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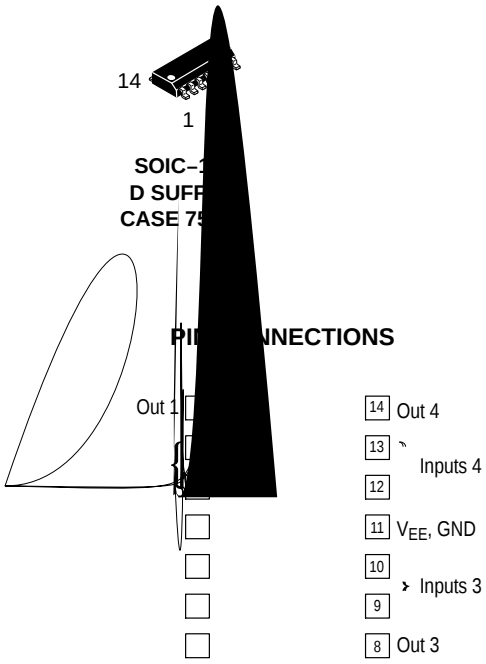


The LM324 series are low−cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one−fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

Features

- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents: 100 nA Maximum (LM324A)
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- ESD Clamps on the Inputs Increase Ruggedness without Affecting Device Operation
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating		Symbol	Value	Unit
Power Supply Voltages				Vdc
Single Supply		V_{CC}	32	
Split Supplies		V_{CC}, V_{EE}	±16	
Input Differential Voltage Range (Note 1)		V_{IDR}	±32	Vdc
Input Common Mode Voltage Range		V_{ICR}	−0.3 to 32	Vdc
Output Short Circuit Duration		t_{SC}	Continuous	
Junction Temperature		T_J	150	°C
Thermal Resistance, Junction−to−Air (Note 2)	Case 646	R_{JA}	118	°C/W
	Case 751A		156	
	Case 948G		190	
Storage Temperature Range		T_{stg}	−65 to +150	°C
Operating Ambient Temperature Range		T_A		°C
	LM224		−25 to +85	
	LM324, LM324A, LM324E		0 to +70	
	LM2902, LM2902E		−40 to +105	
	LM2902V, NCV2902 (Note 3)		−40 to +125	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Split Power Supplies.
2. All R_{JA} measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
3.

ESD RATINGS

Rating	HBM	MM	Unit
ESD Protection at any Pin (Human Body Model − HBM, Machine Model − MM)			
NCV2902 (Note 3)	2000	200	V
LM324E, LM2902E	2000	200	V
LM324DG/DR2G, LM2902DG/DR2G	200	100	V
All Other Devices	2000	200	V

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = GND, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	LM224			LM324A			LM324, LM324E			LM2902, LM2902E			LM2902V/NCV2902			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Output Voltage − High Limit	V_{OH}																V
V_{CC} = 5.0 V, R_L = 2.0 k , T_A = 25°C		3.3	3.5	−	3.3	3.5	−	3.3	3.5	−	3.3	3.5	−	3.3	3.5	−	
V_{CC} = 30 V R_L = 2.0 k (T_A = T_{high} to T_{low}) (Note 7)		26	−	−	26	−	−	26	−	−	26	−	−	26	−	−	
V_{CC} = 30 V R_L = 10 k (T_A = T_{high} to T_{low}) (Note 7)		27	28	−	27	28	−	27	28	−	27	28	−	27	28	−	
Output Voltage − Low Limit, V_{CC} = 5.0 V, R_L = 10 k , T_A = T_{high} to T_{low} (Note 7)	V_{OL}	−	5.0	20	−	5.0	20	−	5.0	20	−	5.0	100	−	5.0	100	mV
Output Source Current (V_{ID} = +1.0 V, V_{CC} = 15 V)	I_{O+}																mA
T_A = 25°C		20	40	−	20	40	−	20	40	−	20	40	−	20	40	−	
T_A = T_{high} to T_{low} (Note 7)		10	20	−	10	20	−	10	20	−	10	20	−	10	20	−	
Output Sink Current	I_{O-}																mA
(V_{ID} = −1.0 V, V_{CC} = 15 V) T_A = 25°C		10	20	−	10	20	−	10	20	−	10	20	−	10	20	−	
T_A = T_{high} to T_{low} (Note 7)		5.0	8.0	−	5.0	8.0	−	5.0	8.0	−	5.0	8.0	−	5.0	8.0	−	
(V_{ID} = −1.0 V, V_O = 200 mV, T_A = 25°C)		12	50	−	12	50	−	12	50	−	−	−	−	−	−	−	A
Output Short Circuit to Ground (Note 8)	I_{SC}	−	40	60	−	40	60	−	40	60	−	40	60	−	40	60	mA
Power Supply Current (T_A = T_{high} to T_{low}) (Note 7)	I_{CC}																mA
V_{CC} = 30 V V_O = 0 V, R_L = ∞		−	−	3.0	−	1.4	3.0	−	−	3.0	−	−	3.0	−	−	3.0	
V_{CC} = 5.0 V, V_O = 0 V, R_L = ∞		−	−	1.2	−	0.7	1.2	−	−	1.2	−	−	1.2	−	−	1.2	

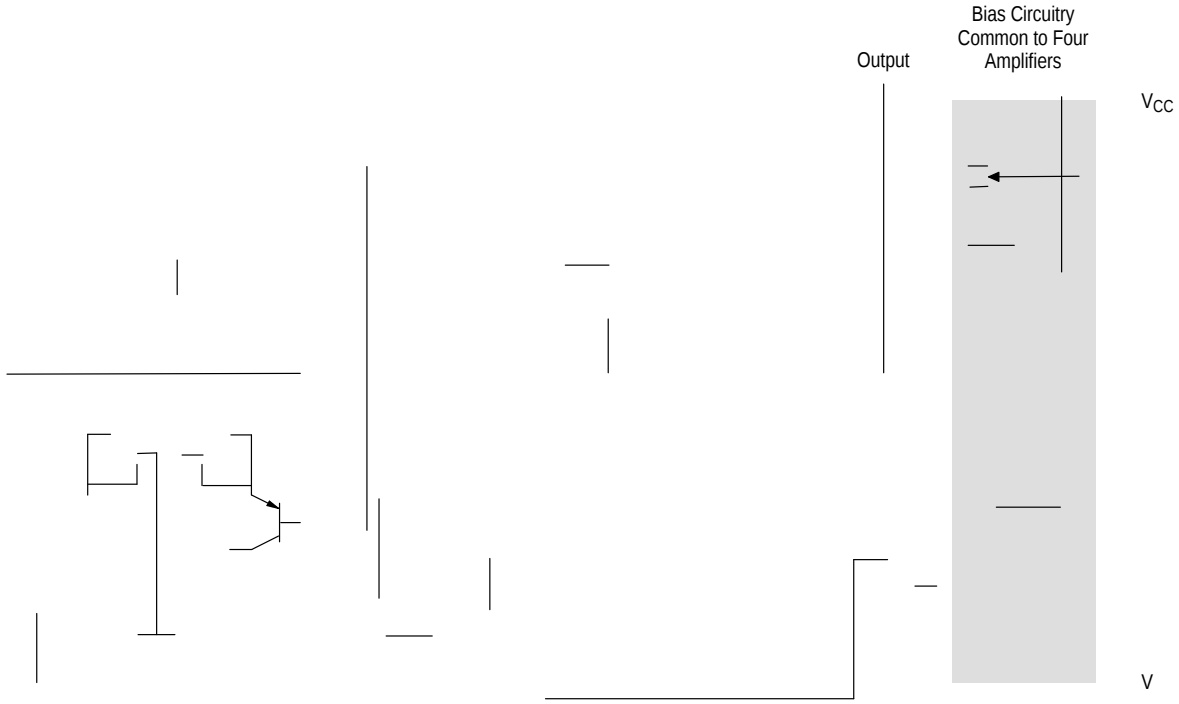


Figure 1. Representative Circuit Diagram
(One−Fourth of Circuit Shown)

CIRCUIT DESCRIPTION

The LM324 series is made using four internally compensated, two−stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single−ended converter. The second stage consists of a standard current source load amplifier stage.

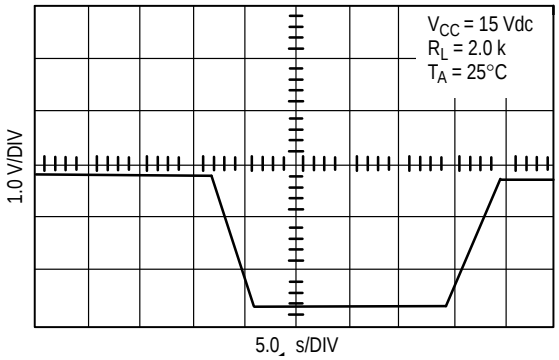
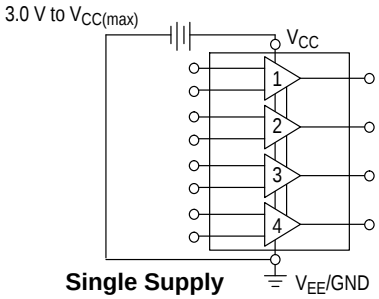
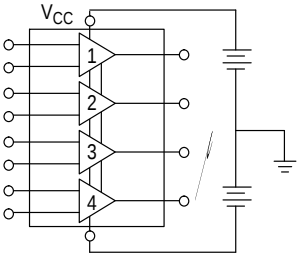


Figure 2. Large Signal Voltage Follower Response

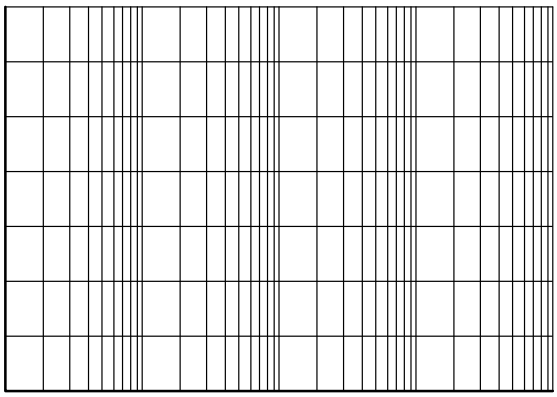
Each amplifier is biased from an internal−voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

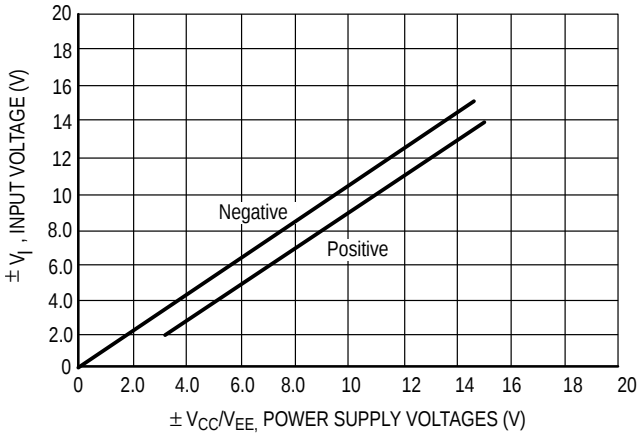


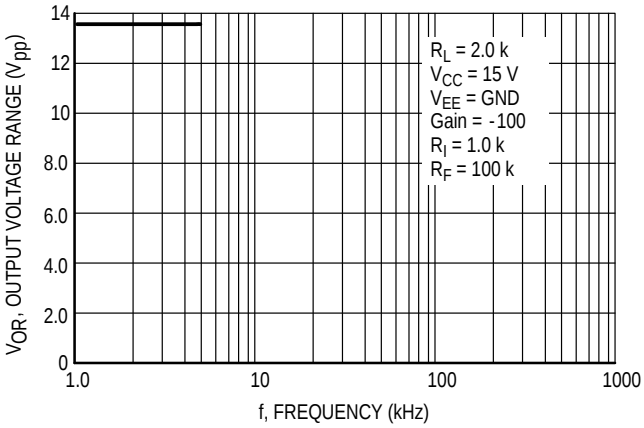
Single Supply

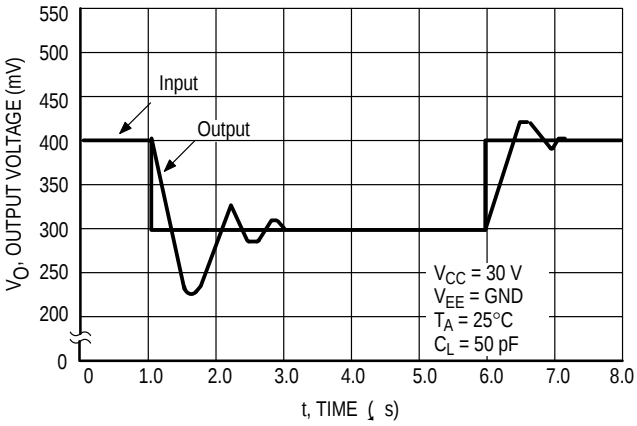


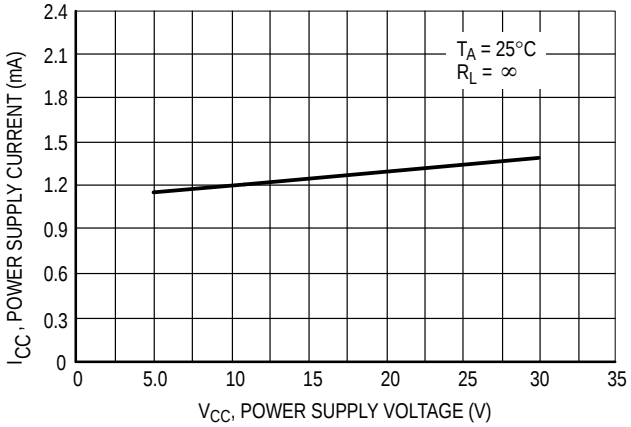
Split Supplies

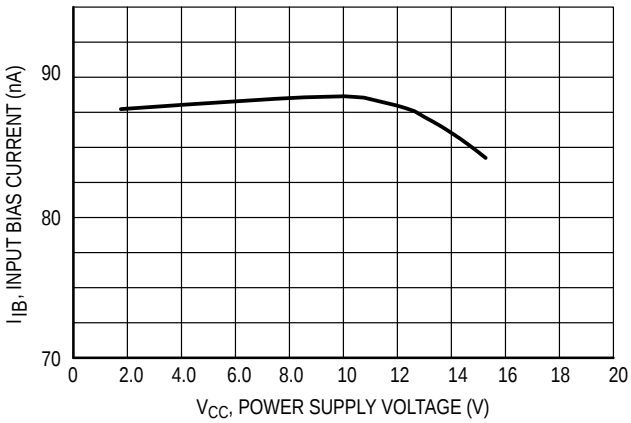



± V_I , INPUT VOLTAGE (V)
± V_CC/V_EE, POWER SUPPLY VOLTAGES (V)
Negative
Positive


V_OR, OUTPUT VOLTAGE RANGE (V_pp)
f, FREQUENCY (kHz)
R_L = 2.0 k
V_CC = 15 V
V_EE = GND
Gain = -100
R_I = 1.0 k
R_F = 100 k


V_O, OUTPUT VOLTAGE (mV)
t, TIME (μs)
Input
Output
V_CC = 30 V
V_EE = GND
T_A = 25°C
C_L = 50 pF


I_CC, POWER SUPPLY CURRENT (mA)
V_CC, POWER SUPPLY VOLTAGE (V)
T_A = 25°C
R_L = ∞


I_IB, INPUT BIAS CURRENT (nA)
V_CC, POWER SUPPLY VOLTAGE (V)

1
2

Given: f

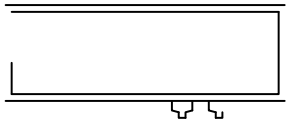
For less than 10% error from operational amplifier, $\frac{Q_0 f_0}{BW} < 0.1$

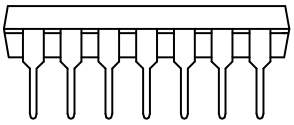
where f_0 and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

ORDERING INFORMATION

Device





STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NO CONNECTION
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NO CONNECTION
12. EMITTER
13. BASE
14. COLLECTOR

STYLE 2:
CANCELLED

STYLE 3:
CANCELLED

STYLE 6:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. NO CONNECTION
5. ANODE/CATHODE
6. NO CONNECTION
7. ANODE/CATHODE
8. ANODE/CATHODE
9. ANODE/CATHODE
10. NO CONNECTION
11. ANODE/CATHODE
12. ANODE/CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 7:
PIN 1. NO CONNECTION
2. ANODE
3. ANODE
4. NO CONNECTION
5. ANODE
6. NO CONNECTION
7. ANODE
8. ANODE
9. ANODE
10. NO CONNECTION
11. ANODE
12. ANODE
13. NO CONNECTION
14. COMMON CATHODE

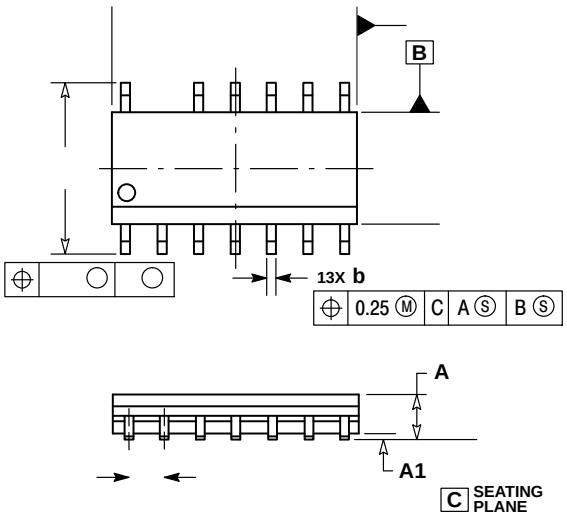
STYLE 8:
PIN 1. NO CONNECTION
2. CATHODE
3. CATHODE
4. NO CONNECTION
5. CATHODE
6. NO CONNECTION
7. CATHODE
8. CATHODE
9. CATHODE
10. NO CONNECTION
11. CATHODE
12. CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 10:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE
6. NO CONNECTION

9. ANODE/CATHODE

SOIC 14 NB
CASE 751A−03
ISSUE L

DATE 03 FEB 2016



SOIC 14
CASE 751A−03
ISSUE L

DATE 03 FEB 2016

STYLE 7:
PIN 1. ANODE/CATHODE
2. COMMON ANODE
3. COMMON CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE