TS324
Quad Operating Amplifier

DIP-14
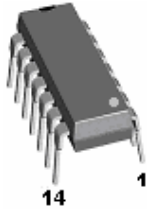
SOP-14
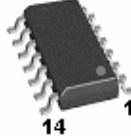
Pin assignment:
1. Output A   14. Output D
2. Input A (-)   13. Input D (-)
3. Input A (+)   12. Input D (+)
4. Vcc   11. Gnd
5. Input B (+)   10. Input C (+)
6. Input B (-)   9. Input C (-)
7. Output B   8. Output C

Supply Voltage Range 3 V to 32V

Quad Channel Amplifier

General Description

The TS324 contains four independent high gain operational amplifiers with internal frequency compensation. The four op-amps use a split power supply. The device has low power supply current drain, regardless or the power supply voltage. The low power drain also makes the TS324 a good choice for battery operation.

When your project calls for a traditional op-amp function, now you can streamline your design with a simple single power supply. Use ordinary +5V common to practically any digital system or personal computer application, without requiring an extra 15V power supply just to have the interface electronics you need.
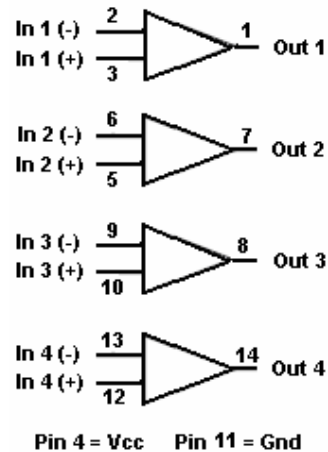
The TS324 is a versatile, rugged workhorse with a thousand-and-one uses, from amplifying signals from a variety of transducers to dc gain blocks, or any op-amp function. The attached pages offer some recipes that will have your project cooking in no time.

The TS358 is offered in 14 pin SOP-14 and DIP-14 package.

Features

✧ Single supply operation: 3V to 32V

✧ Low input bias currents

✧ Internally compensated

✧ Common mode range extends to negative supply

✧ Single and split supply operation

Block Diagram

In 1 (-) 2
In 1 (+) 3 → 1 Out 1

In 2 (-) 6
In 2 (+) 5 → 7 Out 2

In 3 (-) 9
In 3 (+) 10 → 8 Out 3

In 4 (-) 13
In 4 (+) 12 → 14 Out 4

Pin 4 = Vcc   Pin 11 = Gnd

Ordering Information

Part No.	Operating Temp.	Package
TS324CD	0 ~ +70 ^{o}C	DIP-14
TS324CS		SOP-14

Absolute Maximum Rating

Supply Voltage	Vcc, Vcc/Vee	+32 or ±16	Vdc
Differential Input Voltage (note 1)	V_{IDR}	32	Vdc
Input Common Mode Voltage Range (note 2)	V_{ICR}	-0.3 to 32	Vdc
Input Forward Current (note 3)	Iif	50	mA
Output Short Circuit Duration	Isc	Continuous	mA
Operating Junction Temperature Range	T_J	0 ~ +125	^{o}C
Storage Temperature Range	T_{STG}	-65 ~ +150	^{o}C

NOTE :
1. Split Power Supplies.
2. For supply. Voltages less than 32V for the PJ324 the absolute maximum input voltage is equal to the supply voltage.
3. This input current will only exist when the voltage is negative at any of the input leads. Normal output states will reestablish when the input voltage returns to a voltage greater than -0.3V.

Electrical Characteristics

(V_{CC} = 5V, Ta=25 ^{o}C; unless otherwise specified.)

Characteristics	Symbol	Min	Typ	Max	Unit
Input Offset Voltage	Vio	--	2.0	7.0	mV
V_{CC}= 5.0V to 30V, V_{IC}= 0V to Vcc -1.7 V, Vo= 1.4V, R_S= 0Ω					
$T_{LOW} \leq Ta \leq T_{HIGH}$		--	--	9.0	
Average Temperature Coefficient of Input Offset Voltage	ΔIio/ΔT	--	7.0	--	uV/^{o}C
Input Offset Current	Iio	--	5.0	50	nA
$T_{LOW} \leq Ta \leq T_{HIGH}$		--	--	150	
Average Temperature Coefficient of input Offset Current	ΔIio/ΔT	--	10	--	pA/^{o}C
Input Bias Current	I_{IB}	--	45	-250	uA
$T_{LOW} \leq Ta \leq T_{HIGH}$			50	-500	
Input Common-Mode Voltage Range (Note1)	V_{ICR}				
V_{CC} = 30 V		0	--	28.3	V
V_{CC} = 30 V, $T_{LOW} \leq Ta \leq T_{HIGH}$		0	--	28	
Differential Input Voltage Range	V_{IDR}	--	--	V_{CC}	V
Large Signal Open-Loop Voltage Gain	A_{VOL}				
R_L = 2.0K, V_{CC} =15V, For Large V_O Swing,		25	100	--	V/mV
$T_{LOW} \leq Ta \leq T_{HIGH}$		15	--	--	
Channel Separation	--	--	-120	--	dB
1.0 KHz to 20KHz					
Common Mode Rejection Ratio	CMRR	65	70	--	dB
$R_S \leq 10$ kΩ					
Power Supply Rejection Ratio	PSRR	65	100	--	dB
Output Voltage -- High Limit	V_{OH}				V
V_{CC} = 30 V, R_L = 2 kΩ		26	--	--	
V_{CC} = 30 V, R_L = 10 kΩ		27	28	--	
Output Voltage -- Low Limit	V_{OL}	--	5.0	20	mV
V_{CC} = 5.0 V, R_L = 10 kΩ					
Output Source Current V_{ID}=+1.0V,V_{CC}=15V	I_{O+}	20	40	--	mA
Output Sink Current	I_{O-}				
V_{ID} = -1.0 V, V_{CC} = 15 V		10	20	--	mA
V_{ID} = -1.0 V, V_O = 200 mV		12	50	--	uA
Output Short Circuit to Ground (Note 2)	I_{OS}	--	40	60	mA
Power Supply Current ,	I_{CC}				
V_{CC} = 30 VV_O = 0 V, R_L = ∞		--	1.5	3.0	mA
V_{CC} = 5.0 V, V_O = 0 V, R_L = ∞		--	0.7	1.2	

Notes :

1. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is Vcc 17V, but either or both inputs can go to +32V.
2. Short circuits from the output to Vcc can cause excessive heating and eventual destruction. Destructive dissipation can recruit from simultaneous shorts on all amplifiers.

Circuit Description

The TS324 made using four internally compensated, two-stage operational amplifiers. 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 5.0pF) can be employed, thus saving chip area. 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.

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

Electrical Characteristics Curve
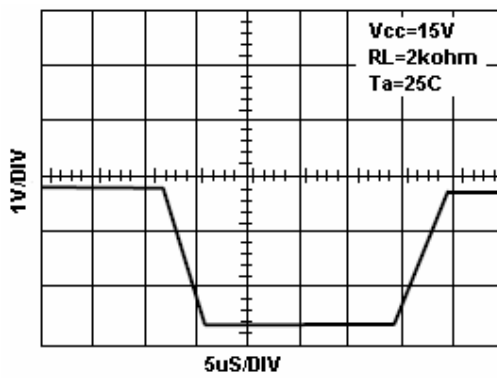
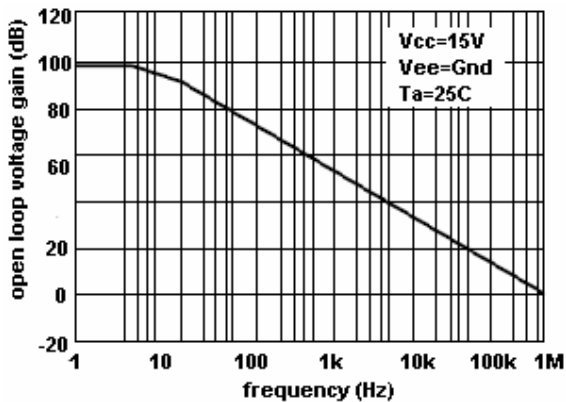Figure 1. large signal voltage follower response
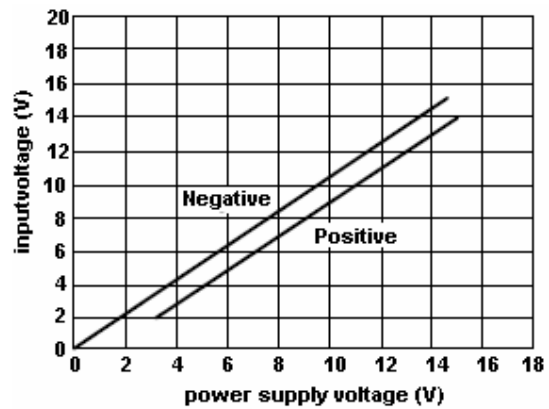
Figure 2. input voltage range

Figure 3. large singal open loop voltage gain

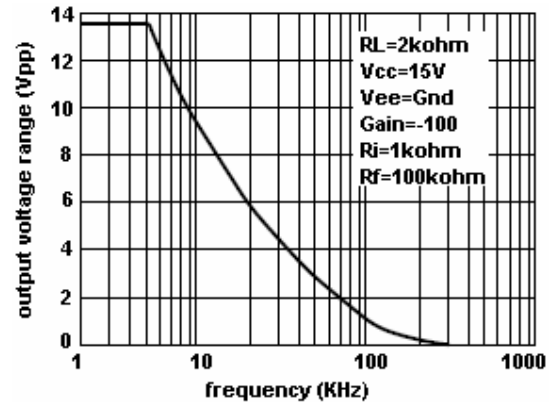Figure 4. larger signal frequency response

Circuit Description
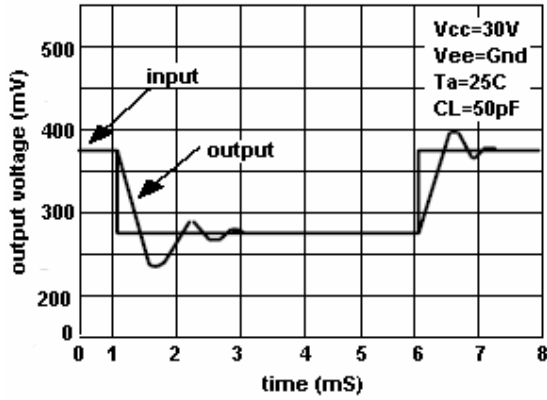
Vcc=30V
Vee=Gnd
Ta=25C
CL=50pF

input

output

Figure 5. small signal voltage follower
pulse response (noninverting)

Ta=25C
RL=∞
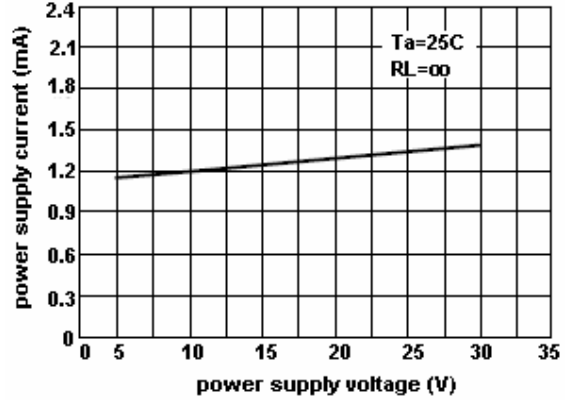
Figure 6. power supply current vs
supply voltage

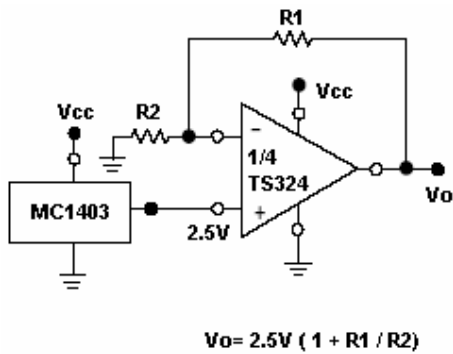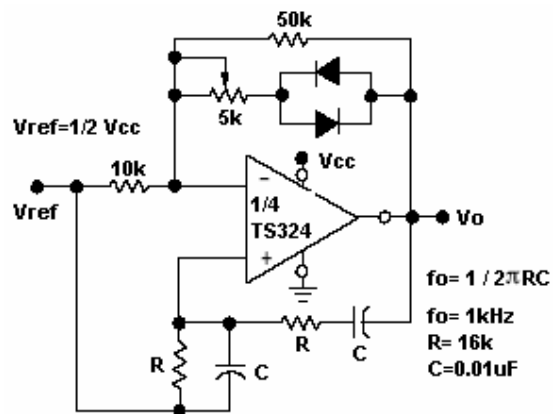Vo= 2.5V (1 + R1 / R2)

Figure 7. voltage reference

Vref=1/2 Vcc

$f_o = 1 / 2\pi RC$

$f_o = 1kHz$

R= 16k

C=0.01uF

Figure 8. wien bridge oscillator

Bandpass Output

Notch output

Where: Tbp= center frequency gain
Tn= passband notch gain

Vref= 1 / 2 Vcc

$f_o = 1/ 2\pi$

R1= RC / QR

R2= R1 / Tbp

R3= Tn R2

C1= 10C

For: fo = 1kHz
      Q = 10
      Tbp = 1
      Tn = 1

R= 160k
C= 1nF
R1= 1.6M
R2= 1.6M
R3= 1.6M
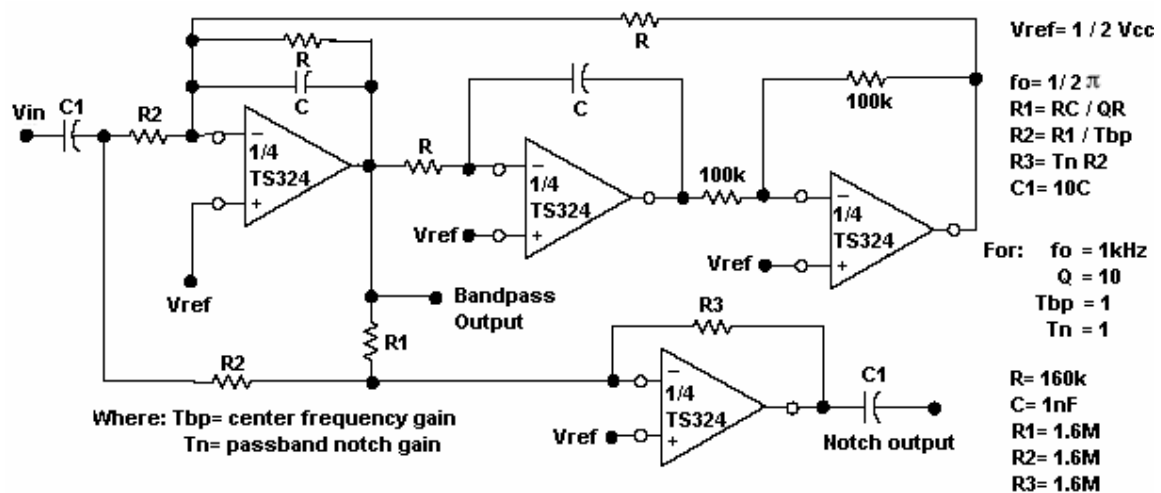
Figure 9. bi-quad filter

Circuit Description (continued)

$$eo= C (1 + a + b) (e2 - e1)$$

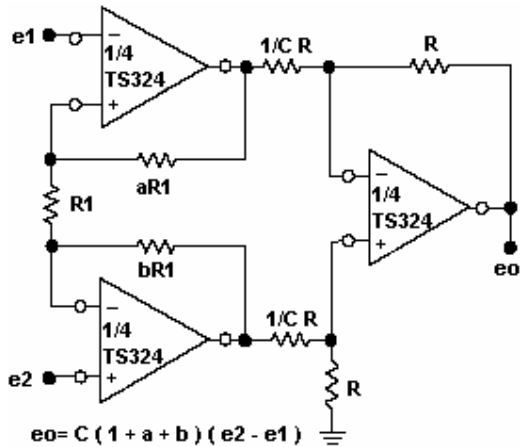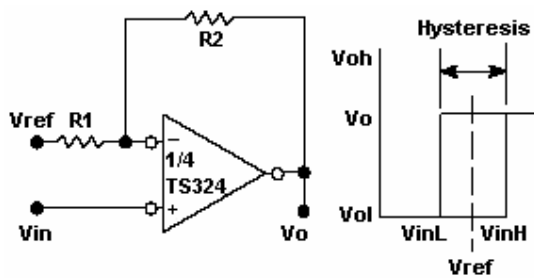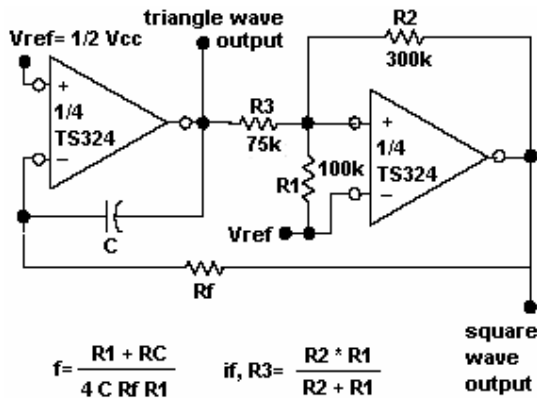**Figure 10. high impedance differential amplifier**

$$VinL= R1 / (R1 + R2) * (Vol - Vref) + Vref$$
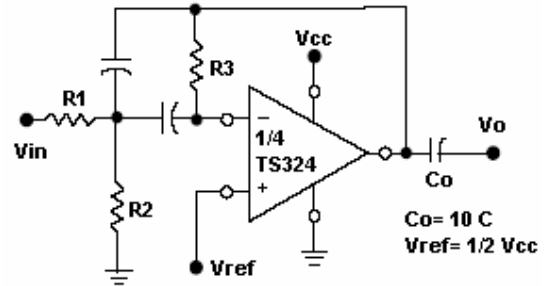
$$VinH= R1 / (R1 + R2) * (Voh - Vref) + Vref$$

$$H= R1 / (R1 + R2) * (Voh - Vol)$$

Figure 11. comparator with hysteresis

$$f= \frac{R1 + RC}{4 C Rf R1} \quad if, R3= \frac{R2 * R1}{R2 + R1}$$

Figure 12. function generator

Given: fo= center frequency
A(fo)= gain at center frequency
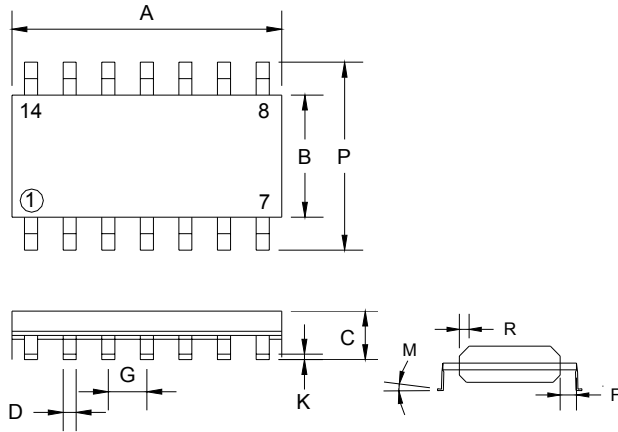
Choose value fo, C
Then: R3= Q / π fo C
R1= R3 / 2A(fo)
R2= R1 * R2 / 4Q2 *R1 - R3

For less than 10% error from operational amplifier,
Qo fo / BW < 0.1
Where fo and BW are expressed in Hz

If source impendance varies, filter may be
preceded with Voltage follower buffer stabilize
filter parameters

Figure 13. multiple feedback bandpass filter

SOP-14 Mechanical Drawing

SOP-14 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 (typ)		0.05 (typ)	
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

DIP-14 Mechanical Drawing
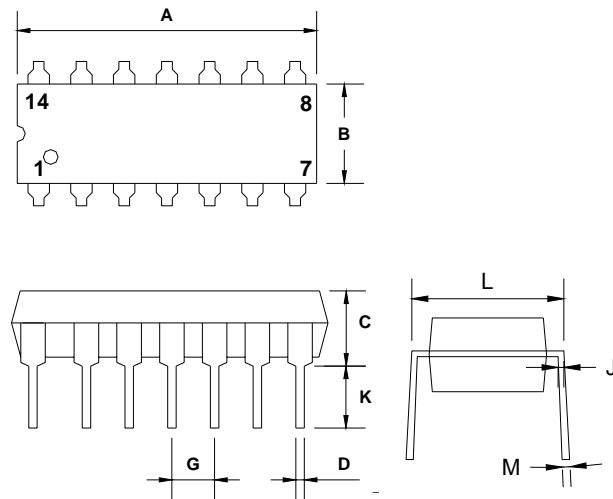
DIP-14 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.55	19.56	0.730	0.770
B	6.22	6.48	0.245	0.255
C	3.18	4.45	0.125	0.135
D	0.35	0.55	0.019	0.020
G	2.54 (typ)		0.10 (typ)	
J	0.29	0.31	0.011	0.012
K	3.25	3.35	0.128	0.132
L	7.75	8.00	0.305	0.315
M	-	10°	-	10°