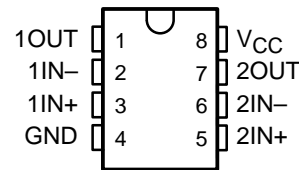


# LM158, LM158A, LM258, LM358 LM258A, LM358A, LM358Y, LM2904, LM2904Q DUAL OPERATIONAL AMPLIFIERS

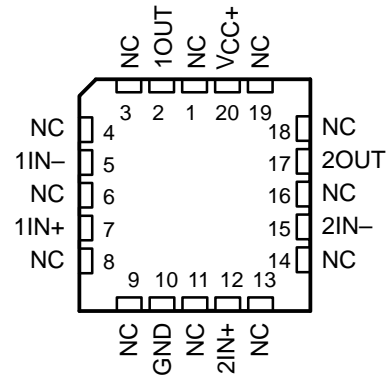
SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

- **Wide Range of Supply Voltages:**  
Single Supply . . . 3 V to 30 V  
(LM2904 and LM2904Q  
3 V to 26 V) or Dual Supplies
- **Low Supply Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground Allowing Direct Sensing Near Ground**
- **Low Input Bias and Offset Parameters:**  
Input Offset Voltage . . . 3 mV Typ  
A Versions . . . 2 mV Typ  
Input Offset Current . . . 2 nA Typ  
Input Bias Current . . . 20 nA Typ  
A Versions . . . 15 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . .  $\pm 32$  V ( $\pm 26$  V for LM2904 and LM2904Q)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

D, DB, JG, P, OR PW PACKAGE  
(TOP VIEW)



LM158, LM158A . . . FK PACKAGE  
(TOP VIEW)



NC – No internal connection

## description

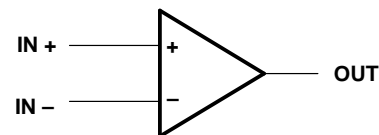
These devices consist of two independent, high-gain, frequency-compensated operational amplifiers that were designed specifically to operate from a single supply over a wide range of voltages. Operation from split supply is also possible so long as the difference between the two supplies is 3 V to 30 V (3 V to 26 V for the LM2904 and LM2904Q), and  $V_{CC}$  is at least 1.5 V more positive than the input common-mode voltage. The low supply current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, these devices can be operated directly off of the standard 5-V supply that is used in digital systems and will easily provide the required interface electronics without requiring additional  $\pm 5$ -V supplies.

The LM2904Q is manufactured to demanding automotive requirements.

The LM158 and LM158A are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The LM258 and LM258A are characterized for operation from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , the LM358 and LM358A from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ , and the LM2904 and LM2904Q from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

## symbol (each amplifier)



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1996, Texas Instruments Incorporated  
On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

# LM158, LM158A, LM258, LM358 LM258A, LM358A, LM358Y, LM2904, LM2904Q DUAL OPERATIONAL AMPLIFIERS

SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

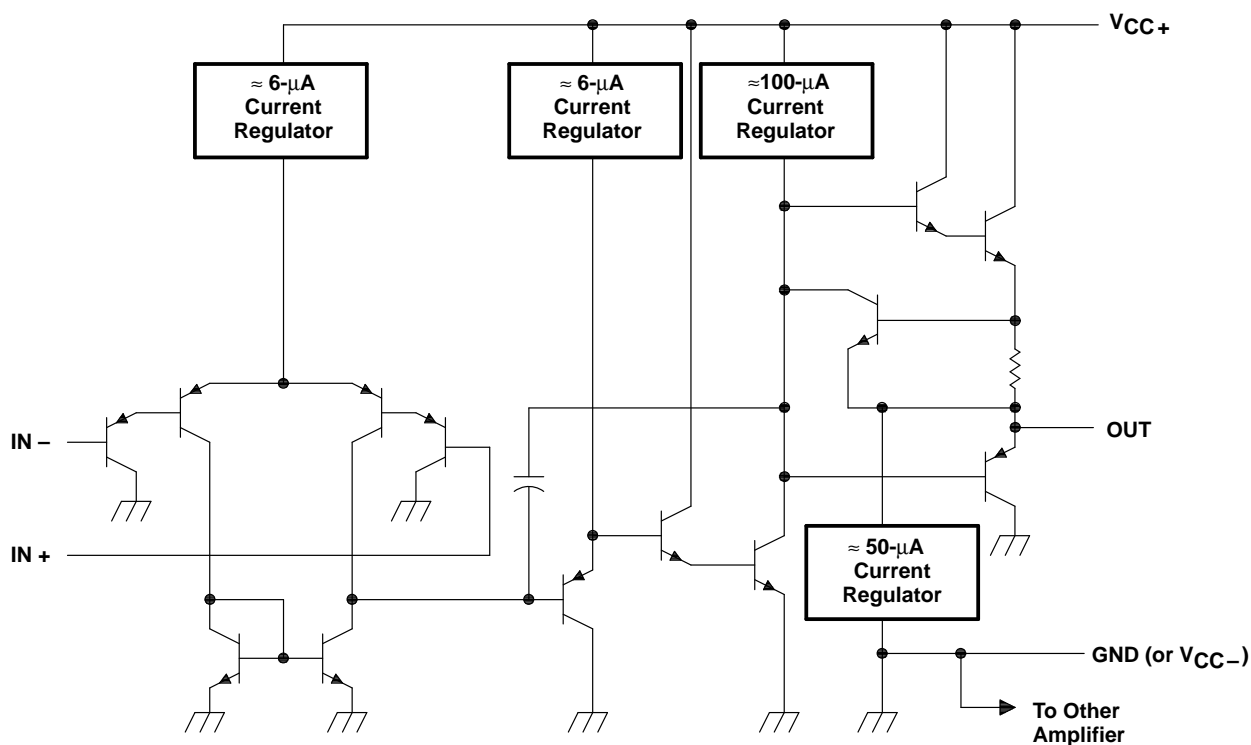
## AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGED DEVICES						CHIP FORM (Y)
		SMALL OUTLINE (D) <sup>†</sup>	SSOP (DB) <sup>‡</sup>	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW) <sup>‡</sup>	
0°C to 70°C	7 mV 3 mV	LM358D	LM358DB			LM358P LM358AP	LM358PW	LM358Y
-25°C to 85°C	5 mV 3 mV	LM258D				LM258P LM258AP		
-40°C to 125°C	7 mV	LM2904D LM2904QD	LM2904DB —			LM2904P LM2904QP	LM2904PW —	
-55°C to 125°C	5 mV 2 mV	LM158D		LM158FK LM158AFK	LM158JG LM158AJG	LM158P		

<sup>†</sup> The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM358DR).

<sup>‡</sup> The DB and PW packages are only available left-end taped and reeled. Add the suffix LE to the device type (e.g., LM358DBLE).

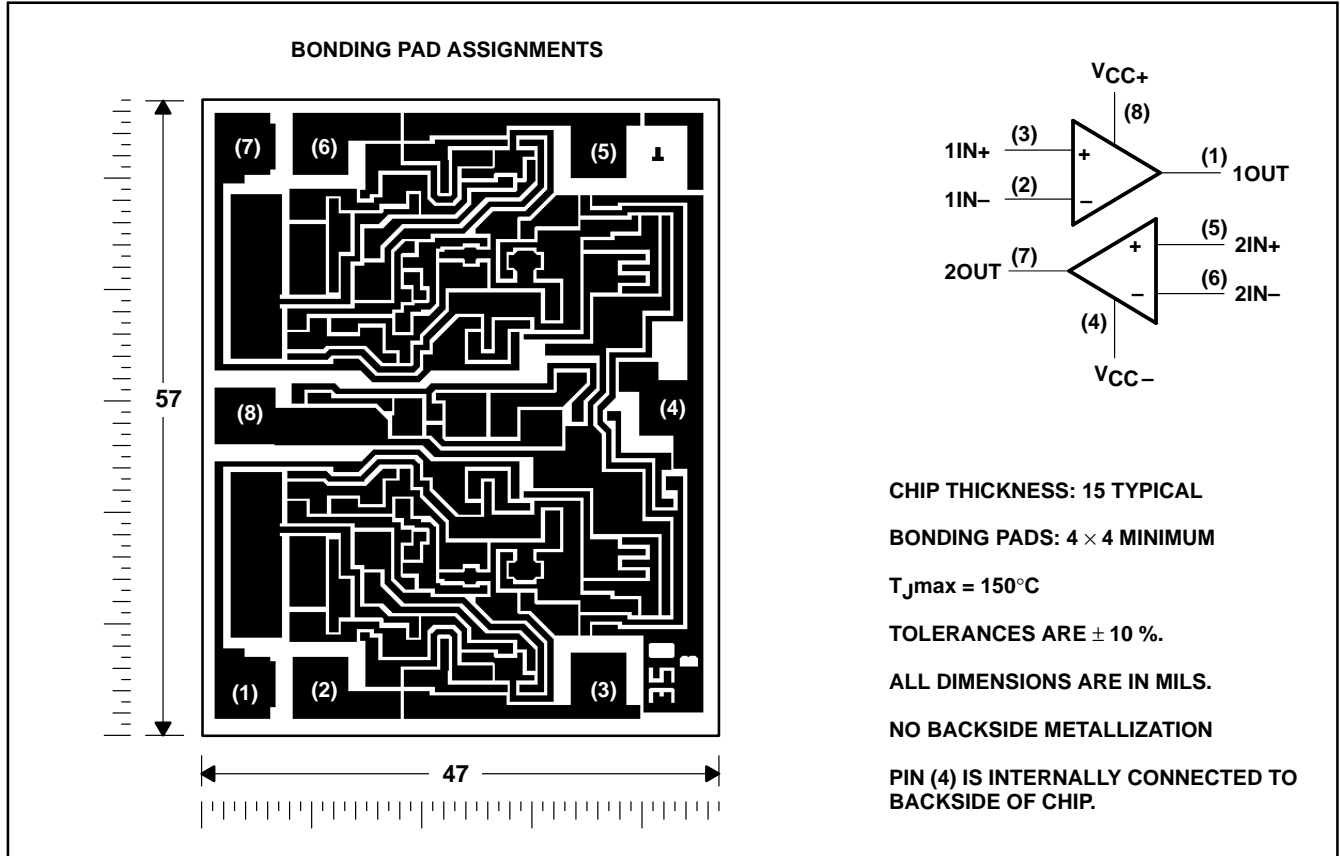
## schematic (each amplifier)



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	7
Transistors	51
Capacitors	2

**LM358Y chip information**

These chips, when properly assembled, display characteristics similar to the LM358. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



**LM158, LM158A, LM258, LM358  
LM258A, LM358A, LM358Y, LM2904, LM2904Q  
DUAL OPERATIONAL AMPLIFIERS**

SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)**

		LM158, LM158A LM258, LM258A LM358, LM358A	LM2904, LM2904Q	UNIT
Supply voltage $V_{CC}$ (see Note 1)		32	26	V
Differential input voltage (see Note 2)		$\pm 32$	$\pm 26$	V
Input voltage (either input)		-0.3 to 32	-0.3 to 26	V
Duration of output short circuit (one amplifier) to ground at (or below) 25°C free-air temperature ( $V_{CC} \leq 15$ V) (see Note 3)		unlimited	unlimited	
Continuous total dissipation		See Dissipation Rating Table		
Operating free-air temperature range	LM158, LM158A	-55 to 125		°C
	LM258, LM258A	-25 to 85		
	LM358, LM358A	0 to 70		
	LM2904, LM2904Q		-40 to 125	
Storage temperature range		-65 to 150	-65 to 150	°C
Case temperature for 60 seconds	FK package	260		°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, DB, P, or PW package	260	260	°C

- NOTES: 1. All voltage values, except differential voltages and  $V_{CC}$  specified for measurement of  $I_{OS}$ , are with respect to the network ground terminal.  
 2. Differential voltages are at  $IN+$  with respect to  $IN-$ .  
 3. Short circuits from outputs to  $V_{CC}$  can cause excessive heating and eventual destruction.

**DISSIPATION RATING TABLE**

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
DB	525 mW	4.2 mW/°C	336 mW	273 mW	–
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW
PW	525 mW	4.2 mW/°C	336 mW	273 mW	–



**LM158, LM158A, LM258, LM358**  
**LM258A, LM358A, LM358Y, LM2904, LM2904Q**  
**DUAL OPERATIONAL AMPLIFIERS**

SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS†	T <sub>A</sub> ‡	LM158, LM258		LM358		LM2904, LM2904Q		UNIT
			MIN	TYP§	MAX	MIN	TYP§	MAX	
V <sub>IO</sub>	V <sub>CC</sub> = 5 V to MAX, V <sub>IC</sub> = V <sub>ICR</sub> min, V <sub>O</sub> = 1.4 V	25°C	3	5	3	7	3	7	mV
α <sub>VIO</sub>		Full range		7		9		10	
I <sub>IO</sub>	V <sub>O</sub> = 1.4 V	Full range	7		7		7		μV/°C
α <sub>IIO</sub>		25°C	2	30	2	50	2	50	nA
I <sub>IO</sub>		Full range	100		10	150	10	300	
α <sub>IIO</sub>		Full range		10		10		10	pA/°C
I <sub>IB</sub>	V <sub>O</sub> = 1.4 V	25°C	-20	-150	-20	-250	-20	-250	nA
I <sub>IB</sub>		Full range	-300		-500		-500		
V <sub>ICR</sub>	V <sub>CC</sub> = 5 V to MAX	25°C	0 to V <sub>CC</sub> - 1.5		0 to V <sub>CC</sub> - 1.5		0 to V <sub>CC</sub> - 1.5		V
V <sub>ICR</sub>		Full range	0 to V <sub>CC</sub> - 2		0 to V <sub>CC</sub> - 2		0 to V <sub>CC</sub> - 2		
V <sub>OH</sub>	R <sub>L</sub> ≥ 2 kΩ	25°C	V <sub>CC</sub> - 1.5		V <sub>CC</sub> - 1.5		V <sub>CC</sub> - 1.5		V
V <sub>OH</sub>	R <sub>L</sub> ≥ 10 kΩ	25°C							
V <sub>OH</sub>	V <sub>CC</sub> = MAX, R <sub>L</sub> = 2 kΩ	Full range	26		26		26		
V <sub>OH</sub>	V <sub>CC</sub> = MAX, R <sub>L</sub> ≥ 10 kΩ	Full range	27	28	27	28	23	24	
V <sub>OL</sub>	R <sub>L</sub> ≤ 10 kΩ	Full range	5	20	5	20	5	20	mV
A <sub>V/D</sub>	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 1 V to 11 V, R <sub>L</sub> = ≥ 2 kΩ	25°C	50	100	25	100	25	100	V/mV
A <sub>V/D</sub>		Full range	25		15		15		
CMRR	V <sub>CC</sub> = 5 V to MAX, V <sub>IC</sub> = V <sub>ICR</sub> min	25°C	70	80	65	80	50	80	dB
k <sub>SVR</sub>	V <sub>CC</sub> = 5 V to MAX	25°C	65	100	65	100	65	100	dB
V <sub>O1</sub> /V <sub>O2</sub>	f = 1 kHz to 20 kHz	25°C	120		120		120		dB

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX V<sub>CC</sub> for testing purposes is 26 V for LM2904 and 30 V for others.

‡ Full range is -55°C to 125°C for LM158, -25°C to 85°C for LM258, 0°C to 70°C for LM358, and -40°C to 125°C for LM2904 and LM2904Q.

§ All typical values are at T<sub>A</sub> = 25°C.



**LM158, LM158A, LM258, LM358**  
**LM258A, LM358A, LM358Y, LM2904, LM2904Q**  
**DUAL OPERATIONAL AMPLIFIERS**  
 SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS†	TA‡	LM158A		LM258A		LM358A		UNIT
			MIN	TYP§	MAX	MIN	TYP§	MAX	
V <sub>IO</sub> Input offset voltage	V <sub>CC</sub> = 5 V to 30 V, V <sub>IC</sub> = V <sub>ICR</sub> min, V <sub>O</sub> = 1.4 V	25°C	2	2	3	2	2	3	mV
		Full range	4		4			5	
α <sub>VIO</sub> Average temperature coefficient of input offset voltage	V <sub>O</sub> = 1.4 V	25°C	7	15*	15	7	7	20	μV/°C
		Full range	2	10	30	2	2	30	nA
I <sub>IO</sub> Input offset current	V <sub>O</sub> = 1.4 V	25°C	10	200	200	10	10	300	pA/°C
		Full range	-15	-50	-100	-15	-15	-100	-200
V <sub>ICR</sub> Common-mode input voltage range	V <sub>CC</sub> = 30 V	25°C	0 to V <sub>CC</sub> -1.5			0 to V <sub>CC</sub> -1.5			V
		Full range	0 to V <sub>CC</sub> -2			0 to V <sub>CC</sub> -2			
V <sub>OH</sub> High-level output voltage	R <sub>L</sub> ≥ 2 kΩ V <sub>CC</sub> = 30 V, R <sub>L</sub> = 2 kΩ	25°C	26			26			V
		Full range	27	28	28	27	28	28	
V <sub>OL</sub> Low-level output voltage	R <sub>L</sub> ≤ 10 kΩ V <sub>CC</sub> = 30 V, R <sub>L</sub> ≥ 10 kΩ	25°C	5	20	20	5	20	20	mV
		Full range	50	100	100	50	100	100	V/mV
A <sub>VD</sub> Large-signal differential voltage amplification	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 1 V to 11 V, R <sub>L</sub> = ≥ 2 kΩ	25°C	25			25			
CMRR Common-mode rejection ratio		25°C	70	80	80	70	80	80	dB
kSVR Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )		25°C	65	100	100	65	100	100	dB
V <sub>O1</sub> /V <sub>O2</sub> Crosstalk attenuation	f = 1 kHz to 20 kHz	25°C	120			120			dB

\*On products compliant to MIL-PRF-38535, this parameter is not production tested.

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified.

‡ Full range is -55°C to 125°C for LM158A, -25°C to 85°C for LM258A, and 0°C to 70°C for LM358A.

§ All typical values are at T<sub>A</sub> = 25°C.



electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted) (continued)

PARAMETER	TEST CONDITION <sup>†</sup>	T <sub>A</sub> <sup>‡</sup>	LM158, LM258		LM358		LM2904, LM2904Q		UNIT
			MIN	TYP <sup>§</sup>	MAX	MIN	TYP <sup>§</sup>	MAX	
I <sub>O</sub> Output current	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 0 V <sub>ID</sub> = 1 V,	25°C	-20	-30	-20	-30	-20	-30	mA
		Full range	-10		-10		-10		
		25°C	10	20	10	20	10	20	
I <sub>OS</sub> Short-circuit output current	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 15 V V <sub>ID</sub> = -1 V, V <sub>O</sub> = 200 mV	25°C	5		5		5		μA
		Full range	12	30	12	30	12	30	
		25°C	±40	±60	±40	±60	±40	±60	
I <sub>CC</sub> Supply current (two amplifiers)	V <sub>CC</sub> = 5 V, V <sub>O</sub> = 0 GND at -5 V,	25°C	0.7	1.2	0.7	1.2	0.7	1.2	mA
V <sub>CC</sub> = MAX, No load	Full range	Full range	1	2	1	2	1	2	

<sup>†</sup> All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX V<sub>CC</sub> for testing purposes is 26 V for LM 2904 and 30 V for others.

<sup>‡</sup> Full range is -55°C to 125°C for LM158, -25°C to 85°C for LM258, 0°C to 70°C for LM358, and -40°C to 125°C for LM2904 and LM2904Q.

<sup>§</sup> All typical values are at T<sub>A</sub> = 25°C.

**LM158, LM158A, LM258, LM358**  
**LM258A, LM358A, LM358Y, LM2904, LM2904Q**  
**DUAL OPERATIONAL AMPLIFIERS**

SLOS068B – JUNE 1976 – REVISED NOVEMBER 1996

**electrical characteristics  $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS†	LM358Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}$ , $V_{IC} = V_{ICRmin}$ , $V_O = 1.4\text{ V}$		3	7	mV
$I_{IO}$ Input offset current			2	50	nA
$I_{IB}$ Input bias current			-20	-250	nA
$V_{ICR}$ Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$		0 to $V_{CC}-1.5$		V
$V_{OH+}$ High-level output voltage	$R_L \geq 10\text{ k}\Omega$		$V_{CC}-1.5$		V
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1\text{ V to }11\text{ V}$ , $R_L = \geq 2\text{ k}\Omega$	15	100		V/mV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR min}$	65	80		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )		65	100		dB
$I_O$ Output current	$V_{CC} = 15\text{ V}$ , $V_{ID} = 1\text{ V}$ , $V_O = 0$	-20	-30	-60	mA
	$V_{CC} = 15\text{ V}$ , $V_{ID} = -1\text{ V}$ , $V_O = 15\text{ V}$	10	20		
	$V_{ID} = 1\text{ V}$ , $V_O = 200\text{ mV}$	12	30		
$I_{OS}$ Short-circuit output current	$V_{CC}$ at 5 V, GND at -5 V, $V_O = 0$		$\pm 40$	$\pm 60$	mA
$I_{CC}$ Supply current (four amplifiers)	$V_O = 2.5\text{ V}$ , No load		0.7	1.2	mA
	$V_{CC} = MAX$ , $V_O = 0.5\text{ V}$ , No load		1	2	

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX  $V_{CC}$  for testing purposes is 30 V.





## **IMPORTANT NOTICE**

Texas Instruments (TI) reserves the right to make changes to its products or to discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information being relied on is current.

TI warrants performance of its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Certain applications using semiconductor products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications").

**TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.**

Inclusion of TI products in such applications is understood to be fully at the risk of the customer. Use of TI products in such applications requires the written approval of an appropriate TI officer. Questions concerning potential risk applications should be directed to TI through a local SC sales office.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein. Nor does TI warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used.