

# LM358, LM258, LM2904, LM2904V

## Dual Low Power Operational Amplifiers

Utilizing the circuit designs perfected for recently introduced Quad Operational Amplifiers, these dual operational amplifiers feature 1) low power drain, 2) a common mode input voltage range extending to ground/ $V_{EE}$ , 3) single supply or split supply operation and 4) pinouts compatible with the popular MC1558 dual operational amplifier. The LM158 series is equivalent to one-half of an LM124.

These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They 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.

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Single and Split Supply Operation
- Similar Performance to the Popular MC1558
- ESD Clamps on the Inputs Increase Ruggedness of the Device without Affecting Operation

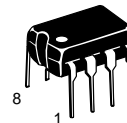
### MAXIMUM RATINGS ( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

Rating	Symbol	LM258 LM358	LM2904 LM2904V	Unit
Power Supply Voltages Single Supply Split Supplies	$V_{CC}$ $V_{CC}, V_{EE}$	32 $\pm 16$	26 $\pm 13$	Vdc
Input Differential Voltage Range (Note 1)	$V_{IDR}$	$\pm 32$	$\pm 26$	Vdc
Input Common Mode Voltage Range (Note 2)	$V_{ICR}$	-0.3 to 32	-0.3 to 26	Vdc
Output Short Circuit Duration	$t_{SC}$	Continuous		
Junction Temperature	$T_J$	150		$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-55 to +125		$^\circ\text{C}$
Operating Ambient Temperature Range	$T_A$			$^\circ\text{C}$
LM258		-25 to +85	-	
LM358		0 to +70	-	
LM2904		-	-40 to +105	
LM2904V		-	-40 to +125	

- NOTES:** 1. Split Power Supplies.  
2. For Supply Voltages less than 32 V for the LM258/358 and 26 V for the LM2904, the absolute maximum input voltage is equal to the supply voltage.

### DUAL DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

#### SEMICONDUCTOR TECHNICAL DATA

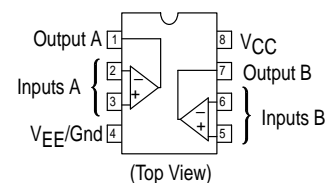


**N SUFFIX**  
PLASTIC PACKAGE  
CASE 626



**D SUFFIX**  
PLASTIC PACKAGE  
CASE 751  
(SO-8)

### PIN CONNECTIONS



### ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM2904D	$T_A = -40^\circ$ to $+105^\circ\text{C}$	SO-8
LM2904N		Plastic DIP
LM2904VD	$T_A = -40^\circ$ to $+125^\circ\text{C}$	SO-8
LM2904VN		Plastic DIP
LM258D	$T_A = -25^\circ$ to $+85^\circ\text{C}$	SO-8
LM258N		Plastic DIP
LM358D	$T_A = 0^\circ$ to $+70^\circ\text{C}$	SO-8
LM358N		Plastic DIP

# LM358, LM258, LM2904, LM2904V

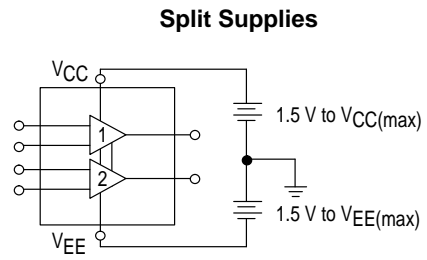
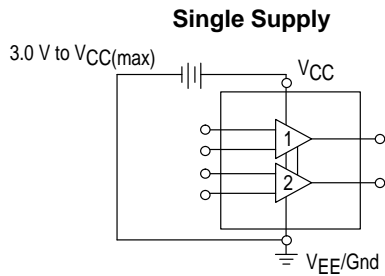
## ELECTRICAL CHARACTERISTICS (V<sub>CC</sub> = 5.0 V, V<sub>EE</sub> = Gnd, T<sub>A</sub> = 25°C, unless otherwise noted.)

Characteristic	Symbol	LM258			LM358			LM2904			LM2904V			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage V <sub>CC</sub> = 5.0 V to 30 V (26 V for LM2904, V), V <sub>IC</sub> = 0 V to V <sub>CC</sub> -1.7 V, V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 0 Ω T <sub>A</sub> = 25°C T <sub>A</sub> = T <sub>high</sub> (Note 1) T <sub>A</sub> = T <sub>low</sub> (Note 1)	V <sub>IO</sub>	–	2.0	5.0	–	2.0	7.0	–	2.0	7.0	–	–	–	mV
Average Temperature Coefficient of Input Offset Voltage T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	ΔV <sub>IO</sub> /ΔT	–	7.0	–	–	7.0	–	–	7.0	–	–	7.0	–	μV/°C
Input Offset Current T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	I <sub>IO</sub>	–	3.0	30	–	5.0	50	–	5.0	50	–	5.0	50	nA
Input Bias Current T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	I <sub>IB</sub>	–	–45	–150	–	–45	–250	–	–45	–250	–	–45	–250	nA
Average Temperature Coefficient of Input Offset Current T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	ΔI <sub>IO</sub> /ΔT	–	10	–	–	10	–	–	10	–	–	10	–	pA/°C
Input Common Mode Voltage Range (Note 2), V <sub>CC</sub> = 30 V (26 V for LM2904, V) V <sub>CC</sub> = 30 V (26 V for LM2904, V), T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub>	V <sub>ICR</sub>	0	–	28.3	0	–	28.3	0	–	24.3	0	–	24.3	V
Differential Input Voltage Range	V <sub>IDR</sub>	–	–	V <sub>CC</sub>	–	–	V <sub>CC</sub>	–	–	V <sub>CC</sub>	–	–	V <sub>CC</sub>	V
Large Signal Open Loop Voltage Gain R <sub>L</sub> = 2.0 kΩ, V <sub>CC</sub> = 15 V, For Large V <sub>O</sub> Swing, T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	A <sub>VOL</sub>	50	100	–	25	100	–	25	100	–	25	100	–	V/mV
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	–	–120	–	–	–120	–	–	–120	–	–	–120	–	dB
Common Mode Rejection R <sub>S</sub> ≤ 10 kΩ	CMR	70	85	–	65	70	–	50	70	–	50	70	–	dB
Power Supply Rejection	PSR	65	100	–	65	100	–	50	100	–	50	100	–	dB
Output Voltage—High Limit (T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> ) (Note 1) V <sub>CC</sub> = 5.0 V, R <sub>L</sub> = 2.0 kΩ, T <sub>A</sub> = 25°C V <sub>CC</sub> = 30 V (26 V for LM2904, V), R <sub>L</sub> = 2.0 kΩ V <sub>CC</sub> = 30 V (26 V for LM2904, V), R <sub>L</sub> = 10 kΩ	V <sub>OH</sub>	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	V
Output Voltage—Low Limit V <sub>CC</sub> = 5.0 V, R <sub>L</sub> = 10 kΩ, T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> (Note 1)	V <sub>OL</sub>	–	5.0	20	–	5.0	20	–	5.0	20	–	5.0	20	mV
Output Source Current V <sub>ID</sub> = +1.0 V, V <sub>CC</sub> = 15 V	I <sub>O+</sub>	20	40	–	20	40	–	20	40	–	20	40	–	mA
Output Sink Current V <sub>ID</sub> = –1.0 V, V <sub>CC</sub> = 15 V V <sub>ID</sub> = –1.0 V, V <sub>O</sub> = 200 mV	I <sub>O–</sub>	10	20	–	10	20	–	10	20	–	10	20	–	mA
Output Short Circuit to Ground (Note 3)	I <sub>SC</sub>	–	40	60	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (T <sub>A</sub> = T <sub>high</sub> to T <sub>low</sub> ) (Note 1) V <sub>CC</sub> = 30 V (26 V for LM2904, V), V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞ V <sub>CC</sub> = 5 V, V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞	I <sub>CC</sub>	–	1.5	3.0	–	1.5	3.0	–	1.5	3.0	–	1.5	3.0	mA
		–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	mA

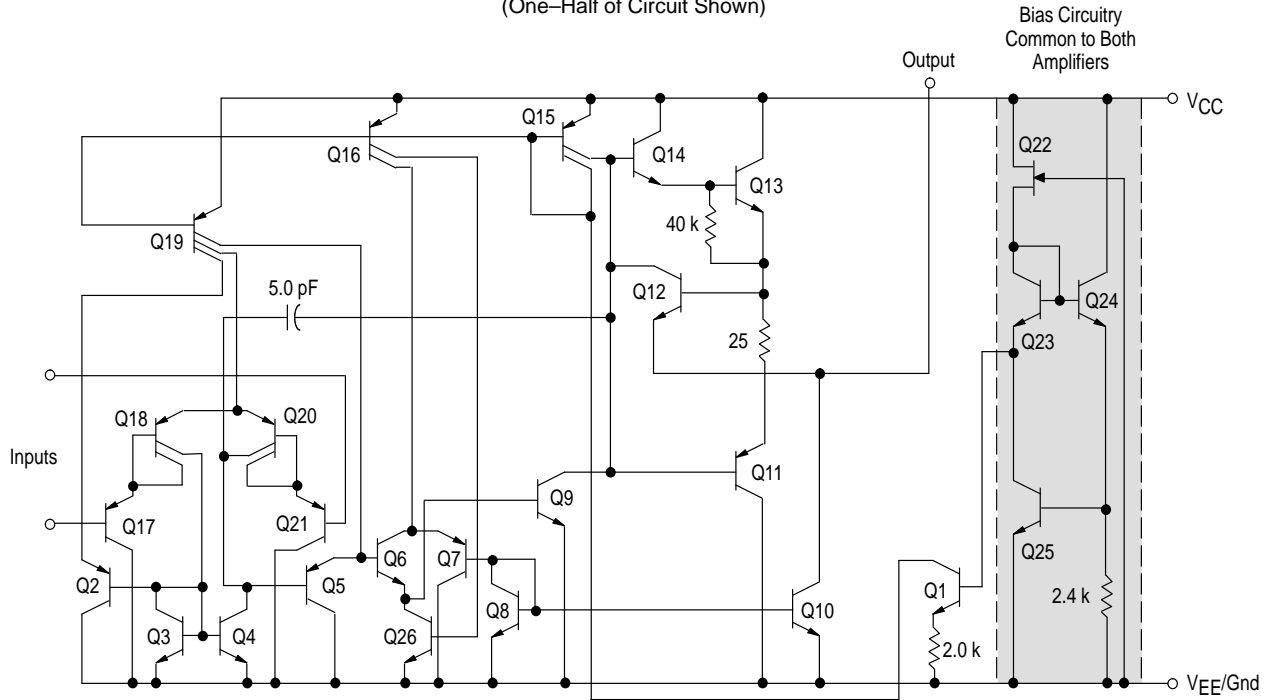
**NOTES:** 1. T<sub>low</sub> = –40°C for LM2904  
= –40°C for LM2904V  
= –25°C for LM258  
= 0°C for LM358  
T<sub>high</sub> = +105°C for LM2904  
= +125°C for LM2904V  
= +85°C for LM258  
= +70°C for LM358

- 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 V<sub>CC</sub> –1.7 V.
- Short circuits from the output to V<sub>CC</sub> can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

# LM358, LM258, LM2904, LM2904V



**Representative Schematic Diagram**  
(One-Half of Circuit Shown)



## CIRCUIT DESCRIPTION

The LM258 series is made using two 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.

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.

## Large Signal Voltage Follower Response

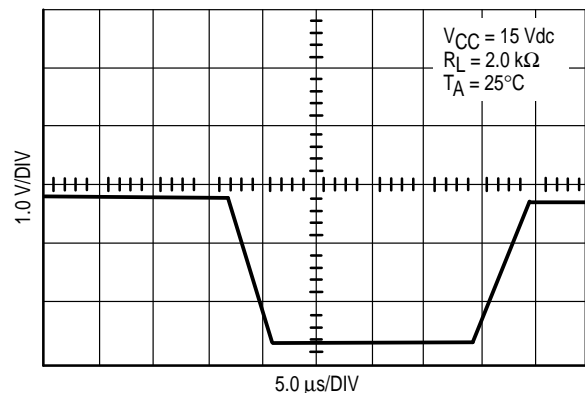


Figure 1. Input Voltage Range

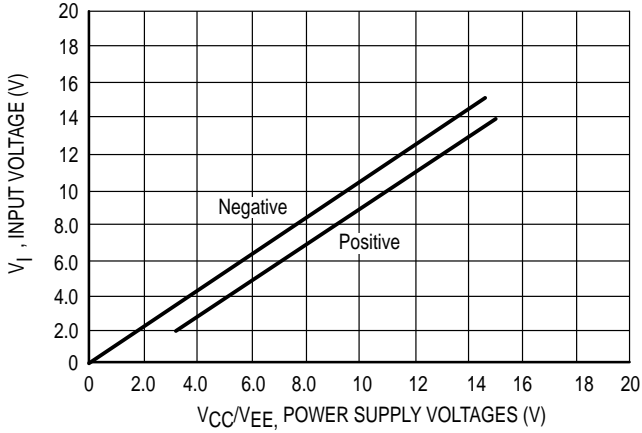


Figure 2. Large-Signal Open Loop Voltage Gain

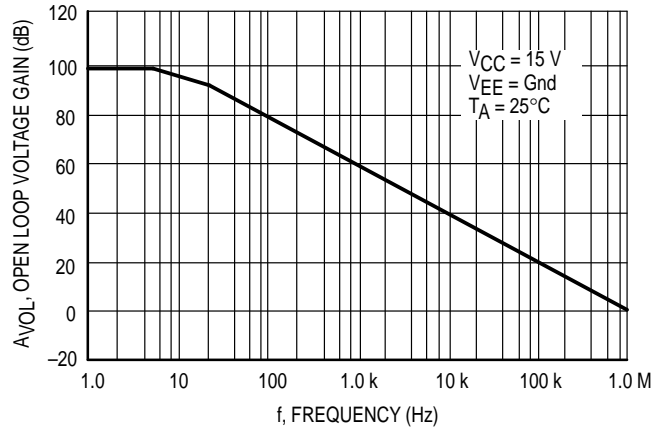


Figure 3. Large-Signal Frequency Response

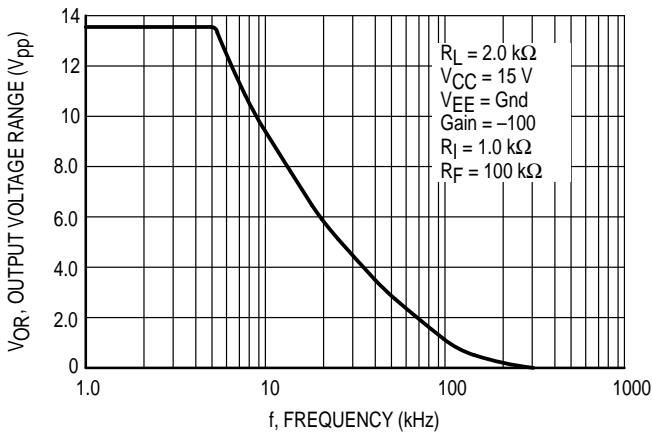


Figure 4. Small Signal Voltage Follower Pulse Response (Noninverting)

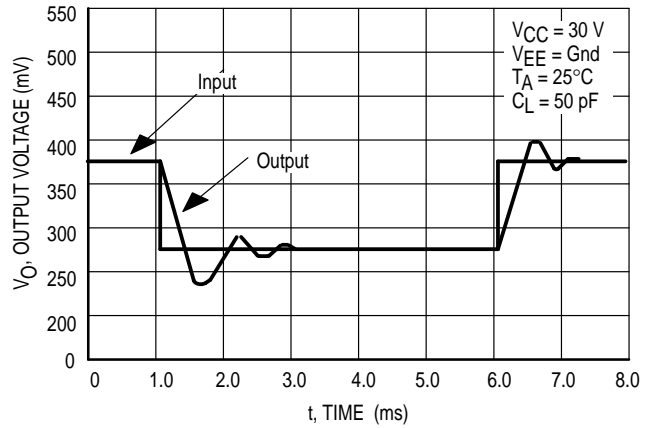


Figure 5. Power Supply Current versus Power Supply Voltage

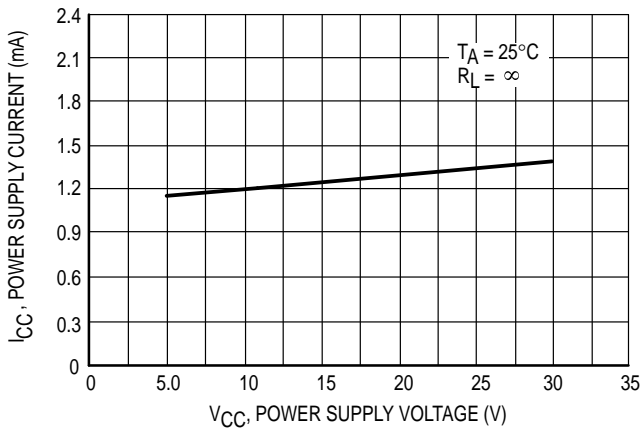
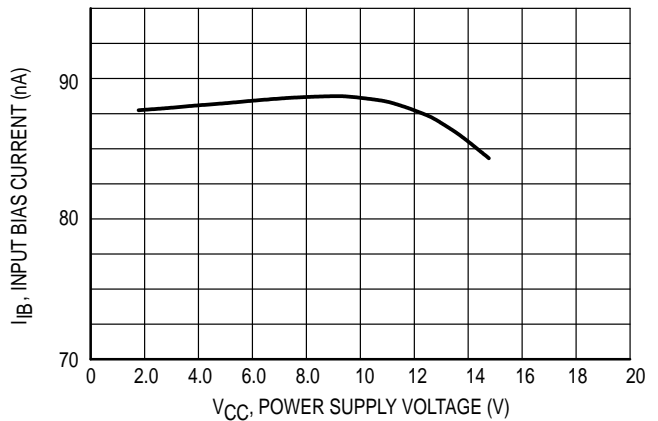


Figure 6. Input Bias Current versus Supply Voltage



# LM358, LM258, LM2904, LM2904V

Figure 7. Voltage Reference

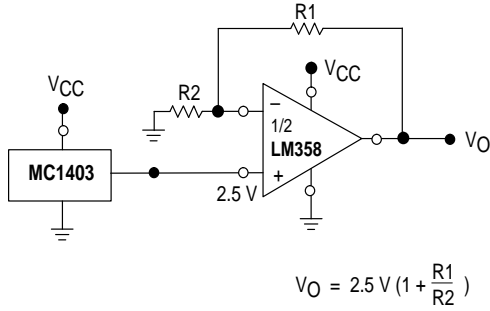


Figure 8. Wien Bridge Oscillator

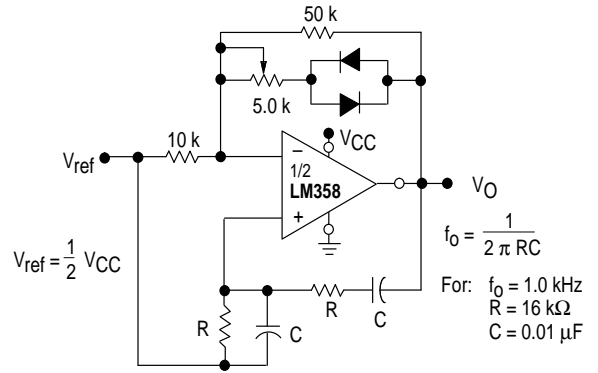


Figure 9. High Impedance Differential Amplifier

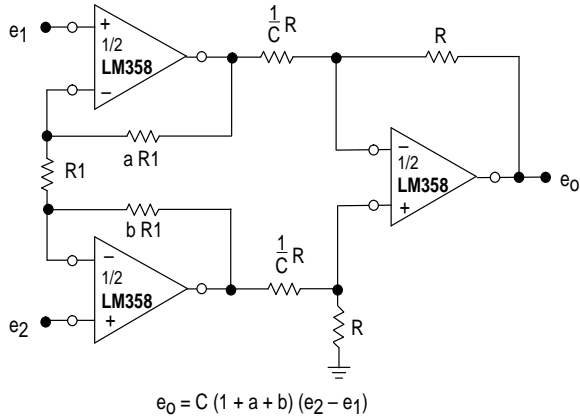


Figure 10. Comparator with Hysteresis

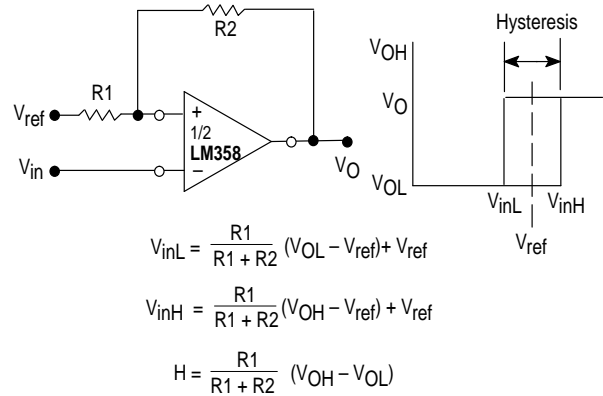


Figure 11. Bi-Quad Filter

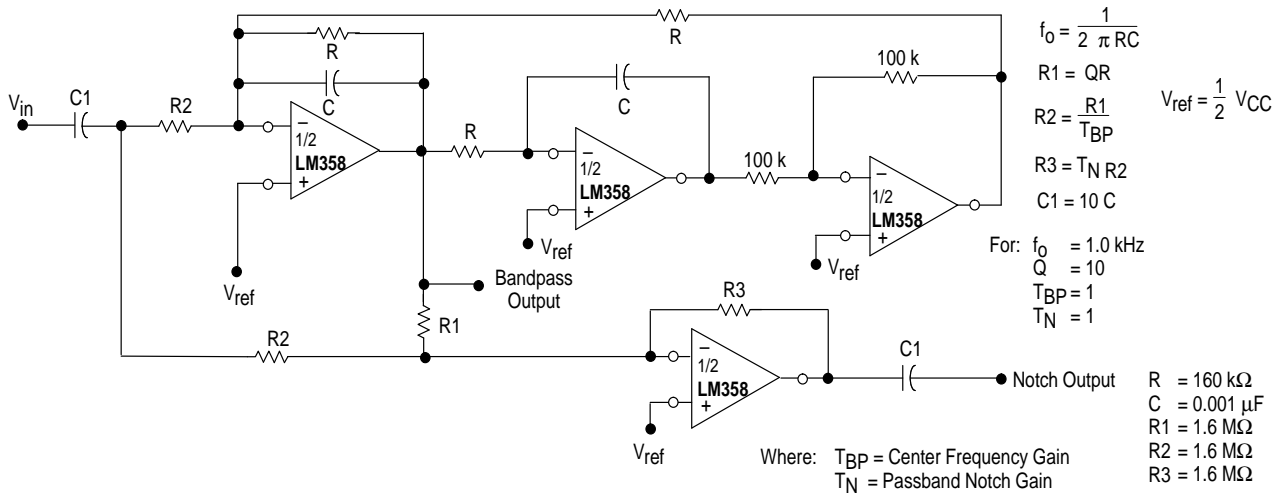
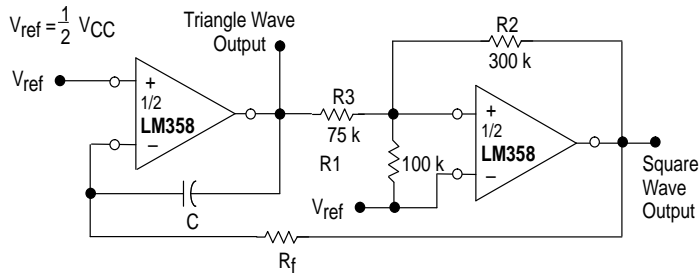
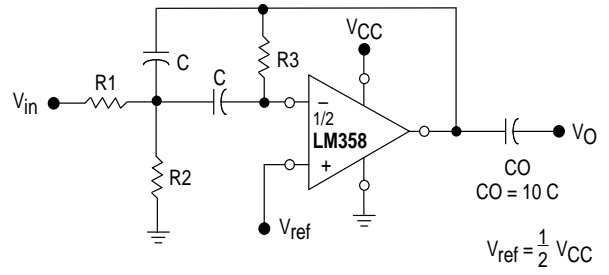


Figure 12. Function Generator



$$f = \frac{R1 + RC}{4 CR_f R1} \quad \text{if, } R3 = \frac{R2 R1}{R2 + R1}$$

Figure 13. Multiple Feedback Bandpass Filter



Given:  $f_0$  = center frequency  
 $A(f_0)$  = gain at center frequency

Choose value  $f_0, C$

$$\text{Then: } R3 = \frac{Q}{\pi f_0 C}$$

$$R1 = \frac{R3}{2 A(f_0)}$$

$$R2 = \frac{R1 R3}{4Q^2 R1 - R3}$$

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

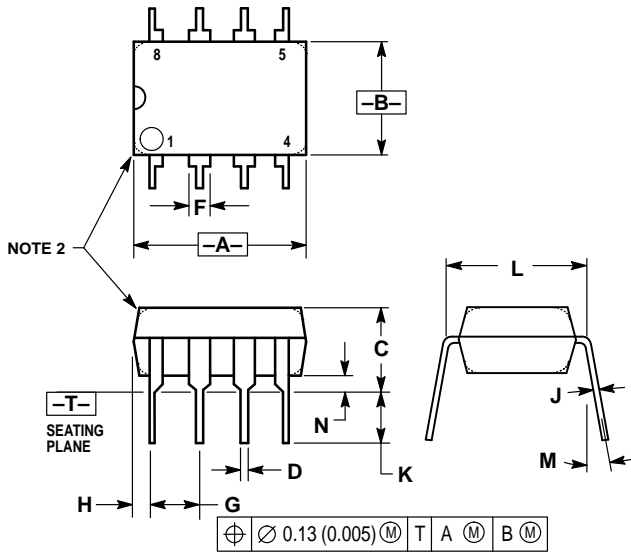
Where  $f_0$  and BW are expressed in Hz.

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

# LM358, LM258, LM2904, LM2904V

## OUTLINE DIMENSIONS

### N SUFFIX PLASTIC PACKAGE CASE 626-05 ISSUE K

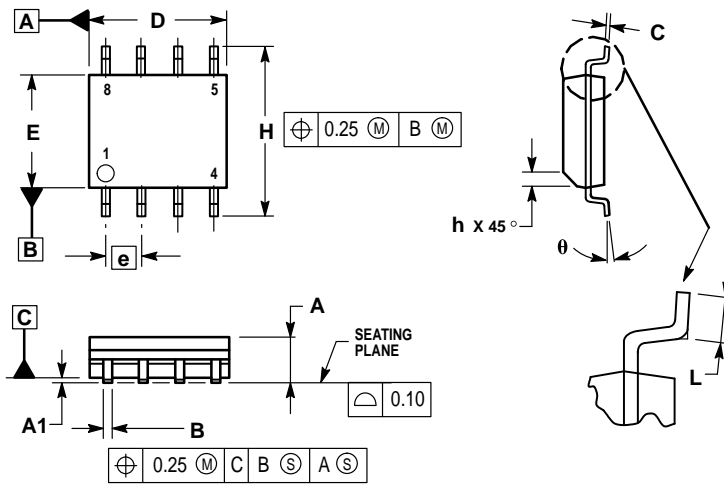


NOTES:

1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	10°		10°	
N	0.76	1.01	0.030	0.040

### D SUFFIX PLASTIC PACKAGE CASE 751-05 (SO-8) ISSUE R




NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS ARE IN MILLIMETERS.
3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE MOLD PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS	
	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.35	0.49
C	0.18	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.25
θ	0° 7°	

# LM358, LM258, LM2904, LM2904V

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and  are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

#### How to reach us:

**USA/EUROPE/Locations Not Listed:** Motorola Literature Distribution;  
P.O. Box 20912; Phoenix, Arizona 85036. 1-800-441-2447 or 602-303-5454

**MFAX:** RMFAX0@email.sps.mot.com – TOUCHTONE 602-244-6609  
**INTERNET:** <http://Design-NET.com>

**JAPAN:** Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center,  
3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 03-81-3521-8315

**ASIA/PACIFIC:** Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,  
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298



**MOTOROLA**



LM358/D

