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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  $\pm 1.5$  V ~ 16 V)  
KA2902: 3 V ~ 26 V (or  $\pm 1.5$  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

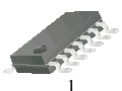
## Description

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

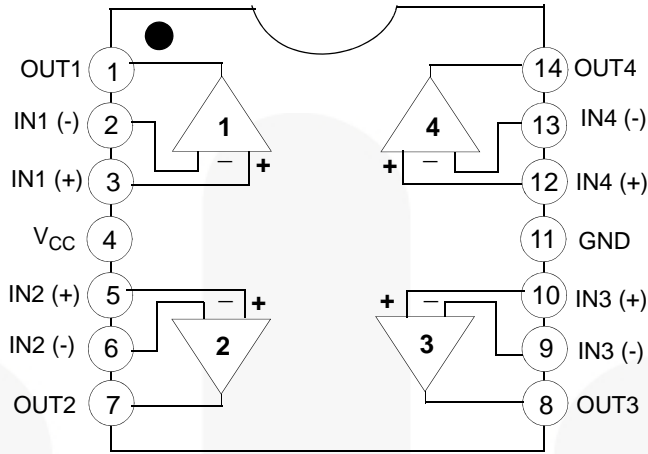


Figure 1. Block Diagram

### Schematic Diagram

(One Section Only)

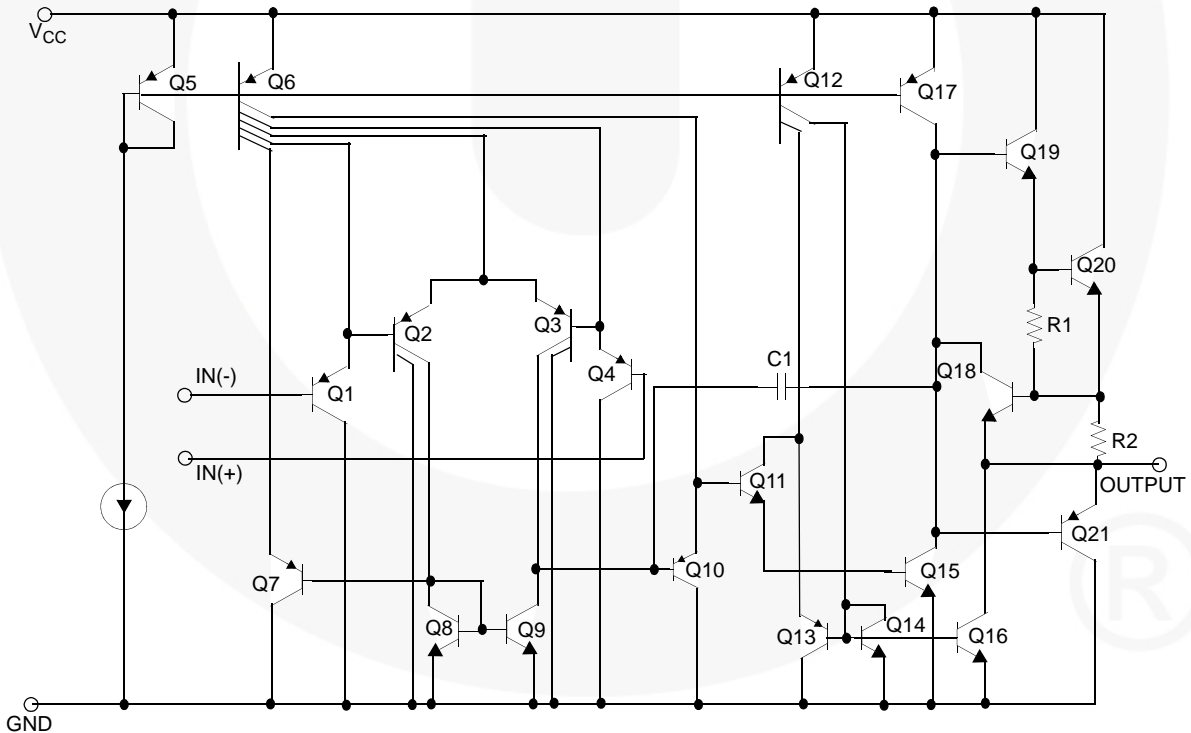


Figure 2. Schematic Diagram

## 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  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Parameter	Symbol	KA324 / KA324A	KA2902	Unit
Power Supply Voltage	$V_{CC}$	$\pm 16$ or 32	$\pm 13$ 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 $V_{CC} = 15\text{ V}, T_A = 25^\circ\text{C}$ (One Amp)	-	Continuous	Continuous	-
Operating Temperature Range	$T_{OPR}$	0 to +70	-40 to +85	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	-65 to +150	-65 to +150	$^\circ\text{C}$

## Thermal Characteristics

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

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

## Electrical Characteristics

Values are at  $V_{CC} = 5.0\text{ V}$ ,  $V_{EE} = \text{GND}$ ,  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

Symbol	Parameter	Conditions	KA324			KA2902			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{IO}$	Input Offset Voltage	$V_{CM} = 0\text{ V to }V_{CC} - 1.5\text{ V}$ , $V_{O(P)} = 1.4\text{ V}$ , $R_S = 0\text{ }\Omega^{(1)}$	-	1.5	7.0	-	1.5	7.0	mV
$I_{IO}$	Input Offset Current	$V_{CM} = 0\text{ V}$	-	3	50	-	3	50	nA
$I_{BIAS}$	Input Bias Current	$V_{CM} = 0\text{ V}$	-	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	$R_L = \infty$ , $V_{CC} = 30\text{ V}$ , (KA2902, $V_{CC} = 26\text{ V}$ )	-	1.0	3.0	-	1.0	3.0	mA
		$R_L = \infty$ , $V_{CC} = 5\text{ V}$	-	0.7	1.2	-	0.7	1.2	mA
$G_V$	Large Signal Voltage Gain	$V_{CC} = 15\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_{O(P)} = 1\text{ V to }11\text{ V}$	25	100	-	25	100	-	V/mV
$V_{O(H)}$	Output Voltage Swing	(1) $R_L = 2\text{ k}\Omega$	26	-	-	22	-	-	V
		$R_L = 10\text{ k}\Omega$	27	28	-	23	24	-	V
$V_{O(L)}$		$V_{CC} = 5\text{ V}$ , $R_L = 10\text{ k}\Omega$	-	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	$f = 1\text{ kHz to }20\text{ kHz}^{(2)}$	-	120	-	-	120	-	dB
$I_{SC}$	Short Circuit to GND	$V_{CC} = 15\text{ V}$	-	40	60	-	40	60	mA
$I_{SOURCE}$	Output Current	$V_{I(+)} = 1\text{ V}$ , $V_{I(-)} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , $V_{O(P)} = 2\text{ V}$	20	40	-	20	40	-	mA
$I_{SINK}$		$V_{I(+)} = 0\text{ V}$ , $V_{I(-)} = 1\text{ V}$ , $V_{CC} = 15\text{ V}$ , $V_{O(P)} = 2\text{ V}$	10	13	-	10	13	-	mA
		$V_{I(+)} = 0\text{ V}$ , $V_{I(-)} = 1\text{ V}$ , $V_{CC} = 15\text{ V}$ , $V_{O(R)} = 200\text{ mV}$	12	45	-	-	-	-	$\mu\text{A}$
$V_{I(DIFF)}$	Differential Input Voltage	-	-	-	$V_{CC}$	-	-	$V_{CC}$	V

### Notes:

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

**Electrical Characteristics** (Continued)

Values are at  $V_{CC} = 5.0\text{ V}$ ,  $V_{EE} = \text{GND}$ , unless otherwise specified.

The following specification apply over the range of  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  for the KA324, and the  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$  for the KA2902.

Symbol	Parameter	Conditions	KA324			KA2902			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{IO}$	Input Offset Voltage	$V_{ICM} = 0\text{ V}$ to $V_{CC} - 1.5\text{ V}$ , $V_{O(P)} = 1.4\text{ V}$ , $R_S = 0\ \Omega$ <sup>(3)</sup>	-	-	9.0	-	-	10.0	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Drift	$R_S = 0\ \Omega$ <sup>(4)</sup>	-	7.0	-	-	7.0	-	$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input Offset Current	$V_{CM} = 0\text{ V}$	-	-	150	-	-	200	nA
$\Delta I_{IO}/\Delta T$	Input Offset Current Drift	$R_S = 0\ \Omega$ <sup>(4)</sup>	-	10	-	-	10	-	$\text{pA}/^\circ\text{C}$
$I_{BIAS}$	Input Bias Current	$V_{CM} = 0\text{ V}$	-	-	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	$V_{CC} = 15\text{ V}$ , $R_L = 2.0\text{ k}\Omega$ , $V_{O(P)} = 1\text{ V}$ to $11\text{ V}$	15	-	-	15	-	-	V/mV
$V_{O(H)}$	Output Voltage Swing	(3) $R_L = 2\text{ k}\Omega$	26	-	-	22	-	-	V
$V_{O(L)}$		$R_L = 10\text{ k}\Omega$	27	28	-	23	24	-	V
$V_{O(L)}$		$V_{CC} = 5\text{ V}$ , $R_L = 10\text{ k}\Omega$	-	5	20	-	5	100	mV
$I_{SOURCE}$	Output Current	$V_{I(+)} = 1\text{ V}$ , $V_{I(-)} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , $V_{O(P)} = 2\text{ V}$	10	20	-	10	20	-	mA
$I_{SINK}$		$V_{I(+)} = 0\text{ V}$ , $V_{I(-)} = 1\text{ V}$ , $V_{CC} = 15\text{ V}$ , $V_{O(P)} = 2\text{ V}$	5	8	-	5	8	-	mA
$V_{I(DIFF)}$	Differential Input Voltage	-	-	-	$V_{CC}$	-	-	$V_{CC}$	V

**Notes:**

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

**Electrical Characteristics** (Continued)Values are at  $V_{CC} = 5.0\text{ V}$ ,  $V_{EE} = \text{GND}$ ,  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

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

**Notes:**5.  $V_{CC} = 30\text{ V}$  for KA324A.

6. This parameter, although guaranteed is not 100% tested in production.

**Electrical Characteristics** (Continued)

Values are at  $V_{CC} = 5.0\text{ V}$ ,  $V_{EE} = \text{GND}$ , unless otherwise specified.

The following specifications apply over the range of  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  for the KA324A.

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

**Notes:**

7.  $V_{CC} = 30\text{ V}$  for KA324A.

8. This parameter, although guaranteed is not 100% tested in production.



Typical Performance Characteristics

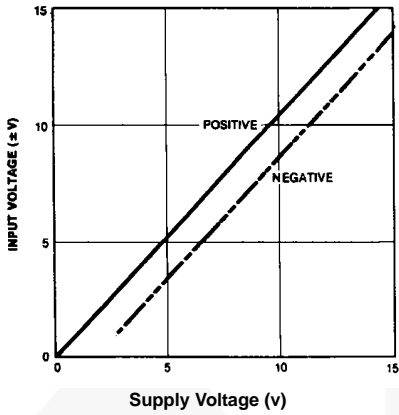


Figure 3. Input Voltage Range vs. Supply Voltage

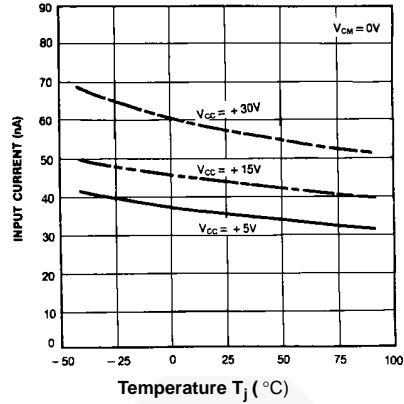


Figure 4. Input Current vs. Temperature

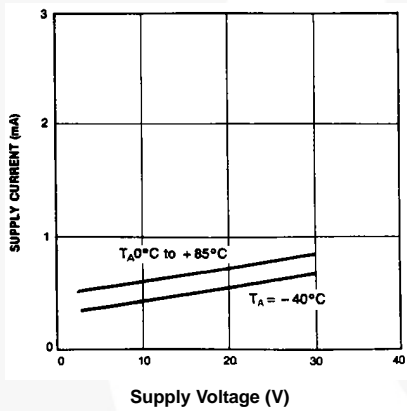


Figure 5. Supply Current vs. Supply Voltage

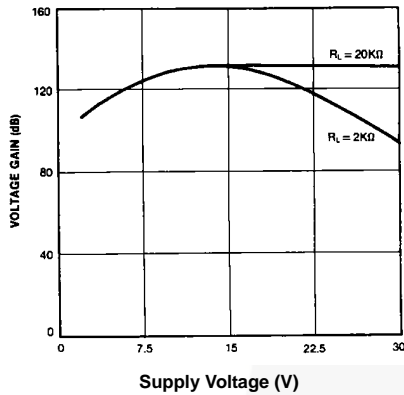


Figure 6. Voltage Gain vs. Supply Voltage

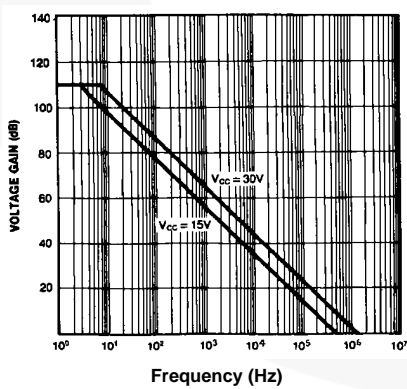


Figure 7. Open Loop Frequency Response

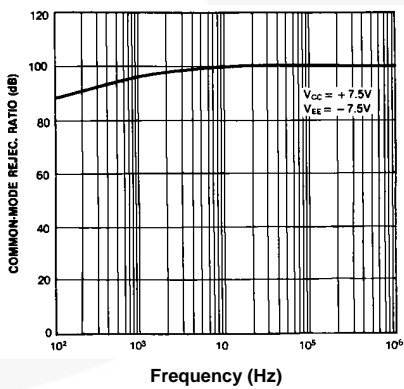


Figure 8. Common Mode Rejection Ratio

Typical Performance Characteristics (Continued)

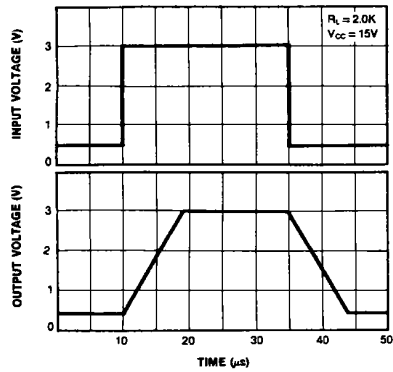


Figure 9. Voltage Follower Pulse Response

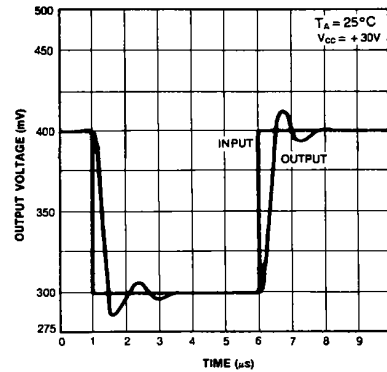


Figure 10. Voltage Follower Pulse Response (Small Signal)

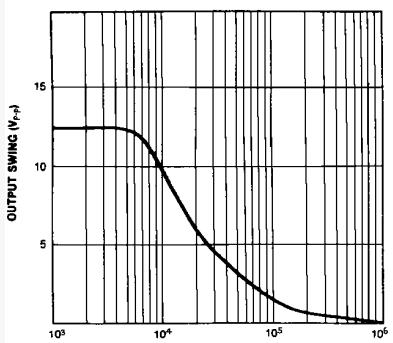


Figure 11. Large Signal Frequency Response

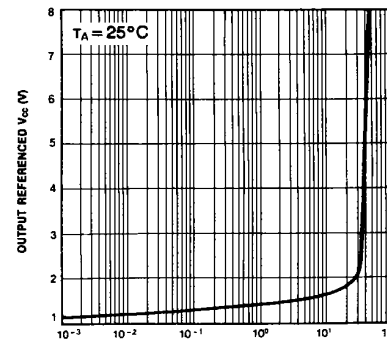


Figure 12. Output Characteristics vs. Current Sourcing

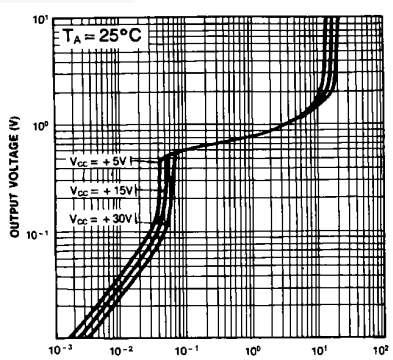


Figure 13. Output Characteristics vs. Current Sinking

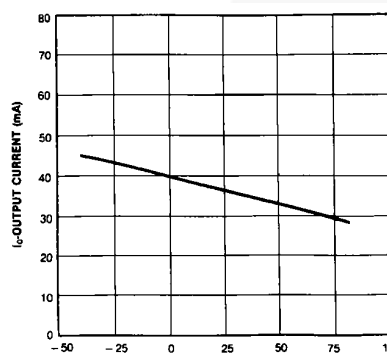
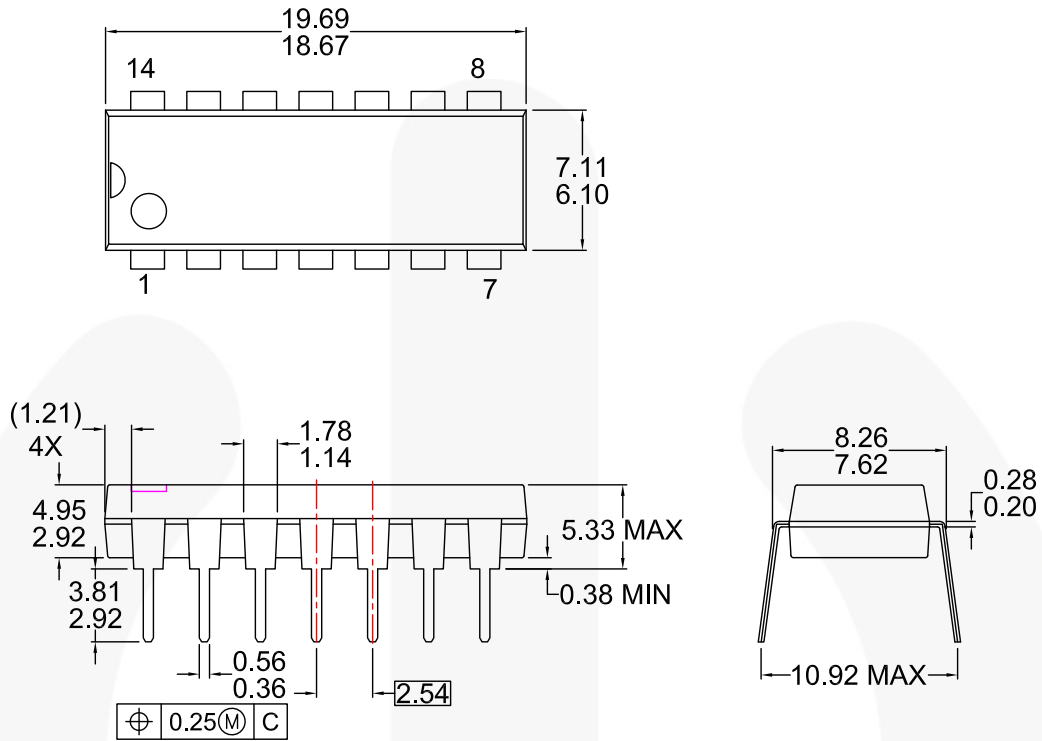


Figure 14. Current Limiting vs. Temperature

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

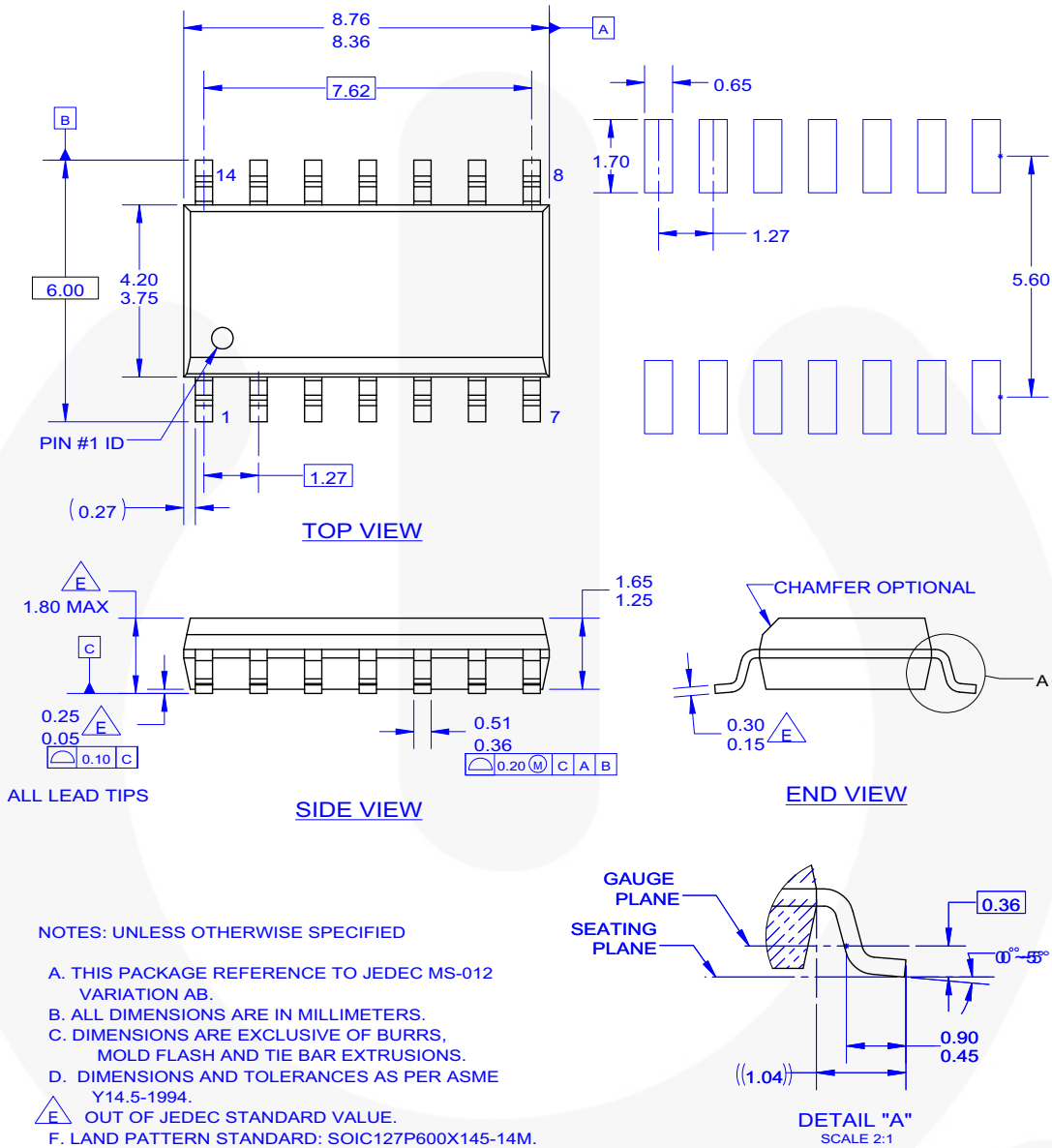


Figure 16. 14-Lead, SOIC, NON-JEDEC, .150 INCH NARROW BODY, 225SOP



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FAST®	MTi®	SuperSOT™-6	VoltagePlus™
FastvCore™	MTx®	SuperSOT™-8	XS™
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