

# TL081, TL081A, TL081B, TL082, TL082A, TL082B TL084, TL084A, TL084B JFET-INPUT OPERATIONAL AMPLIFIERS

SLOS081G – FEBRUARY 1977 – REVISED SEPTEMBER 2004

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/ $\mu$ s Typ
- Common-Mode Input Voltage Range Includes  $V_{CC+}$

## description/ordering information

The TL08x JFET-input operational amplifier family is designed to offer a wider selection than any previously developed operational amplifier family. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset-voltage temperature coefficient. Offset adjustment and external compensation options are available within the TL08x family.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The Q-suffix devices are characterized for operation from –40°C to 125°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

## ORDERING INFORMATION

$T_J$	$V_{IOmax}$ AT 25°C	PACKAGE†	ORDERABLE PART NUMBER	TOP-SIDE MARKING	
0°C to 70°C	15 mV	PDIP (P)	Tube of 50	TL081CP	TL081CP
			Tube of 50	TL082CP	TL082CP
		PDIP (N)	Tube of 25	TL084CN	TL084CN
		SOIC (D)	Tube of 75	TL081CD	TL081C
			Reel of 2500	TL081CDR	
			Tube of 75	TL082CD	TL082C
			Reel of 2500	TL082CDR	
			Tube of 50	TL084CD	TL084C
			Reel of 2500	TL084CDR	
		SOP (PS)	Reel of 2000	TL081CPSR	T081
			Reel of 2000	TL082CPSR	T082
		SOP (NS)	Reel of 2000	TL084CNSR	TL084
		TSSOP (PW)	Tube of 150	TL082CPW	T082
			Reel of 2000	TL082CPWR	
			Tube of 90	TL084CPW	T084
			Reel of 2000	TL084CPWR	

† 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).



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.

**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL084, TL084A, TL084B  
JFET-INPUT OPERATIONAL AMPLIFIERS**

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**description/ordering information (continued)**

**ORDERING INFORMATION**

T <sub>J</sub>	V <sub>I0</sub> max AT 25°C	PACKAGE†	ORDERABLE PART NUMBER	TOP-SIDE MARKING	
0°C to 70°C	6 mV	PDIP (P)	Tube of 50	TL081ACP	TL081ACP
			Tube of 50	TL082ACP	TL082ACP
		PDIP (N)	Tube of 25	TL084ACN	TL084ACN
		SOIC (D)	Tube of 75	TL081ACD	081AC
			Reel of 2500	TL081ACDR	
			Tube of 75	TL082ACD	082AC
			Reel of 2500	TL082ACDR	
		SOIC (D)	Tube of 50	TL084ACD	TL084AC
	Reel of 2500		TL084ACDR		
	SOP (PS)	Reel of 2000	TL082ACPSR	T082A	
	SOP (NS)	Reel of 2000	TL084ACNSR	TL084A	
	3 mV	PDIP (P)	Tube of 50	TL081BCP	TL081BCP
			Tube of 50	TL082BCP	TL082BCP
		PDIP (N)	Tube of 25	TL084BCN	TL084BCN
SOIC (D)		Tube of 75	TL081BCD	081BC	
		Reel of 2500	TL081BCDR		
		Tube of 75	TL082BCD	082BC	
		Reel of 2500	TL082BCDR		
SOIC (D)		Tube of 50	TL084BCD	TL084BC	
	Reel of 2500	TL084BCDR			
-40°C to 85°C	6 mV	PDIP (P)	Tube of 50	TL081IP	TL081IP
			Tube of 50	TL082IP	TL082IP
		PDIP (N)	Tube of 25	TL084IN	TL081IN
		SOIC (D)	Tube of 75	TL081ID	TL081I
			Reel of 2500	TL081IDR	
			Tube of 75	TL082ID	TL082I
			Reel of 2500	TL082IDR	
		SOIC (D)	Tube of 50	TL084ID	TL084I
	Reel of 2500		TL084IDR		
	TSSOP (PW)	Reel of 2000	TL082IPWR	Z082	
-40°C to 125°C	9 mV	SOIC (D)	Tube of 50	TL084QD	TL084QD
			Reel of 2500	TL084QDR	
-55°C to 125°C	9 mV	CDIP (J)	Tube of 25	TL084MJ	TL084MJ
		LCCC (FK)	Reel of 55	TL084FK	TL084FK
	6 mV	CDIP (JG)	Tube of 50	TL082MJG	TL082MJG
		LCCC (FK)	Tube of 55	TL082MFK	TL082MFK

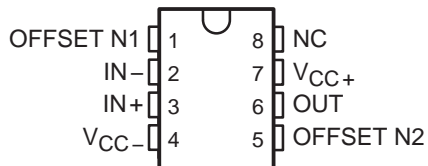
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



# TL081, TL081A, TL081B, TL082, TL082A, TL082B TL084, TL084A, TL084B JFET-INPUT OPERATIONAL AMPLIFIERS

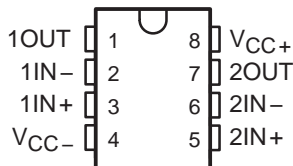
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**TL081, TL081A, TL081B**  
D, P, OR PS PACKAGE  
(TOP VIEW)

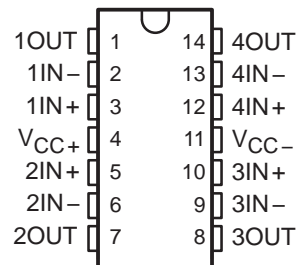


NC – No internal connection

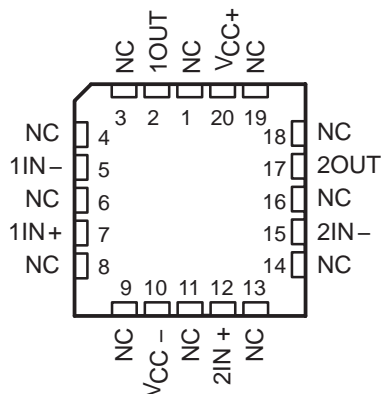
**TL082, TL082A, TL082B**  
D, JG, P, PS, OR PW PACKAGE  
(TOP VIEW)



**TL084, TL084A, TL084B**  
D, J, N, NS, OR PW PACKAGE  
(TOP VIEW)

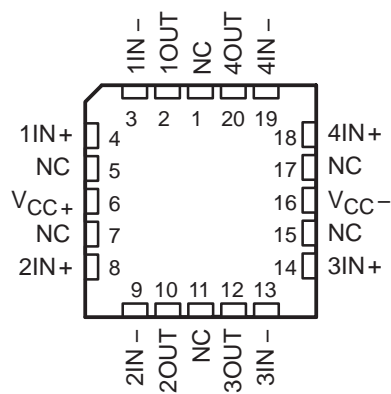


**TL082M . . . FK PACKAGE**  
(TOP VIEW)



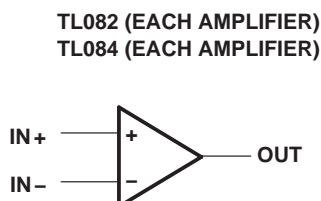
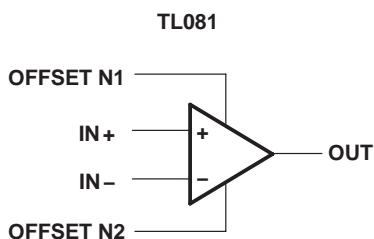
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**TL084M . . . FK PACKAGE**  
(TOP VIEW)



NC – No internal connection

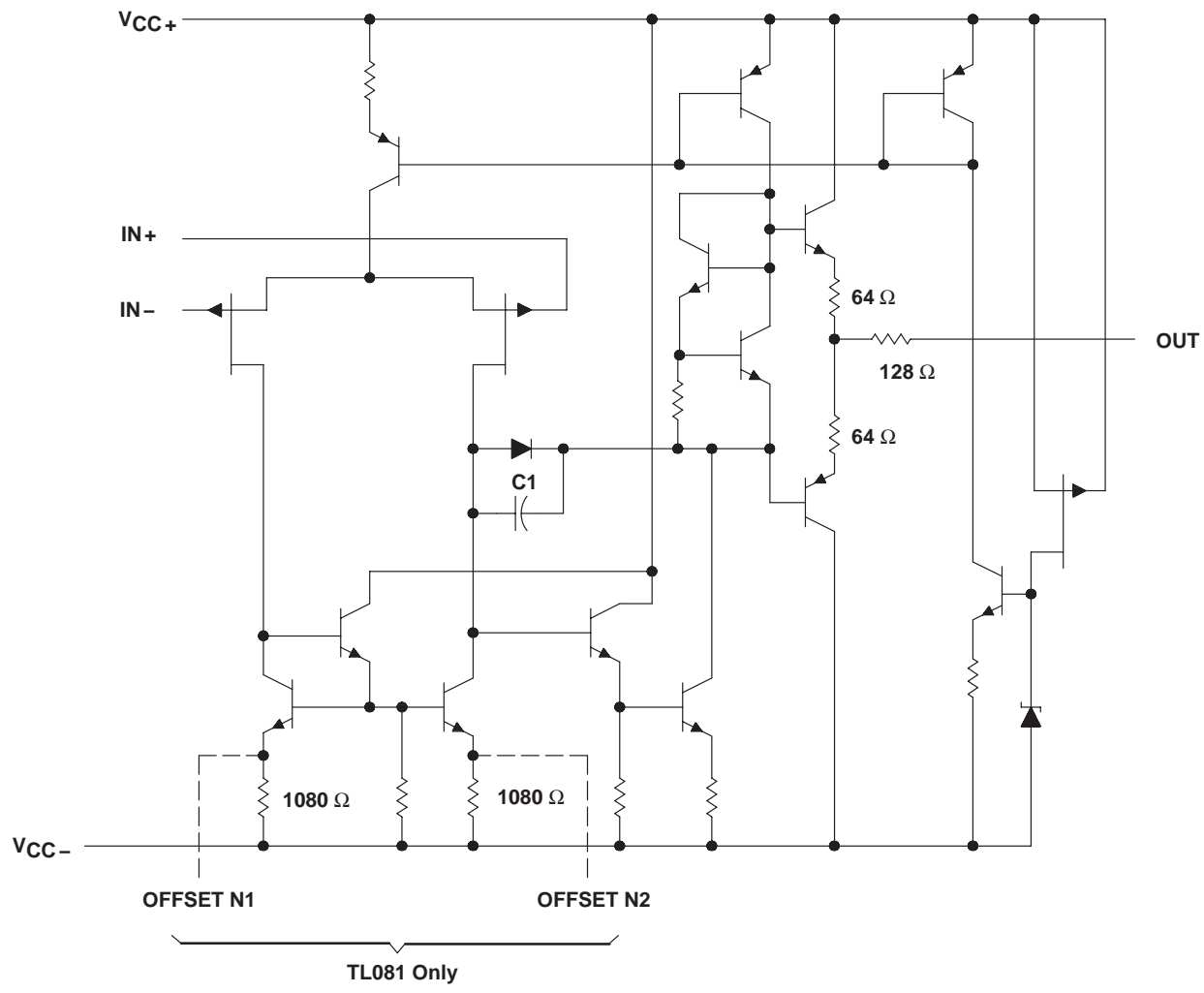
## symbols



**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL084, TL084A, TL084B  
JFET-INPUT OPERATIONAL AMPLIFIERS**

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**schematic (each amplifier)**



Component values shown are nominal.

# TL081, TL081A, TL081B, TL082, TL082A, TL082B TL084, TL084A, TL084B JFET-INPUT OPERATIONAL AMPLIFIERS

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

	TL08_C TL08_AC TL08_BC	TL08_I	TL084Q	TL08_M	UNIT
Supply voltage, $V_{CC+}$ (see Note 1)	18	18	18	18	V
Supply voltage $V_{CC-}$ (see Note 1)	-18	-18	-18	-18	V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 30$	$\pm 30$	$\pm 30$	$\pm 30$	V
Input voltage, $V_I$ (see Notes 1 and 3)	$\pm 15$	$\pm 15$	$\pm 15$	$\pm 15$	V
Duration of output short circuit (see Note 4)	Unlimited	Unlimited	Unlimited	Unlimited	
Continuous total power dissipation	See Dissipation Rating Table				
Operating free-air temperature range, $T_A$	0 to 70	-40 to 85	-40 to 125	-55 to 125	$^{\circ}\text{C}$
Package thermal impedance, $\theta_{JA}$ (see Notes 5 and 6)	D package (8-pin)	97	97		$^{\circ}\text{C}/\text{W}$
	D package (14-pin)	86	86		
	N package (14-pin)	76	76		
	NS package (14-pin)	80			
	P package (8-pin)	85	85		
	PS package (8-pin)	95	95		
	PW package (8-pin)	149			
	PW package (14-pin)	113	113		
Operating virtual junction temperature	150	150	150	150	$^{\circ}\text{C}$
Case temperature for 60 seconds, $T_C$	FK package			260	$^{\circ}\text{C}$
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds	J or JG package			300	$^{\circ}\text{C}$
Storage temperature range, $T_{stg}$	-65 to 150	-65 to 150	-65 to 150	-65 to 150	$^{\circ}\text{C}$

† 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:
- All voltage values, except differential voltages, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
  - Differential voltages are at  $IN+$  with respect to  $IN-$ .
  - The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
  - The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
  - Maximum power dissipation is a function of  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150 $^{\circ}\text{C}$  can affect reliability.
  - 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	DERATE ABOVE $T_A$	$T_A = 70^{\circ}\text{C}$ POWER RATING	$T_A = 85^{\circ}\text{C}$ POWER RATING	$T_A = 125^{\circ}\text{C}$ POWER RATING
D (14 pin)	680 mW	7.6 mW/ $^{\circ}\text{C}$	60 $^{\circ}\text{C}$	604 mW	490 mW	186 mW
FK	680 mW	11.0 mW/ $^{\circ}\text{C}$	88 $^{\circ}\text{C}$	680 mW	680 mW	273 mW
J	680 mW	11.0 mW/ $^{\circ}\text{C}$	88 $^{\circ}\text{C}$	680 mW	680 mW	273 mW
JG	680 mW	8.4 mW/ $^{\circ}\text{C}$	69 $^{\circ}\text{C}$	672 mW	546 mW	210 mW



**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL084, TL084A, TL084B  
JFET-INPUT OPERATIONAL AMPLIFIERS**

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electrical characteristics,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TA†	TL081C TL082C TL084C			TL081AC TL082AC TL084AC			TL081BC TL082BC TL084BC			TL081I TL082I TL084I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage V <sub>O</sub> = 0 R <sub>S</sub> = 50 Ω	25°C	3	15	6	3	6	2	3	3	6	3	6	mV	
		Full range		20	7.5		5	9							
α <sub>VIO</sub>	Temperature coefficient of input offset voltage V <sub>O</sub> = 0 R <sub>S</sub> = 50 Ω	Full range	18			18			18			18		μV/°C	
		25°C	5	200	100	5	100	5	100	5	100	5	100		
I <sub>IO</sub>	Input offset current ‡ V <sub>O</sub> = 0	Full range		2	2		2		2		2		10	pA	
		25°C	30	400	200	30	200	30	200	30	200	30	200		
I <sub>IB</sub>	Input bias current ‡ V <sub>O</sub> = 0	Full range		10	7		7		7		7		20	nA	
		25°C	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	±11		-12 to 15
V <sub>ICR</sub>	Common-mode input voltage range	25°C	±12	±13.5	±12	±13.5	±12	±13.5	±12	±13.5	±12	±13.5	±12	V	
		Full range	±12		±12		±10	±12	±10	±12	±10	±12	±10		±12
V <sub>OM</sub>	Maximum peak output voltage swing	25°C	±10	±12	±10	±12	±10	±12	±10	±12	±10	±12	±10	V	
		Full range	±10		±10		±10	±12	±10	±12	±10	±12	±10		±12
A <sub>V/D</sub>	Large-signal differential voltage amplification V <sub>O</sub> = ±10 V, R <sub>L</sub> ≥ 2 kΩ	25°C	25	200	50	200	50	200	50	200	50	200	50	V/mV	
		Full range	15		25		25		25		25		25		
B <sub>1</sub>	Unity-gain bandwidth	25°C	3		3		3		3		3		3	MHz	
		25°C	10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		
r <sub>i</sub>	Input resistance	25°C	70	86	75	86	75	86	75	86	75	86	75	Ω	
		25°C	70	86	75	86	75	86	75	86	75	86	75		86
CMRR	Common-mode rejection ratio	25°C	70	86	75	86	75	86	75	86	75	86	75	dB	
		25°C	70	86	75	86	75	86	75	86	75	86	75		86
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	25°C	70	86	75	86	75	86	75	86	75	86	75	dB	
		25°C	70	86	75	86	75	86	75	86	75	86	75		86
I <sub>CC</sub>	Supply current (per amplifier)	25°C	1.4	2.8	1.4	2.8	1.4	2.8	1.4	2.8	1.4	2.8	1.4	mA	
		25°C	1.4	2.8	1.4	2.8	1.4	2.8	1.4	2.8	1.4	2.8	1.4		2.8
V <sub>O1</sub> /V <sub>O2</sub>	Crosstalk attenuation	25°C	120		120		120		120		120		120	dB	
		25°C	120		120		120		120		120		120		

† All characteristics are measured under open-loop conditions with zero common-mode voltage, unless otherwise specified. Full range for T<sub>A</sub> is 0°C to 70°C for TL08\_C, TL08\_AC, TL08\_BC and -40°C to 85°C for TL08\_I.

‡ Input bias currents of an FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive, as shown in Figure 17. Pulse techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.



**TL081, TL081A, TL081B, TL082, TL082A, TL082B  
TL084, TL084A, TL084B  
JFET-INPUT OPERATIONAL AMPLIFIERS**

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**electrical characteristics,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS†	$T_A$	TL081M, TL082M			TL084Q, TL084M			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 0, R_S = 50\ \Omega$	25°C	3	6		3	9	mV	
		Full range			9		15		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50\ \Omega$	Full range	18			18			$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current‡	$V_O = 0$	25°C	5	100		5	100	pA	
		125°C	20			20			nA
$I_{IB}$ Input bias current‡	$V_O = 0$	25°C	30	200		30	200	pA	
		125°C	50			50			nA
$V_{ICR}$ Common-mode input voltage range		25°C	$\pm 11$	-12 to 15		$\pm 11$	-12 to 15	V	
$V_{OM}$ Maximum peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$	V	
	$R_L \geq 10\ \text{k}\Omega$	Full range	$\pm 12$		$\pm 12$				
	$R_L \geq 2\ \text{k}\Omega$		$\pm 10$	$\pm 12$	$\pm 10$	$\pm 12$			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V}, R_L \geq 2\ \text{k}\Omega$	25°C	25	200		25	200	V/mV	
	$V_O = \pm 10\ \text{V}, R_L \geq 2\ \text{k}\Omega$	Full range	15		15				
$B_1$ Unity-gain bandwidth		25°C	3			3			MHz
$r_i$ Input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	80	86		80	86	dB	
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC} = \pm 15\ \text{V to } \pm 9\ \text{V}, V_O = 0, R_S = 50\ \Omega$	25°C	80	86		80	86	dB	
$I_{CC}$ Supply current (per amplifier)	$V_O = 0, \text{ No load}$	25°C	1.4	2.8		1.4	2.8	mA	
$V_{O1}/V_{O2}$ Crosstalk attenuation	$A_{VD} = 100$	25°C	120			120			dB

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

‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive, as shown in Figure 17. Pulse techniques must be used that maintain the junction temperatures as close to the ambient temperature as possible.

**operating characteristics,  $V_{CC\pm} = \pm 15\ \text{V}, T_A = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
SR Slew rate at unity gain	$V_I = 10\ \text{V}, R_L = 2\ \text{k}\Omega, C_L = 100\ \text{pF}, \text{ See Figure 1}$	8*	13		V/ $\mu\text{s}$	
	$V_I = 10\ \text{V}, R_L = 2\ \text{k}\Omega, C_L = 100\ \text{pF}, T_A = -55^\circ\text{C to } 125^\circ\text{C}, \text{ See Figure 1}$	5*				
$t_r$ Rise time	$V_I = 20\ \text{mV}, R_L = 2\ \text{k}\Omega, C_L = 100\ \text{pF}, \text{ See Figure 1}$	0.05			$\mu\text{s}$	
Overshoot factor		20			%	
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$	f = 1 kHz			$\text{nV}/\sqrt{\text{Hz}}$	
		f = 10 Hz to 10 kHz			$\mu\text{V}$	
$I_n$ Equivalent input noise current	$R_S = 20\ \Omega, f = 1\ \text{kHz}$	0.01			$\text{pA}/\sqrt{\text{Hz}}$	
THD Total harmonic distortion	$V_{rms} = 6\ \text{V}, f = 1\ \text{kHz}$	$A_{VD} = 1, R_S \leq 1\ \text{k}\Omega, R_L \geq 2\ \text{k}\Omega,$	0.003			%

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



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operating characteristics,  $V_{CC\pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR Slew rate at unity gain	$V_I = 10\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , See Figure 1	8	13		$\text{V}/\mu\text{s}$
$t_r$ Rise time	$V_I = 20\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , See Figure 1		0.05		$\mu\text{s}$
Overshoot factor			20		%
$V_n$ Equivalent input noise voltage	$R_S = 20\ \Omega$	$f = 1\text{ kHz}$	18		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{ Hz to } 10\text{ kHz}$	4		$\mu\text{V}$
$I_n$ Equivalent input noise current	$R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		0.01		$\text{pA}/\sqrt{\text{Hz}}$
THD Total harmonic distortion	$V_{I\text{rms}} = 6\text{ V}$ , $f = 1\text{ kHz}$ , $A_{VD} = 1$ , $R_S \leq 1\text{ k}\Omega$ , $R_L \geq 2\text{ k}\Omega$ ,		0.003		%

**PARAMETER MEASUREMENT INFORMATION**

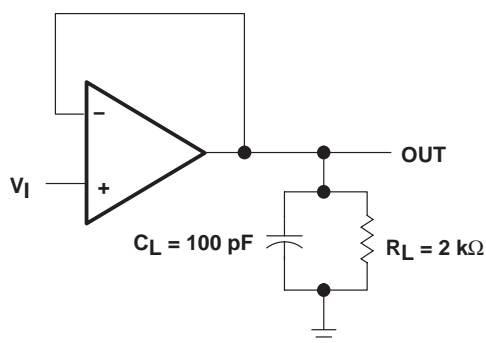


Figure 1

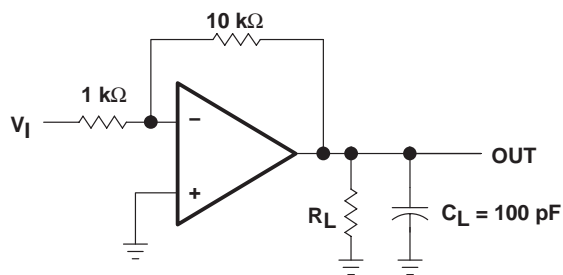


Figure 2

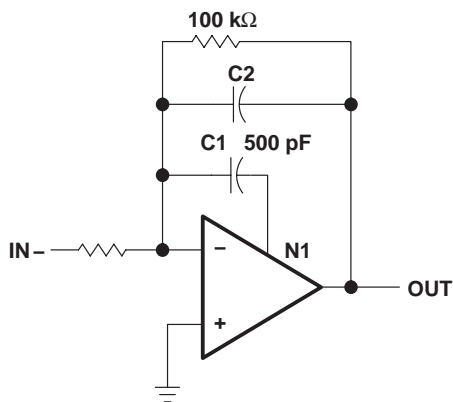


Figure 3

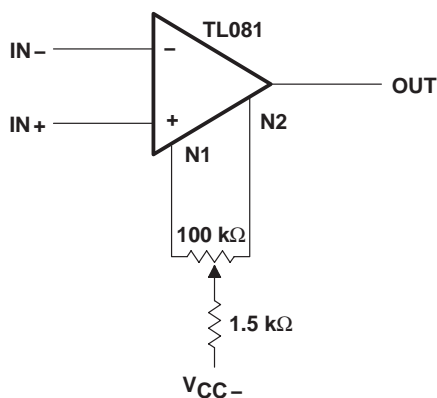


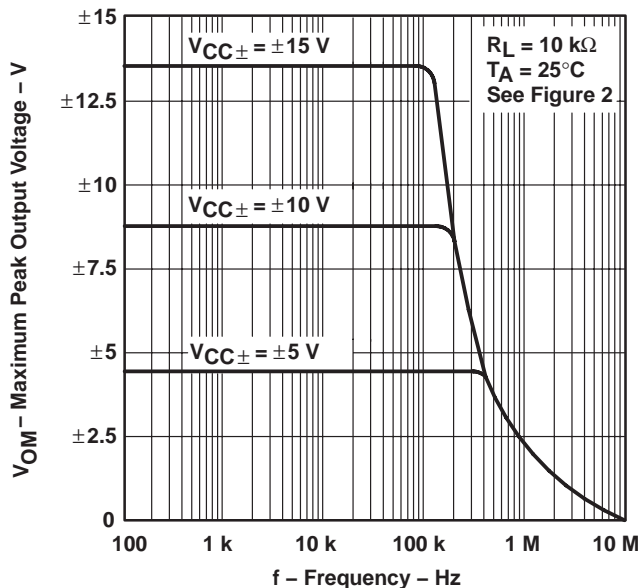
Figure 4

**TYPICAL CHARACTERISTICS**

**Table of Graphs**

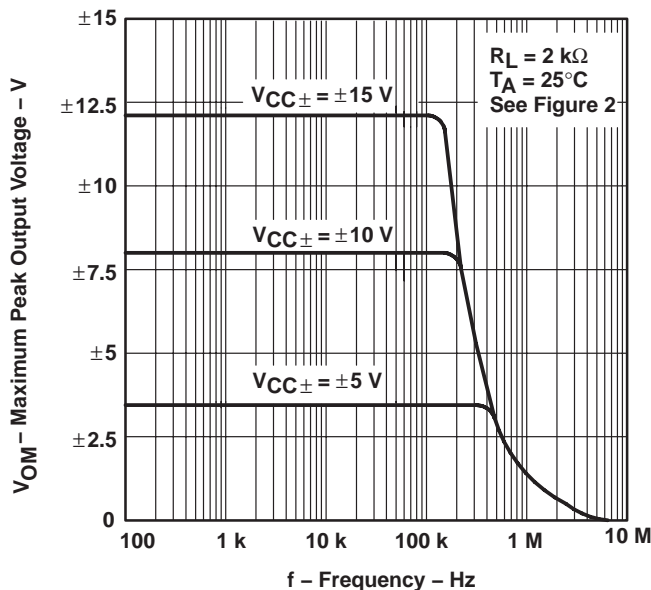
		FIGURE
V <sub>OM</sub>	Maximum peak output voltage	vs Frequency
		vs Free-air temperature
		vs Load resistance
		vs Supply voltage
AVD	Large-signal differential voltage amplification	vs Free-air temperature
		vs Frequency
	Differential voltage amplification	vs Frequency with feed-forward compensation
PD	Total power dissipation	vs Free-air temperature
I <sub>CC</sub>	Supply current	vs Free-air temperature
		vs Supply voltage
I <sub>IB</sub>	Input bias current	vs Free-air temperature
	Large-signal pulse response	vs Time
V <sub>O</sub>	Output voltage	vs Elapsed time
CMRR	Common-mode rejection ratio	vs Free-air temperature
V <sub>n</sub>	Equivalent input noise voltage	vs Frequency
THD	Total harmonic distortion	vs Frequency

**MAXIMUM PEAK OUTPUT VOLTAGE  
 vs  
 FREQUENCY**



**Figure 5**

**MAXIMUM PEAK OUTPUT VOLTAGE  
 vs  
 FREQUENCY**



**Figure 6**