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November 2014

# KA324 / KA324A / KA2902
# Quad Operational Amplifier

## Features

- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100 dB
- Wide Power Supply Range:
  KA324 / KA324A: 3 V ~ 32 V (or ±1.5 V ~ 16 V)
  KA2902: 3 V ~ 26 V (or ±1.5 V ~ 13 V)
- Input Common Mode Voltage Range Includes Ground
- Large Output Voltage Swing: 0 V to $V_{CC}$ -1.5 V
- 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 V to 32 V. 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**


**14-SOP**


## Ordering Information

| Part Number | Operating Temperature Range | Top Mark | Package | Packing Method |
|---|---|---|---|---|
| KA324 | 0 to +70°C | KA324 | MDIP 14L | Rail |
| KA324A | | KA324A | MDIP 14L | Rail |
| KA324DTF | | KA324D | SOP 14L | Tape and Reel |
| KA324ADTF | | KA324AD | SOP 14L | Tape and Reel |
| KA2902DTF | -40 to +85°C | KA2902D | SOP 14L | Tape and Reel |

## Block Diagram

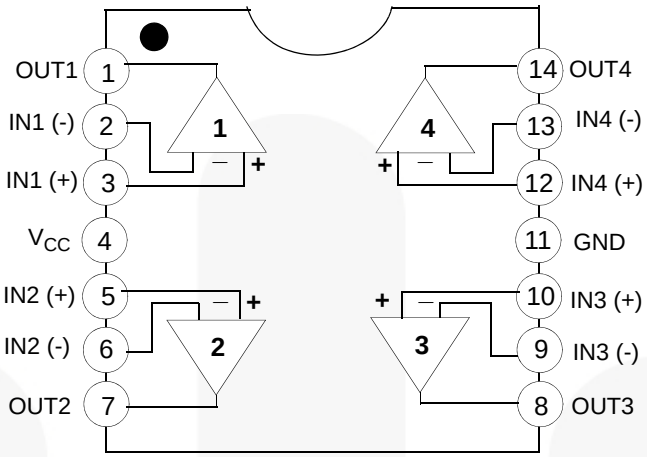



**Figure 1. Block Diagram**

## Schematic Diagram

(One Section Only)

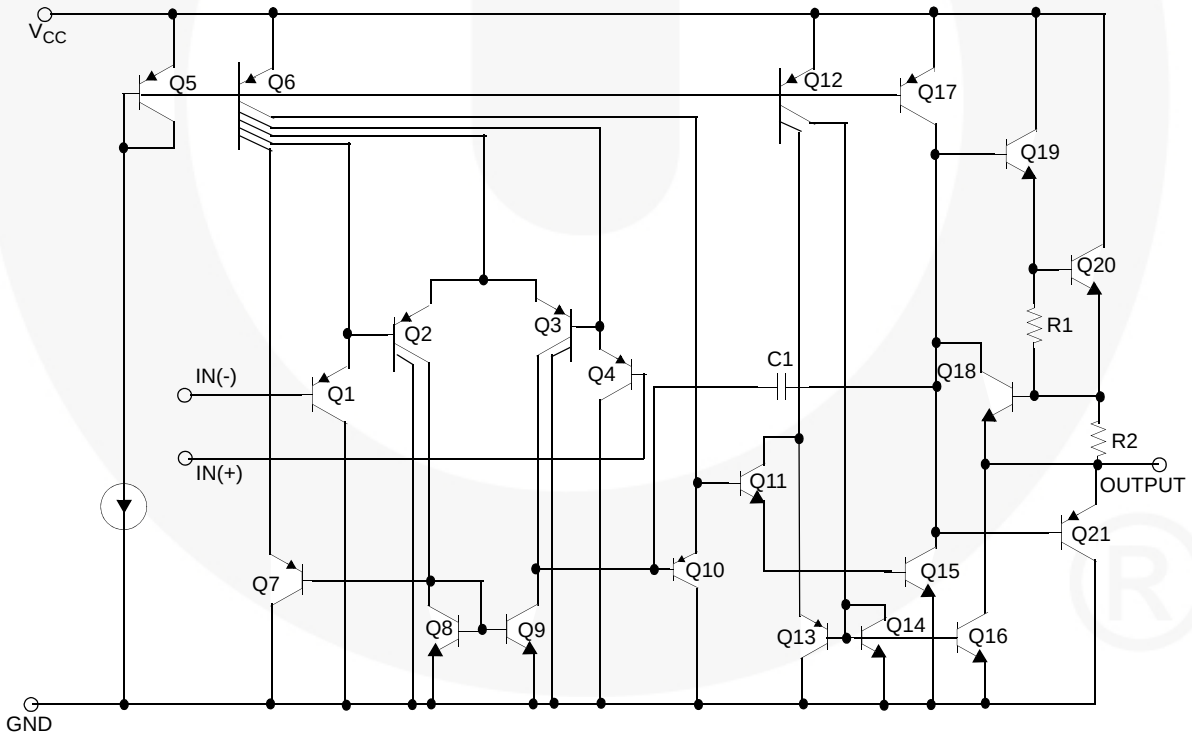



**Figure 2. Schematic Diagram**

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at $T_A$ = 25°C unless otherwise noted.

| Parameter | Symbol | KA324 / KA324A | KA2902 | Unit |
|---|---|---|---|---|
| Power Supply Voltage | $V_{CC}$ | ±16 or 32 | ±13 or 26 | V |
| Differential Input Voltage | $V_{I(DIFF)}$ | 32 | 26 | V |
| Input Voltage | $V_I$ | -0.3 to +32 | -0.3 to +26 | V |
| Output Short Circuit to GND<br>$V_{CC} \leq$ 15 V, $T_A$ = 25 ℃ (One Amp) | - | Continuous | Continuous | - |
| Operating Temperature Range | $T_{OPR}$ | 0 to +70 | -40 to +85 | °C |
| Storage Temperature Range | $T_{STG}$ | -65 to +150 | -65 to +150 | °C |

## Thermal Characteristics

Values are at $T_A$ = 25°C unless otherwise noted.

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $P_D$ | Power Dissipation, $T_A$ = 25 ℃ | **14-DIP** | 1310 | mW |
| | | **14-SOP** | 640 | |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient, Max. | **14-DIP** | 95 | °C/W |
| | | **14-SOP** | 195 | |

## Electrical Characteristics

Values are at $V_{CC}$ = 5.0 V, $V_{EE}$ = GND, $T_A$ = 25 ℃, unless otherwise specified.

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

**Notes:**

1. $V_{CC}$ = 30 V for KA324, $V_{CC}$ = 26 V for KA2902.
2. This parameter, although guaranteed is not 100% tested in production.

## Electrical Characteristics (Continued)

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

| Symbol | Parameter | Conditions | KA324 | | | KA2902 | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| $V_{IO}$ | Input Offset Voltage | $V_{ICM}$ = 0 V to $V_{CC}$ -1.5 V, $V_{O(P)}$ = 1.4 V, $R_S$ = 0 Ω (3) | - | - | 9.0 | - | - | 10.0 | mV |
| $\Delta V_{IO}/\Delta T$ | Input Offset Voltage Drift | $R_S$ = 0 Ω (4) | - | 7.0 | - | - | 7.0 | - | μV/ °C |
| $I_{IO}$ | Input Offset Current | $V_{CM}$ = 0 V | - | - | 150 | - | - | 200 | nA |
| $\Delta I_{IO}/\Delta T$ | Input Offset Current Drift | $R_S$ = 0 Ω (4) | - | 10 | - | - | 10 | - | pA/ °C |
| $I_{BIAS}$ | Input Bias Current | $V_{CM}$ = 0 V | - | - | 500 | - | - | 500 | nA |
| $V_{I(R)}$ | Input Common Mode Voltage Range | (3) | 0 | - | $V_{CC}$ -2.0 | 0 | - | $V_{CC}$ -2.0 | V |
| $G_V$ | Large Signal Voltage Gain | $V_{CC}$ = 15 V, $R_L$ = 2.0 kΩ, $V_{O(P)}$ = 1 V to 11 V | 15 | - | - | 15 | - | - | V/mV |
| $V_{O(H)}$ | Output Voltage Swing | (3) $R_L$ = 2 kΩ | 26 | - | - | 22 | - | - | V |
| | | $R_L$ = 10 kΩ | 27 | 28 | - | 23 | 24 | - | V |
| $V_{O(L)}$ | | $V_{CC}$ = 5 V, $R_L$= 10 kΩ | - | 5 | 20 | - | 5 | 100 | mV |
| $I_{SOURCE}$ | Output Current | $V_{I(+)}$ = 1 V, $V_{I(-)}$ = 0 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 10 | 20 | - | 10 | 20 | - | mA |
| $I_{SINK}$ | | $V_{I(+)}$ = 0 V, $V_{I(-)}$ = 1 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 5 | 8 | - | 5 | 8 | - | mA |
| $V_{I(DIFF)}$ | Differential Input Voltage | - | - | - | $V_{CC}$ | - | - | $V_{CC}$ | V |

**Notes:**

3. $V_{CC}$ = 30 V for KA324, $V_{CC}$ = 26 V for KA2902.
4. These parameters, although guaranteed are not 100% tested in production.

## Electrical Characteristics (Continued)

Values are at $V_{CC}$ = 5.0 V, $V_{EE}$ = GND, $T_A$ = 25 ℃, unless otherwise specified.

| Symbol | Parameter | Conditions | KA324A | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $V_{IO}$ | Input Offset Voltage | $V_{CM}$ = 0 V to $V_{CC}$ -1.5 V, $V_{O(P)}$ = 1.4 V, $R_S$ = 0 Ω(5) | - | 1.5 | 3.0 | mV |
| $I_{IO}$ | Input Offset Current | $V_{CM}$ = 0 V | - | 3 | 30 | nA |
| $I_{BIAS}$ | Input Bias Current | $V_{CM}$ = 0 V | - | 40 | 100 | nA |
| $V_{I(R)}$ | Input Common-Mode Voltage Range | (5) | 0 | - | $V_{CC}$ -1.5 | V |
| $I_{CC}$ | Supply Current | $V_{CC}$ = 30 V, $R_L$ = ∞ | - | 1.5 | 3.0 | mA |
| | | $V_{CC}$ = 5 V, $R_L$ = ∞ | - | 0.7 | 1.2 | mA |
| $G_V$ | Large Signal Voltage Gain | $V_{CC}$ = 15 V, $R_L$= 2 kΩ, $V_{O(P)}$ = 1 V to 11 V | 25 | 100 | - | V/mV |
| $V_{O(H)}$ | Output Voltage Swing | (5) $R_L$ = 2 kΩ | 26 | - | - | V |
| | | (5) $R_L$ = 10 kΩ | 27 | 28 | - | V |
| $V_{O(L)}$ | | $V_{CC}$ = 5 V, $R_L$= 10 kΩ | - | 5 | 20 | mV |
| CMRR | Common-Mode Rejection Ratio | - | 65 | 85 | - | dB |
| PSRR | Power Supply Rejection Ratio | - | 65 | 100 | - | dB |
| CS | Channel Separation | f = 1 kHz to 20 kHz(6) | - | 120 | - | dB |
| $I_{SC}$ | Short Circuit to GND | $V_{CC}$ = 15 V | - | 40 | 60 | mA |
| $I_{SOURCE}$ | Output Current | $V_{I(+)}$ = 1 V, $V_{I(-)}$ = 0 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 20 | 40 | - | mA |
| $I_{SINK}$ | | $V_{I(+)}$ = 0 V, $V_{I(-)}$ = 1 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 10 | 20 | - | mA |
| | | $V_{I(+)}$ = 0 V, $V_{I(-)}$ = 1 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 200 mV | 12 | 50 | - | µA |
| $V_{I(DIFF)}$ | Differential Input Voltage | - | - | - | $V_{CC}$ | V |

**Notes:**

5. $V_{CC}$=30V for KA324A.
6. This parameter, although guaranteed is not 100% tested in production.

## Electrical Characteristics (Continued)

Values are at $V_{CC}$ = 5.0 V, $V_{EE}$ = GND, unless otherwise specified.
The following specification apply over the range of 0°C ≤ $T_A$ ≤ +70°C for the KA324A.

| Symbol | Parameter | Conditions | KA324A | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $V_{IO}$ | Input Offset Voltage | $V_{CM}$ = 0 V to $V_{CC}$ -1.5 V, $V_{O(P)}$ = 1.4V, $R_S$ = 0Ω[7] | - | - | 5.0 | mV |
| $\Delta V_{IO}/\Delta T$ | Input Offset Voltage Drift | $R_S$ = 0 Ω [8] | - | 7 | 30 | µV/°C |
| $I_{IO}$ | Input Offset Current | $V_{CM}$ = 0 V | - | - | 75 | nA |
| $\Delta I_{IO}/\Delta T$ | Input Offset Current Drift | $R_S$ = 0 Ω [8] | - | 10 | 300 | pA/°C |
| $I_{BIAS}$ | Input Bias Current | $V_{CM}$ = 0 V | - | 40 | 200 | nA |
| $V_{I(R)}$ | Input Common-Mode Voltage Range | [7] | 0 | - | $V_{CC}$ -2.0 | V |
| $G_V$ | Large Signal Voltage Gain | $V_{CC}$ = 15 V, $R_L$= 2.0 kΩ | 15 | - | - | V/mV |
| $V_{O(H)}$ | Output Voltage Swing | [7] $R_L$ = 2 kΩ | 26 | - | - | V |
| | | [7] $R_L$ = 10 kΩ | 27 | 28 | - | V |
| $V_{O(L)}$ | | $V_{CC}$ = 5 V, $R_L$= 10 kΩ | - | 5 | 20 | mV |
| $I_{SOURCE}$ | Output Current | $V_{I(+)}$ = 1 V, $V_{I(-)}$ = 0 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 10 | 20 | - | mV |
| $I_{SINK}$ | | $V_{I(+)}$ = 0 V, $V_{I(-)}$ = 1 V, $V_{CC}$ = 15 V, $V_{O(P)}$ = 2 V | 5 | 8 | - | mA |
| $V_{I(DIFF)}$ | Differential Input Voltage | - | - | - | $V_{CC}$ | V |

**Notes:**

7. $V_{CC}$=30V for KA324A.
8. This parameter, although guaranteed is not 100% tested in production.

## Typical Performance Characteristics

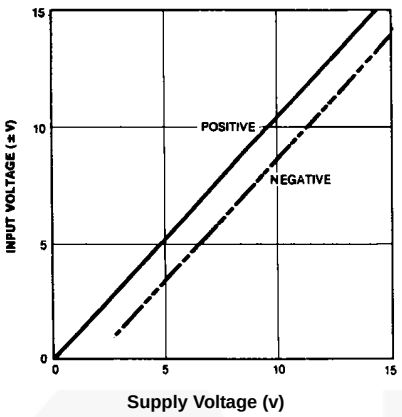



**Figure 3. Input Voltage Range vs. Supply Voltage**

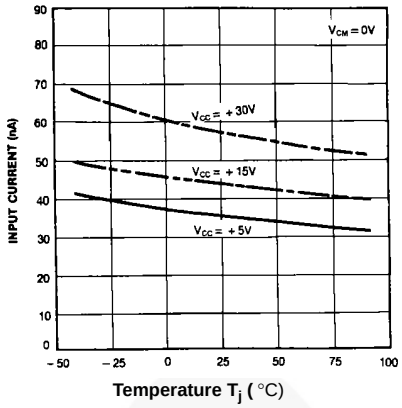



**Figure 4. Input Current vs. Temperature**

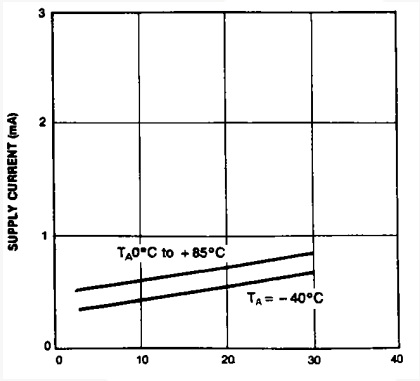



**Figure 5. Supply Current vs. Supply Voltage**

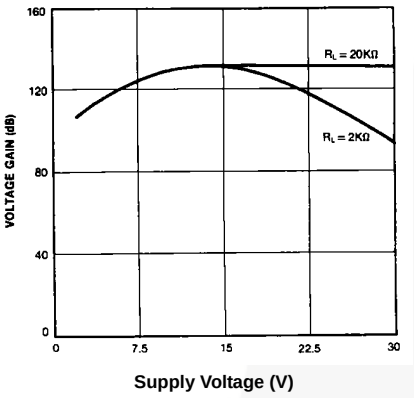



**Figure 6. Voltage Gain vs. Supply Voltage**

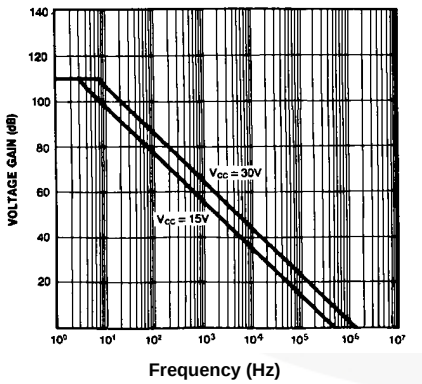



**Figure 7. Open Loop Frequency Response**

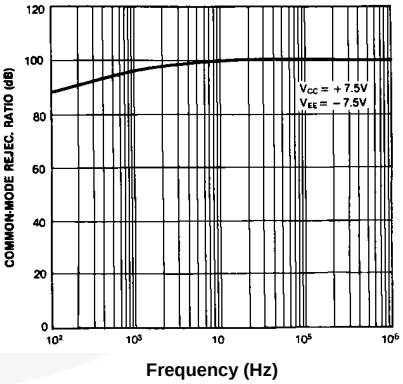



**Figure 8. Common Mode Rejection Ratio**

## Typical Performance Characteristics (Continued)

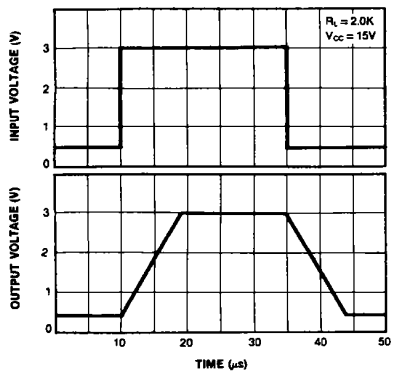



**Figure 9. Voltage Follower Pulse Response**

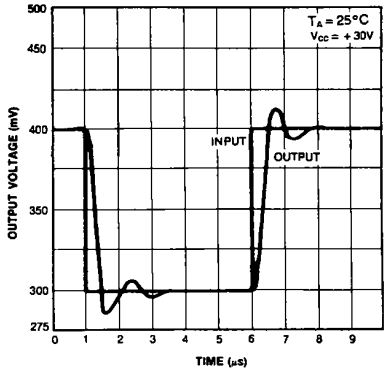



**Figure 10. Voltage Follower Pulse Response (Small Signal)**

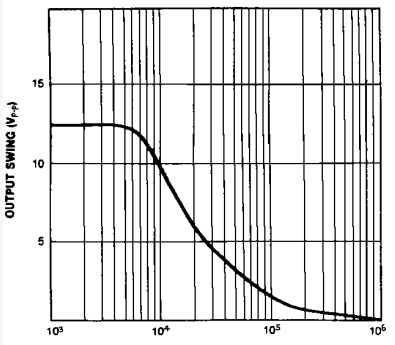



**Figure 11. Large Signal Frequency Response**

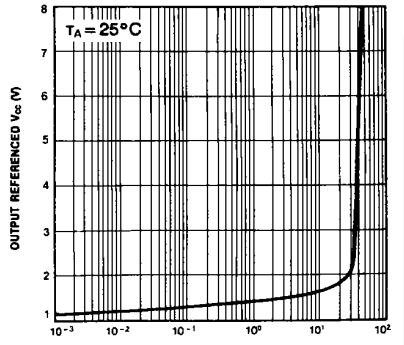



**Figure 12. Output Characteristics vs. Current Sourcing**

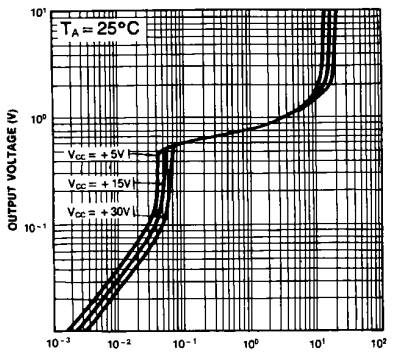



**Figure 13. Output Characteristics vs. Current Sinking**

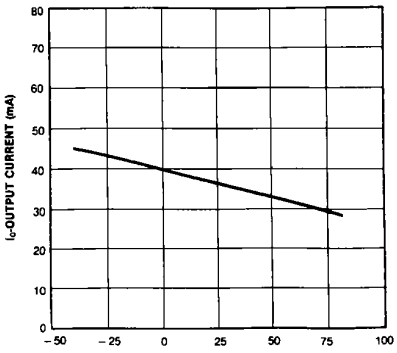
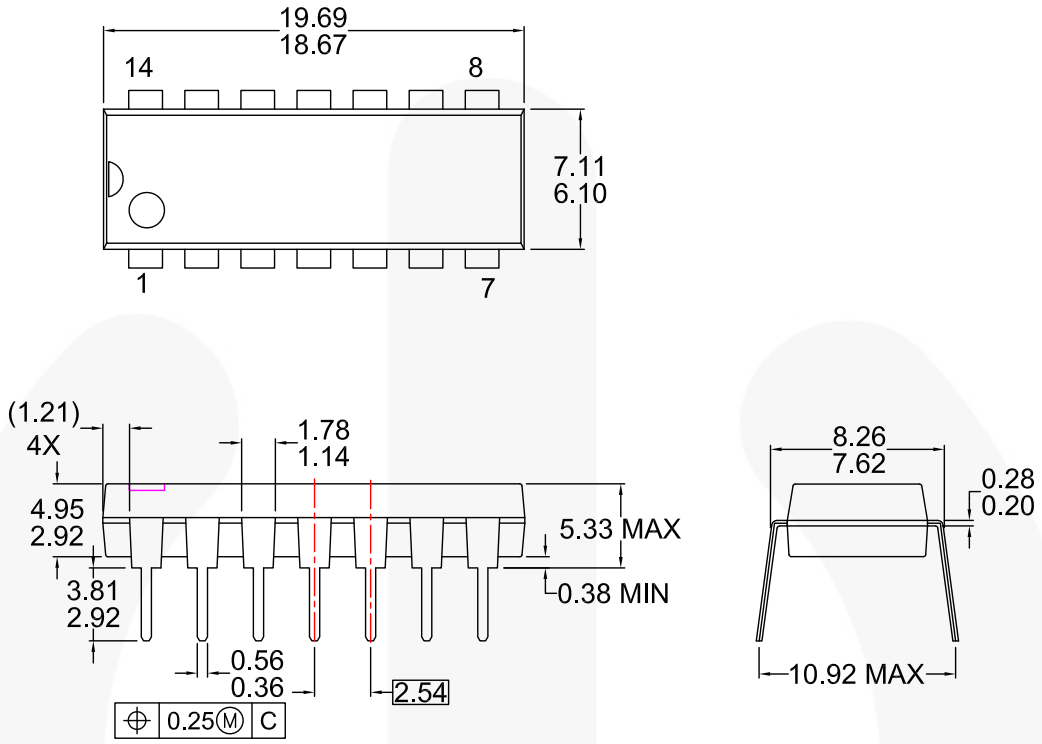



**Figure 14. Current Limiting vs. Temperature**

## Physical Dimensions




NOTES: UNLESS OTHERWISE SPECIFIED

THIS PACKAGE CONFORMS TO

A) JEDEC MS-001 VARIATION AA

B) ALL DIMENSIONS ARE IN MILLIMETERS.

DIMENSIONS ARE EXCLUSIVE OF BURRS,

C) MOLD FLASH, AND TIE BAR EXTRUSIONS.

D) DIMENSIONS AND TOLERANCES PER ASME Y14.5-1994

E) DRAWING FILE NAME: MKT-N14AREV8

**Figure 15. 14-LEAD, MDIP, JEDEC MS-001, .300 INCH WIDE**

## Physical Dimensions

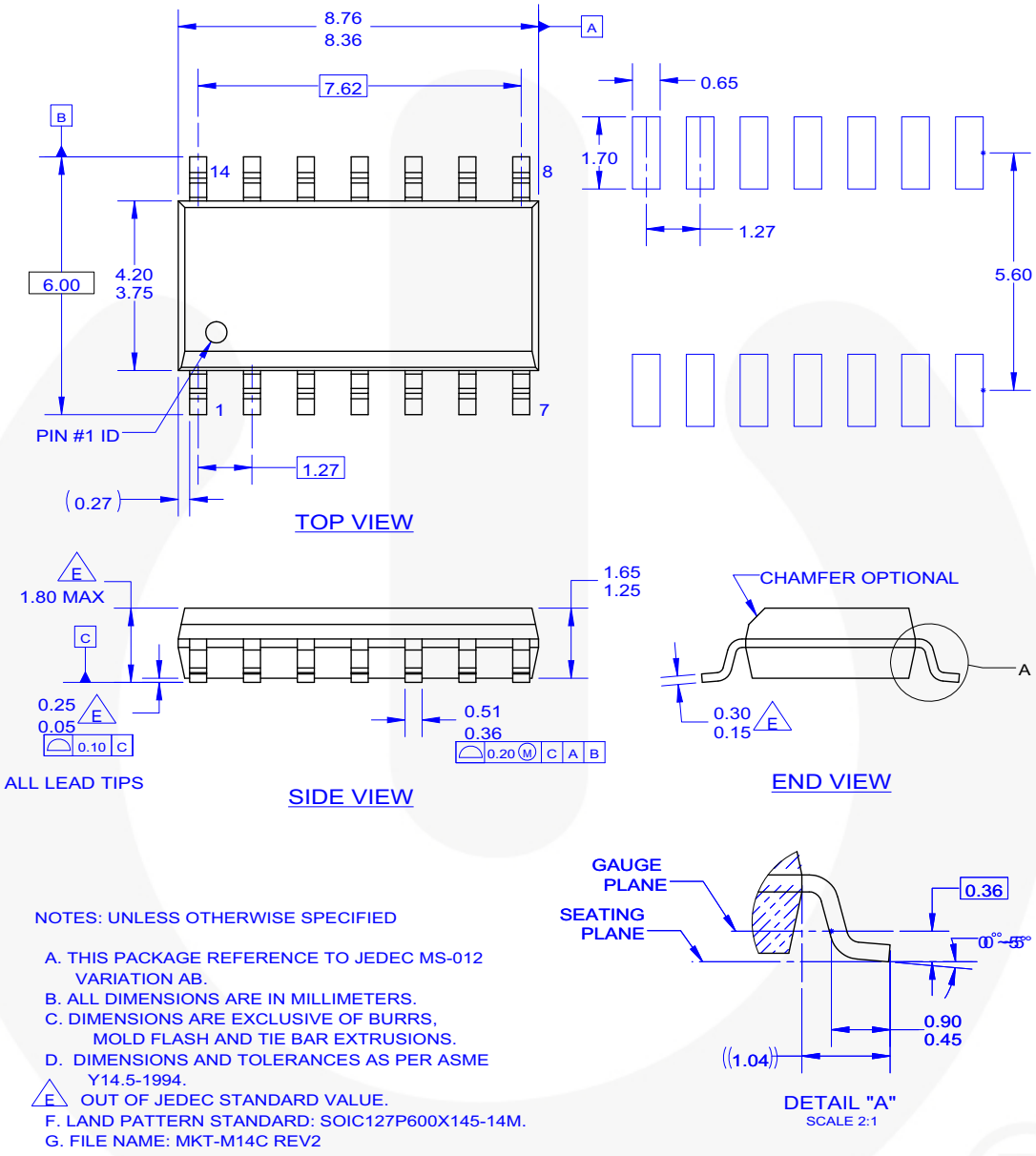



**Figure 16. 14-Lead, SOIC, NON-JEDEC, .150 INCH NARROW BODY, 225SOP**

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TinyCalc™
TinyLogic®
TINYOPTO™
TinyPower™
TinyPWM™
TinyWire™
TranSiC™
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TRUECURRENT®*
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SerDes™
UHC®
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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## ANTI-COUNTERFEITING POLICY

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Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

## PRODUCT STATUS DEFINITIONS

**Definition of Terms**

| Datasheet Identification | Product Status | Definition |
|---|---|---|
| Advance Information | Formative / In Design | Datasheet contains the design specifications for product development. Specifications may change in any manner without notice. |
| Preliminary | First Production | Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design. |
| No Identification Needed | Full Production | Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design. |
| Obsolete | Not In Production | Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only. |

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