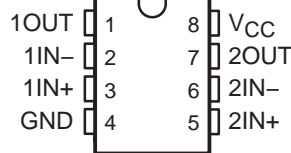


# LM158, LM158A, LM258, LM258A LM358, LM358A, LM2904, LM2904V DUAL OPERATIONAL AMPLIFIERS

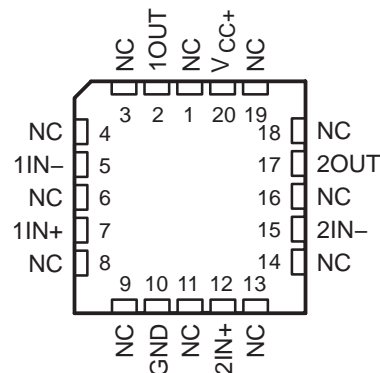
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- **Wide Supply Range:**
  - Single Supply . . . 3 V to 32 V  
(26 V for LM2904)
  - or Dual Supplies . . .  $\pm 1.5$  V to  $\pm 16$  V  
( $\pm 13$  V for LM2904)
- **Low Supply-Current Drain, Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode 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 . . . 32 V (26 V for LM2904)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

LM158, LM158A . . . JG PACKAGE  
LM258, LM258A . . . D, DGK, OR P PACKAGE  
LM358 . . . D, DGK, P, PS, OR PW PACKAGE  
LM358A . . . D, DGK, P, OR PW PACKAGE  
LM2904 . . . D, DGK, P, PS, OR PW PACKAGE  
(TOP VIEW)



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



NC – No internal connection

## description/ordering information

These devices consist of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2904), 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 implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily can provide the required interface electronics without additional  $\pm 5$ -V supplies.



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**

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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, LM258A  
LM358, LM358A, LM2904, LM2904V  
DUAL OPERATIONAL AMPLIFIERS**

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**description/ordering information (continued)**

**ORDERING INFORMATION**

$T_A$	$V_{IOmax}$ AT 25°C	MAX TESTED $V_{CC}$	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	7 mV	30 V	PDIP (P)	Tube of 50	LM358P	LM358P
			SOIC (D)	Tube of 75	LM358D	LM358
				Reel of 2500	LM358DR	
			SOP (PS)	Reel of 2000	LM358PSR	L358
			TSSOP (PW)	Tube of 150	LM358PW	L358
	Reel of 2000	LM358PWR				
	3 mV	30 V	MSOP/VSSOP (DGK)	Reel of 2500	LM358DGKR	M5_‡
			PDIP (P)	Tube of 50	LM358AP	LM358AP
				Tube of 75	LM358AD	
			SOIC (D)	Reel of 2500	LM358ADR	LM358A
Tube of 150				LM358APW		
TSSOP (PW)	Reel of 2000	LM358APWR	L358A			
MSOP/VSSOP (DGK)	Reel of 2500	LM358ADGKR	M6_‡			
-25°C to 85°C	5 mV	30 V	PDIP (P)	Tube of 50	LM258P	LM258P
			SOIC (D)	Tube of 75	LM258D	LM258
				Reel of 2500	LM258DR	
	MSOP/VSSOP (DGK)	Reel of 2500	LM258DGKR	M2_‡		
	3 mV	30 V	PDIP (P)	Tube of 50	LM258AP	LM258AP
			SOIC (D)	Tube of 75	LM258AD	LM258A
Reel of 2500				LM258ADR		
MSOP/VSSOP (DGK)	Reel of 2500	LM258ADGKR	M3_‡			
-40°C to 125°C	7 mV	26 V	PDIP (P)	Tube of 50	LM2904P	LM2904P
			SOIC (D)	Tube of 75	LM2904D	LM2904
				Reel of 2500	LM2904DR	
			SOP (PS)	Reel of 2000	LM2904PSR	L2904
			TSSOP (PW)	Tube of 150	LM2904PW	L2904
	Reel of 2000	LM2904PWR				
	MSOP/VSSOP (DGK)	Reel of 2500	LM2904DGKR	MB_‡		
	7 mV	32 V	SOIC (D)	Reel of 2500	LM2904VQDR	L2904V
			TSSOP (PW)	Reel of 2000	LM2904VQPWR	L2904V
	2 mV	32 V	SOIC (D)	Reel of 2500	LM2904AVQDR	L2904AV
TSSOP (PW)			Reel of 2000	LM2904AVQPWR	L2904AV	
-55°C to 125°C	5 mV	30 V	CDIP (JG)	Tube of 50	LM158JG	LM158JG
			LCCC (FK)	Tube of 55	LM158FK	LM158FK
	2 mV	30 V	CDIP (JG)	Tube of 50	LM158AJG	LM158AJG
			LCCC (FK)	Tube of 55	LM158AFK	LM158AFK

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

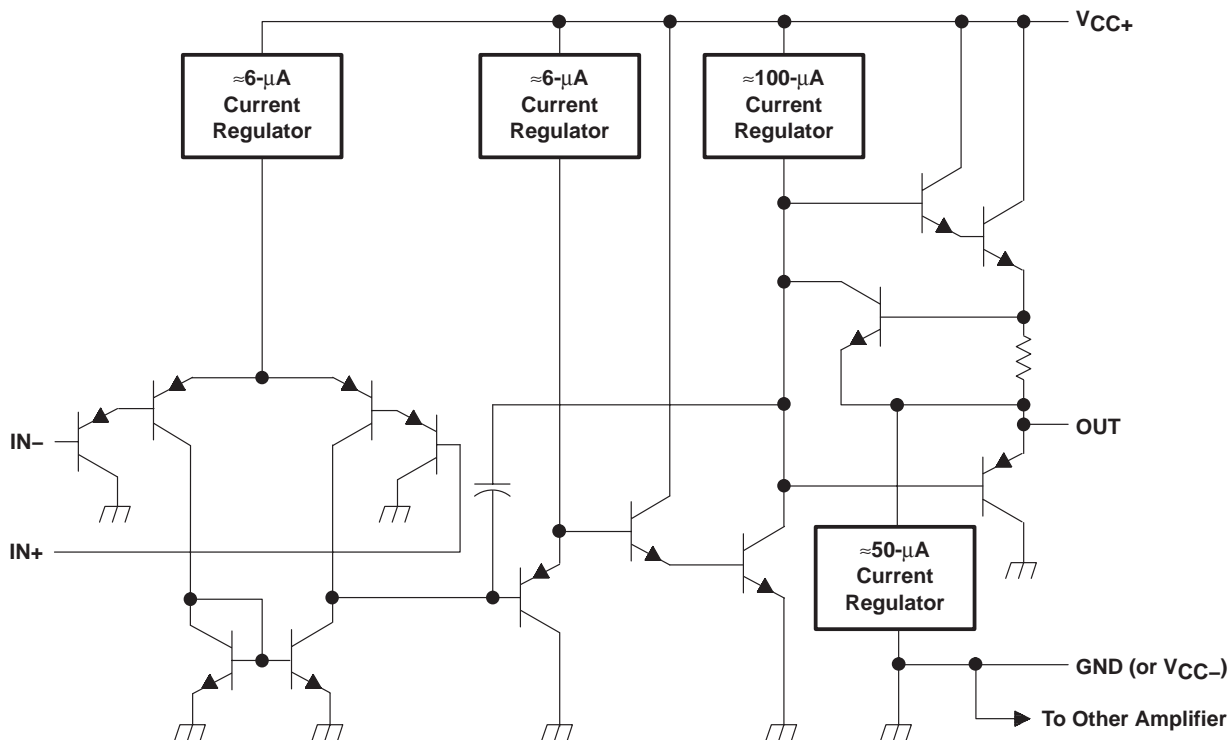
‡ The actual top-side marking has one additional character that designates the assembly/test site.



symbol (each amplifier)



schematic (each amplifier)



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

**LM158, LM158A, LM258, LM258A  
LM358, LM358A, LM2904, LM2904V  
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**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

		LM158, LM158A LM258, LM258A LM358, LM358A LM2904V	LM2904	UNIT
Supply voltage, $V_{CC}$ (see Note 1)		±16 or 32	±13 or 26	V
Differential input voltage, $V_{ID}$ (see Note 2)		±32	±26	V
Input voltage, $V_I$ (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	
Package thermal impedance, $\theta_{JA}$ (see Notes 4 and 5)	D package	97	97	°C/W
	DGK package	172	172	
	P package	85	85	
	PS package	95	95	
	PW package	149	149	
Package thermal impedance, $\theta_{JC}$ (see Notes 6 and 7)	FK package	5.61		°C/W
	JG package	14.5		
Operating free-air temperature range, $T_A$	LM158, LM158A	-55 to 125		°C
	LM258, LM258A	-25 to 85		
	LM358, LM358A	0 to 70		
	LM2904	-40 to 125	-40 to 125	
Operating virtual junction temperature, $T_J$		150	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
Storage temperature range, $T_{stg}$		-65 to 150	-65 to 150	°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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.
4. Maximum power dissipation is a function of  $T_J(max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
5. The package thermal impedance is calculated in accordance with JESD 51-7.
6. Maximum power dissipation is a function of  $T_J(max)$ ,  $\theta_{JC}$ , and  $T_C$ . The maximum allowable power dissipation at any allowable case temperature is  $P_D = (T_J(max) - T_C)/\theta_{JC}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
7. The package thermal impedance is calculated in accordance with MIL-STD-883.



**LM158, LM158A, LM258, LM258A**  
**LM358, LM358A, LM2904, LM2904V**  
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**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONST	$T_A$ ‡	LM158 LM258			LM358			UNIT	
			MIN	TYP§	MAX	MIN	TYP§	MAX		
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}$ , $V_{IC} = V_{ICR(\text{min})}$ , $V_O = 1.4\text{ V}$	25°C	3		5	3		7	mV	
		Full range			7			9		
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage		Full range		7			7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C	2		30	2		50	nA	
		Full range			100			150		
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current		Full range		10			10		$\text{pA}/^\circ\text{C}$	
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C	-20		-150	-20		-250	nA	
		Full range			-300			-500		
$V_{ICR}$ Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	25°C	0 to		$V_{CC} - 1.5$	0 to		$V_{CC} - 1.5$	V	
		Full range	0 to		$V_{CC} - 2$	0 to		$V_{CC} - 2$		
$V_{OH}$ High-level output voltage	$R_L \geq 2\text{ k}\Omega$	25°C	$V_{CC} - 1.5$			$V_{CC} - 1.5$			V	
		25°C	$V_{CC} - 1.5$			$V_{CC} - 1.5$				
	$V_{CC} = \text{MAX}$	$R_L = 2\text{ k}\Omega$	Full range	26			26			
		$R_L \geq 10\text{ k}\Omega$	Full range	27		28	27			28
$V_{OL}$ Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5		20	5		20	mV	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1\text{ V to }11\text{ V}$ , $R_L \geq 2\text{ k}\Omega$	25°C	50		100	25		100	V/mV	
		Full range	25			15				
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX}$ , $V_{IC} = V_{ICR(\text{min})}$	25°C	70		80	65		80	dB	
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{CC} = 5\text{ V to MAX}$	25°C	65		100	65		100	dB	
$V_{O1}/V_{O2}$ Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120			120			dB	
$I_O$ Output current	$V_{CC} = 15\text{ V}$ , $V_{ID} = 1\text{ V}$ , $V_O = 0$	Source	25°C	-20		-30	-20		-30	mA
			Full range	-10			-10			
	Sink	25°C	10		20	10		20		
		Full range	5			5				
$I_O$ Output current	$V_{ID} = -1\text{ V}$ , $V_O = 200\text{ mV}$	25°C	12		30	12		30	$\mu\text{A}$	
$I_{OS}$ Short-circuit output current	$V_{CC}$ at 5 V, GND at -5 V, $V_O = 0$	25°C	$\pm 40$		$\pm 60$	$\pm 40$		$\pm 60$	mA	
$I_{CC}$ Supply current (two amplifiers)	$V_O = 2.5\text{ V}$ , No load	Full range	0.7		1.2	0.7		1.2	mA	
	$V_{CC} = \text{MAX}$ , $V_O = 0.5\text{ V}$ , No load	Full range	1		2	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 26 V for the LM2904 and 30 V for others.

‡ Full range is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for LM158,  $-25^\circ\text{C}$  to  $85^\circ\text{C}$  for LM258,  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for LM358, and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for LM2904.

§ All typical values are at  $T_A = 25^\circ\text{C}$ .



**LM158, LM158A, LM258, LM258A  
LM358, LM358A, LM2904, LM2904V  
DUAL OPERATIONAL AMPLIFIERS**

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

PARAMETER	TEST CONDITIONS†		$T_A$ ‡	LM2904			UNIT
				MIN	TYP§	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX,}$ $V_{IC} = V_{ICR(min)},$ $V_O = 1.4\text{ V}$	Non-A devices	25°C	3	7	mV	
			Full range	10			
		A-suffix devices	25°C	1	2		
			Full range	4			
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage			Full range	7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	Non-V device	25°C	2	50	nA	
			Full range	300			
		V-suffix device	25°C	2	50		
			Full range	150			
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current			Full range	10		$\text{pA}/^\circ\text{C}$	
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$		25°C	-20	-250	nA	
			Full range	-500			
$V_{ICR}$ Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$		25°C	0 to $V_{CC} - 1.5$		V	
			Full range	0 to $V_{CC} - 2$			
$V_{OH}$ High-level output voltage	$R_L \geq 10\text{ k}\Omega$		25°C	$V_{CC} - 1.5$		V	
		$V_{CC} = \text{MAX,}$ Non-V device	$R_L = 2\text{ k}\Omega$	Full range	22		
			$R_L \geq 10\text{ k}\Omega$	Full range	23		24
		$V_{CC} = \text{MAX,}$ V-suffix device	$R_L = 2\text{ k}\Omega$	Full range	26		
$R_L \geq 10\text{ k}\Omega$	Full range		27	28			
$V_{OL}$ Low-level output voltage	$R_L \leq 10\text{ k}\Omega$		Full range	5	20	mV	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V, } V_O = 1\text{ V to } 11\text{ V,}$ $R_L \geq 2\text{ k}\Omega$		25°C	25	100	V/mV	
			Full range	15			
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX,}$ $V_{IC} = V_{ICR(min)}$	Non-V device	25°C	50	80	dB	
		V-suffix device	25°C	65	80		
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{CC} = 5\text{ V to MAX}$		25°C	65	100	dB	
$V_{O1}/V_{O2}$ Crosstalk attenuation	$f = 1\text{ kHz to } 20\text{ kHz}$		25°C	120		dB	
$I_O$ Output current	$V_{CC} = 15\text{ V,}$ $V_{ID} = 1\text{ V, } V_O = 0$	Source	25°C	-20	-30	mA	
			Full range	-10		mA	
	$V_{CC} = 15\text{ V,}$ $V_{ID} = -1\text{ V,}$ $V_O = 15\text{ V}$	Sink	25°C	10	20	mA	
			Full range	5		mA	
	$V_{ID} = -1\text{ V,}$ $V_O = 200\text{ mV}$	Non-V device	25°C	30		$\mu\text{A}$	
		V-suffix device	25°C	12	40		
$I_{OS}$ Short-circuit output current	$V_{CC}$ at 5 V, GND at -5 V, $V_O = 0$		25°C	$\pm 40$	$\pm 60$	mA	
$I_{CC}$ Supply current (two amplifiers)	$V_O = 2.5\text{ V, No load}$		Full range	0.7	1.2	mA	
	$V_{CC} = \text{MAX, } V_O = 0.5\text{ V, No load}$		Full range	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 26 V for the LM2904, 32 V for the LM2904V, and 30 V for others.

‡ Full range is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for LM158,  $-25^\circ\text{C}$  to  $85^\circ\text{C}$  for LM258,  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for LM358, and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for LM2904.

§ All typical values are at  $T_A = 25^\circ\text{C}$ .



**LM158, LM158A, LM258, LM258A**  
**LM358, LM358A, LM2904, LM2904V**  
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**electrical characteristics at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONST	$T_A$ ‡	LM158A			LM258A			UNIT	
			MIN	TYP§	MAX	MIN	TYP§	MAX		
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$ , $V_{IC} = V_{ICR(\text{min})}$ , $V_O = 1.4\text{ V}$	25°C	2			2 3			mV	
		Full range	4			4				
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage		Full range	7 15*			7 15			$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C	2 10			2 15			nA	
		Full range	30			30				
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current		Full range	10 200			10 200			$\text{pA}/^\circ\text{C}$	
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C	–15 –50			–15 –80			nA	
		Full range	–100			–100				
$V_{ICR}$ Common-mode input voltage range	$V_{CC} = 30\text{ V}$	25°C	0 to $V_{CC} - 1.5$			0 to $V_{CC} - 1.5$			V	
		Full range	0 to $V_{CC} - 2$			0 to $V_{CC} - 2$				
$V_{OH}$ High-level output voltage	$R_L \geq 2\text{ k}\Omega$ $V_{CC} = 30\text{ V}$	25°C	$V_{CC} - 1.5$			$V_{CC} - 1.5$			V	
		Full range	26			26				
			27 28			27 28				
$V_{OL}$ Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5 20			5 20			mV	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1\text{ V to }11\text{ V}$ , $R_L \geq 2\text{ k}\Omega$	25°C	50 100			50 100			V/mV	
		Full range	25			25				
CMRR Common-mode rejection ratio		25°C	70 80			70 80			dB	
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )		25°C	65 100			65 100			dB	
$V_{O1}/V_{O2}$ Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120			120			dB	
$I_O$ Output current	$V_{CC} = 15\text{ V}$ , $V_{ID} = 1\text{ V}$ , $V_O = 0$	Source	25°C	–20 –30 –60			–20 –30 –60			mA
		Full range	–10			–10				
	$V_{CC} = 15\text{ V}$ , $V_{ID} = -1\text{ V}$ , $V_O = 15$	Sink	25°C	10 20			10 20			
		Full range	5			5				
$V_{ID} = -1\text{ V}$ , $V_O = 200\text{ mV}$		25°C	12 30			12 30			$\mu\text{A}$	
$I_{OS}$ Short-circuit output current	$V_{CC}$ at 5 V, GND at –5 V, $V_O = 0$	25°C	$\pm 40 \pm 60$			$\pm 40 \pm 60$			mA	
$I_{CC}$ Supply current (two amplifiers)	$V_O = 2.5\text{ V}$ , No load	Full range	0.7 1.2			0.7 1.2			mA	
	$V_{CC} = \text{MAX}$ , $V_O = 0.5\text{ V}$ , No load	Full range	1 2			1 2				

\*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. MAX  $V_{CC}$  for testing purposes is 26 V for LM2904 and 30 V for others.

‡ 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  $T_A = 25^\circ\text{C}$ .

