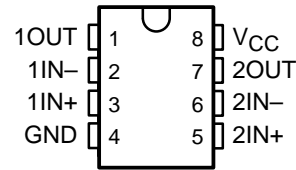


LM158, LM158A, LM258, LM258A LM358, LM358A, LM2904, LM2904Q DUAL OPERATIONAL AMPLIFIERS

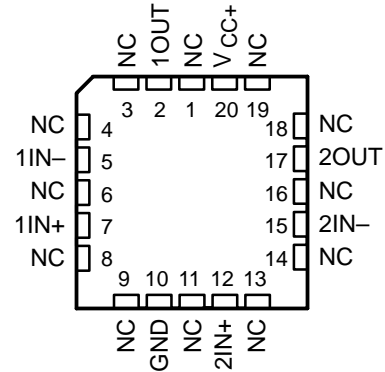
SLOS068D – JUNE 1976 – REVISED SEPTEMBER 2001

- **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 . . . ± 32 V (LM2904 and LM2904Q . . . ± 26 V)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

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



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



NC – No internal connection

description

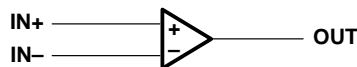
These devices consist of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 30 V (3 V to 26 V for the LM2904 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 from the standard 5-V supply used in digital systems and easily provide the required interface electronics without additional ± 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°C to 125°C . The LM258 and LM258A are characterized for operation from -25°C to 85°C , the LM358 and LM358A from 0°C to 70°C , and the LM2904 and LM2904Q from -40°C to 125°C .

logic diagram (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**

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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.

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LM358, LM358A, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS

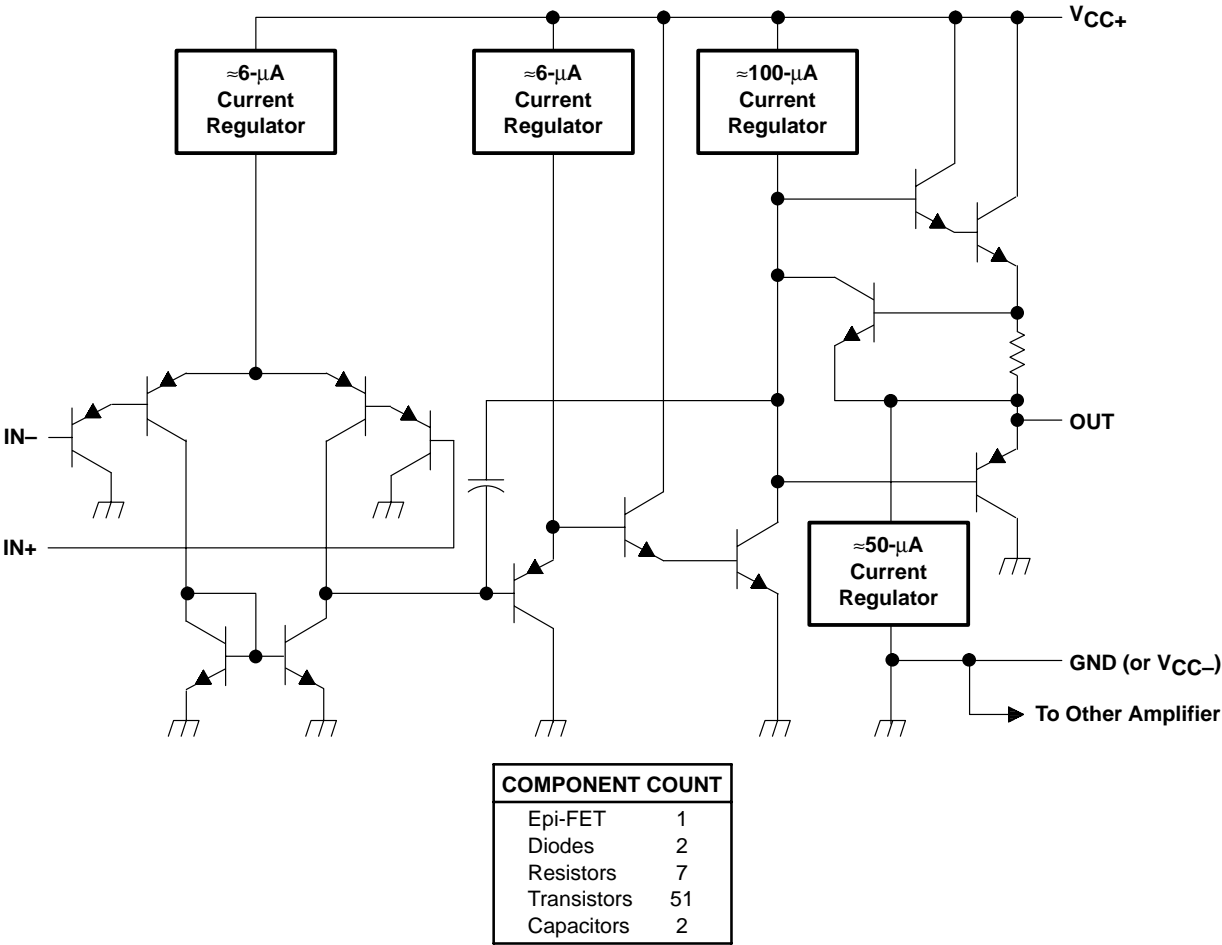
SLOS068D – JUNE 1976 – REVISED SEPTEMBER 2001

AVAILABLE OPTIONS

T _A	V _{IO(max)} AT 25°C	PACKAGED DEVICES				
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)
0°C to 70°C	7 mV	LM358D	—	—	LM358P	LM358PW
	3 mV	—	—	—	LM358AP	—
–25°C to 85°C	5 mV	LM258D	—	—	LM258P	—
	3 mV	—	—	—	LM258AP	—
–40°C to 125°C	7 mV	LM2904D LM2904QD	—	—	LM2904P	LM2904PW
	—	—	—	—	—	—
–55°C to 125°C	5 mV	—	LM158FK	LM158JG	—	—
	2 mV	—	LM158AFK	LM158AJG	—	—

The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM358DR). The PW package is only available taped and reeled.

schematic (each amplifier)



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, 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} ≤ 15 V) (see Note 3)		Unlimited	Unlimited	
Package thermal impedance, θ _{JA} (see Note 4)	D package	97	97	°C
	P package	85	85	
	PW package	149	149	
Continuous total power dissipation		See Dissipation Rating Table		
Operating free-air temperature range, T _A	LM158, LM158A	−55 to 125		°C
	LM258, LM258A	−25 to 85		
	LM358, LM358A	0 to 70		
	LM2904, LM2904Q		−40 to 125	
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, P, or PW package	260	260	°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. The package thermal impedance is calculated in accordance with JESD 51-7.

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
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

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

SLOS068D – JUNE 1976 – REVISED SEPTEMBER 2001

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

PARAMETER		TEST CONDITIONS†		T _A ‡	LM158 LM258			LM358			UNIT
					MIN	TYP§	MAX	MIN	TYP§	MAX	
V _{IO}	Input offset voltage	V _{CC} = 5 V to MAX, V _{IC} = V _{ICR} (min), V _O = 1.4 V		25°C	3	5		3	7	mV	
				Full range	7			9			
α _{V_{IO}}	Average temperature coefficient of input offset voltage			Full range	7			7			μV/°C
I _{IO}	Input offset current	V _O = 1.4 V		25°C	2	30		2	50	nA	
				Full range	100			150			
α _{I_{IO}}	Average temperature coefficient of input offset current			Full range	10			10			pA/°C
I _{IB}	Input bias current	V _O = 1.4 V		25°C	–20	–150		–20	–250	nA	
				Full range	–300			–500			
V _{ICR}	Common-mode input voltage range	V _{CC} = 5 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 ≥ 2 kΩ		25°C	V _{CC} –1.5			V _{CC} –1.5			V
		R _L ≥ 10 kΩ		25°C							
		V _{CC} = MAX	R _L = 2 kΩ	Full range	26			26			
			R _L ≥ 10 kΩ	Full range	27	28		27	28		
V _{OL}	Low-level output voltage	R _L ≤ 10 kΩ		Full range	5	20		5	20	mV	
A _{VD}	Large-signal differential voltage amplification	V _{CC} = 15 V, V _O = 1 V to 11 V, R _L = ≥ 2 kΩ		25°C	50	100		25	100	V/mV	
				Full range	25			15			
CMRR	Common-mode rejection ratio	V _{CC} = 5 V to MAX, V _{IC} = V _{ICR} (min)		25°C	70	80		65	80	dB	
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{CC} = 5 V to MAX		25°C	65	100		65	100	dB	
V _{O1} /V _{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C	120			120			dB
I _O	Output current	V _{CC} = 15 V, V _{ID} = 1 V, V _O = 0		25°C	–20	–30		–20	–30	mA	
				Full range	–10			–10			
		V _{CC} = 15 V, V _{ID} = –1 V, V _O = 15 V		25°C	10	20		10	20		
				Full range	5			5			
		V _{ID} = –1 V, V _O = 200 mV		25°C	12	30		12	30	μA	
I _{OS}	Short-circuit output current	V _{CC} at 5 V, GND at –5 V, V _O = 0		25°C	±40	±60		±40	±60	mA	
I _{CC}	Supply current (two amplifiers)	V _O = 2.5 V, No load		Full range	0.7	1.2		0.7	1.2	mA	
		V _{CC} = MAX, V _O = 0.5 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 LM 2904 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 $T_A = 25^\circ\text{C}$.



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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 LM2904Q			UNIT
					MIN	TYP§	MAX	
V _{IO}	Input offset voltage	V _{CC} = 5 V to MAX, V _{IC} = V _{ICR} (min), V _O = 1.4 V		25°C	3	7	mV	
				Full range	10			
α _{V_{IO}}	Average temperature coefficient of input offset voltage			Full range	7		μV/°C	
I _{IO}	Input offset current	V _O = 1.4 V		25°C	2	50	nA	
				Full range	300			
α _{I_{IO}}	Average temperature coefficient of input offset current			Full range	10		pA/°C	
I _{IB}	Input bias current	V _O = 1.4 V		25°C	–20	–250	nA	
				Full range	–500			
V _{ICR}	Common-mode input voltage range	V _{CC} = 5 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 ≥ 2 kΩ		25°C			V	
		R _L ≥ 10 kΩ		25°C	V _{CC} –1.5			
		V _{CC} = MAX	R _L = 2 kΩ	Full range	26			
			R _L ≥ 10 kΩ	Full range	23	24		
V _{OL}	Low-level output voltage	R _L ≤ 10 kΩ		Full range	5	20	mV	
A _{VD}	Large-signal differential voltage amplification	V _{CC} = 15 V, V _O = 1 V to 11 V, R _L = ≥ 2 kΩ		25°C	25	100	V/mV	
				Full range	15			
CMRR	Common-mode rejection ratio	V _{CC} = 5 V to MAX, V _{IC} = V _{ICR} (min)		25°C	50	80	dB	
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{CC} = 5 V to MAX		25°C	65	100	dB	
V _{O1} /V _{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C	120		dB	
I _O	Output current	V _{CC} = 15 V, V _{ID} = 1 V, V _O = 0		25°C	–20	–30	mA	
				Full range	–10			
		V _{CC} = 15 V, V _{ID} = –1 V, V _O = 15 V		25°C	10	20		
				Full range	5			
		V _{ID} = –1 V, V _O = 200 mV		25°C	30			μA
I _{OS}	Short-circuit output current	V _{CC} at 5 V, GND at –5 V, V _O = 0		25°C	±40	±60	mA	
I _{CC}	Supply current (two amplifiers)	V _O = 2.5 V, No load		Full range	0.7	1.2	mA	
		V _{CC} = MAX, V _O = 0.5 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 LM 2904 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 $T_A = 25^\circ\text{C}$.

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

SLOS068D – JUNE 1976 – REVISED SEPTEMBER 2001

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

PARAMETER	TEST CONDITION†	T_A ‡	LM158A			LM258A			UNIT
			MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to } 30\text{ V}$, $V_{IC} = V_{ICR(\min)}$, $V_O = 1.4\text{ V}$	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		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		–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	$R_L \geq 2\text{ k}\Omega$	25°C			$V_{CC}-1.5$			$V_{CC}-1.5$	V
	$V_{CC} = 30\text{ V}$	$R_L = 2\text{ k}\Omega$			26			26	
		$R_L \geq 10\text{ k}\Omega$			27	28		27	
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range			5	20		5	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	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	25°C		–20	–30	–60		–20	mA
		Full range		–10				–10	
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15$	25°C		10	20			10	
		Full range		5				5	
	$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	25°C		12	30			12	μA
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at –5 V $V_O = 0$	25°C			± 40	± 60		± 40	mA
I_{CC} Supply current (two amplifiers)	$V_O = 2.5\text{ V}$, No load	Full range			0.7	1.2		0.7	mA
	$V_{CC} = \text{MAX}$, $V_O = 0.5\text{ V}$ No load	Full range			1	2		1	

*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 $T_A = 25^\circ\text{C}$.



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

SLOS068D – JUNE 1976 – REVISED SEPTEMBER 2001

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

PARAMETER	TEST CONDITIONS†	T_A ‡	LM358A			UNIT
			MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$, $V_{IC} = V_{ICR(min)}$, $V_O = 1.4\text{ V}$	25°C	2	3		mV
		Full range			5	
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage		Full range	7	20		$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C	2	30		nA
		Full range			75	
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current		Full range	10	300		$\text{pA}/^\circ\text{C}$
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C	–15	–100		nA
		Full range			–200	
V_{ICR} Common-mode input voltage range	$V_{CC} = 30\text{ V}$	25°C	0 to $V_{CC}-1.5$			V
		Full range	0 to $V_{CC}-2$			
V_{OH} High-level output voltage	$R_L \geq 2\text{ k}\Omega$	25°C	$V_{CC}-1.5$			V
	$V_{CC} = 30\text{ V}$	Full range	26			
		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		25°C	65	80		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		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	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	25°C	–20	–30	–60	mA
		Full range	–10			
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	25°C	10	20		
		Full range	5			
	$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	25°C	30			μA
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at –5 V $V_O = 0$	25°C	±40	±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 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 $T_A = 25^\circ\text{C}$.



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