HA17301P

Quad Operational Amplifier

HITACHI

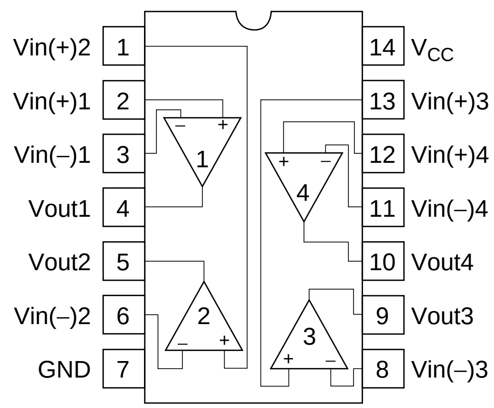
Description

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

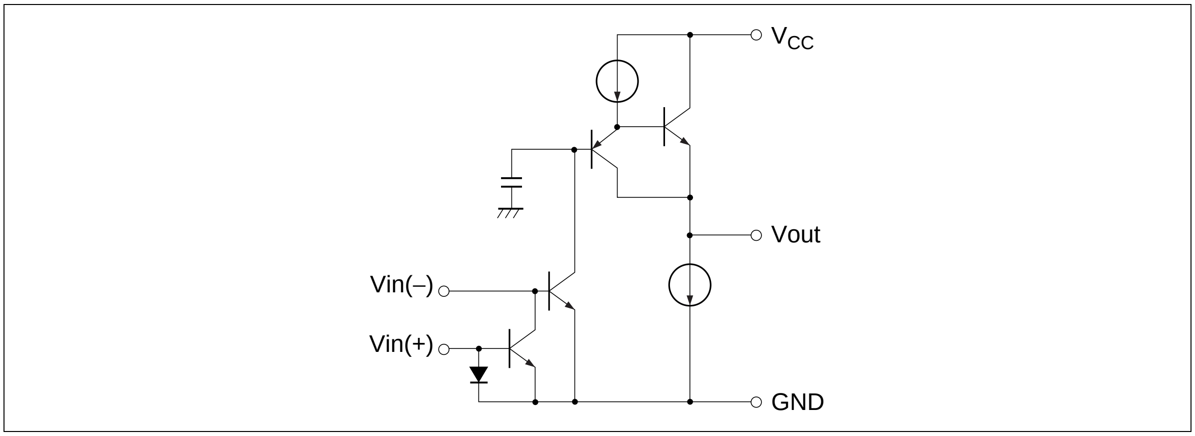
- Wide operating temperature range
- Single-voltage power supply operation
- Internal phase compensation
- Low input bias current

Pin Arrangement



(Top view)

Circuit Structure (1/4)



Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Ratings	Unit
Power-supply voltage	V_{CC}	28	V
Noninverting input current	Ir	5	mA
Sink current	Io sink	50	mA
Source current	Io source	50	mA
Allowable power dissipation*	P_T	625	mW
Operating temperature	Topr	–20 to +75	°C
Storage temperature	Tstg	–55 to +125	°C

Note: This is the allowable value up to Ta = 50°C for the HA17301P. Derate by 8.3 mW/°C above that temperature.

Electrical Characteristics (V_{CC} = +15 V, R_L = 5.0 kΩ, Ta = 25°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	Ir = 200 µA
Output source current	Io source	3	13	—	mA	V_{OH} = 0.4 V
		—	10	—	mA	V_{OH} = 9.0 V
Output sink current	Io sink	0.5	0.75	—	mA	V_{OL} = 0.4 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	Rin	0.1	1.0	—	MΩ	Inverting input only
Slew rate	SR	—	0.2	—	V/µs	C_L = 100 pF, R_L = 5.0 kΩ
Bandwidth	BW	—	2.6	—	MHz	A_{VD} = 1
Phase margin	φm	—	87	—	deg	
Power-supply rejection ratio	PSRR	—	63	—	dB	f = 100 Hz
Channel separation	CS	—	63	—	dB	f = 1.0 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

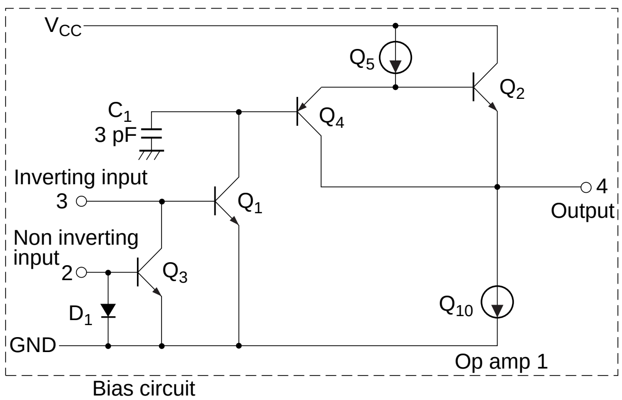


Figure 1 HA17301 Internal Equivalent Circuit

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_5 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.

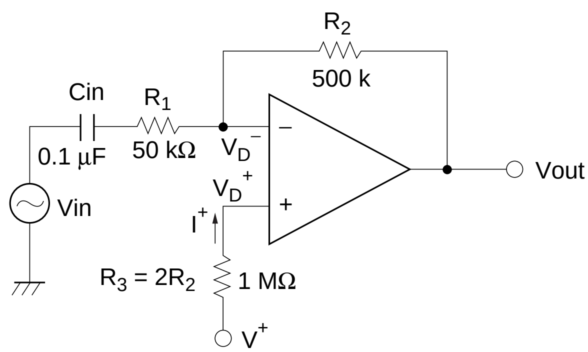


Figure 2 Single Power Supply Bias Technique

$$\frac{Vout}{Vin} = -\frac{R_2}{R_1} \qquad (1)$$

2. NV_{BE} Bias Technique

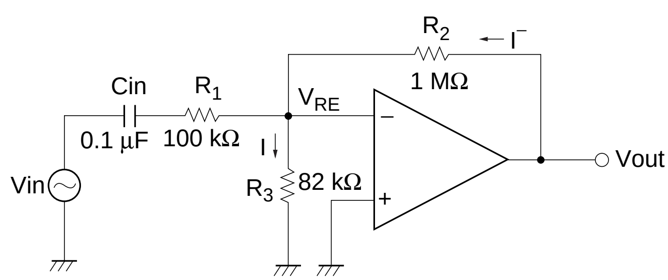


Figure 3 NV_{BE} Bias Technique

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.

$$\frac{Vout}{Vin} = -\frac{R_2}{R_1} \qquad (2)$$

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.

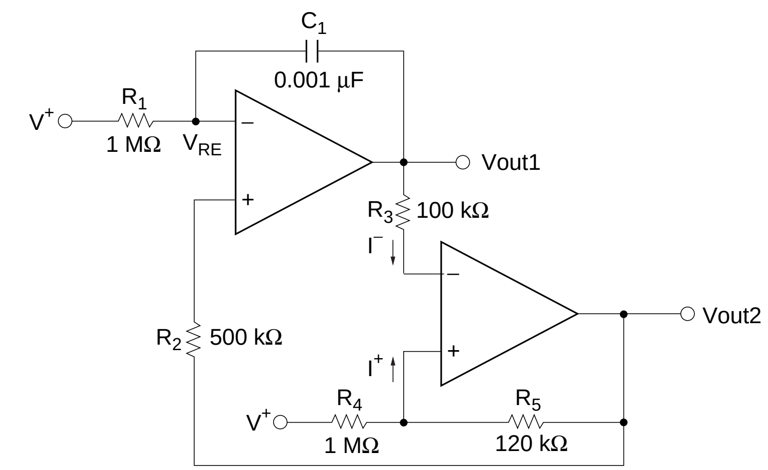


Figure 4 Triangular Wave Oscillator

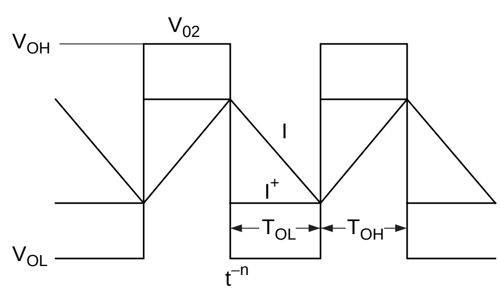


Figure 5 Triangular Wave Generator Operation

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

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

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

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

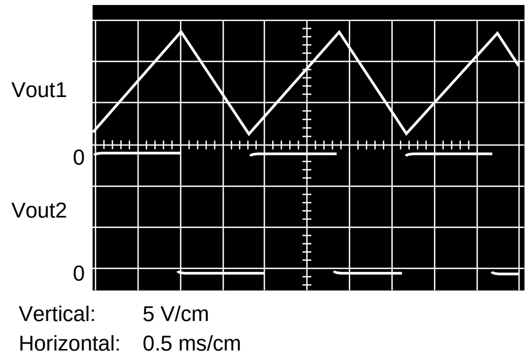


Figure 6 Triangular Wave Generator Operating Waveform

Table 1

Test Item		Tested Value	Calculated Value	Unit	Test Condition
Triangular wave generator	T_{OH}	1.06	0.83	ms	V_{CC} = 15 V, V^+ = 15 V, C_1 = 0.001 µF, R_1 = 1 MΩ, R_2 = 500 kΩ, R_3 = 100 kΩ, R_4 = 1 MΩ, R_5 = 120 kΩ Figure 4
	T_{OL}	0.82	0.83	ms	
	V_{OIH}	13.5	14	V	
	V_{OIL}	1.5	1.5	V	

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

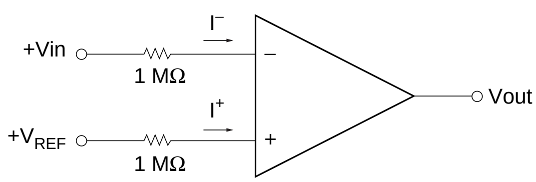


Figure 7 Positive Input Voltage Comparator

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

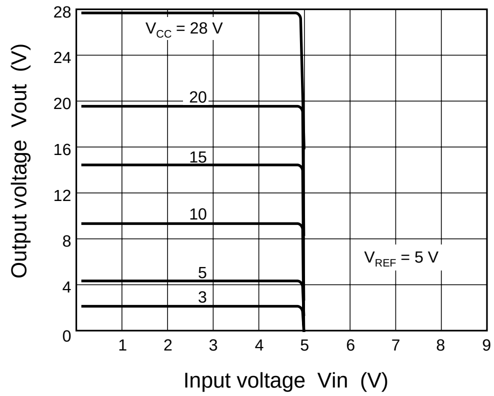


Figure 8 Positive Input Voltage Comparator Operating Characteristics (1)

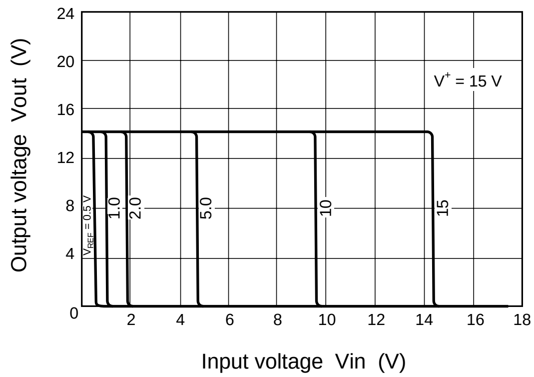


Figure 9 Positive Input Voltage Comparator Operating Characteristics (2)

2. Negative Input Voltage Comparator

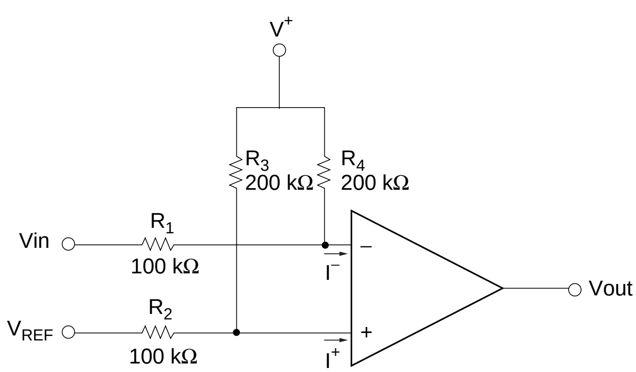


Figure 10 Negative Input Voltage Comparator

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

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, Vout will be V_{OH} when $I^- < I^+$ and V_{OL} when $I^- > I^+$, as was the case for the positive input voltage comparator.

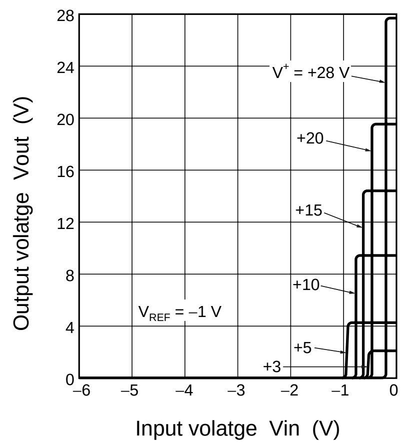


Figure 11 Negative Input Voltage Comparator Operating Characteristics (1)

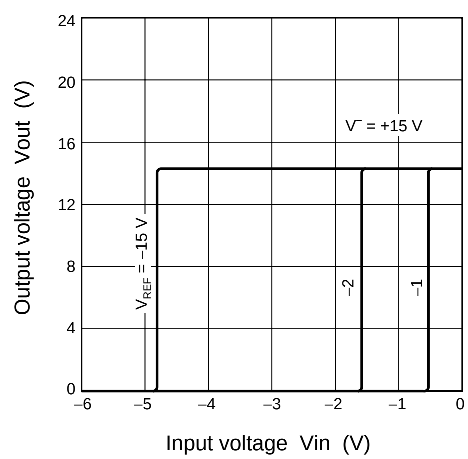


Figure 12 Negative Input Voltage Comparator Operating Characteristics (2)

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.

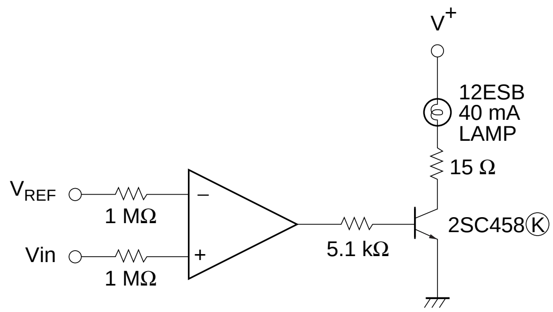


Figure 13 Power Comparator

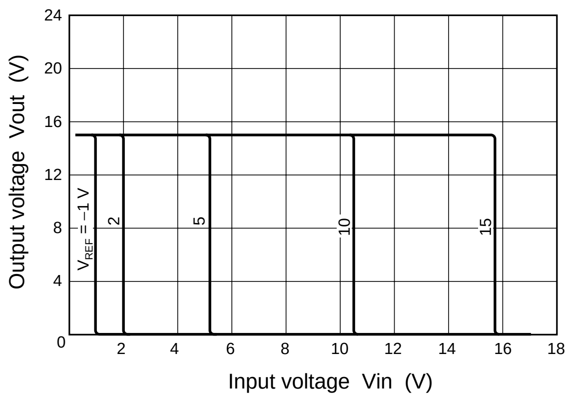
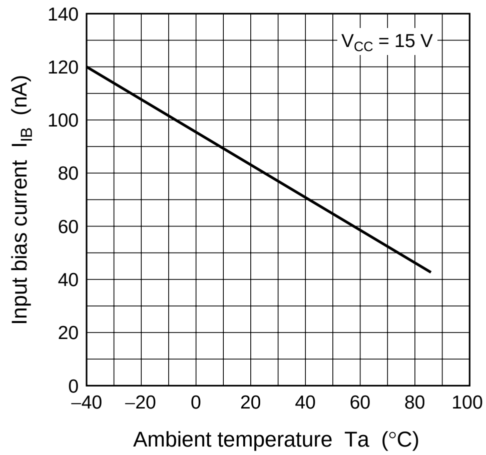


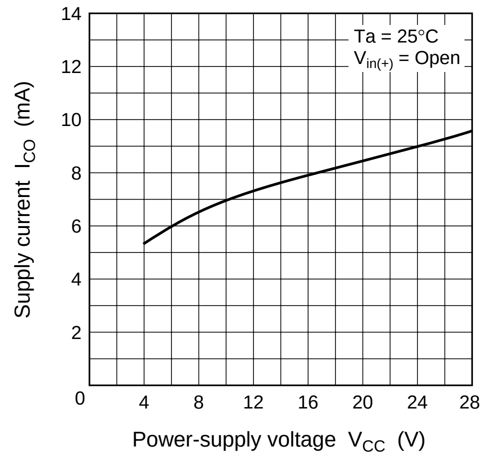
Figure 14 Power Comparator Operating Characteristics

Characteristic Curves

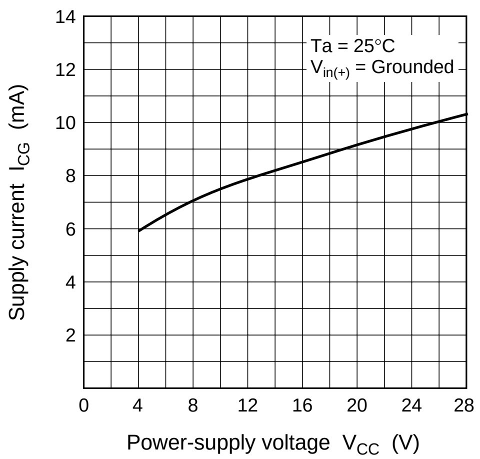
Input Bias Current vs. Ambient Temperature



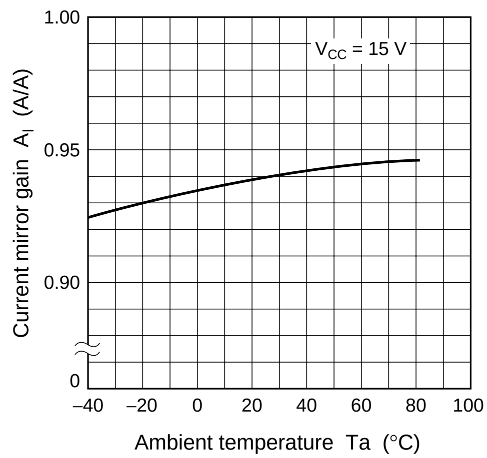
Supply current vs. Power-Supply Voltage (1)



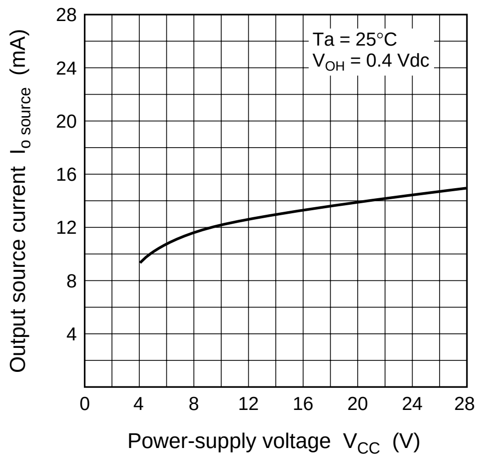
Supply current vs. Power-Supply Voltage (2)



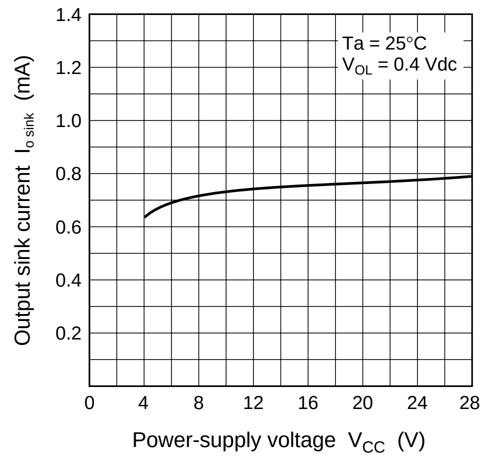
Current Mirror Gain vs Ambient Temperature



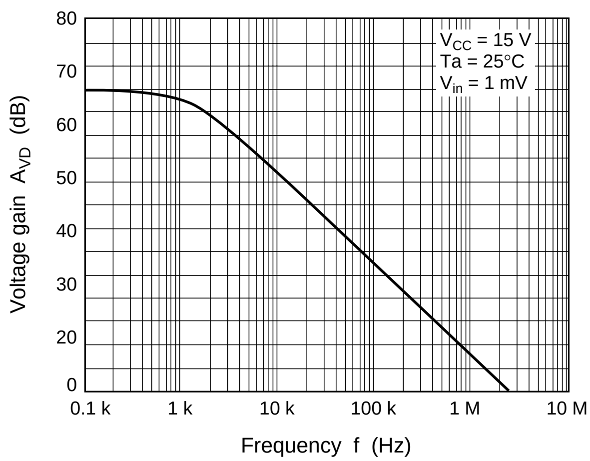
Output Source Current vs. Power-Supply Voltage



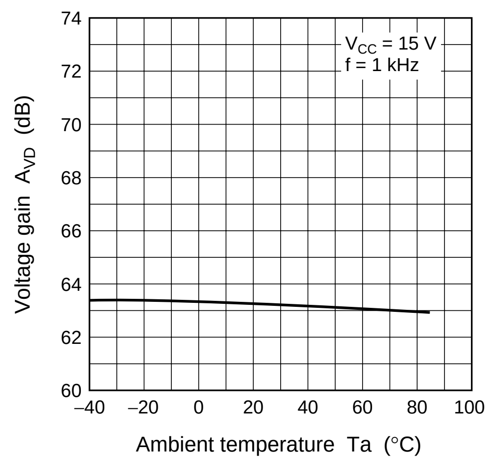
Output Sink Current vs. Power-Supply Voltage



Voltage Gain vs. Frequency

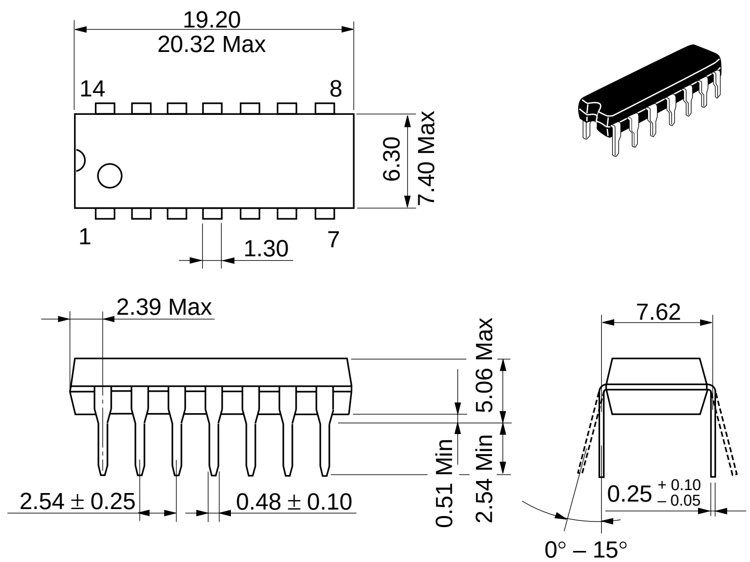


Voltage Gain vs. Ambient Temperature



Package Dimensions

Unit: mm



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

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