# KA224/KA224A, KA324/KA324A, KA2902

## Quad Operational Amplifier

### Features

- Internally frequency compensated for unity gain
- Large DC voltage gain: 100dB
- Wide power supply range:
  KA224 / KA224A, KA324 / KA324A : 3V~32V (or ±1.5 ~ 15V)
  KA2902: 3V~26V (or ±1.5V ~ 13V)
- Input common mode voltage range includes ground
- Large output voltage swing: 0V to $V_{CC}$ -1.5V
- Power drain suitable for battery operation

### Description

The KA324 series consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range. Operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts. Application areas include transducer amplifier, DC gain blocks and all the conventional OP amp circuits which now can be easily implemented in single power supply systems.

**14-DIP**

1

**14-SOP**

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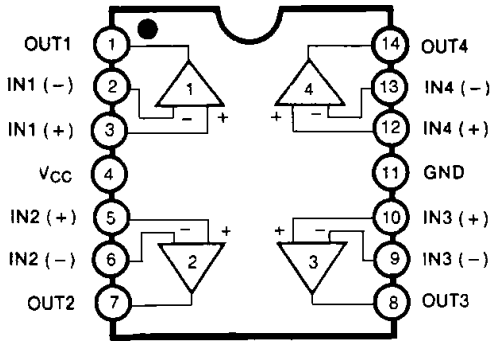
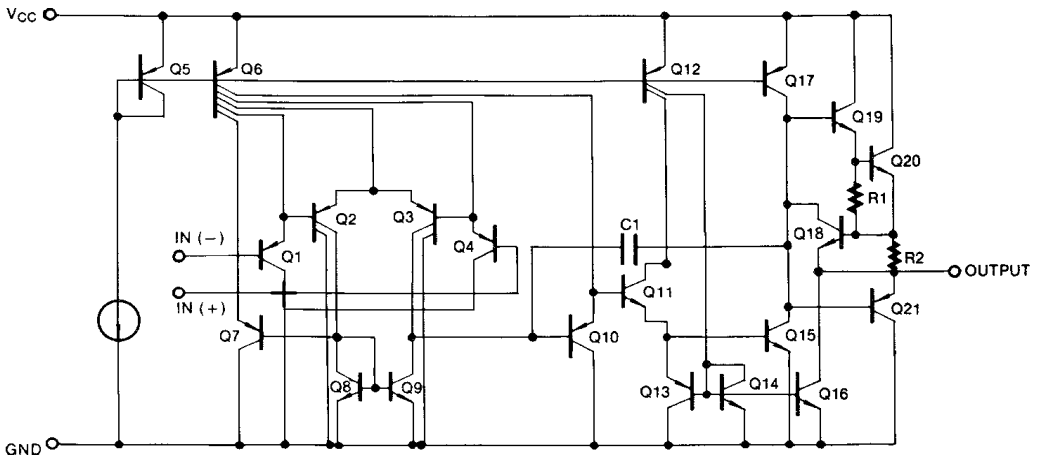
### Internal Block Diagram




Rev. 1.0.1

## Schematic Diagram

(One Section Only)




## Absolute Maximum Ratings

| Parameter | Symbol | KA224/KA224A | KA324/KA324A | KA2902 | Unit |
|---|---|---|---|---|---|
| Power Supply Voltage | $V_{CC}$ | ±16 or 32 | ±16 or 32 | ±13 or 26 | V |
| Differential Input Voltage | $V_{I(DIFF)}$ | 32 | 32 | 26 | V |
| Input Voltage | $V_I$ | -0.3 to +32 | -0.3 to +32 | -0.3 to +26 | V |
| Output Short Circuit to GND Vcc≤15V, TA=25°C(one Amp) | - | Continuous | Continuous | Continuous | - |
| Power Dissipation | $P_D$ | 570 | 570 | 570 | mW |
| Operating Temperature Range | $T_{OPR}$ | -25 ~ +85 | 0 ~ +70 | -40 ~ +85 | °C |
| Storage Temperature Range | $T_{STG}$ | -65 ~ +150 | -65 ~ +150 | -65 ~ +150 | °C |

## Electrical Characteristics

($V_{CC}$=5.0V, $V_{EE}$=GND, $T_A$=25 °C, unless otherwise specified)

| Parameter | Symbol | Conditions | KA224 | | | KA324 | | | KA2902 | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Input Offset Voltage | $V_{IO}$ | $V_{CM}$ = 0V to $V_{CC}$ -1.5V<br>$V_{O(P)}$ = 1.4V, $R_S$ = 0Ω | - | 1.5 | 5.0 | - | 1.5 | 7.0 | - | 1.5 | 7.0 | mV |
| Input Offset Current | $I_{IO}$ | - | - | 2.0 | 30 | - | 3.0 | 50 | - | 3.0 | 50 | nA |
| Input Bias Current | $I_{BIAS}$ | - | - | 40 | 150 | - | 40 | 250 | - | 40 | 250 | nA |
| Common-Mode Input Voltage Range | $V_{I(R)}$ | Note1 | 0 | - | $V_{CC}$ -1.5 | 0 | $V_{CC}$ -1.5 | - | 0 | - | $V_{CC}$ -1.5 | V |
| Supply Current | $I_{CC}$ | $R_L$ = ∞,$V_{CC}$ = 30V (all Amps) | - | 1.0 | 3 | - | 1.0 | 3 | - | 1.0 | 3 | mA |
| | | $R_L$ = ∞,$V_{CC}$ = 5V (all Amps) ($V_{CC}$ = 26V for KA2902) | - | 0.7 | 1.2 | - | 0.7 | 1.2 | - | 0.7 | 1.2 | mA |
| Large Signal Voltage Gain | $G_V$ | $V_{CC}$ = 15V, $R_L$≥2KΩ<br>$V_{O(P)}$ = 1V to 11V | 50 | 100 | - | 25 | 100 | - | - | 100 | - | V/mV |
| Output Voltage Swing | $V_{O(H)}$ | Note1, $R_L$ = 2KΩ | 26 | - | - | 26 | - | - | 22 | - | - | V |
| | | Note1, $R_L$ = 10KΩ | 27 | 28 | - | 27 | 28 | - | 23 | 24 | - | V |
| | $V_{O(L)}$ | $V_{CC}$ = 5V, $R_L$≥10KΩ | - | 5 | 20 | - | 5 | 20 | - | 5 | 100 | mV |
| Common-Mode Rejection Ratio | CMRR | - | 70 | 85 | - | 65 | 75 | - | 50 | 75 | - | dB |
| Power Supply Rejection Ratio | PSRR | - | 65 | 100 | - | 65 | 100 | - | 50 | 100 | - | dB |
| Channel Separation | CS | f = 1KHz to 20KHz | - | 120 | - | - | 120 | - | - | 120 | - | dB |
| Short Circuit to GND | $I_{SC}$ | - | - | 40 | 60 | - | 40 | 60 | - | 40 | 60 | mA |
| Output Current | $I_{SOURCE}$ | $V_{I(+)}$ = 1V, $V_{I(-)}$ = 0V<br>$V_{CC}$ = 15V, $V_{O(P)}$ = 2V | 20 | 40 | - | 20 | 40 | - | 20 | 40 | - | mA |
| | $I_{SINK}$ | $V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V, $V_{O(P)}$ = 2V | 10 | 13 | - | 10 | 13 | - | 10 | 13 | - | mA |
| | | $V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V,$V_{O(R)}$ = 200mV | 12 | 45 | - | 12 | 45 | - | - | - | - | µA |
| Differential Input Voltage | $V_{I(DIFF)}$ | - | - | - | $V_{CC}$ | - | - | $V_{CC}$ | - | - | $V_{CC}$ | V |

**Note.**

1. $V_{CC}$=30V for KA224 / KA224A , KA324 / KA324A , $V_{CC}$ = 26V for KA2902

## Electrical Characteristics

($V_{CC}$ = 5.0V, $V_{EE}$ = GND, unless otherwise specified)
The following specification apply over the range of -25 °C ≤ $T_A$ ≤ + 85 °C for the KA224; and the 0 °C ≤ $T_A$ ≤ +70 °C for the KA324 ; and the - 40°C ≤ $T_A$ ≤ +85 °C for the KA2902

| Parameter | Symbol | Conditions | KA224 | | | KA324 | | | KA2902 | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Input Offset Voltage | $V_{IO}$ | $V_{ICM}$ = 0V to $V_{CC}$ -1.5V<br>$V_{O(P)}$ = 1.4V, $R_S$ = 0Ω | - | - | 7.0 | - | - | 9.0 | - | - | 10.0 | mV |
| Input Offset Voltage Drift | $\Delta V_{IO}/\Delta T$ | - | - | 7.0 | - | - | 7.0 | - | - | 7.0 | - | μV/°C |
| Input Offset Current | $I_{IO}$ | - | - | - | 100 | - | - | 150 | - | - | 200 | nA |
| Input Offset Current Drift | $\Delta I_{IO}/\Delta T$ | - | - | 10 | - | - | 10 | - | - | 10 | - | pA/°C |
| Input Bias Current | $I_{BIAS}$ | - | - | - | 300 | - | - | 500 | - | - | 500 | nA |
| Common-Mode Input Voltage Range | $V_{I(R)}$ | Note1 | 0 | - | $V_{CC}$ -2.0 | 0 | - | $V_{CC}$ -2.0 | 0 | - | $V_{CC}$ -2.0 | V |
| Large Signal Voltage Gain | $G_V$ | $V_{CC}$ = 15V, $R_L$ ≥ 2.0KΩ<br>$V_{O(P)}$ = 1V to 11V | 25 | - | - | 15 | - | - | 15 | - | - | V/mV |
| Output Voltage Swing | $V_{O(H)}$ | Note1, $R_L$ = 2KΩ | 26 | - | - | 26 | - | - | 22 | - | - | V |
| | | Note1, $R_L$ = 10KΩ | 27 | 28 | - | 27 | 28 | - | 23 | 24 | - | V |
| | $V_{O(L)}$ | $V_{CC}$ = 5V, $R_L$≥ 10KΩ | | 5 | 20 | - | 5 | 20 | - | 5 | 100 | mV |
| Output Current | $I_{SOURCE}$ | $V_{I(+)}$ = 1V, $V_{I(-)}$ = 0V<br>$V_{CC}$ = 15V, VO(P) = 2V | 10 | 20 | - | 10 | 20 | - | 10 | 20 | - | mA |
| | $I_{SINK}$ | $V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V, $V_{O(P)}$ = 2V | 10 | 13 | - | 5 | 8 | - | 5 | 8 | - | mA |
| Differential Input Voltage | $V_{I(DIFF)}$ | - | - | - | $V_{CC}$ | - | - | $V_{CC}$ | - | - | $V_{CC}$ | V |

**Note.**
1. $V_{CC}$=30V for KA224/KA224A , KA324/KA324A , $V_{CC}$ = 26V for KA2902

## Electrical Characteristics

($V_{CC}$=5.0V, $V_{EE}$ = GND, $T_A$=25 °C, unless otherwise specified)

| Parameter | Symbol | Conditions | KA224A | | | KA324A | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Input Offset Voltage | $V_{IO}$ | $V_{CM}$ = 0V to $V_{CC}$ -1.5V<br>$V_{O(P)}$ = 1.4V, $R_S$ = 0 Ω | - | 1.0 | 3.0 | - | 1.5 | 3.0 | mV |
| Input Offset Current | $I_{IO}$ | - | - | 2 | 15 | - | 3.0 | 30 | nA |
| Input Bias Current | $I_{BIAS}$ | - | - | 40 | 80 | - | 40 | 100 | nA |
| Input Common-Mode Voltage Range | $V_{I(R)}$ | $V_{CC}$ = 30V | 0 | - | $V_{CC}$ -1.5 | 0 | - | $V_{CC}$ -1.5 | V |
| Supply Current (All Amps) | $I_{CC}$ | $V_{CC}$ = 30V | - | 1.5 | 3 | - | 1.5 | 3 | mA |
| | | $V_{CC}$ = 5V | - | 0.7 | 1.2 | - | 0.7 | 1.2 | mA |
| Large Signal Voltage Gain | $G_V$ | $V_{CC}$ = 15V, $R_L$≥ 2 KΩ<br>$V_{O(P)}$ = 1V to 11V | 50 | 100 | - | 25 | 100 | - | V/mV |
| Output Voltage Swing | $V_{O(H)}$ | Note1, $R_L$ = 2 KΩ | 26 | - | - | 26 | - | - | V |
| | | Note1, $R_L$ = 10 KΩ | 27 | 28 | - | 27 | 28 | - | V |
| | $V_{O(L)}$ | $V_{CC}$ = 5V, $R_L$≥ 10 KΩ | - | 5 | 20 | - | 5 | 20 | mV |
| Common-Mode Rejection Ratio | CMRR | - | 70 | 85 | - | 65 | 85 | - | dB |
| Power Supply Rejection Ratio | PSRR | - | 65 | 100 | - | 65 | 100 | - | dB |
| Channel Separation | CS | f = 1KHz to 20KHz | - | 120 | - | - | 120 | - | dB |
| Short Circuit to GND | $I_{SC}$ | - | - | 40 | 60 | - | 40 | 60 | mA |
| Output Current | $I_{SOURCE}$ | $V_{I(+)}$ = 1V, $V_{I(-)}$ = 0V<br>$V_{CC}$ = 15V | 20 | 40 | - | 20 | 40 | - | mA |
| | $I_{SINK}$ | $V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V, $V_{O(P)}$ = 2V | 10 | 20 | - | 10 | 20 | - | mA |
| | | $V_{I(+)}$ = 0v, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V, $V_{O(P)}$ = 200mV | 12 | 50 | - | 12 | 50 | - | µA |
| Differential Input Voltage | $V_{I(DIFF)}$ | - | - | - | $V_{CC}$ | - | - | $V_{CC}$ | V |

**Note.**

1. $V_{CC}$=30V for KA224 / KA224A , KA324 / KA324A

## Electrical Characteristics

($V_{CC}$ = 5.0V, $V_{EE}$ = GND, unless otherwise specified)
The following specification apply over the range of -25°C ≤ $T_A$ ≤ + 85 °C for the KA224A; and the 0 °C ≤ $T_A$ ≤ +70 °C for the KA324A

| Parameter | Symbol | Conditions | KA224A | | | KA324A | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Input Offset Voltage | $V_{IO}$ | $V_{CM}$ = 0V to $V_{CC}$ -1.5V<br>$V_{O(P)}$ = 1.4V, $R_S$ = 0Ω | - | - | 4.0 | - | - | 5.0 | mV |
| Input Offset Voltage Drift | $\Delta V_{IO}/\Delta T$ | - | - | 7.0 | 20 | - | 7.0 | 30 | μV/ °C |
| Input Offset Current | $I_{IO}$ | - | - | - | 30 | - | - | 75 | nA |
| Input Offset Current Drift | $\Delta I_{IO}/\Delta T$ | - | - | 10 | 200 | - | 10 | 300 | pA/ °C |
| Input Bias Current | $I_{BIAS}$ | - | - | 40 | 100 | - | 40 | 200 | nA |
| Common-Mode Input Voltage Range | $V_{I(R)}$ | $V_{CC}$ = 30V | 0 | - | $V_{CC}$ -2.0 | 0 | - | $V_{CC}$ -2.0 | V |
| Large Signal Voltage Gain | $G_V$ | $V_{CC}$ = 15V, $R_L$≥ 2.0KΩ | 25 | - | - | 15 | - | - | V/mV |
| Output Voltage Swing | $V_{O(H)}$ | $V_{CC}$ = 30V, $R_L$ = 2KΩ | 26 | - | - | 26 | - | - | V |
| | | $V_{CC}$ = 30V, $R_L$ = 10KΩ | 27 | 28 | - | 27 | 28 | - | |
| | $V_{O(L)}$ | $V_{CC}$ = 5V, $R_L$≥ 10KΩ | - | 5 | 20 | - | 5 | 20 | mA |
| Output Current | $I_{SOURCE}$ | $V_{I(+)}$ = 1V, $V_{I(-)}$ = 0V<br>$V_{CC}$ = 15V | 10 | 20 | - | 10 | 20 | - | mA |
| | $I_{SINK}$ | $V_{I(+)}$ = 0V, $V_{I(-)}$ = 1V<br>$V_{CC}$ = 15V | 5 | 8 | - | 5 | 8 | - | mA |
| Differential Input Voltage | $V_{I(DIFF)}$ | - | - | - | $V_{CC}$ | - | - | $V_{CC}$ | V |

# Typical Performance Characteristics

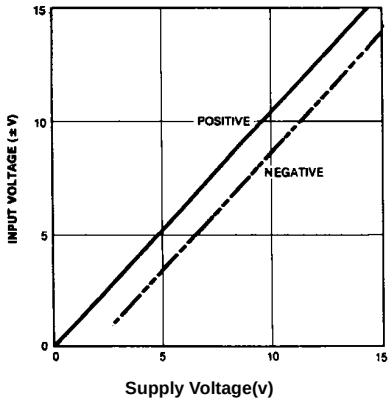



**Figure 1. Input Voltage Range vs Supply Voltage**

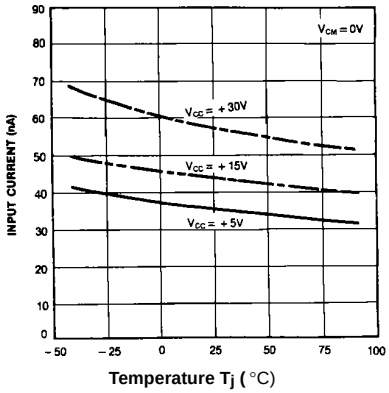



**Figure 2. Input Current vs Temperature**

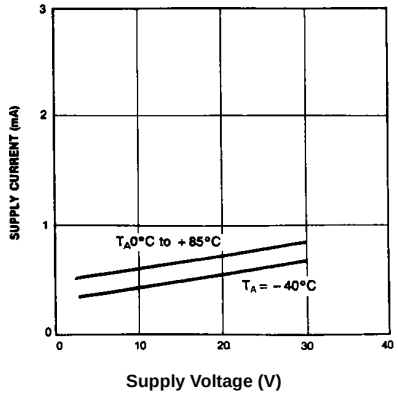



**Figure 3. Supply Current vs Supply Voltage**

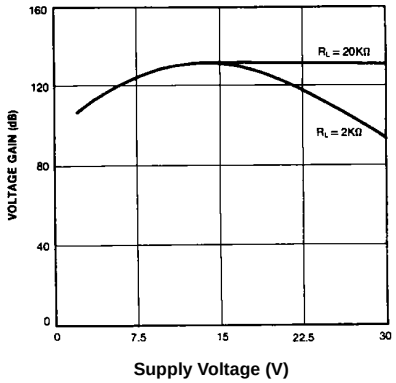



**Figure 4. Voltage Gain vs Supply Voltage**

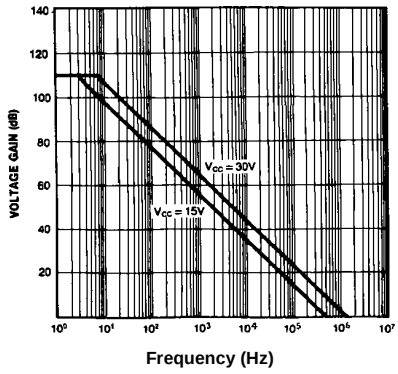



**Figure 5. Open Loop Frequency Response**

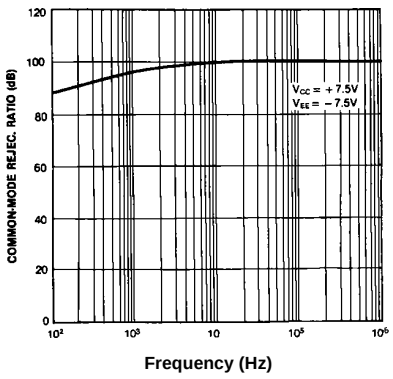



**Figure 6. Common mode Rejection Ratio**

## Typical Performance Characteristics (continued)

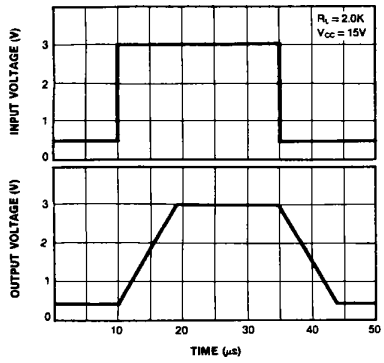



Figure 7. Slew Rate

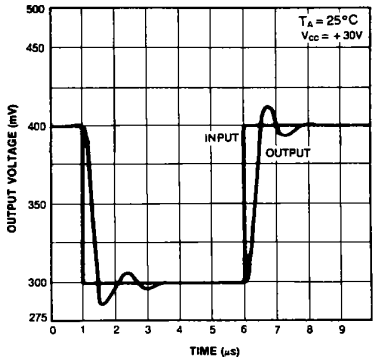



Figure 8. Voltage Follower Pulse Response

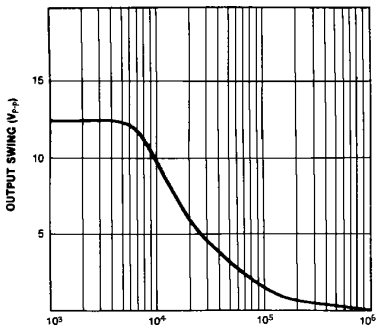



Figure 9. Large Signal Frequency Response

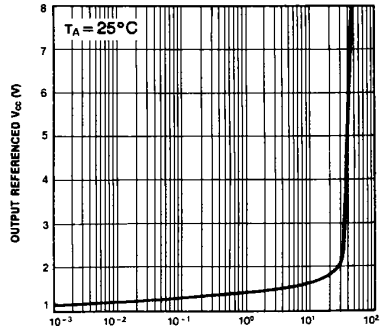



Figure 10. Output Characteristics vs Current Sourcing

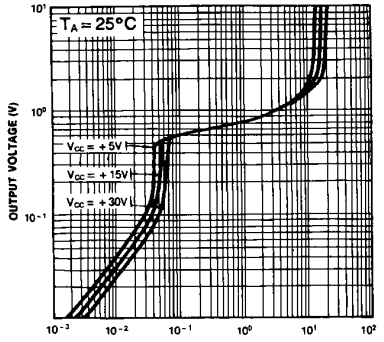



Figure 11. Output Characteristics vs Current Sinking

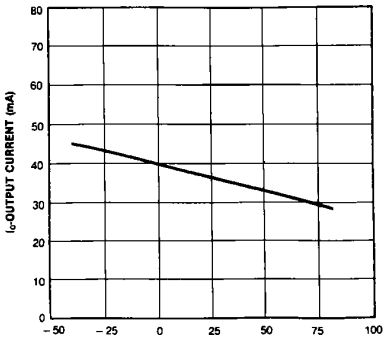
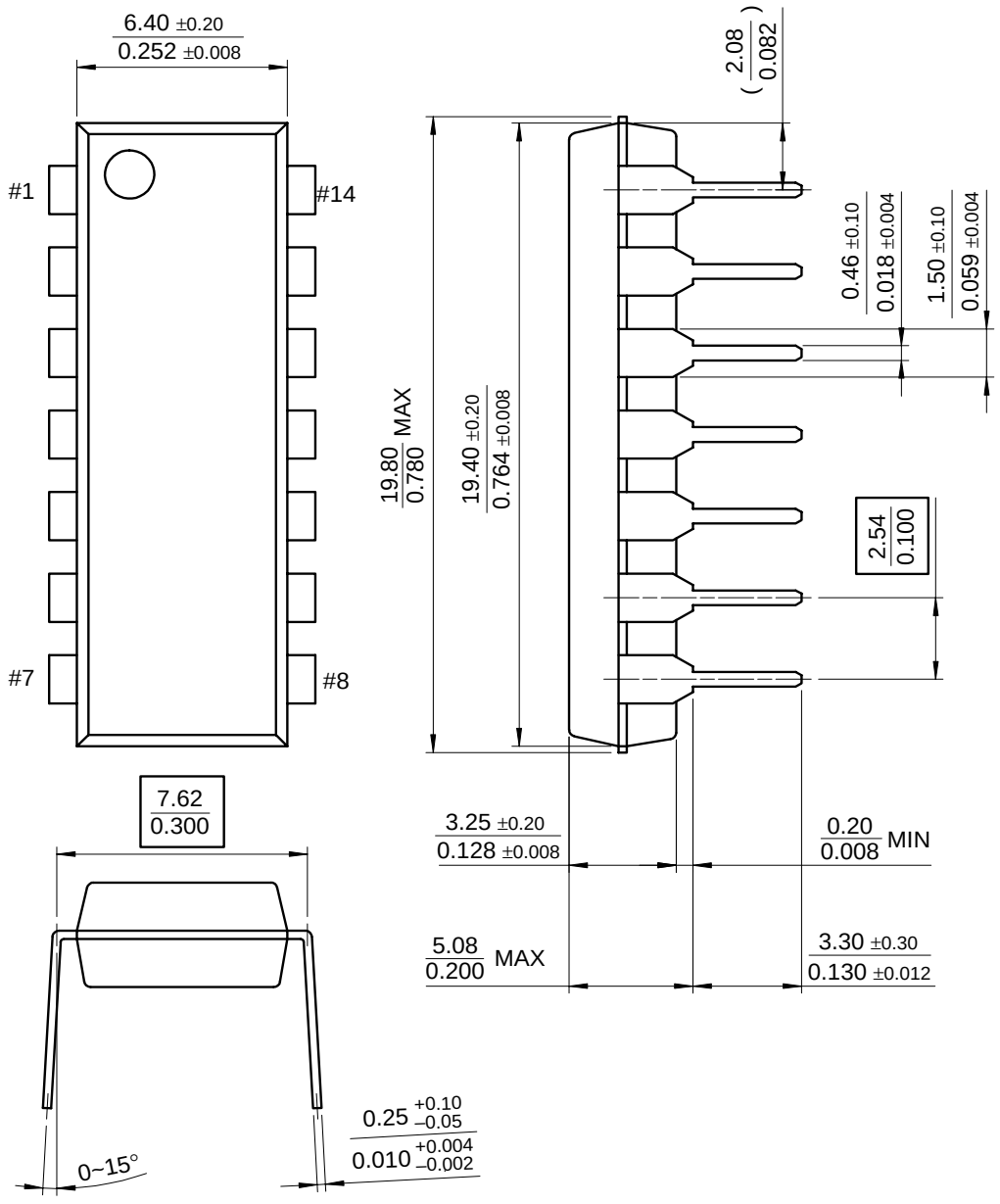



Figure 12. Current Limiting vs Temperature

## Mechanical Dimensions

### Package

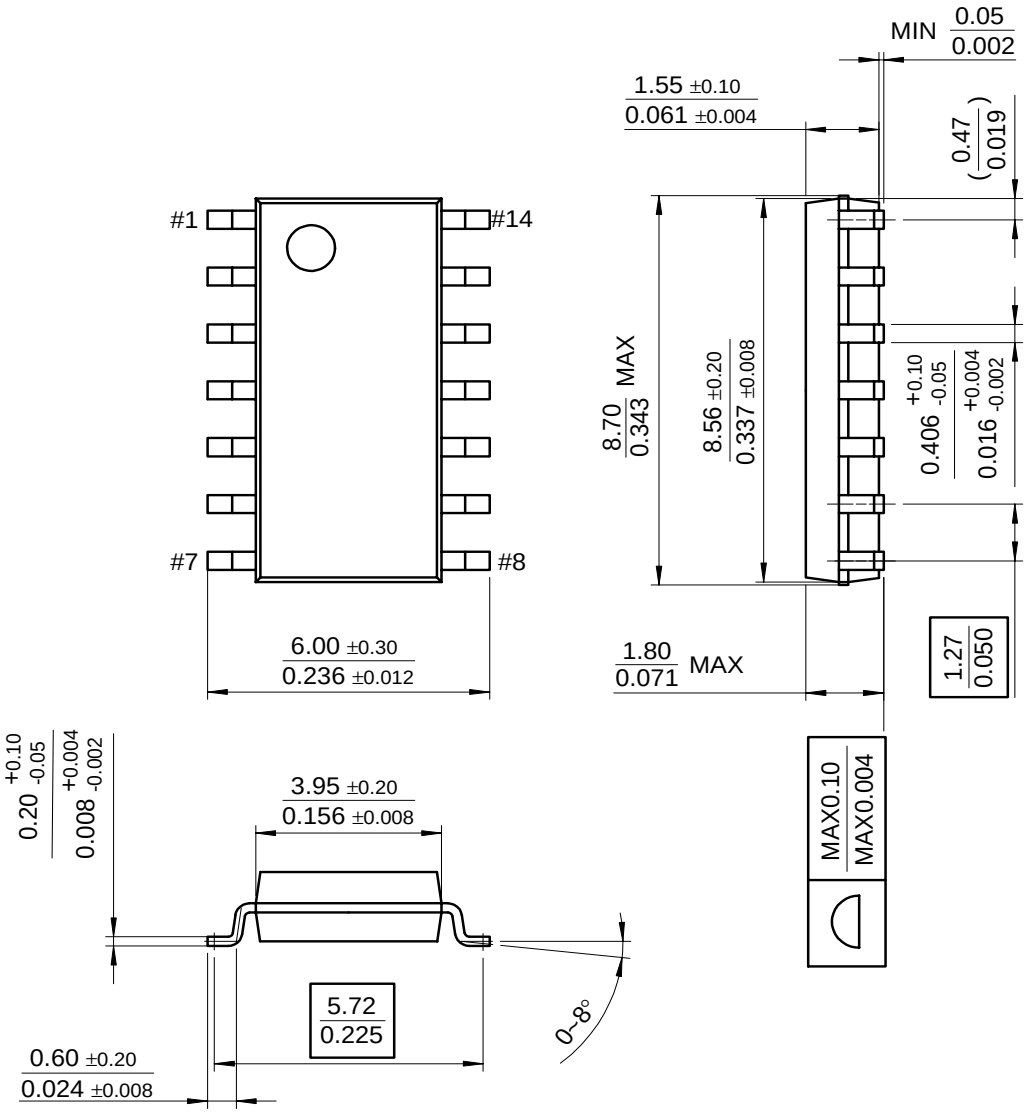
# 14-DIP



## Mechanical Dimensions (Continued)

### Package

# 14-SOP



## Ordering Information

| Product Number | Package | Operating Temperature |
|---|---|---|
| KA324 | 14-DIP | 0 ~ + 70 °C |
| KA324A | | |
| KA324D | 14-SOP | |
| KA324AD | | |
| KA224 | 14-DIP | -25 ~ +85 °C |
| KA224A | | |
| KA224D | 14-SOP | |
| KA224AD | | |
| KA2902 | 14-DIP | -40 ~ + 85 °C |
| KA2902D | 14-SOP | |

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