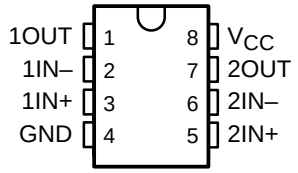
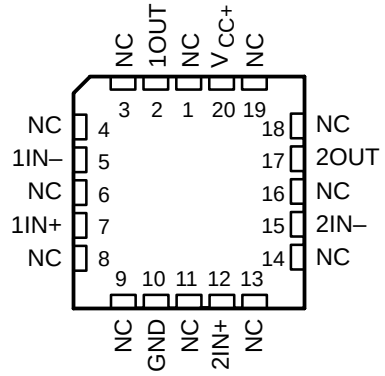
- **Wide Range of Supply Voltages:**
  - **Single Supply . . . 3 V to 30 V (LM2904 and LM2904Q . . . 3 V to 26 V) or**
  - **Dual Supplies**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near 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

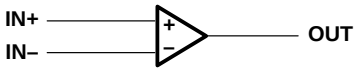
These devices consist of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 30 V (3 V to 26 V for the LM2904 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)



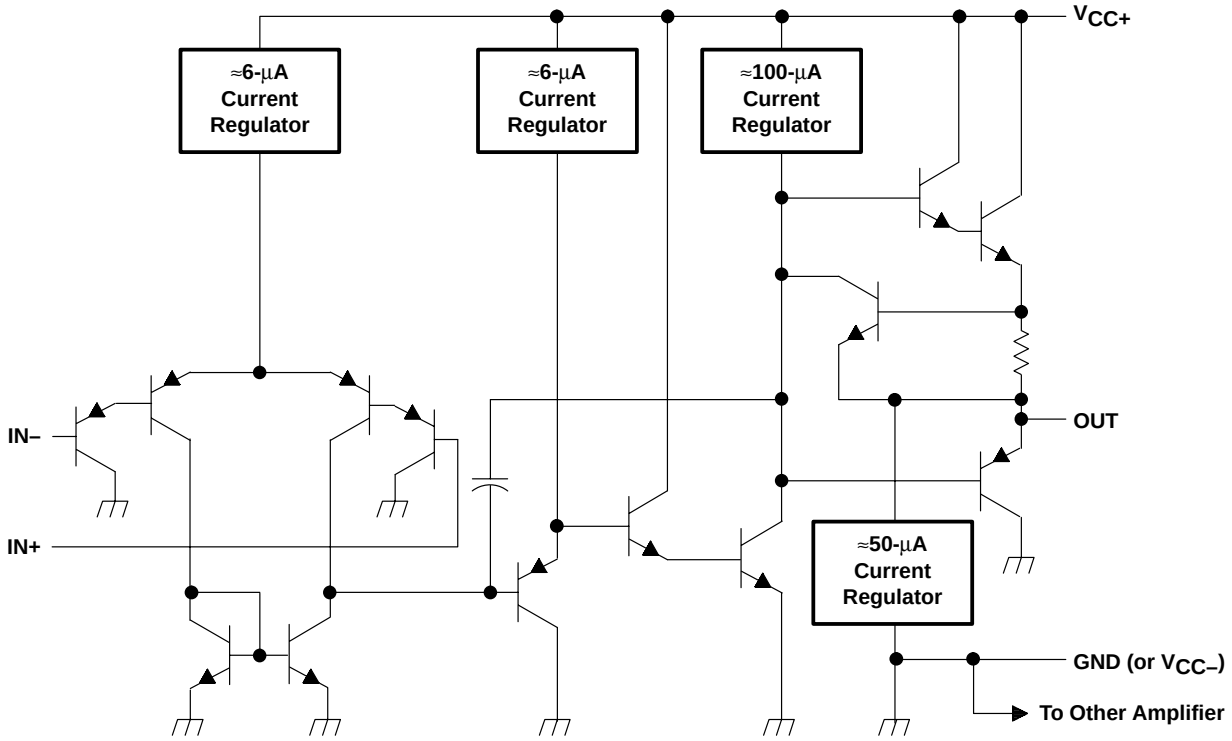
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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	—	—	LM2904P	LM2904PW
		LM2904QD	—	—	—	—
–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)



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

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 ($V_{CC} \le 15$ 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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ 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

electrical characteristics at specified free-air temperature, V_{CC} = 5 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	
$\alpha_{V_{IO}}$	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_{IIO}	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	$R_L \geq 2$ kΩ		25°C	V_{CC}–1.5			V_{CC}–1.5			V
		$R_L \geq 10$ kΩ		25°C							
		V_{CC} = MAX	R_L = 2 kΩ	Full range	26			26			
			$R_L \geq 10$ kΩ	Full range	27	28		27	28		
V_{OL}	Low-level output voltage	$R_L \leq 10$ 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, $R_L \geq 2$ 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 ($\Delta V_{DD}/\Delta V_{IO}$)	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°C.

electrical characteristics at specified free-air temperature, V_{CC} = 5 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	
$\alpha_{V_{IO}}$	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_{IIO}	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	$R_L \geq 2$ kΩ		25°C				V
		$R_L \geq 10$ kΩ		25°C	V_{CC}–1.5			
		V_{CC} = MAX	R_L = 2 kΩ	Full range	26			
			$R_L \geq 10$ kΩ	Full range	23	24		
V_{OL}	Low-level output voltage	$R_L \leq 10$ kΩ		Full range		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, $R_L = \geq 2$ 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 ($\Delta V_{DD}/\Delta V_{IO}$)	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°C.

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

PARAMETER		TEST CONDITIONS†		T_A‡	LM158A			LM258A			UNIT
					MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, $V_{IC} = V_{ICR(min)}$, V_O = 1.4 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	µV/°C
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	10		2	15	nA
				Full range			30			30	
α_{IIO}	Average temperature coefficient of input offset current			Full range		10	200		10	200	pA/°C
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–15	–50		–15	–80	nA
				Full range			–100			–100	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 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	$R_L \geq 2$ kΩ		25°C	V_{CC}–1.5			V_{CC}–1.5			V
		V_{CC} = 30 V	R_L = 2 kΩ	Full range	26			26			
			$R_L \geq 10$ kΩ	Full range	27	28		27	28		
V_{OL}	Low-level output voltage	$R_L \leq 10$ 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, $R_L \geq 2$ kΩ		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 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	–60	–20	–30	–60	mA
				Full range	–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15		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	

*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°C.

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

PARAMETER		TEST CONDITIONS†		T_A‡	LM358A			UNIT
					MIN	TYP§	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, $V_{IC} = V_{ICR(min)}$, V_O = 1.4 V		25°C		2	3	mV
				Full range			5	
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage			Full range		7	20	µV/°C
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	30	nA
				Full range			75	
α_{IIO}	Average temperature coefficient of input offset current			Full range		10	300	pA/°C
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–15	–100	nA
				Full range			–200	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 V		25°C	0 to V_{CC}–1.5			V
				Full range	0 to V_{CC}–2			
V_{OH}	High-level output voltage	$R_L \geq 2$ kΩ		25°C	V_{CC}–1.5			V
		V_{CC} = 30 V	R_L = 2 kΩ	Full range	26			
			$R_L \geq 10$ kΩ	Full range	27	28		
V_{OL}	Low-level output voltage	$R_L \leq 10$ 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			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 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	–60	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 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°C.

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