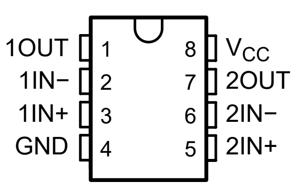
Dual Operational Amplifiers

Check for Samples: LM158, LM258, LM258A, LM358, LM358A, LM2904, LM2904V

FEATURES

- **Wide Supply Ranges**
  - **Single Supply: 3 V to 32 V (26 V for LM2904)**
  - **Dual Supplies: ±1.5 V to ±16 V (±13 V for LM2904)**
- **Low Supply-Current Drain, Independent of Supply Voltage: 0.7 mA Typ**
- **Wide Unity Gain Bandwidth: 0.7MHz**
- **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 Gain: 100dB Typ**
- **Internal Frequency Compensation**
- **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 . . . 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)

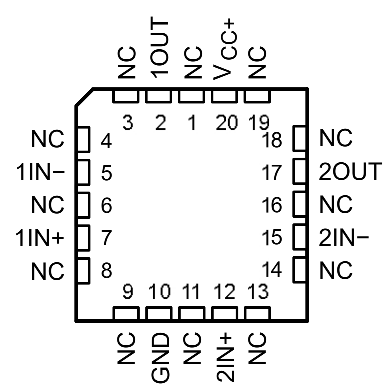


DESCRIPTION

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 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 ±5-V supplies.

LM158, LM158A . . . FK Package
(Top View)

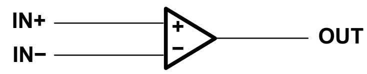


NC − No internal connection

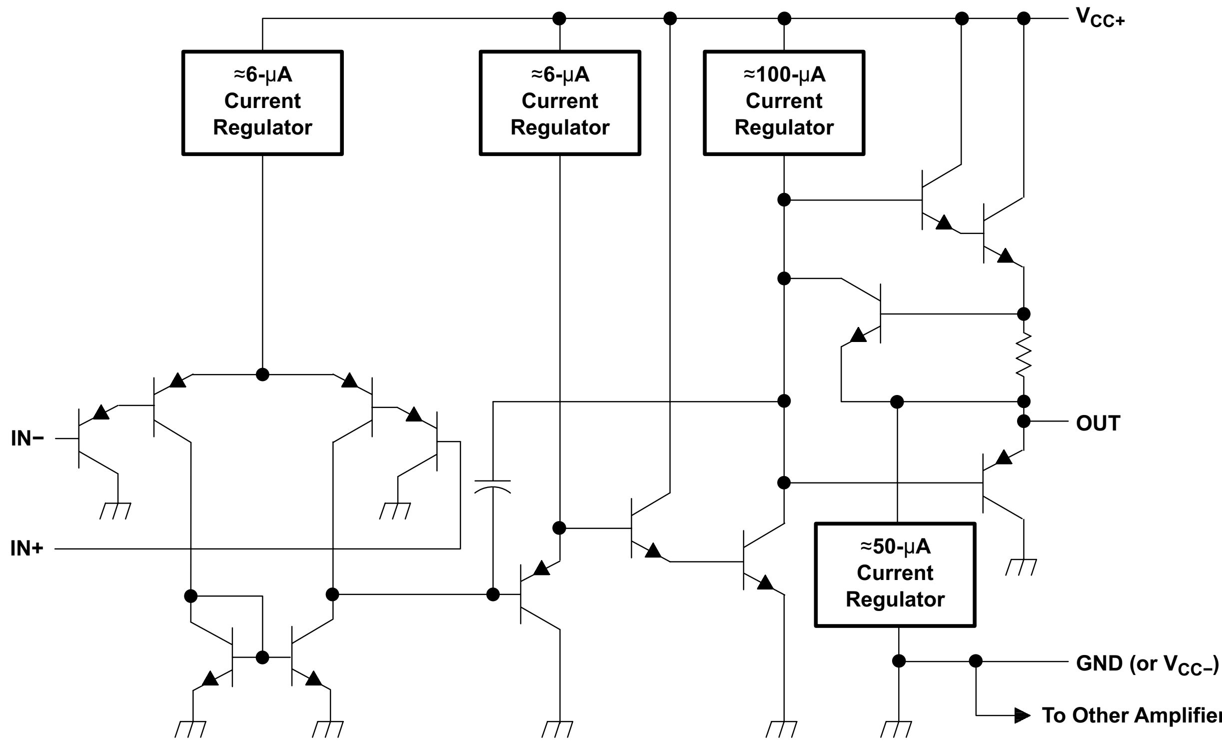
This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Symbol (Each Amplifier)



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)(1)

		LM158, LM158A LM258, LM258A LM358, LM358A LM2904V	LM2904	UNIT
Supply voltage, V_{CC}(2)		±16 or 32	±13 or 26	V
Differential input voltage, V_{ID}(3)		±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) T_A = 25°C, V_{CC} ≤ 15 V(4)		Unlimited	Unlimited	
Package thermal impedance, θ_{JA}(4)(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, θ_{JC}(6)(7)	D package	72.2		°C/W
	FK package	5.61		
	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

(1) 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.
(2) All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
(3) Differential voltages are at IN+, with respect to IN−.
(4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
(5) Maximum power dissipation is a function of T_J(max), θ_{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.
(6) Maximum power dissipation is a function of T_J(max), θ_{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.

Electrical Characteristics

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

PARAMETER		TEST CONDITIONS(1)		T_A(2)	LM158 LM258 MIN	LM158 LM258 TYP(3)	LM158 LM258 MAX	LM358 MIN	LM358 TYP(3)	LM358 MAX	UNIT
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	
αV_{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	
αI_{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	Source	25°C	–20	–30		–20	–30		mA
				Full range	–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	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, V_O = 0, GND at –5 V		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_{CC}, No load		Full range		1	2		1	2	

(1) 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 LM2902 and 30 V for the others.
(2) Full range is –55°C to 125°C for LM158, –25°C to 85°C for LM258, and 0°C to 70°C for LM358, and –40°C to 125°C for LM2904 .
(3) 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[1]		T_A[2]	LM2904 MIN	LM2904 TYP[3]	LM2904 MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, V_{IC} = $V_{ICR(min)}$, V_O = 1.4 V	Non-A-suffix devices	25°C		3	7	mV
				Full range			10	
			A-suffix devices	25°C		1	2	
				Full range			4	
αV_{IO}	Average temperature coefficient of input offset voltage			Full range		7		μV/°C
I_{IO}	Input offset current	V_O = 1.4 V	Non-V device	25°C		2	50	nA
				Full range			300	
			V-suffix device	25°C		2	50	
				Full range			150	
αI_{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 ≥ 10 kΩ		25°C	V_{CC} – 1.5			V
		V_{CC} = MAX, Non-V device	R_L = 2 kΩ	Full range	22			
			R_L ≥ 10 kΩ	Full range	23	24		
		V_{CC} = MAX V-suffix device	R_L = 2 kΩ	Full range	26			
			R_L ≥ 10 kΩ	Full range	27	28		
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} = 5V 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 (ΔV_{CC} /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	Source	25°C	–20	–30		mA
				Full range	–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	25°C	10	20		
				Full range	5			
		V_{ID} = –1 V, V_O = 200 mV	Non-V device	25°C		30		μA
			V-suffix device	25°C	12	40		
I_{OS}	Short-circuit output current	V_{CC} at 5 V, V_O = 0, GND at −5 V		25°C		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V, No load		Full range		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V_{CC}, No load		Full range		1	2	

(1) 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 LM2902 and 32 V for LM2902V.
(2) 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.
(3) 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[1]		T_A[1]	LM158A			LM258A			UNIT
					MIN	TYP[2]	MAX	MIN	TYP[2]	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	
αV_{IO}	Average temperature coefficient of input offset voltage			Full range		7	15[3]		7	15	μA/°C
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	10		2	15	nA
				Full range			30			30	
αI_{IO}	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 ≥ 2 kΩ		25°C	V_{CC} – 1.5			V_{CC} – 1.5			V
		V_{CC} = 30 V	R_L= 2kΩ	Full range	26			26			
			R_L≥ 10kΩ	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		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 (ΔV_D /ΔV_{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	Source	25°C	–20	–30	–60	–20	–30	–60	mA
				Full range	–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	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 (four amplifiers)	V_O = 2.5 V, No load		Full range		0.7	1.2		0.7	1.2	mA
		V_{CC} = MAX V, V_O = 0.5 V, No load		Full range		1	2		1	2	

(1) 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.
(2) All typical values are at T_A = 25°C.
(3) On products compliant to MIL-PRF-38535, this parameter is not production tested.

Electrical Characteristics

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

PARAMETER		TEST CONDITIONS[1]		T_A[2]	LM358A MIN	LM358A TYP[3]	LM358A MAX	UNIT
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	
αV_{IO}	Average temperature coefficient of input offset voltage			Full range		7	20	μA/°C
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	30	nA
				Full range			75	
αI_{IO}	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 ≥ 2 kΩ		25°C	V_{CC} – 1.5			V
		V_{CC} = 30 V	R_L= 2kΩ	Full range	26			
			R_L≥ 10kΩ	Full range	27	28		
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			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	Source	25°C	–20	–30	–60	mA
				Full range	–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	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 (four amplifiers)	V_O = 2.5 V, No load		Full range		0.7	1.2	mA
		V_{CC} = MAX V, V_O = 0.5 V, No load		Full range		1	2	

(1) 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.
(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.
(3) All typical values are at T_A = 25°C.

Operating Conditions, V_{CC} = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	R_L = 1 MΩ, C_L = 30 pF, V_I = ±10 V (see Figure 1)	0.3	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 1Figure 1)	0.7	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 2)	40	nV/√Hz

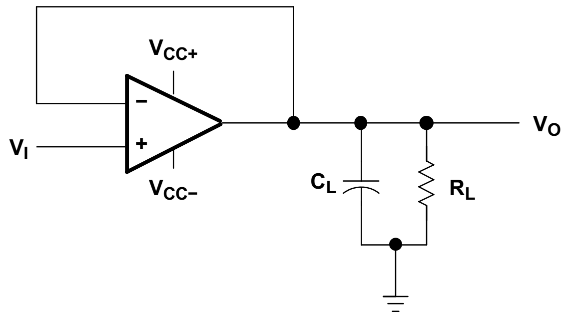


Figure 1. Unity-Gain Amplifier

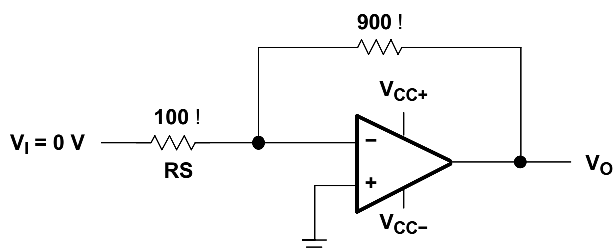


Figure 2. Noise-Test Circuit

Typical Characteristics

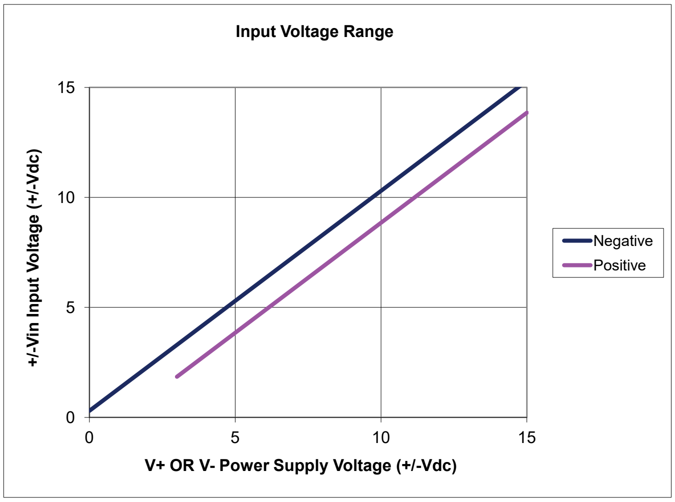


Figure 3.

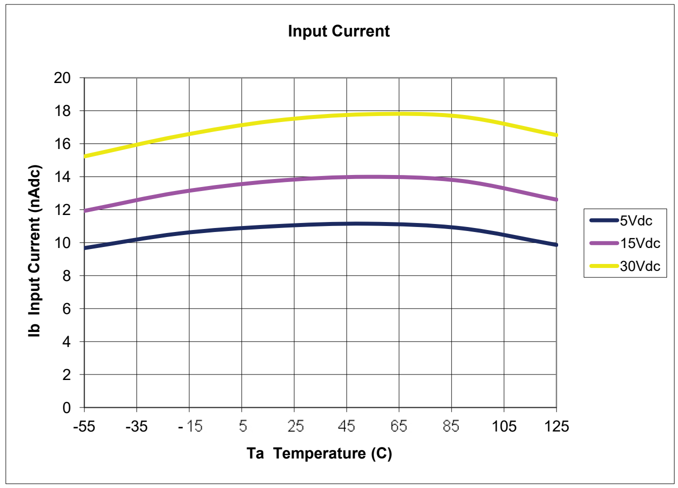


Figure 4.

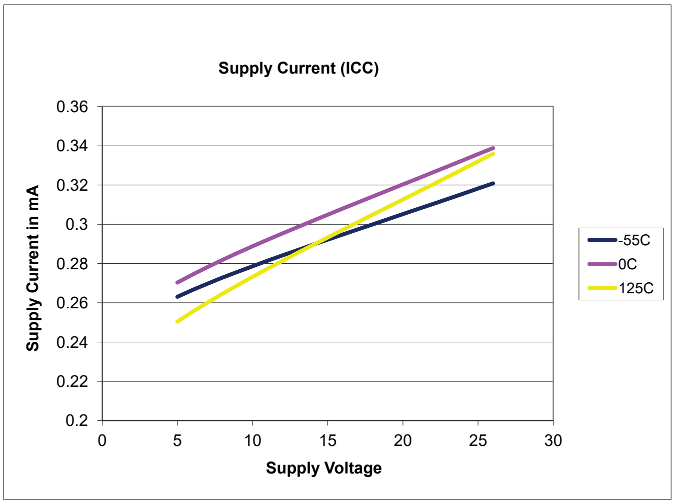


Figure 5.

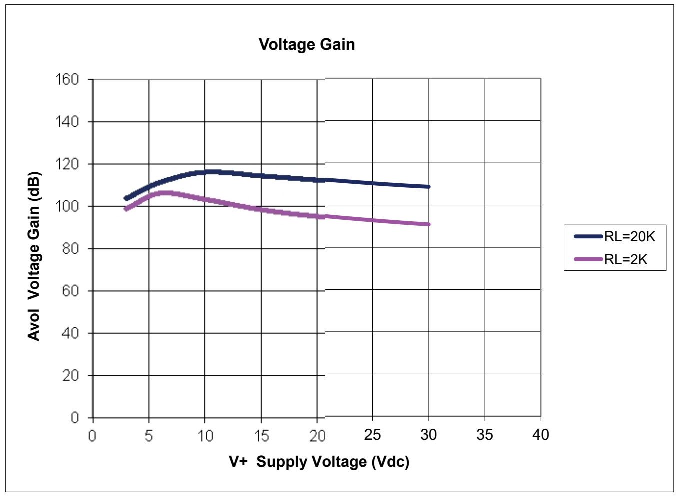


Figure 6.

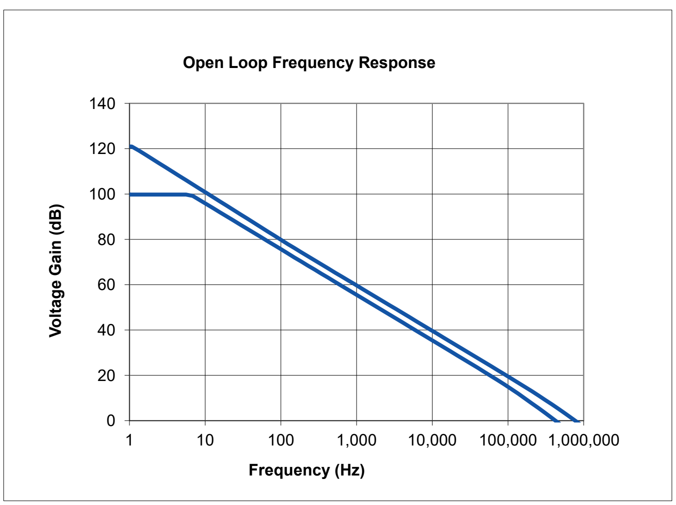


Figure 7. Min & Max Gain Over Temperature Range

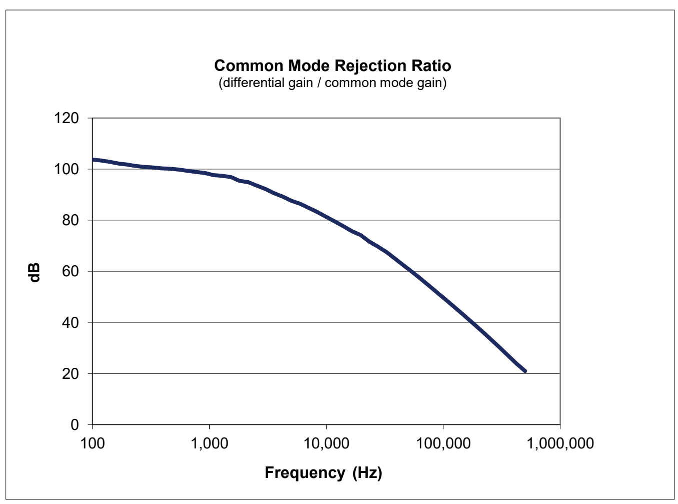


Figure 8.