

# HA17301P

## Quad Operational Amplifier

# HITACHI

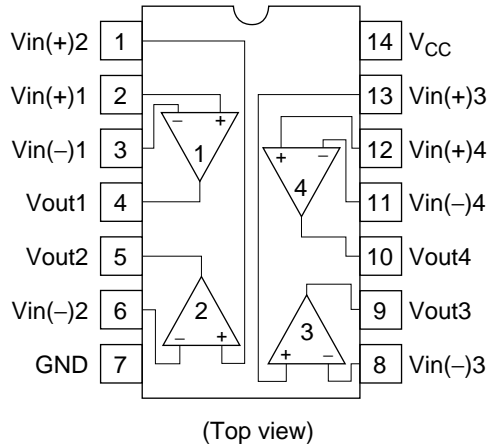
### Description

The HA17301P is an internal-compensation quad operational amplifier that operates on a single-voltage power supply. Typical applications for the HA17301P include waveform generators, voltage regulators, logic circuits, and voltage-controlled oscillators.

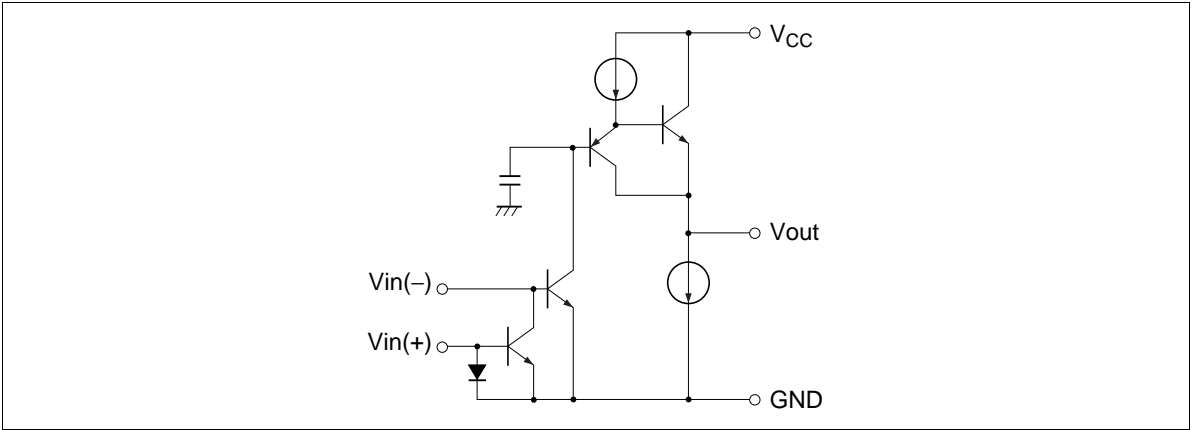
### Features

- Wide operating temperature range
- Single-voltage power supply operation
- Internal phase compensation
- Low input bias current

### Pin Arrangement



**Circuit Structure (1/4)**



**Absolute Maximum Ratings** ( $T_a = 25^\circ\text{C}$ )

Item	Symbol	Ratings	Unit
Power-supply voltage	$V_{CC}$	28	V
Noninverting input current	$I_r$	5	mA
Sink current	$I_o$ sink	50	mA
Source current	$I_o$ source	50	mA
Allowable power dissipation*	$P_T$	625	mW
Operating temperature	$T_{opr}$	-20 to +75	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55 to +125	$^\circ\text{C}$

Note: This is the allowable value up to  $T_a = 50^\circ\text{C}$  for the HA17301P. Derate by 8.3 mW/ $^\circ\text{C}$  above that temperature.

**Electrical Characteristics** ( $V_{CC} = +15\text{ V}$ ,  $R_L = 5.0\text{ k}\Omega$ ,  $T_a = 25^\circ\text{C}$ )

Item	Symbol	Min	Typ	Max	Unit	Test Conditions
Voltage gain	$A_{VD}$	1,000	1,400	—	V/V	
Supply current	$I_{CO}$	—	7.7	10	mA	Non inverting input open
	$I_{CG}$	—	8.3	14	mA	Non inverting input grounded
Input bias current	$I_{IB}$	—	80	300	nA	$R_L = \infty$
Current mirror gain	$A_I$	0.80	0.94	1.16	A/A	$I_r = 200\ \mu\text{A}$
Output source current	$I_o$ source	3	13	—	mA	$V_{OH} = 0.4\text{ V}$
		—	10	—	mA	$V_{OH} = 9.0\text{ V}$
Output sink current	$I_o$ sink	0.5	0.75	—	mA	$V_{OL} = 0.4\text{ V}$
Output voltage	$V_{OH}$	13.5	13.9	—	V	
	$V_{OL(inv)}$	—	0.04	0.1	V	Inverting input driven
	$V_{OL(non)}$	—	0.55	—	V	Non inverting input driven
Input resistance	$R_{in}$	0.1	1.0	—	$\text{M}\Omega$	Inverting input only
Slew rate	SR	—	0.2	—	V/ $\mu\text{s}$	$C_L = 100\text{ pF}$ , $R_L = 5.0\text{ k}\Omega$
Bandwidth	BW	—	2.6	—	MHz	$A_{VD} = 1$
Phase margin	$\phi_m$	—	87	—	deg	
Power-supply rejection ratio	PSRR	—	63	—	dB	$f = 100\text{ Hz}$
Channel separation	CS	—	63	—	dB	$f = 1.0\text{ kHz}$

## HA17301P Application Examples

The HA17301P is a quad operational amplifier, and consists of four operational amplifier circuits and one bias current circuit. The HA17301P features a wide operating temperature range, single-voltage power supply operation, internal phase compensation, a wide zero-cross bandwidth, a low input bias current, and a high open-loop gain. Thus the HA17301P can be used in a wide range of applications. This section describes several applications using the HA17301P.

### HA17301 Circuit Operation

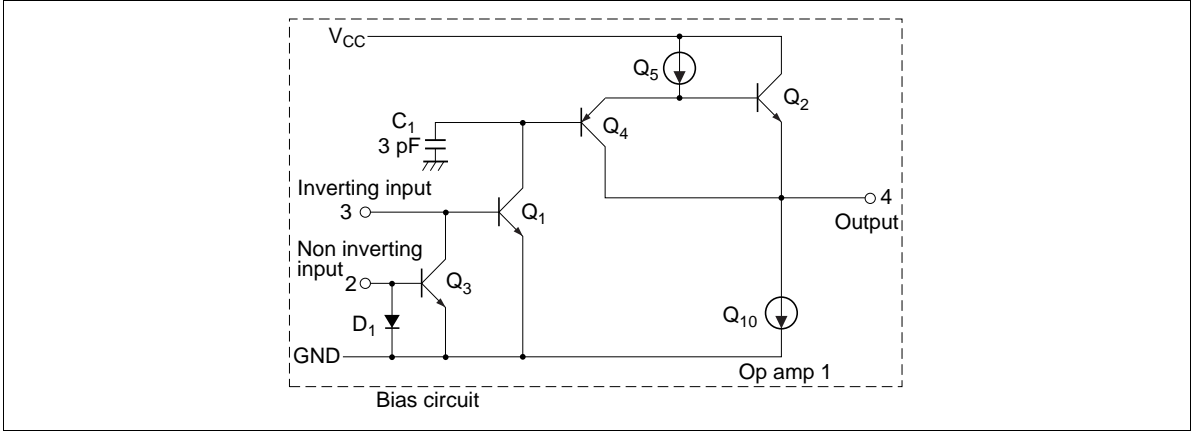


Figure 1 HA17301 Internal Equivalent Circuit

Figure 1 shows the internal equivalent circuit for the HA17301P bias circuit and one operational amplifier circuit (Op amp 1).

Op amp 1 is basically an emitter ground type operational amplifier in which the input transistor  $Q_1$ , the buffer transistor  $Q_4$ , the current source transistor  $Q_5$ , the output emitter-follower transistor  $Q_2$ , and the current source transistor  $Q_{10}$  form an inverting amplifier. The voltage gain of this circuit is all given by the transistor  $Q_1$ , and the adoption of the current-supply load  $Q_3$  allows this circuit to provide a large open-loop gain even at low power-supply voltages. Next, the emitter-follower transistor  $Q_2$  lowers the output impedance of this circuit. The use of the power-supply transistor  $Q_{10}$  as the load for  $Q_2$  gives this circuit an extremely large dynamic range, and essentially an amplitude from ground to  $(V_{CC} - 1)$  can be acquired. Also, the buffer transistor  $Q_4$  is used to reduce the input current without increasing the DC input voltage level. Since the capacitor  $C_1$  is used to preserve stability when this inverting amplifier is used as a closed circuit, no external compensation is required.

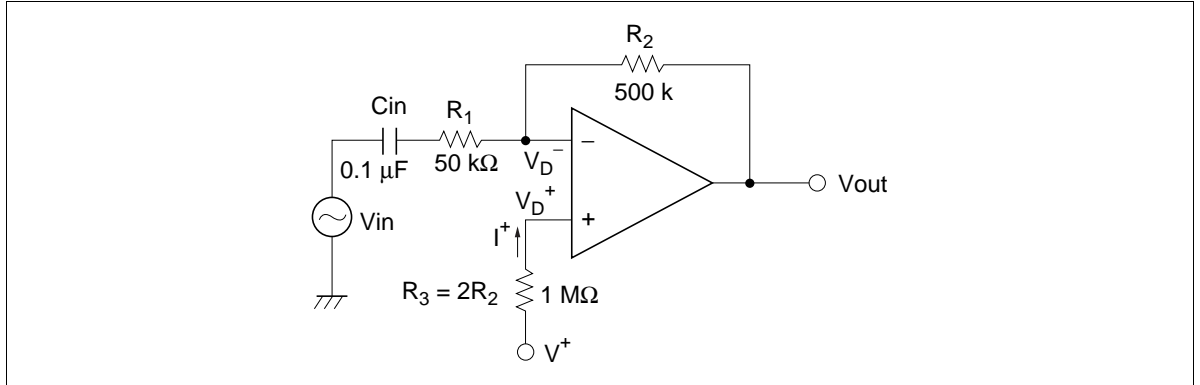
Now consider the non inverting circuit. Assuming that the current amplification ratio provided by  $Q_3$  is adequately large for the current flowing into the non inverting input, then all that current will flow through diode  $D_1$  and the voltage drop induced in the diode  $D_1$  by this input current will be applied to the  $Q_3$  base-emitter junction. Therefore, if  $D_1$  and  $Q_3$  are matched, a current equal to the input current will flow in the  $Q_3$  emitter. Assuming that the current amplification ratio provided by  $Q_3$  is adequately large, a current equal to the input current will flow in the  $Q_3$  collector. This is called a "current mirror", and when an external feedback resistor is used, a current equal to the non inverting input current will flow in this resistor and thus determine the output voltage.

### Inverting Amplifier

There are three bias techniques for biasing the inverting amplifier, the single power supply bias technique, the  $NV_{BE}$  bias technique, and the load voltage bias technique.

#### 1. Single Power Supply Bias Technique

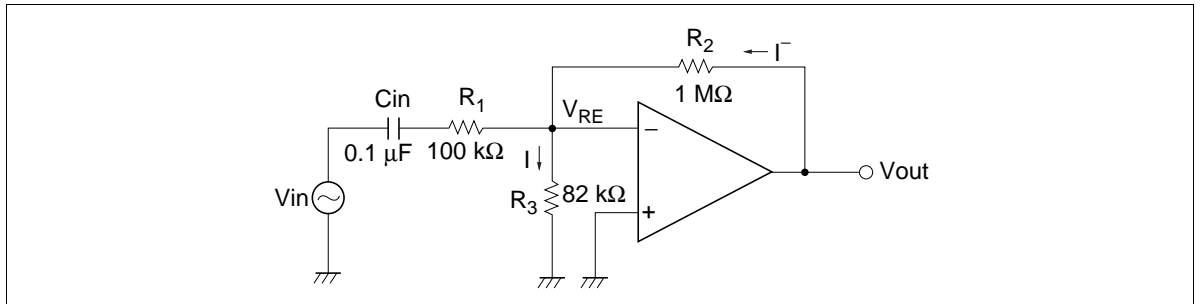
Figure 2 shows a common AC amplifier that is biased by the same power supply as the supply that operates the amplifier.



**Figure 2 Single Power Supply Bias Technique**

$$\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1} \quad (1)$$

#### 2. $NV_{BE}$ Bias Technique



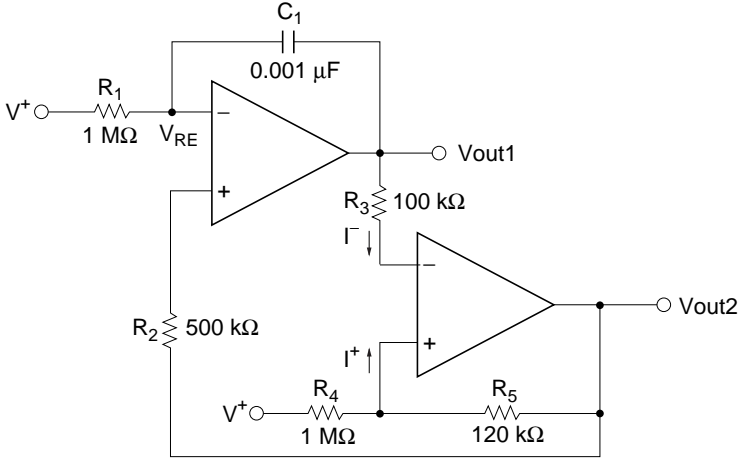
**Figure 3  $NV_{BE}$  Bias Technique**

This is the most useful application of an inverting AC amplifier. In this circuit, the input bias voltage  $V_{BE}$  for the inverting input is determined by the current that flows to ground through the resistor  $R_3$ .

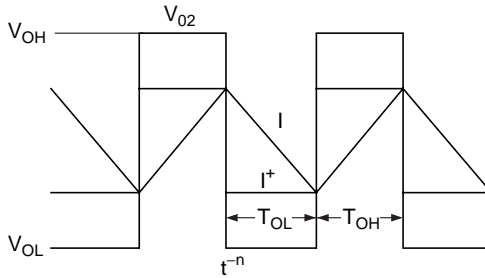
$$\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1} \quad (2)$$

## Triangular Wave oscillator

Triangular waveforms are usually acquired by integrating an alternating positive and negative DC voltage. Figure 4 shows the relation between the input and output in this circuit.



**Figure 4 Triangular Wave Oscillator**



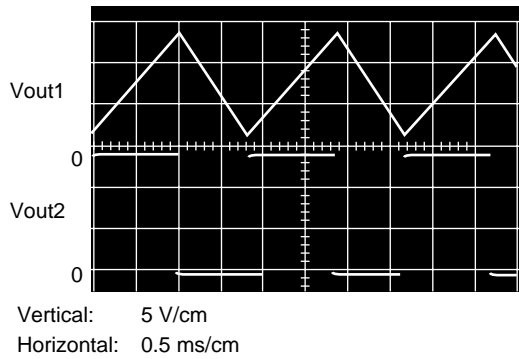
**Figure 5 Triangular Wave Generator Operation**

$$T_{OL} = \frac{C_1 R_1 R_3 V_{OH}}{R_5 (V^+ - V_{BE})} \quad (3)$$

$$T_{OH} = \frac{C_1 R_3 V^+}{R_5 \left( \frac{V_{OH}}{R_2} - \frac{V^+ - V_{BE}}{R_1} \right)} \quad (4)$$

Here, if  $R_1 = 2 \cdot R_2$ ,  $V_{OH} = V^+$ , and  $V^+ > V_{BE}$ , then:

$$T_{OH} + T_{OL} = \frac{2C_1 R_1 R_3}{R_5} \quad (5)$$



**Figure 6 Triangular Wave Generator Operating Waveform**

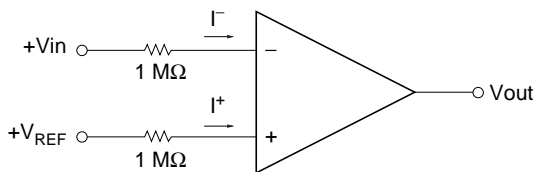
**Table 1**

Test Item		Tested Value	Calculated Value	Unit	Test Condition
Triangular wave generator	$T_{OH}$	1.06	0.83	ms	$V_{CC} = 15\text{ V}$ , $V^+ = 15\text{ V}$ , $C_1 = 0.001\text{ }\mu\text{F}$ ,
	$T_{OL}$	0.82	0.83	ms	$R_1 = 1\text{ M}\Omega$ , $R_2 = 500\text{ k}\Omega$ , $R_3 = 100\text{ k}\Omega$ ,
	$V_{OH}$	13.5	14	V	$R_4 = 1\text{ M}\Omega$ , $R_5 = 120\text{ k}\Omega$
	$V_{OL}$	1.5	1.5	V	Figure 4

### Comparators

This section describes three comparator circuits implemented using the HA17301P, a positive input voltage comparator, a negative input voltage comparator, and a power voltage comparator.

#### 1. Positive Input Voltage Comparator



**Figure 7 Positive Input Voltage Comparator**

$V_{out}$  in the circuit shown in figure 7 will be  $V_{OH}$  when  $V^- < V^+$  and  $V_{OL}$  when  $V^- > V^+$ . To assure that this circuit operates correctly, the reference voltage must be greater than  $V_{BE}$ .

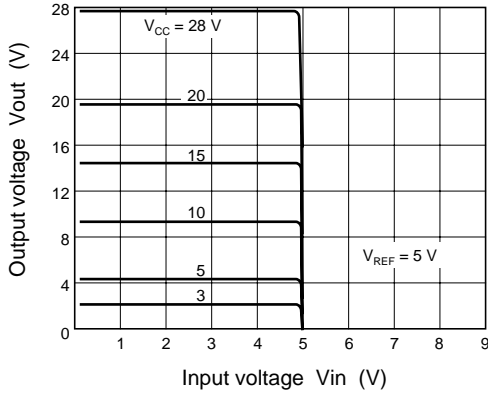


Figure 8 Positive Input Voltage Comparator Operating Characteristics (1)

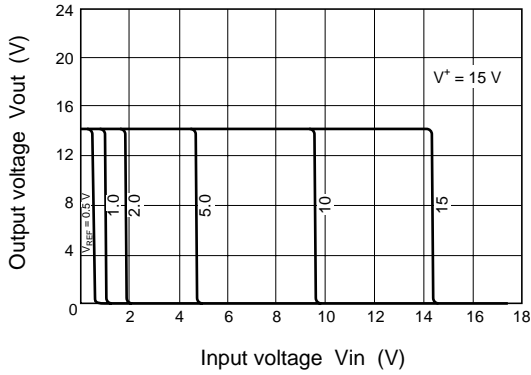


Figure 9 Positive Input Voltage Comparator Operating Characteristics (2)

2. Negative Input Voltage Comparator

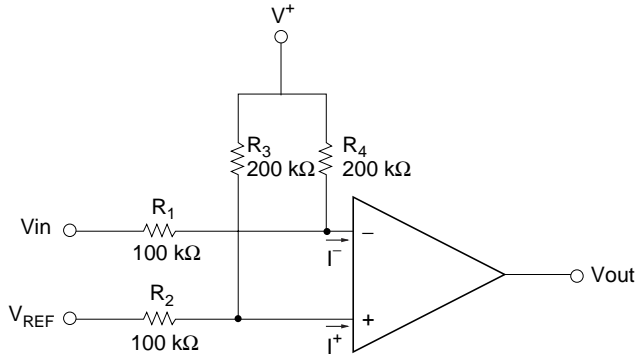


Figure 10 Negative Input Voltage Comparator



$$V_{IN} > R_1 \left\{ V_{BE} \left( \frac{1}{R_1} + \frac{1}{R_4} \right) - \frac{V^+}{R_4} \right\} \quad (6)$$

If resistor  $R_4$  is chosen so that formula 6 holds, and

$$V_{REF} > R_2 \left\{ V_{BE} \left( \frac{1}{R_2} + \frac{1}{R_3} \right) - \frac{V^+}{R_3} \right\} \quad (7)$$

if resistor  $R_4$  is chosen so that formula 7 holds, then even if  $V_{IN}$  and  $V_{REF}$  are negative,  $V_{out}$  will be  $V_{OH}$  when  $\Gamma < \Gamma^+$  and  $V_{OL}$  when  $\Gamma > \Gamma^+$ , as was the case for the positive input voltage comparator.

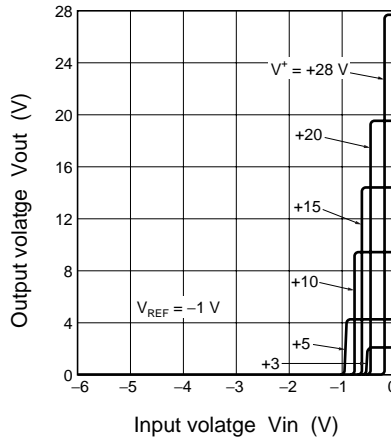


Figure 11 Negative Input Voltage Comparator Operating Characteristics (1)

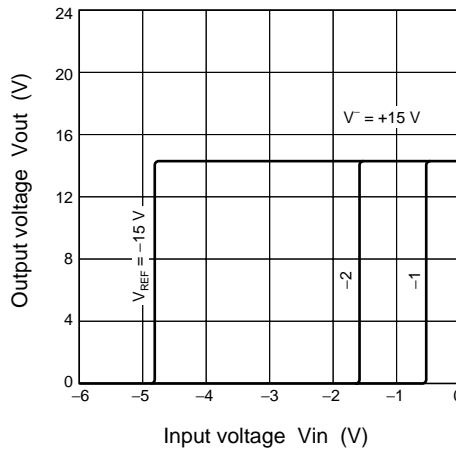
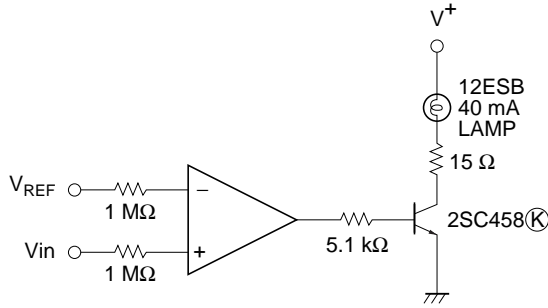


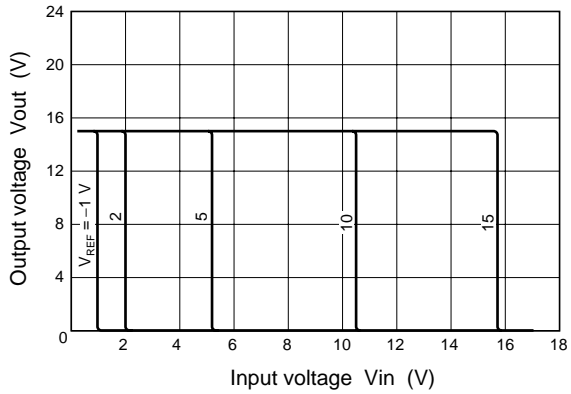
Figure 12 Negative Input Voltage Comparator Operating Characteristics (2)

## 3. Power Comparator

As shown in figure 13, adding an external transistor allows the circuit to drive loads that require a larger current than the output current that the HA17301P can supply.



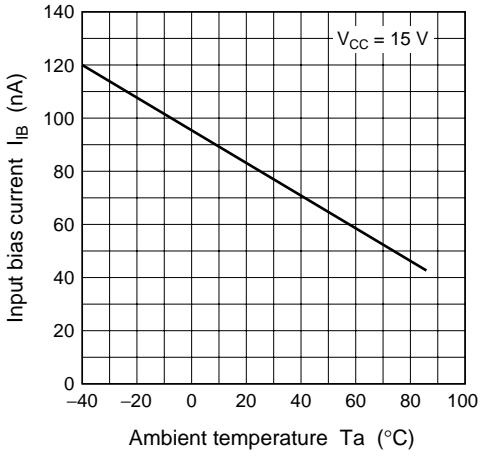
**Figure 13 Power Comparator**



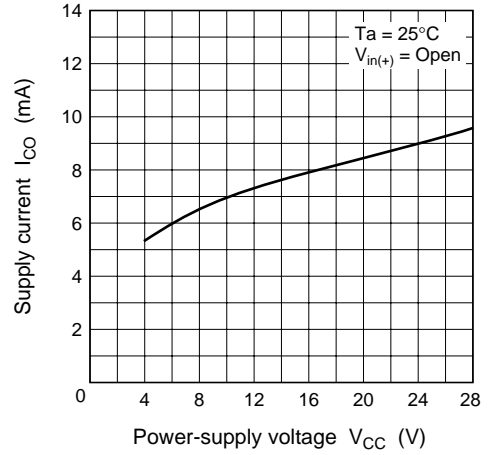
**Figure 14 Power Comparator Operating Characteristics**

Characteristic Curves

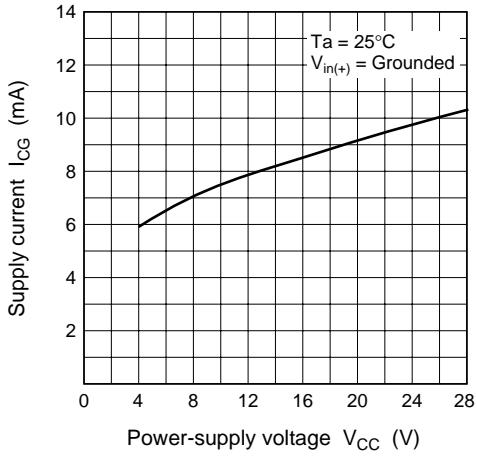
Input Bias Current vs. Ambient Temperature



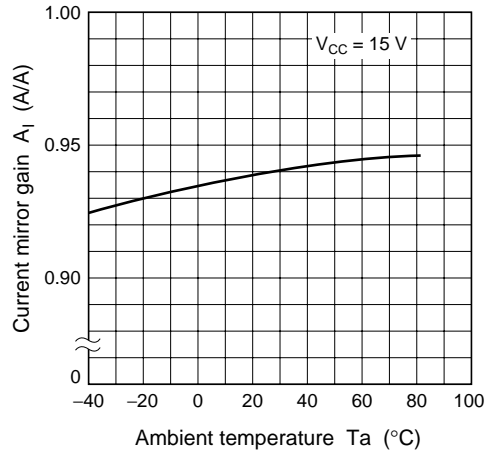
Supply current vs. Power-Supply Voltage (1)



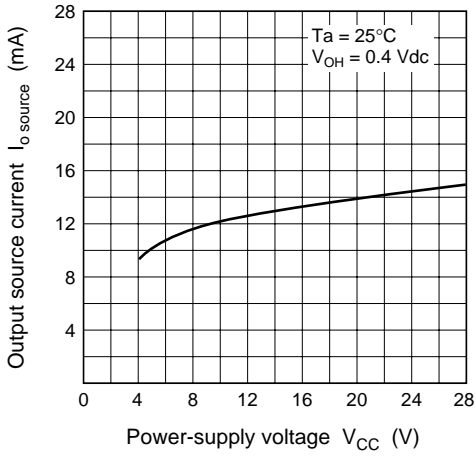
Supply current vs. Power-Supply Voltage (2)



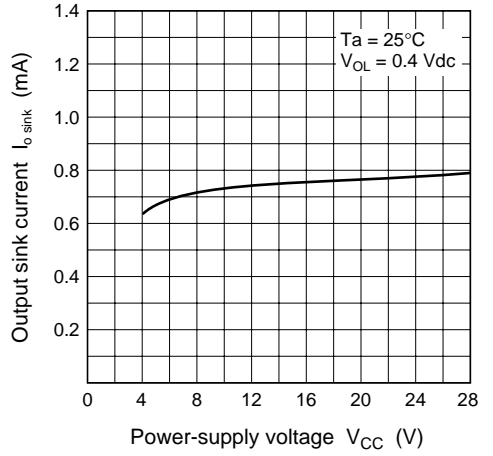
Current Mirror Gain vs. Ambient Temperature



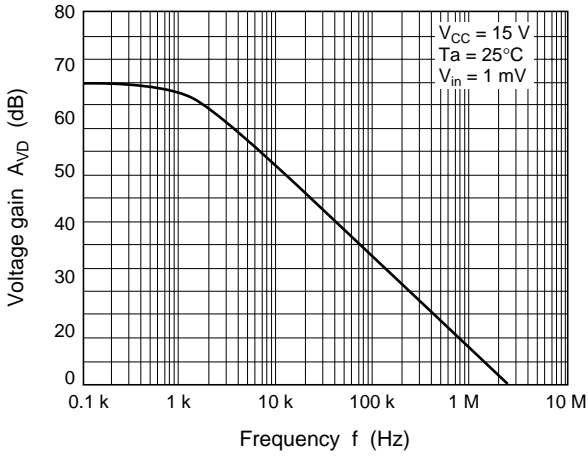
**Output Source Current vs. Power-Supply Voltage**



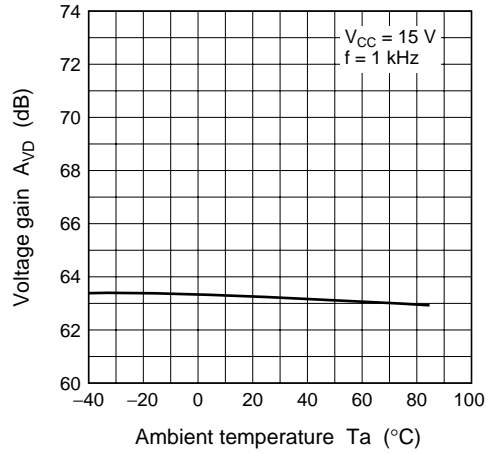
**Output Sink Current vs. Power-Supply Voltage**



**Voltage Gain vs. Frequency**

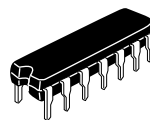
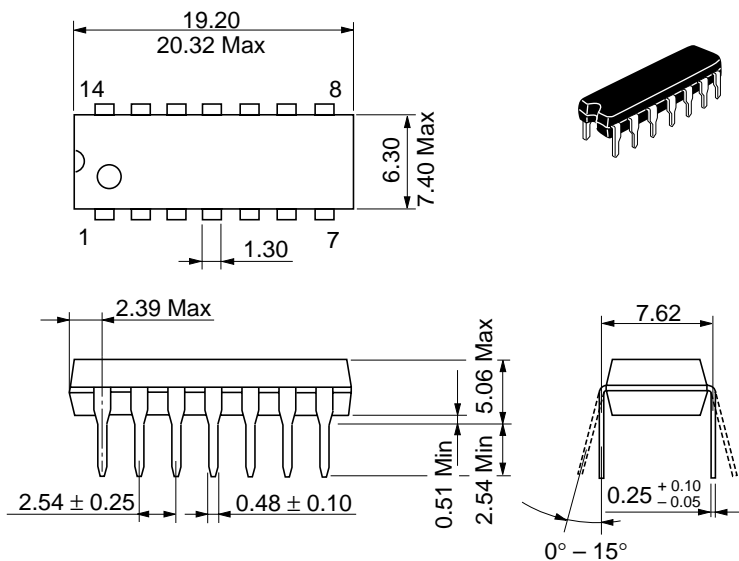


**Voltage Gain vs. Ambient Temperature**



Package Dimensions

Unit: mm



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

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