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# HA17008RP/RFP

## 8-Bit Multiplying Digital to Analog Converter

# HITACHI

ADE-204-060 (Z)

Rev. 0

Dec. 2000

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### Description

The HA17008R series are 8-bit monolithic D/A converters which have built in, a reference current amplifier, an R-2R ladder resistor, and 8 high speed current switches.

By setting the reference voltage and resistance, the maximum output current can be freely varied in response to the application.

The reference current is distributed to the current value for each bit by the R-2R ladder resistor, and the maximum output current is 255/256 of the reference current. For example, if the input reference current is 2.0 mA, then the maximum available output current is 1.992 mA.

Applications for the HA17008R are wide ranging, and include CRT displays, stepping motor control, programmable power supplies, audio equipment, and attenuators.

### Features

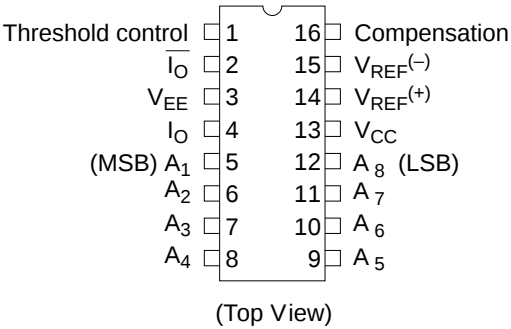
- Linearity of  $\pm 0.19\%$  ( $\pm 1/2$  LSB) guaranteed.
- The settling time is short, 85 ns (typ), enabling rapid conversions.
- Low power dissipation has been reduced: 135 mW typ.
- Compatible with TTL and CMOS logic.
- The standard supply voltage is  $V_{CC} = +15.0$  V,  $V_{EE} = -15.0$  V.
- A wide output voltage range can be provided. From  $-10$  V to  $+18$  V.

### Ordering Information

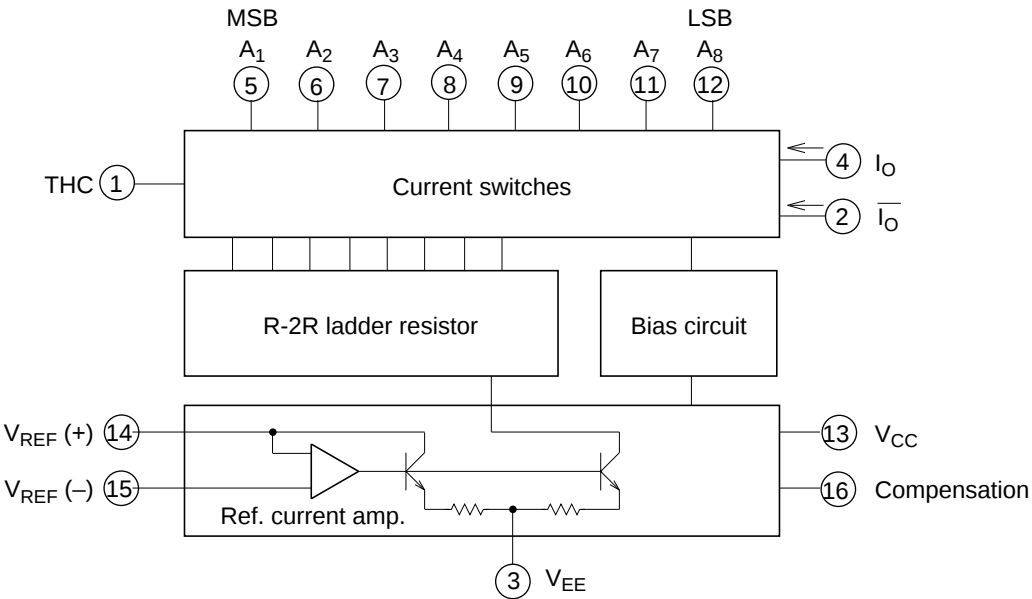
| Type No.   | Package |
|------------|---------|
| HA17008RP  | DP-16   |
| HA17008RFP | FP-16DA |

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Pin Arrangement



Block Diagram



## Functions

### Reference differential amplifier and phase compensation

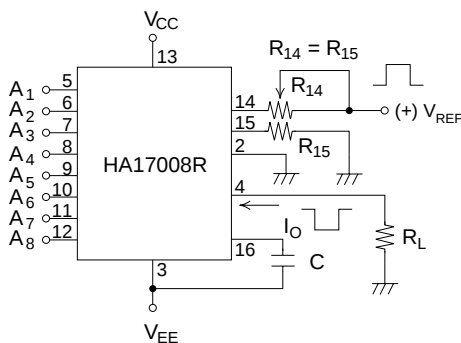
The reference amplifier is a circuit which converts the reference voltage applied to pin 14 through the external resistor  $R_{14}$  from a voltage to a current. The converted current is supplied to each bit by a current mirror and the ladder resistor. Note that this should be used with the polarity of the current flowing in to pin 14. The reference voltage source provides all of the current flowing into pin 14.

Also, even removing the resistor  $R_{15}$  will have a minimal influence on precision and temperature drift.

To preserve an appropriate value of the phase margin, it is necessary to increase the value of the phase compensation capacitance as  $R_{14}$  is increased. For example, if  $R_{14}$  is 1 k, 2.5 k, or

5 k, the minimum capacitances should be 15 pF, 37 pF, and 75 pF, respectively. The capacitor is connected to  $V_{EE}$ . If high impedance is required in the reference current source, connect  $R_{14}$  to ground and connect  $R_{15}$  to the negative reference voltage. (Refer figure 2.) If a DC reference voltage is used, a bypass capacitor should be inserted in the reference voltage source to reduce compounded hum and noise. We cannot recommend the use of noisy 5 V logic power supplies. When a logic control 5 V power supply of good stability is used for the reference supply, connect a resistor to the reference supply and connect a 0.1  $\mu$ F capacitor between the reference supply and the resistor contact.

When pin 14 is controlled by a high impedance such as a fixed current supply, phase compensation will not be possible with the above method. Therefore, provide adequate phase compensation in the frequency band of the fixed current supply.



**Figure 1 Positive Reference Potential Application Example**

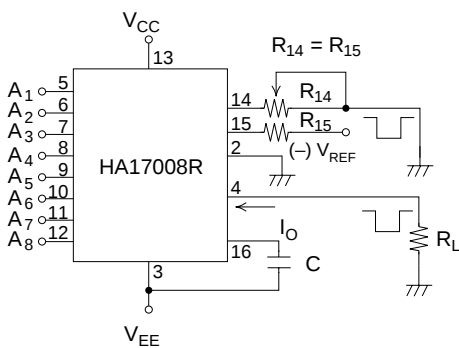


Figure 2 Negative Reference Potential Application Example

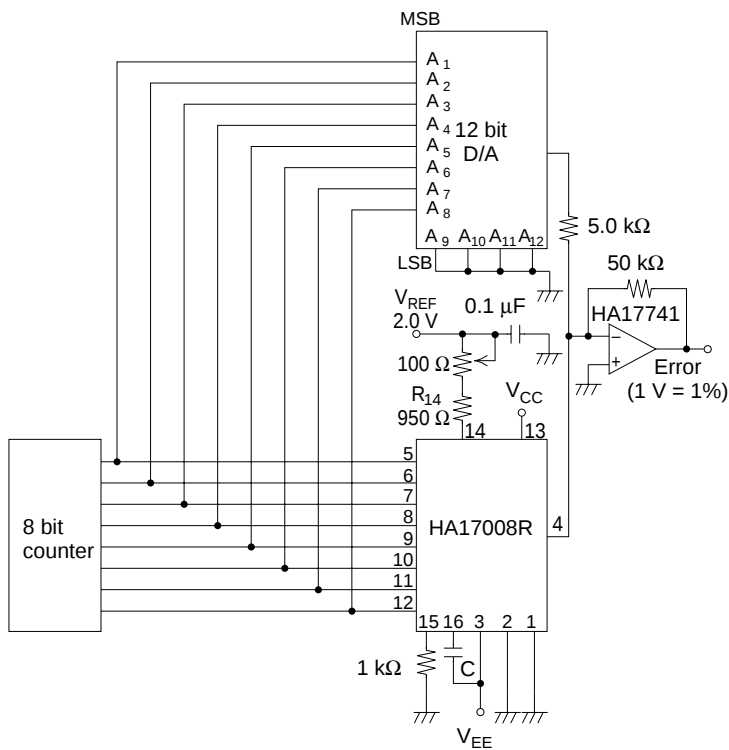
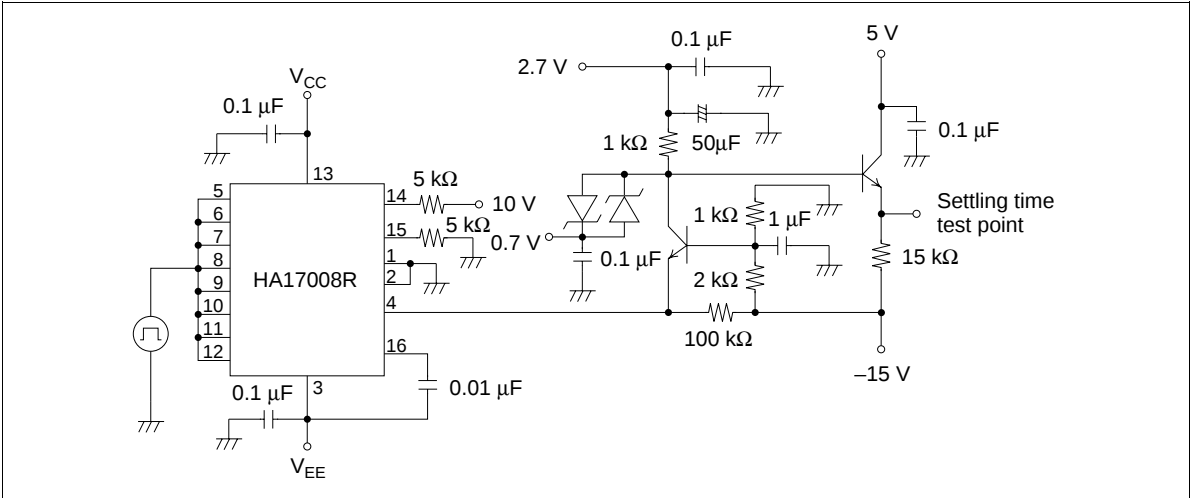


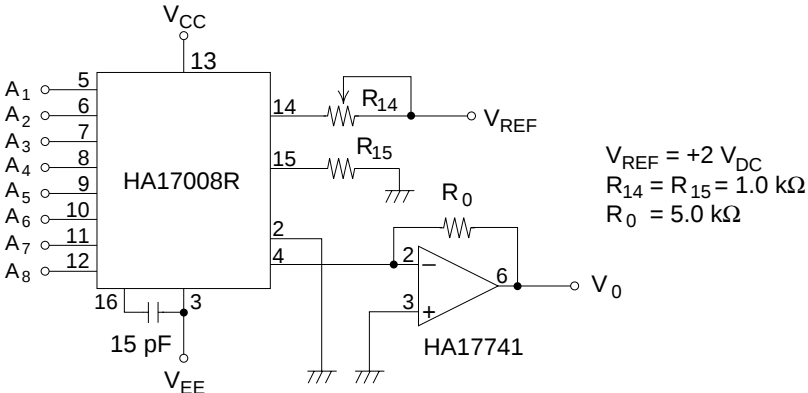
Figure 3 Non Linearity Measurement Circuit



### Figure 4 Settling Time Test Circuit

## Operation Example

- **Current to voltage converter using an op-amp**



Logical output  $V_0$

$$V_0 = \frac{V_{REF}}{R_{14}} (R_0) \left( \frac{A_1}{2} + \frac{A_2}{4} + \frac{A_3}{8} + \frac{A_4}{16} + \frac{A_5}{32} + \frac{A_6}{64} + \frac{A_7}{128} + \frac{A_8}{256} \right)$$

When  $V_{REF}$ ,  $R_{14}$ , and  $R_0$  are determined, the output voltage becomes 9.961 V in case of all-high input bits.

$$V_0 = \frac{2 \text{ V}}{1 \text{ k}\Omega} (5 \text{ k}\Omega) \left( \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \frac{1}{128} + \frac{1}{256} \right)$$

Absolute Maximum Ratings (Ta = 25°C)

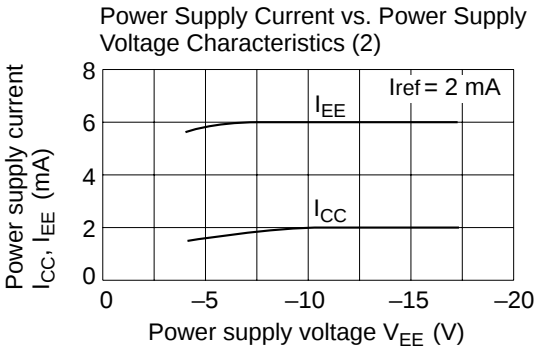
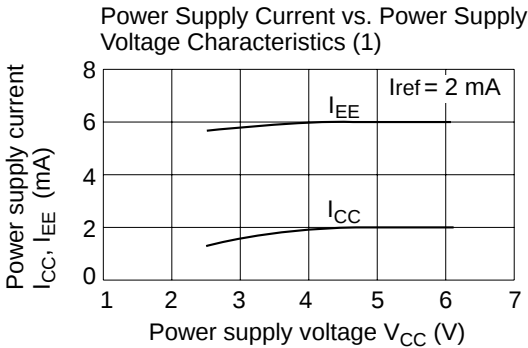
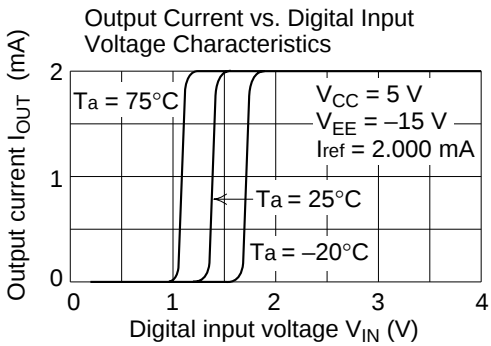
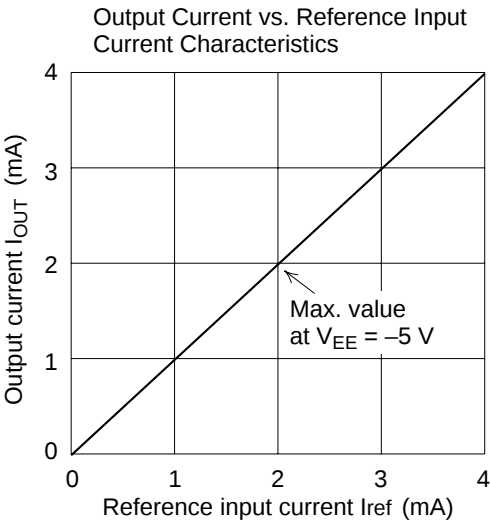
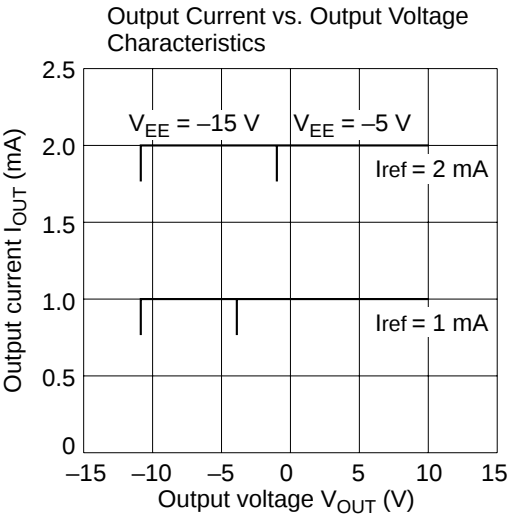
| Item                                    | Symbol                            | Rating                                    | Unit |
|-----------------------------------------|-----------------------------------|-------------------------------------------|------|
| Power supply voltage                    | V <sub>CC</sub>                   | +18                                       | V    |
|                                         | V <sub>EE</sub>                   | −18                                       | V    |
| Digital input voltage                   | V <sub>5</sub> to V <sub>12</sub> | V <sub>EE</sub> to V <sub>EE</sub> + 36 V | V    |
| Reference current                       | I <sub>14</sub>                   | 5                                         | mA   |
| Reference amplifier input voltage range | V <sub>REF</sub>                  | V <sub>CC</sub> to V <sub>EE</sub>        | V    |
| Power dissipation                       | P <sub>T</sub>                    | 500* <sup>1</sup>                         | mW   |
| Operating temperature                   | Topr                              | −20 to +75                                | °C   |
| Storage temperature                     | Tstg                              | −55 to +125                               | °C   |

Note: 1. This is the allowable value up to Ta = 65°C for HA17008RP. Derate by 8.3mW/°C above that temperature.  
In case of HA17008RFP, see notes on SOP Package usage in Reliability section.

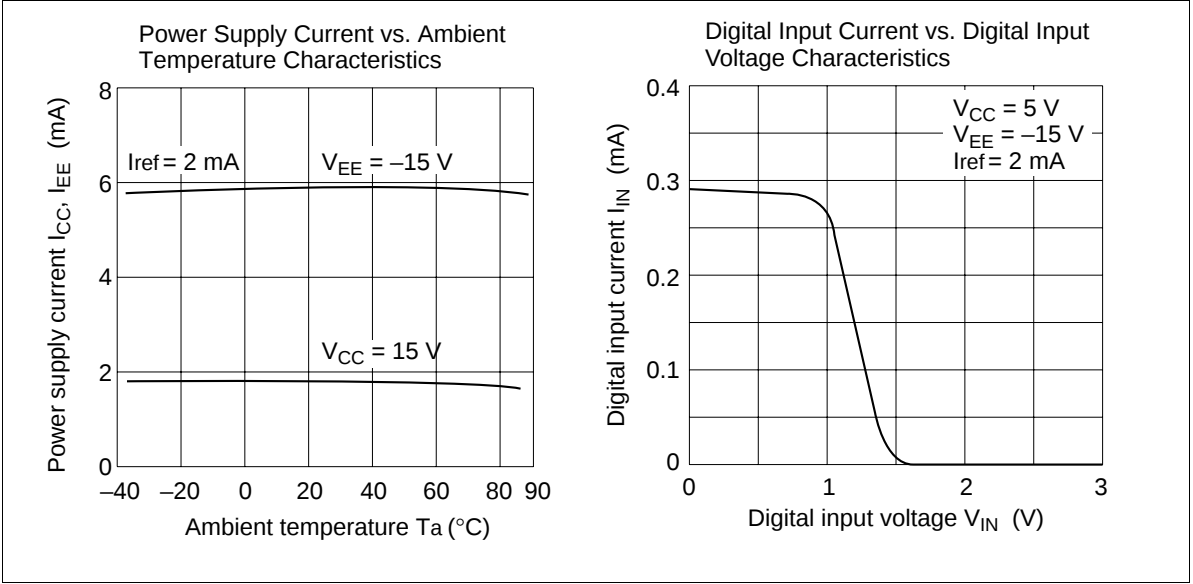
**Electrical Characteristics** ( $V_{CC} = 15\text{ V}$ ,  $V_{EE} = -15\text{ V}$ ,  $I_{REF} = 2\text{ mA}$ ,  $V_{THC} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

| Item                                              | Symbol                | Min  | Typ      | Max        | Unit                  | Test Conditions                                                     |
|---------------------------------------------------|-----------------------|------|----------|------------|-----------------------|---------------------------------------------------------------------|
| Nonlinearity                                      | NL                    | —    | —        | $\pm 0.19$ | %FS                   |                                                                     |
| Settling time ( $\pm 1/2$ LSB)                    | $t_s$                 | —    | 85       | 150        | ns                    | All bits OFF to ON                                                  |
| Propagation delay time                            | $t_{PLH}$ , $t_{PHL}$ | —    | 35       | 60         | ns                    |                                                                     |
| Full scale current temperature dependence         | $T_{CIFS}$            | —    | $\pm 10$ | $\pm 50$   | ppm/ $^\circ\text{C}$ |                                                                     |
| Digital input level                               | $V_{IH}$              | 2    | —        | —          | V                     |                                                                     |
|                                                   | $V_{IL}$              | —    | —        | 0.8        | V                     |                                                                     |
| Digital input current (MSB)                       | $I_{IH}$              | —    | 0.002    | 10         | $\mu\text{A}$         | $V_{IH} = 5\text{ V}$                                               |
|                                                   | $I_{IL}$              | -10  | -2       | —          | $\mu\text{A}$         | $V_{IL} = 0.8\text{ V}$                                             |
| Reference input bias current                      | $I_{15}$              | -3   | -1       | —          | $\mu\text{A}$         |                                                                     |
| Output current range                              | $I_{FSR}$             | 0    | 2        | 2.1        | mA                    | $V_{EE} = -5\text{ V}$                                              |
|                                                   |                       | 0    | 2        | 4.2        | mA                    | $V_{EE} = -8\text{ to }-18\text{ V}$                                |
| Full scale output current                         | $I_{FS}$              | 1.94 | 1.99     | 2.04       | mA                    | $V_{ref} = 10\text{ V}$ , $R_{14}$ , $R_{15} = 5\text{ k}\Omega$    |
| Zero scale output current                         | $I_Z$                 | —    | 0        | 2          | $\mu\text{A}$         | All Bits Low                                                        |
| Output voltage range                              | $V_{OC}$              | -10  | —        | +18        | V                     | $\Delta I_{FS} \leq 1/2\text{ LSB}$                                 |
| Reference current slew rate                       | $dl/dt$               | 4    | 8        | —          | mA/ $\mu\text{s}$     | $R_{REF} \leq 200\Omega$ , $C_C = 0\text{ pf}$                      |
| Power supply current                              | $I_{CC}$              | —    | 1.8      | 3.8        | mA                    | $V_{CC} = 5\text{ V}$ , $I_{REF} = 1\text{ mA}$ ,                   |
|                                                   | $I_{EE}$              | -5.8 | -3.7     | —          | mA                    | $V_{EE} = -5\text{ V}$                                              |
|                                                   | $I_{CC}$              | —    | 1.9      | 3.8        | mA                    | $V_{CC} = 5\text{ V}$ , $I_{REF} = 2\text{ mA}$ ,                   |
|                                                   | $I_{EE}$              | -7.8 | -5.8     | —          | mA                    | $V_{EE} = -15\text{ V}$                                             |
|                                                   | $I_{CC}$              | —    | 2.1      | 3.8        | mA                    | $V_{CC} = 15\text{ V}$ , $I_{REF} = 2\text{ mA}$ ,                  |
|                                                   | $I_{EE}$              | -7.8 | -5.9     | —          | mA                    | $V_{EE} = -15\text{ V}$                                             |
| Power supply voltage                              | $V_{CC}$              | 4.5  | 15       | 18         | V                     | $I_{REF} = 1\text{ mA}$                                             |
|                                                   | $V_{EE}$              | -18  | -15      | -4.5       | V                     |                                                                     |
| Differential full scale output current difference | $I_{FSS}$             | -8   | $\pm 1$  | +8         | $\mu\text{A}$         | $I_{FS4} - I_{FS2}$                                                 |
| Digital input voltage range                       | $V_{IS}$              | -10  | —        | +18        | V                     | $V_{THR} = -10\text{ to }+13.5\text{ V}$                            |
| Threshold voltage range                           | $V_{THR}$             | -10  | 0        | 13.5       | V                     | $V_{THR} \equiv V_{THC} + 1.3\text{ V}$                             |
| Power supply voltage dependence                   | $P_{SS}I_{FS}^+$      | -100 | —        | 100        | ppmFS/%V              | $V_{CC} = -4.5\text{ to }-18\text{ V}$ ,<br>$I_{REF} = 1\text{ mA}$ |
|                                                   | $P_{SS}I_{FS}^-$      | -100 | —        | 100        | ppmFS/%V              | $V_{EE} = -4.5\text{ to }-18\text{ V}$ ,<br>$I_{REF} = 1\text{ mA}$ |

Standard Characteristics Curves

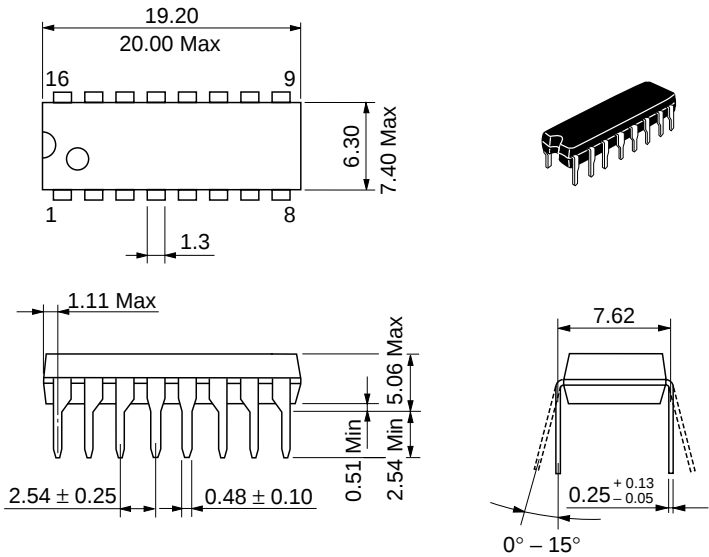


Standard Characteristics Curves (cont)



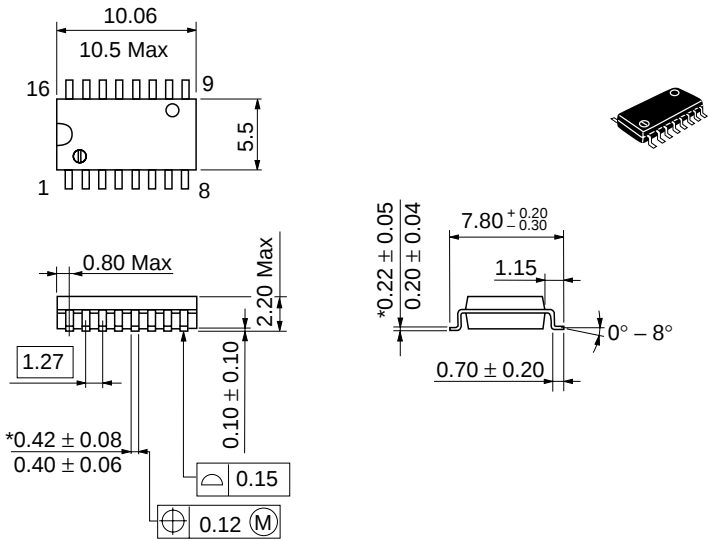
Package Dimensions

Unit: mm



|                        |          |
|------------------------|----------|
| Hitachi Code           | DP-16    |
| JEDEC                  | Conforms |
| EIAJ                   | Conforms |
| Mass (reference value) | 1.07 g   |

Unit: mm



\*Dimension including the plating thickness  
Base material dimension

|                        |          |
|------------------------|----------|
| Hitachi Code           | FP-16DA  |
| JEDEC                  | —        |
| EIAJ                   | Conforms |
| Mass (reference value) | 0.24 g   |

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