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November 2014

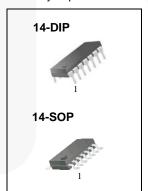
# KA324 / KA324A / KA2902 Quad Operational Amplifier

#### **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<sub>CC</sub> -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.



### **Ordering Information**

Part Number	Operating Temperature Range	Top Mark	Package	Packing Method
KA324		KA324	MDIP 14L	Rail
KA324A	0 to +70°C	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**

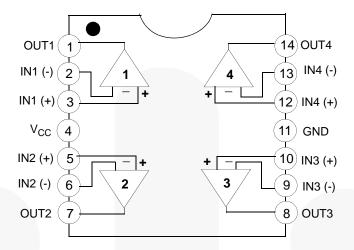


Figure 1. Block Diagram

### **Schematic Diagram**

(One Section Only)

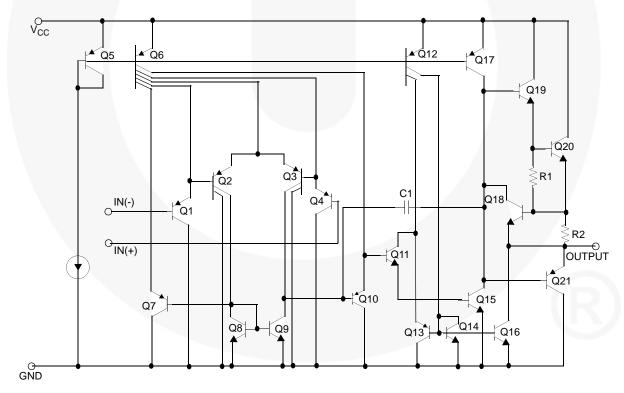


Figure 2. Schematic Diagram

### **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 <sub>CC</sub>	±16 or 32	±13 or 26	V
Differential Input Voltage	V <sub>I(DIFF)</sub>	32	26	V
Input Voltage	V <sub>I</sub>	-0.3 to +32	-0.3 to +26	V
Output Short Circuit to GND V <sub>CC</sub> 15 V, T <sub>A</sub> = 25 °C (One Amp)	-	Continuous	Continuous	-
Operating Temperature Range	T <sub>OPR</sub>	0 to +70	-40 to +85	°C
Storage Temperature Range	T <sub>STG</sub>	-65 to +150	-65 to +150	°C

### **Thermal Characteristics**

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

Symbol	Parameter	Value	Unit	
D	Power Dissipation T = 25 %	14-DIP	1310	mW
$P_{D}$	Power Dissipation, T <sub>A</sub> = 25 ℃	14-SOP	640	11100
В	Thermal Peniatanaa Junatian ta Ambiant May	14-DIP	95	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient, Max.	14-SOP	195	C/VV

### **Electrical Characteristics**

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

Cumbal	Doromotor	Conditions		KA324			KA2902			Unit
Symbol	Parameter		Conditions	Min.	Тур.	Max.	Min.	Тур.	Max.	Unit
V <sub>IO</sub>	Input Offset Voltage	V <sub>CM</sub> : V <sub>O(P)</sub>	= 0 V to $V_{CC}$ - 1.5 V, = 1.4 V, $R_S$ = 0 $\Omega^{(1)}$	-	1.5	7.0	-	1.5	7.0	mV
I <sub>IO</sub>	Input Offset Current	V <sub>CM</sub>	= 0 V	-	3	50	-	3	50	nA
I <sub>BIAS</sub>	Input Bias Current	V <sub>CM</sub>	= 0 V	-	40	250	-	40	250	nA
V <sub>I(R)</sub>	Input Common Mode Voltage Range	(1)		0	-	V <sub>CC</sub> -1.5	0	-	V <sub>CC</sub> -1.5	V
I <sub>CC</sub>	Supply Current		∞, V <sub>CC</sub> = 30 V, 902, V <sub>CC</sub> = 26 V)	1	1.0	3.0	-	1.0	3.0	mA
		R <sub>L</sub> =	∞, V <sub>CC</sub> = 5 V	ı	0.7	1.2	-	0.7	1.2	mA
G <sub>V</sub>	Large Signal Voltage Gain		= 15 V, $R_L = 2 k\Omega$ , = 1 V to 11 V	25	100	-	25	100	-	V/mV
V	V		$R_L = 2 k\Omega$	26	-	-	22	-	-	V
V О(Н)	V <sub>O(H)</sub> Output Voltage Swing		$R_L = 10 \text{ k}\Omega$	27	28	-	23	24	-	V
$V_{O(L)}$		V <sub>CC</sub> :	= 5 V, $R_L$ = 10 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	kHz to 20 kHz <sup>(2)</sup>	-	120	-	-	120	-	dB
I <sub>SC</sub>	Short Circuit to GND	V <sub>CC</sub> :	= 15 V	-	40	60	-	40	60	mA
I <sub>SOURCE</sub>		V <sub>I(+)</sub> :	= 1 V, $V_{I(-)} = 0$ V, = 15 V, $V_{O(P)} = 2$ V	20	40	-	20	40	-	mA
Output Current		V <sub>I(+)</sub> :	= 0 V, $V_{I(-)}$ = 1 V, = 15 V, $V_{O(P)}$ = 2 V	10	13	-	10	13	-	mA
I <sub>SINK</sub>	I <sub>SINK</sub>		= 0 V, V <sub>I(-)</sub> = 1 V, = 15 V, = 200 mV	12	45	- 7	1	-	-	μΑ
V <sub>I(DIFF)</sub>	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  $0^{\circ}C \le T_{A} \le +70^{\circ}C$  for the KA324, and the -40°C  $\le T_{A} \le +85^{\circ}C$  for the KA2902.

Symbol	Parameter	eter Conditions		KA324			k	Unit		
Symbol	Parameter			Min.	Тур.	Max.	Min.	Тур.	Max.	
V <sub>IO</sub>	Input Offset Voltage		$V_{ICM} = 0 \text{ V to } V_{CC} - 1.5 \text{ V},$ $V_{O(P)} = 1.4 \text{ V}, R_S = 0 \Omega^{(3)}$		-	9.0	-	-	10.0	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Drift	R <sub>S</sub> =	0 Ω <sup>(4)</sup>	-	7.0	-	-	7.0	-	μV/°C
I <sub>IO</sub>	Input Offset Current	V <sub>CM</sub> :	= 0 V	-	-	150	-	-	200	nA
$\Delta I_{IO}/\Delta T$	Input Offset Current Drift	R <sub>S</sub> =	$0\Omega^{(4)}$	-	10	-	-	10	-	pA/°C
I <sub>BIAS</sub>	Input Bias Current	V <sub>CM</sub> :	= 0 V	-	-	500	-	-	500	nA
V <sub>I(R)</sub>	Input Common Mode Voltage Range	(3)		0	-	V <sub>CC</sub> -2.0	0	-	V <sub>CC</sub> -2.0	V
G <sub>V</sub>	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		(3)	$R_L = 2 k\Omega$	26	-	-	22	-	-	V
V <sub>O(H)</sub>	Output Voltage Swing	,	$R_L = 10 \text{ k}\Omega$	27	28	-	23	24	-	V
$V_{O(L)}$		V <sub>CC</sub> =	= 5 V, R <sub>L</sub> = 10 kΩ	-	5	20	-	5	100	mV
I <sub>SOURCE</sub>	Output Current		= 1 V, V <sub>I(-)</sub> = 0 V, = 15 V, V <sub>O(P)</sub> = 2 V	10	20	-	10	20	-	mA
I <sub>SINK</sub>			= 0 V, V <sub>I(-)</sub> = 1 V, = 15 V, V <sub>O(P)</sub> = 2 V	5	8	-	5	8	-	mA
V <sub>I(DIFF)</sub>	Differential Input Voltage		-	-	-	V <sub>CC</sub>	-	-	V <sub>CC</sub>	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 °C, unless otherwise specified.

Symbol	Parameter		Conditions		Unit		
Symbol	Parameter		Conditions	Min.	Тур.	Max.	Oilit
V <sub>IO</sub>	Input Offset Voltage	V <sub>CM</sub> = V <sub>O(P)</sub>	= 0 V to $V_{CC}$ -1.5 V, = 1.4 V, $R_S$ = 0 $\Omega^{(5)}$	-	1.5	3.0	mV
I <sub>IO</sub>	Input Offset Current	V <sub>CM</sub> =	= 0 V	-	3	30	nA
I <sub>BIAS</sub>	Input Bias Current	V <sub>CM</sub> =	= 0 V	ı	40	100	nA
V <sub>I(R)</sub>	Input Common-Mode Voltage Range	(5)		0	-	V <sub>CC</sub> -1.5	V
	Supply Current	V <sub>CC</sub> =	: 30 V, R <sub>L</sub> = ∞	-	1.5	3.0	mA
I <sub>CC</sub>	Supply Current	V <sub>CC</sub> =	5 V, R <sub>L</sub> = ∞	-	0.7	1.2	mA
G <sub>V</sub>	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	Output Voltage Swing	(5) $R_{L} = 2 k\Omega$ $R_{L} = 10 k\Omega$		26	-	-	V
V <sub>O(H)</sub>				27	28	-	V
V <sub>O(L)</sub>		V <sub>CC</sub> =	5 V, R <sub>L</sub> = 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 k	Hz to 20 kHz <sup>(6)</sup>	-	120	-	dB
I <sub>SC</sub>	Short Circuit to GND	V <sub>CC</sub> = 15 V		-	40	60	mA
I <sub>SOURCE</sub>	Output Current		= 1 V, $V_{I(-)} = 0$ V, = 15 V, $V_{O(P)} = 2$ V	20	40	-	mA
I <sub>SINK</sub>			$V_{I(+)} = 0 \text{ V}, V_{I(-)} = 1 \text{ V},$ $V_{CC} = 15 \text{ V}, V_{O(P)} = 2 \text{ V}$		20	-	mA
			$0 \text{ V, V}_{\text{I(-)}} = 1 \text{ V,}$ $15 \text{ V, V}_{\text{O(P)}} = 200 \text{ mV}$	12	50	-	μА
V <sub>I(DIFF)</sub>	Differential Input Voltage		-	-	-	V <sub>CC</sub>	V

### Notes:

- 5. V<sub>CC</sub>=30V for KA324A.6. This parameter, although guaranteed is not 100% tested in production.

### **Electrical Characteristics** (Continued)

Values are at V<sub>CC</sub> = 5.0 V, V<sub>EE</sub> = GND, unless otherwise specified. The following specification apply over the range of  $0^{\circ}$ C  $\leq$  T<sub>A</sub>  $\leq$  +70 $^{\circ}$ C for the KA324A.

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

### Notes:

- 7. V<sub>CC</sub>=30V for KA324A.
- 8. This parameter, although guaranteed is not 100% tested in production.

### **Typical Performance Characteristics**

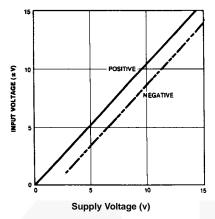


Figure 3. Input Voltage Range vs. Supply Voltage

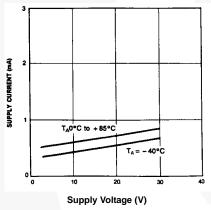


Figure 5. Supply Current vs. Supply Voltage

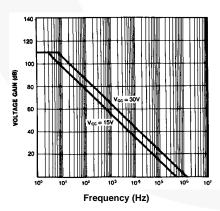


Figure 7. Open Loop Frequency Response

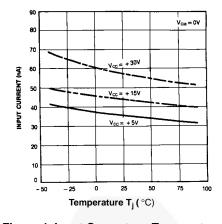


Figure 4. Input Current vs. Temperature

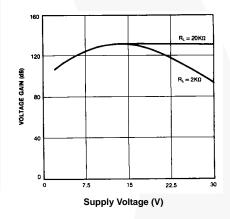


Figure 6. Voltage Gain vs. Supply Voltage

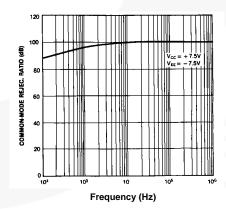


Figure 8. Common Mode Rejection Ratio

### **Typical Performance Characteristics** (Continued)

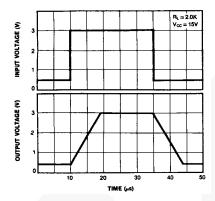


Figure 9. Voltage Follower Pulse Response

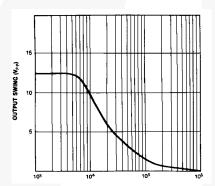


Figure 11. Large Signal Frequency Response

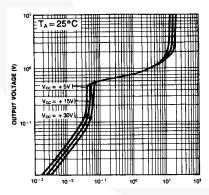


Figure 13. Output Characteristics vs. Current Sinking

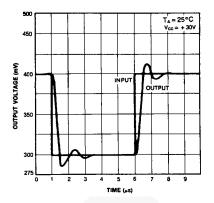


Figure 10. Voltage Follower Pulse Response (Small Signal)

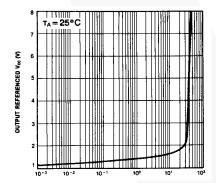


Figure 12. Output Characteristics vs. Current Sourcing

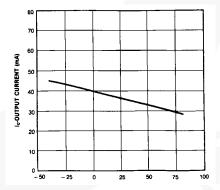
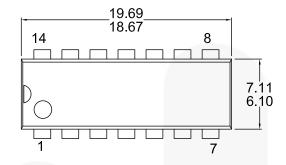
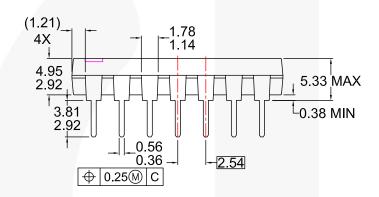
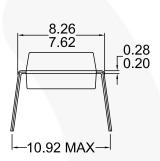


Figure 14. Current Limiting vs. Temperature

### **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

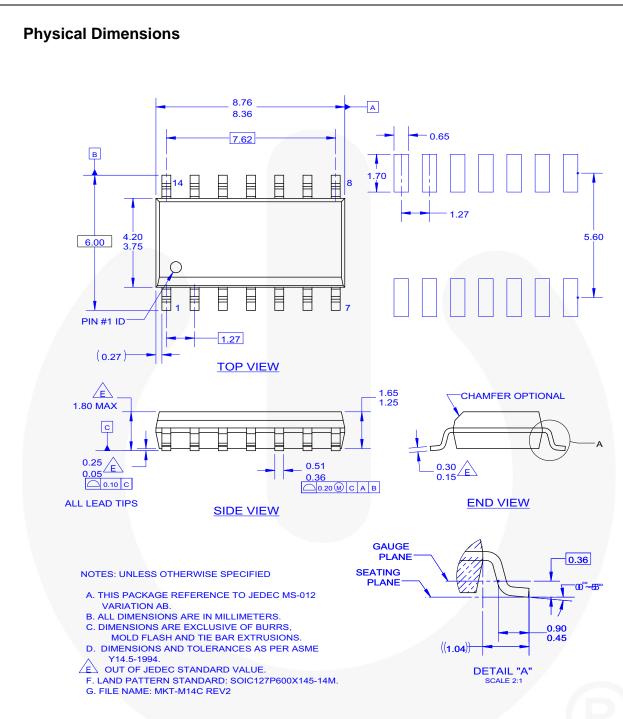


Figure 16. 14-Lead, SOIC, NON-JEDEC, .150 INCH NARROW BODY, 225SOP





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