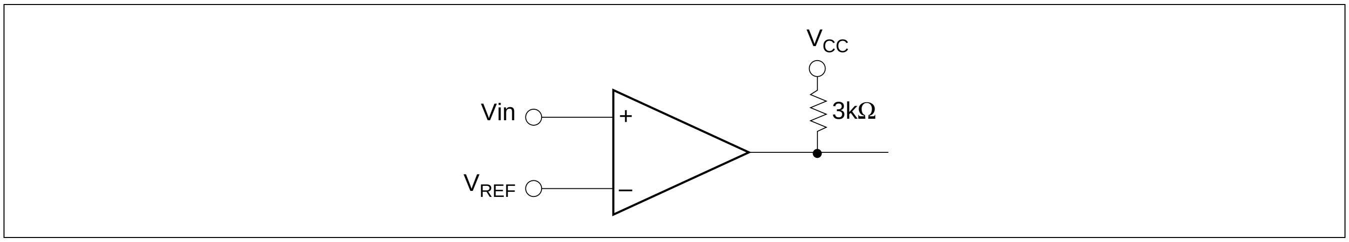



**Figure 6 Basic Comparator**

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, Vout will be inverted to the low level once again when the value of the noninverting input, $(Vout - V_{IN}) \times R_1/(R_1 + R_2)$, 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 Vout will invert from low to high when $+V_{IN}$ is > 9.06V.

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

(Assuming Vout = 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.

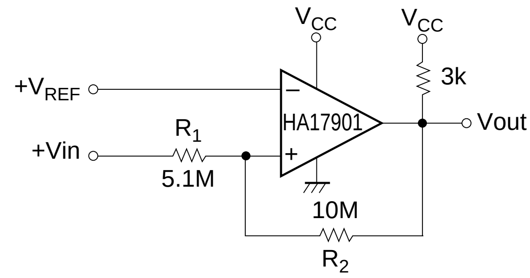



**Figure 7 Noninverting Comparator**

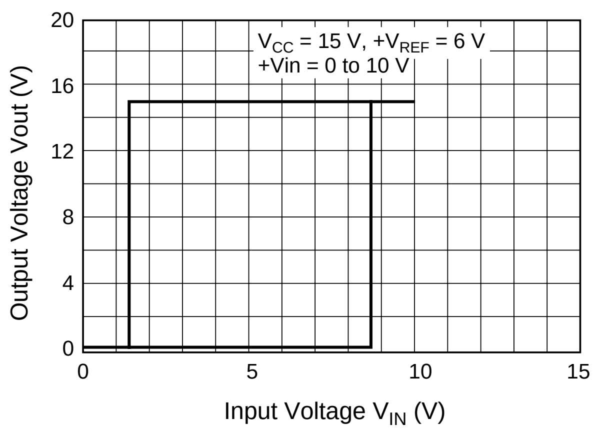



**Figure 8 Noninverting Comparator I/O Transfer Characteristics**

6. Inverting Comparator (with Hysteresis)

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

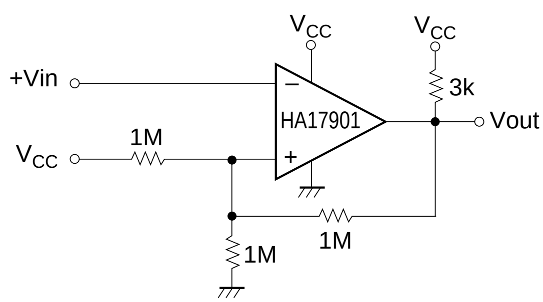



**Figure 9 Inverting Comparator**

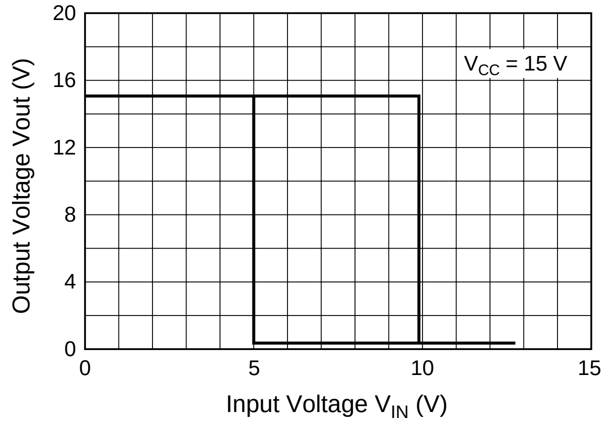



**Figure 10 Inverting Comparator I/O Transfer Characteristics**

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

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

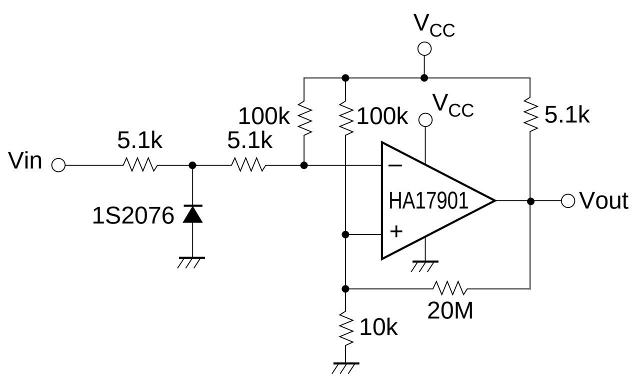
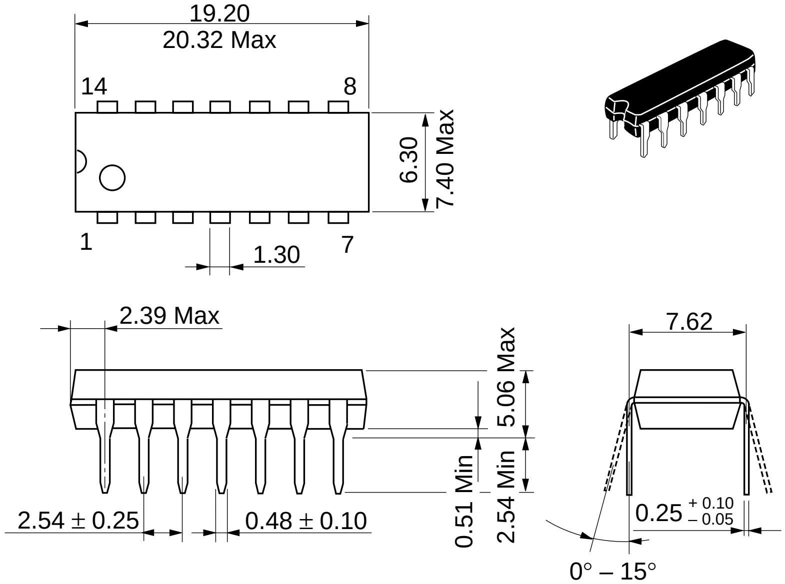



**Figure 11 Zero-Cross Detector**

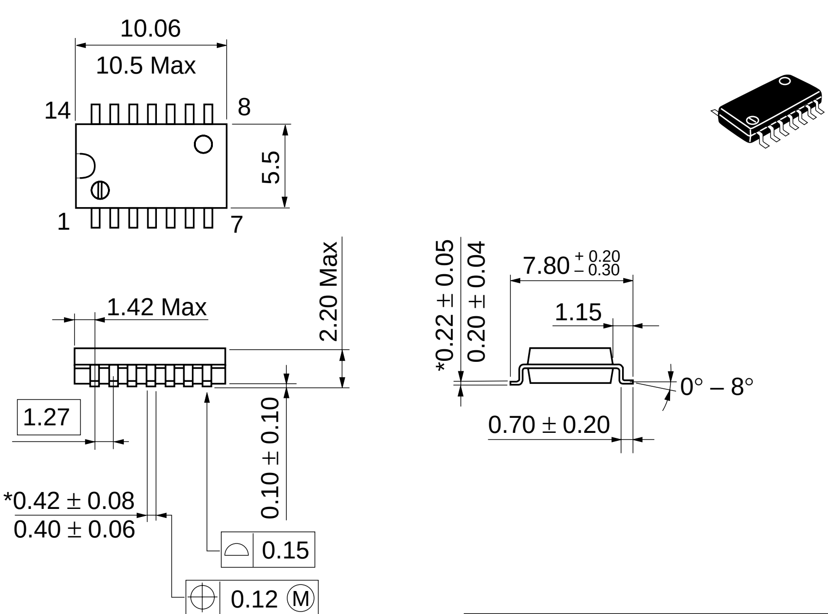
## Package Dimensions

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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