

TL070 JFET-INPUT OPERATIONAL AMPLIFIER

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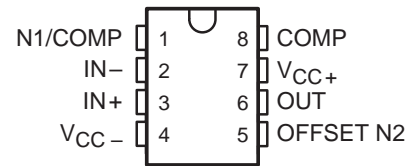
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion
0.003% Typ
- Low Noise
 $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ at $f = 1 \text{ kHz}$
- High Input Impedance . . . JFET Input Stage
- Common-Mode Input Voltage Range
Includes V_{CC+}
- Latch-Up-Free Operation
- High Slew Rate . . . 13 $\text{V}/\mu\text{s}$ Typ

description

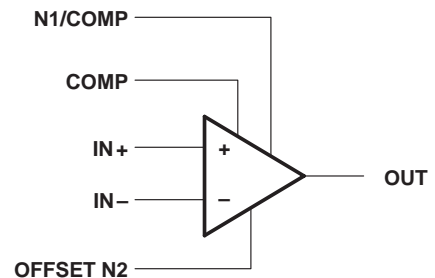
The JFET-input TL070 operational amplifier is designed as the lower-noise version of the TL080 amplifier with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL070 ideally suited for high-fidelity and audio preamplifier applications. This amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The TL070C device is characterized for operation from 0°C to 70°C. The TL070I device is characterized for operation from –40°C to 85°C. The TL070M device is characterized for operation from –55°C to 125°C.

D, P, OR PW PACKAGE
(TOP VIEW)



symbol



AVAILABLE OPTIONS

T_A	V_{IO}^{max} AT 25°C	PACKAGE		
		SMALL OUTLINE (D)	PLASTIC DIP (P)	TSSOP (PW)
0°C to 70°C	10 mV	TL070CD	TL070CP	TL070CPW
–40°C to 85°C	10 mV	TL070ID	TL070IP	—
–55°C to 125°C	10 mV	TL070MD	TL070MP	—

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**

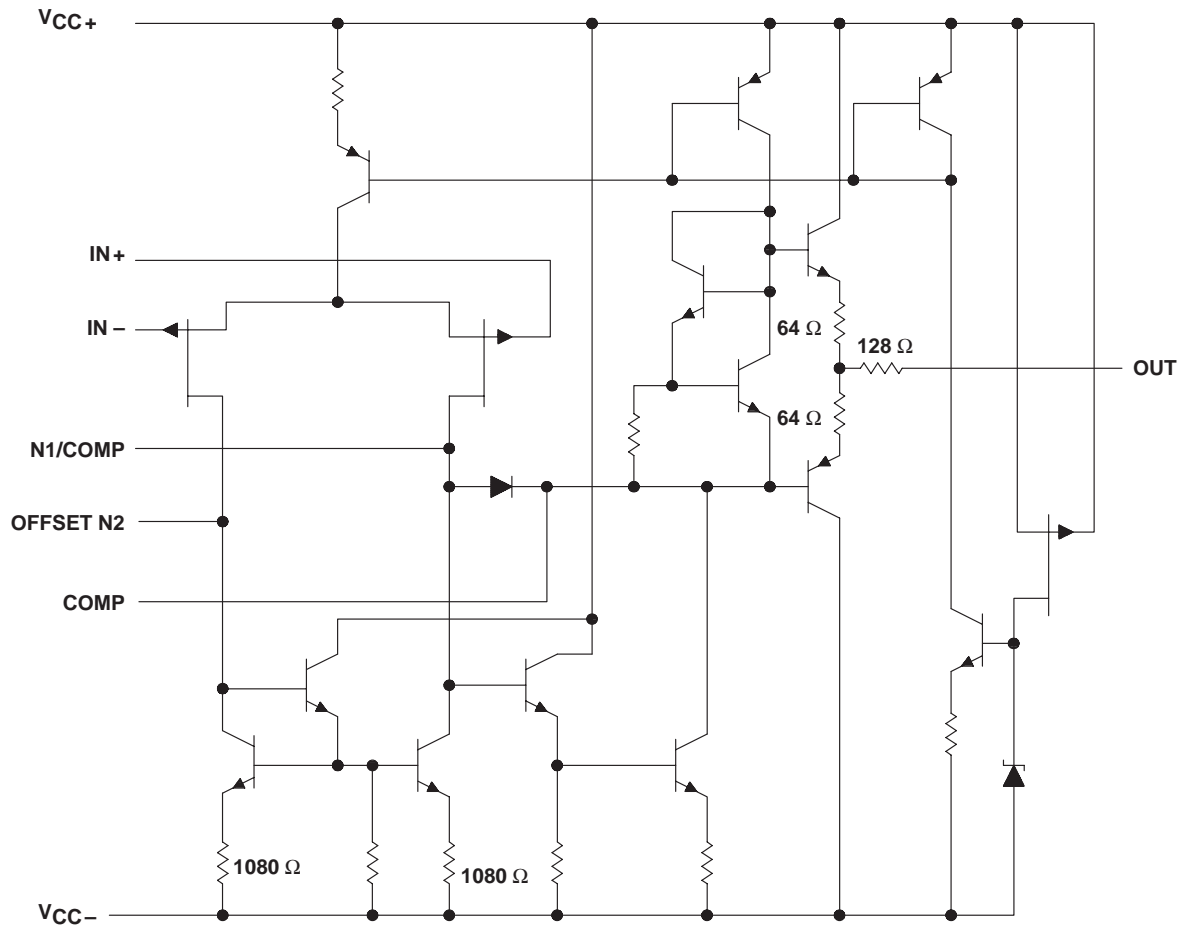
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schematic



All component values shown are nominal.

COMPONENT COUNT †	
Transistors	13
Diodes	2
Resistors	10
epi-FET	1
JFET	2

† Includes all bias and trim circuitry

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

Supply voltage, V_{CC+} (see Note 1)	18 V
Supply voltage, V_{CC-}	-18 V
Differential input voltage, V_{ID} (see Note 2)	± 30 V
Input voltage, V_I (see Notes 1 and 3)	± 15 V
Duration of short-circuit current (see Note 4)	unlimited
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix	-40°C to 85°C
M suffix	-55°C to 125°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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, are with respect to the midpoint between V_{CC+} and V_{CC-} .
 2. Differential voltages are at $IN+$ with respect to $IN-$.
 3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
 4. 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.

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	680 mW	5.8 mW/°C	33°C	464 mW	377 mW	145 mW
P	680 mW	8.0 mW/°C	65°C	640 mW	520 mW	200 mW
PW	525 mW	4.2 mW/°C	70°C	336 mW	N/A	N/A



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

PARAMETER	TEST CONDITIONS	T_A †	TL070C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_O = 0, R_S = 50 \Omega$	25°C		3	10	mV
		Full range			13	
α_{VIO} Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50 \Omega$	Full range		18		$\mu V/^\circ C$
I_{IO} Input offset current	$V_O = 0$	25°C		5	100	pA
		Full range			10	nA
I_{IB} Input bias current‡	$V_O = 0$	25°C		65	200	pA
		Full range			7	nA
V_{ICR} Common-mode input voltage range		25°C	± 11	-12 to 15		V
V_{OM} Maximum peak output voltage swing	$R_L = 10 k\Omega$	25°C	± 12	± 13.5		V
	$R_L \geq 10 k\Omega$	Full range	± 12			
	$R_L \geq 2 k\Omega$		± 10			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10$ V, $R_L \geq 2 k\Omega$	25°C	25	200		V/mV
		Full range	15			
B_1 Unity-gain bandwidth		25°C	3			MHz
r_i Input resistance		25°C	10^{12}			Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50 \Omega$	25°C	70	100		dB
k_{SVR} Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9$ V to ± 15 V, $V_O = 0, R_S = 50 \Omega$	25°C	70	100		dB
I_{CC} Supply current	$V_O = 0, \text{No load}$	25°C	1.4	2.5		mA
V_{O1}/V_{O2} Crosstalk attenuation	$A_{VD} = 100$	25°C	120			dB

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range for T_A is 0°C to 70°C.

‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 5. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

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

PARAMETER	TEST CONDITIONS	T_A †	TL070I			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_O = 0, R_S = 50 \Omega$	25°C		3	10	mV
		Full range			13	
α_{VIO} Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50 \Omega$	Full range		18		$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 0$	25°C		5	100	pA
		Full range			10	nA
I_{IB} Input bias current‡	$V_O = 0$	25°C		65	200	pA
		Full range			20	nA
V_{ICR} Common-mode input voltage range		25°C	± 11	-12 to 15		V
V_{OM} Maximum peak output voltage swing	$R_L = 10 \text{ k}\Omega$	25°C	± 12	± 13.5		V
	$R_L \geq 10 \text{ k}\Omega$	Full range	± 12			
	$R_L \geq 2 \text{ k}\Omega$		± 10			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10 \text{ V}, R_L \geq 2 \text{ k}\Omega$	25°C	25	200		V/mV
		Full range	15			
B_1 Unity-gain bandwidth		25°C		3		MHz
r_i Input resistance		25°C		10^{12}		Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50 \Omega$	25°C	70	100		dB
k_{SVR} Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9 \text{ V to } \pm 15 \text{ V}, V_O = 0, R_S = 50 \Omega$	25°C	70	100		dB
I_{CC} Supply current	$V_O = 0, \text{ No load}$	25°C		1.4	2.5	mA
V_{O1}/V_{O2} Crosstalk attenuation	$A_{VD} = 100$	25°C		120		dB

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range for T_A is -40°C to 85°C .

‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 5. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.



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

PARAMETER	TEST CONDITIONS	T_A †	TL070M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_O = 0$, $R_S = 50 \Omega$	25°C		3	10	mV
		Full range			13	
α_{VIO} Temperature coefficient of input offset voltage	$V_O = 0$, $R_S = 50 \Omega$	Full range		18		$\mu V/^\circ C$
I_{IO} Input offset current	$V_O = 0$	25°C		5	100	pA
		Full range			20	nA
I_{IB} Input bias current‡	$V_O = 0$	25°C		65	200	pA
		Full range			50	nA
V_{ICR} Common-mode input voltage range		25°C	± 11	-12 to 15		V
V_{OM} Maximum peak output voltage swing	$R_L = 10 k\Omega$	25°C	± 12	± 13.5		V
	$R_L \geq 10 k\Omega$	Full range	± 12			
	$R_L \geq 2 k\Omega$		± 10			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10$ V, $R_L \geq 2 k\Omega$	25°C	25	200		V/mV
		Full range	15			
B_1 Unity-gain bandwidth		25°C		3		MHz
r_i Input resistance		25°C		10^{12}		Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50 \Omega$, $V_O = 0$	25°C	70	100		dB
k_{SVR} Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9$ V to ± 15 V, $R_S = 50 \Omega$, $V_O = 0$	25°C	70	100		dB
I_{CC} Supply current	$V_O = 0$, No load	25°C		1.4	2.5	mA
V_{O1}/V_{O2} Crosstalk attenuation	$A_{VD} = 100$	25°C		120		dB

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range for T_A is $-55^\circ C$ to $125^\circ C$.

‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 5. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

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

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR Slew rate at unity gain	$V_I = 10$ V, $R_L = 2 k\Omega$, $C_L = 100$ pF, See Figure 1	8	13		V/ μs
t_r Rise time overshoot factor	$V_I = 20$ mV, $R_L = 2 k\Omega$, $C_L = 100$ pF, See Figure 1		0.1		μs
			20		%
V_n Equivalent input noise voltage	$R_S = 20 \Omega$	$f = 1$ kHz	18		nV/ \sqrt{Hz}
		$f = 10$ Hz to 10 kHz	4		μV
I_n Equivalent input noise current	$R_S = 20 \Omega$, $f = 1$ kHz		0.01		pA/ \sqrt{Hz}
THD Total harmonic distortion	$V_{O(rms)} = 10$ V, $R_S \leq 1 k\Omega$, $R_L \geq 2 k\Omega$, $f = 1$ kHz		0.003		%



PARAMETER MEASUREMENT INFORMATION

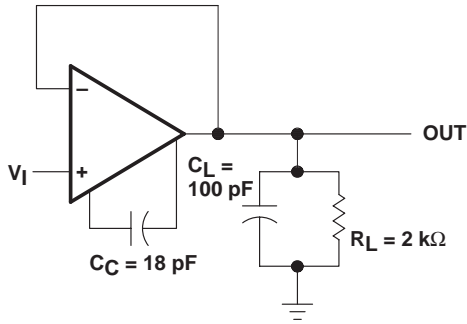


Figure 1. Unity-Gain Amplifier

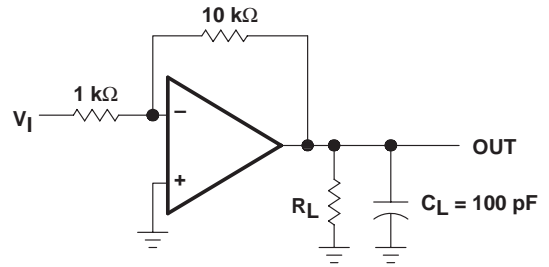


Figure 2. Gain-of-10 Inverting Amplifier

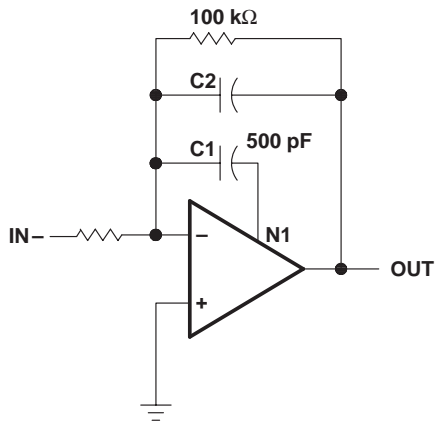


Figure 3. Feed-Forward Compensation

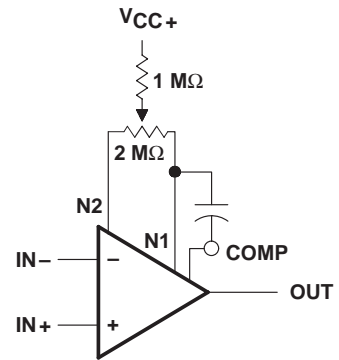


Figure 4. Input Offset Voltage Null Circuit

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TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
I_{IB}	Input bias current	vs Free-air temperature	5
V_{OM}	Maximum output voltage	vs Frequency	6, 7, 8
		vs Free-air temperature	9
		vs Load resistance	10
		vs Supply voltage	11
A_{VD}	Large-signal differential voltage amplification	vs Free-air temperature	12
		vs Frequency	14
A_{VD}	Differential voltage amplification	vs Frequency	13
	Phase shift	vs Frequency	14
	Normalized unity-gain bandwidth	vs Free-air temperature	15
	Normalized phase shift	vs Free-air temperature	15
CMRR	Common-mode rejection ratio	vs Free-air temperature	16
I_{CC}	Supply current	vs Supply voltage	17
		vs Free-air temperature	18
P_D	Total power dissipation	vs Free-air temperature	19
		Normalized slew rate	vs Free-air temperature
V_n	Equivalent input noise voltage	vs Frequency	21
THD	Total harmonic distortion	vs Frequency	22
		Large-signal pulse response	vs Time
V_O	Output voltage	vs Elapsed time	24



TYPICAL CHARACTERISTICS†

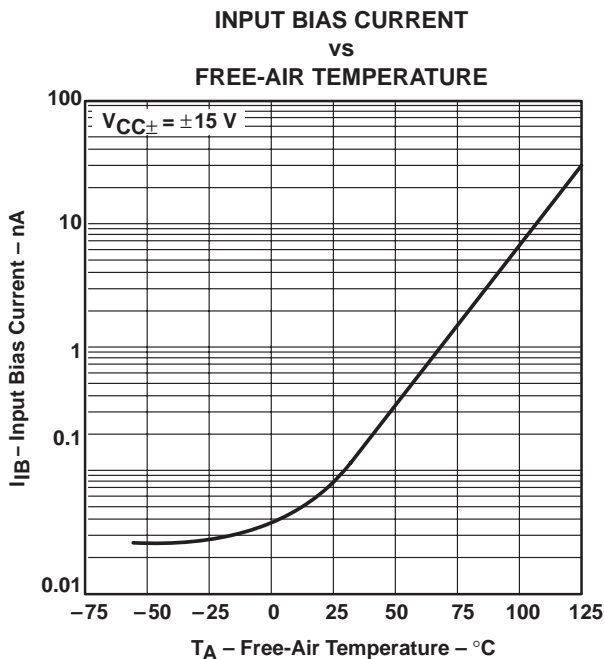


Figure 5

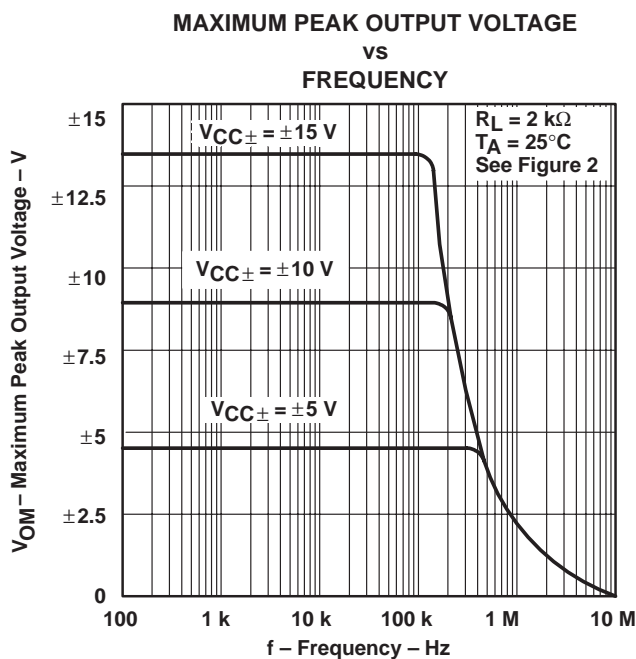


Figure 6

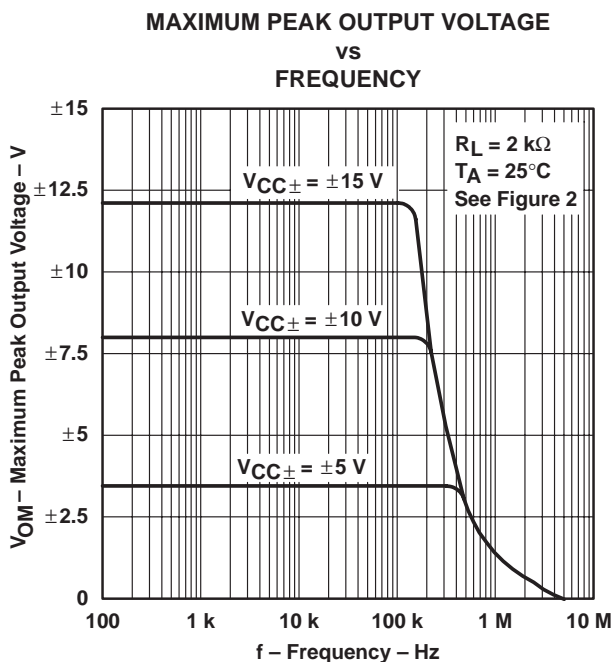


Figure 7

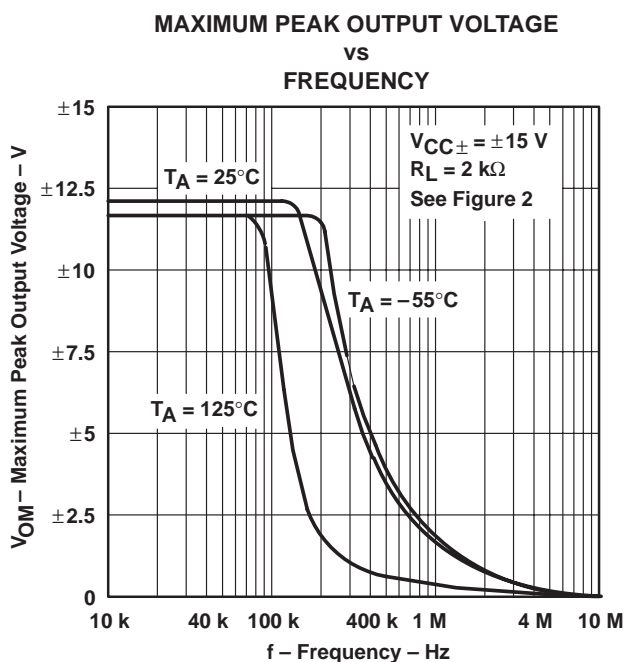


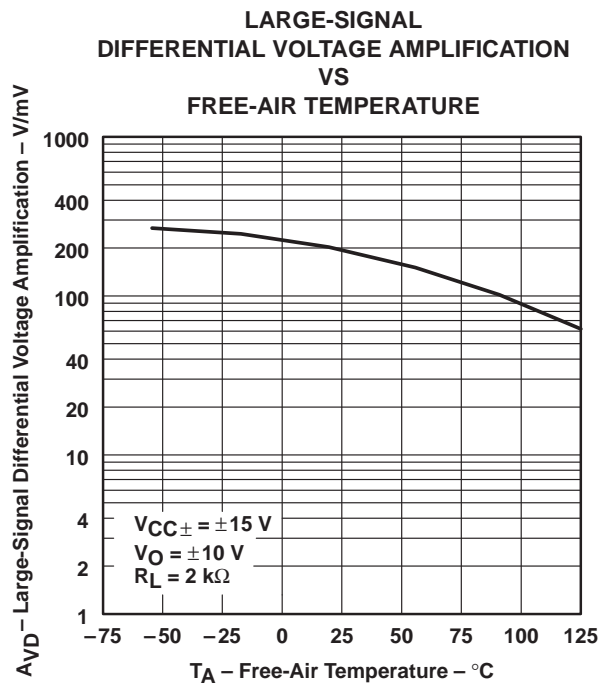
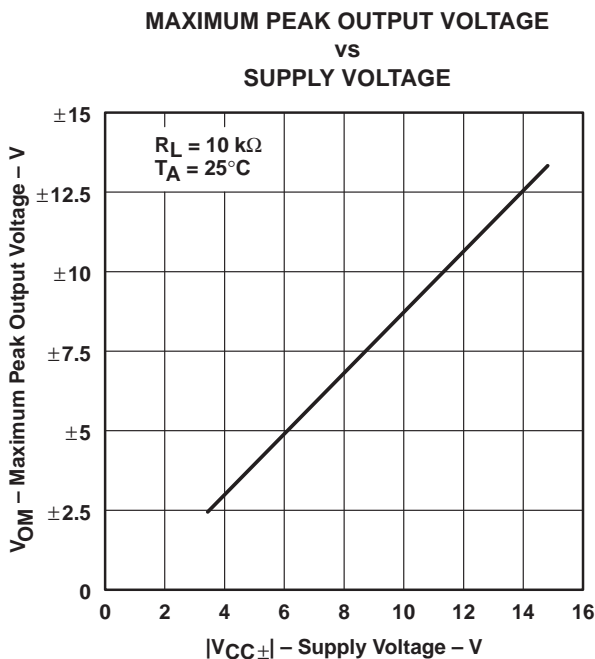
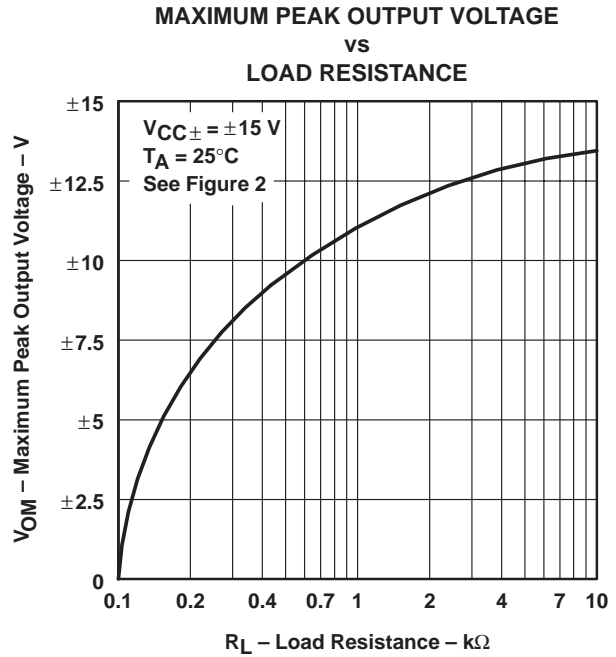
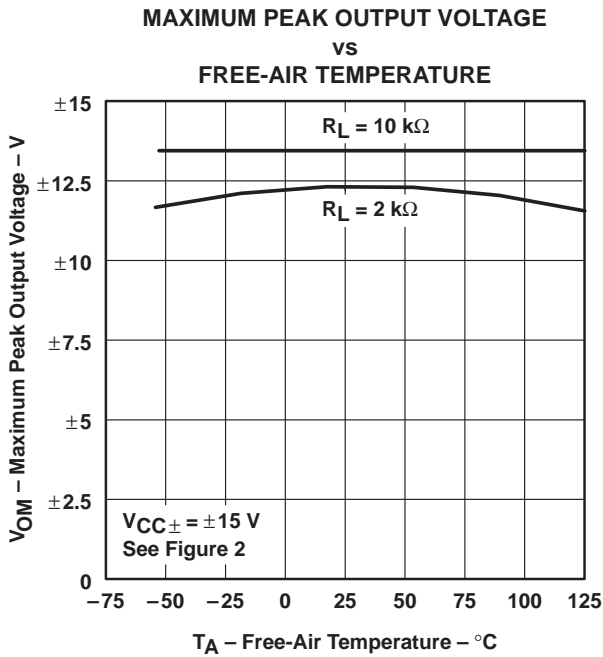
Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

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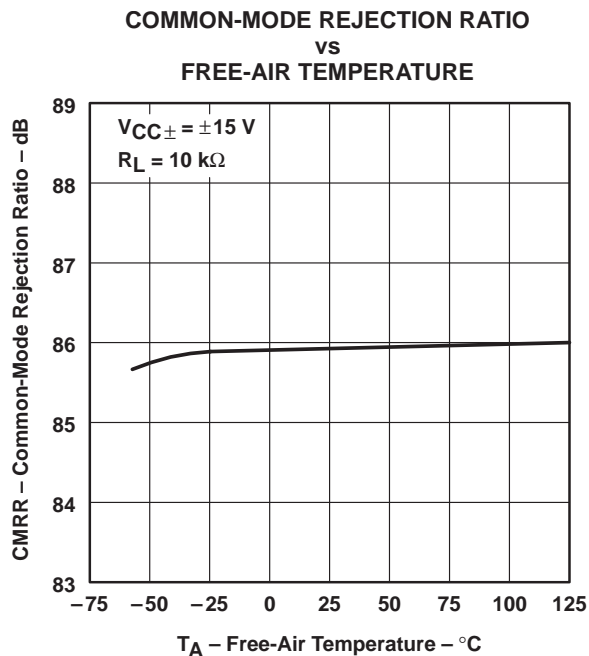
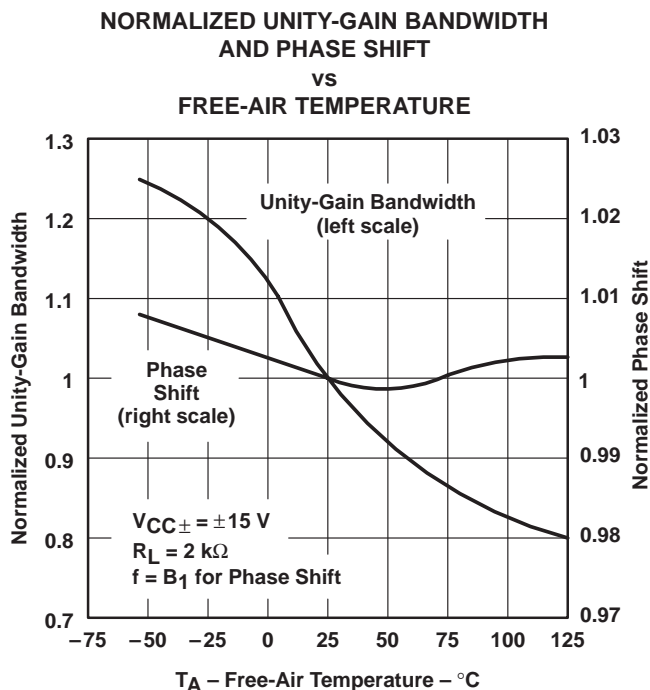
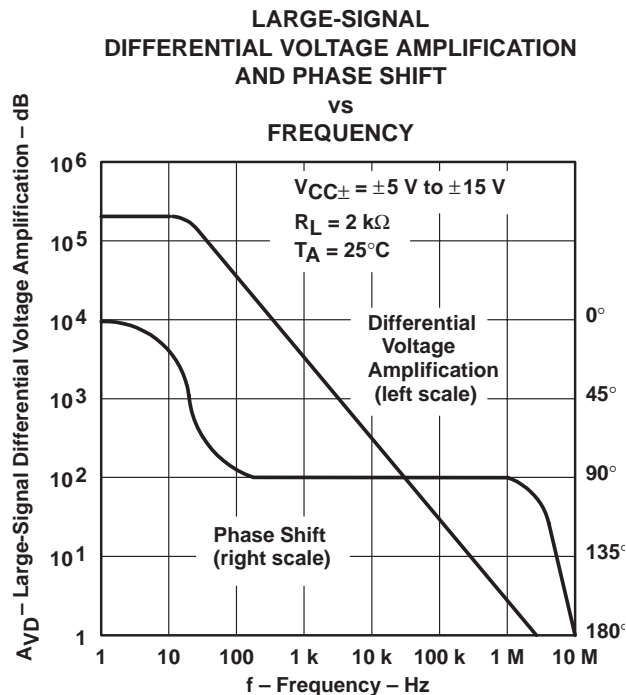
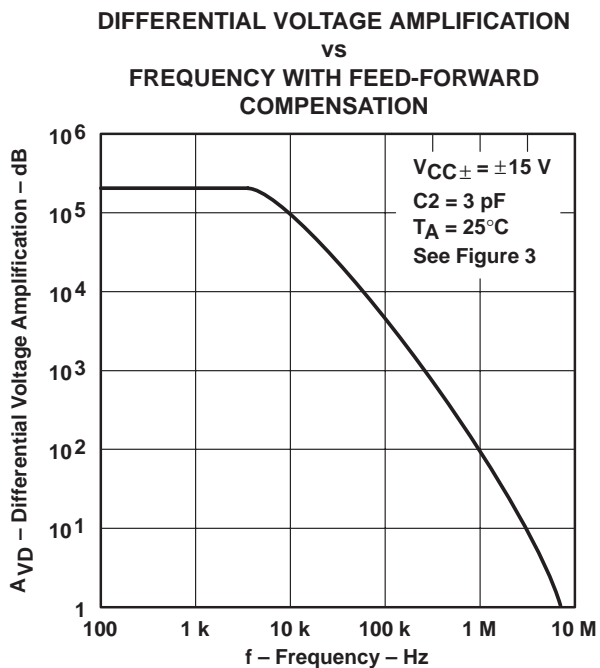
TYPICAL CHARACTERISTICS†



† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.



TYPICAL CHARACTERISTICS†



† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.

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TYPICAL CHARACTERISTICS†

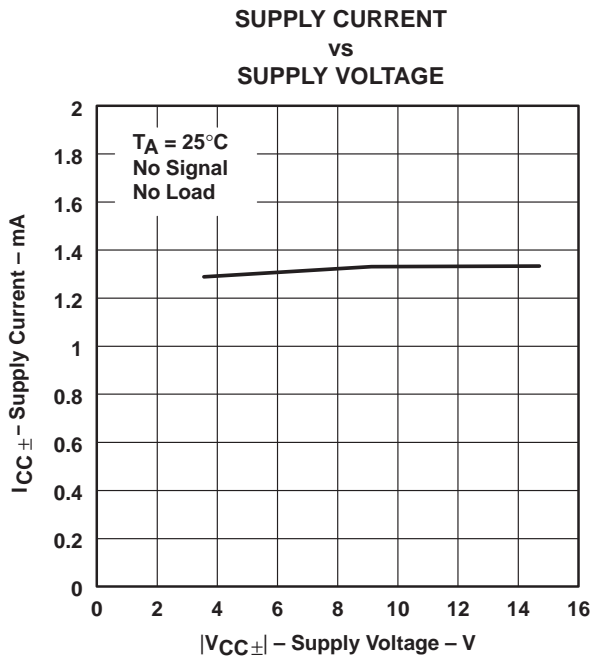


Figure 17

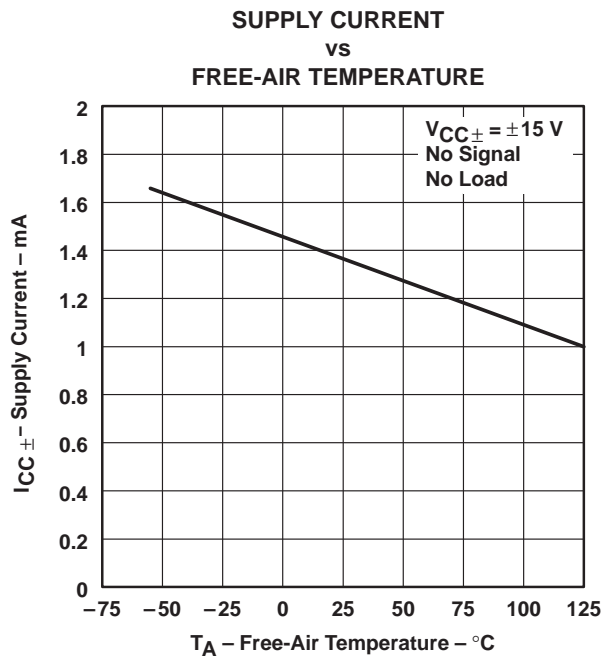


Figure 18

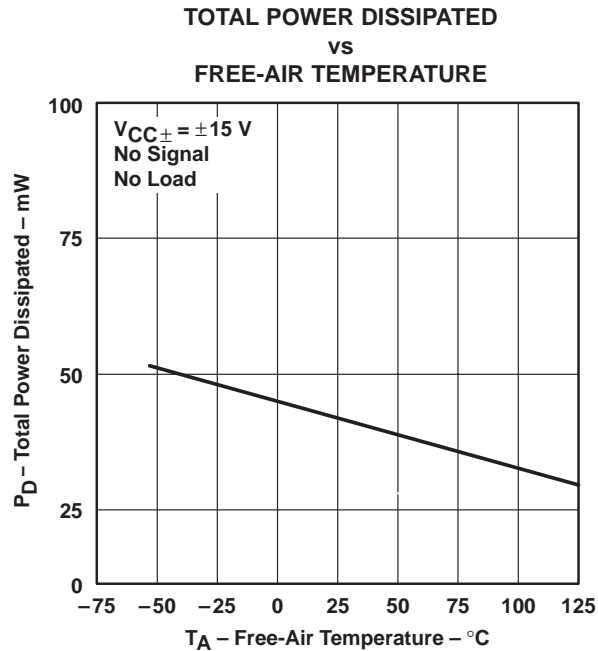


Figure 19

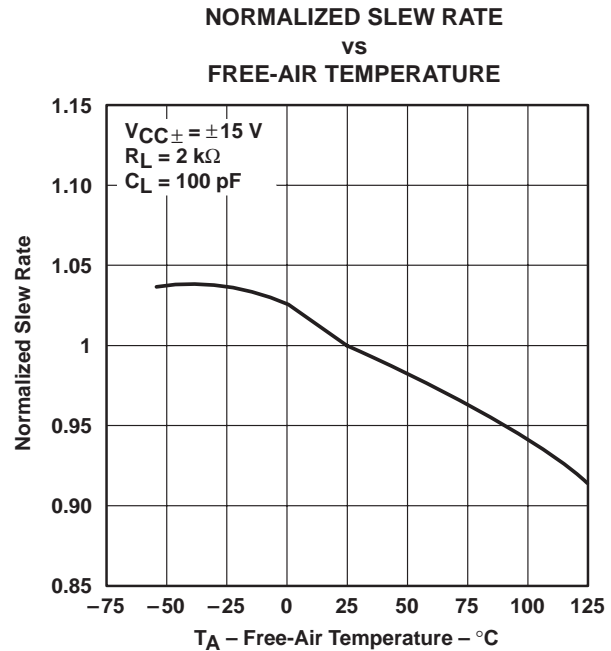


Figure 20

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used.



TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
 vs
 FREQUENCY

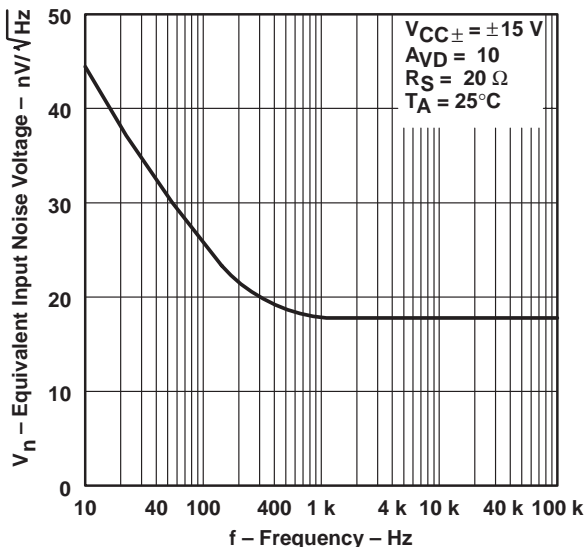


Figure 21

TOTAL HARMONIC DISTORTION
 vs
 FREQUENCY

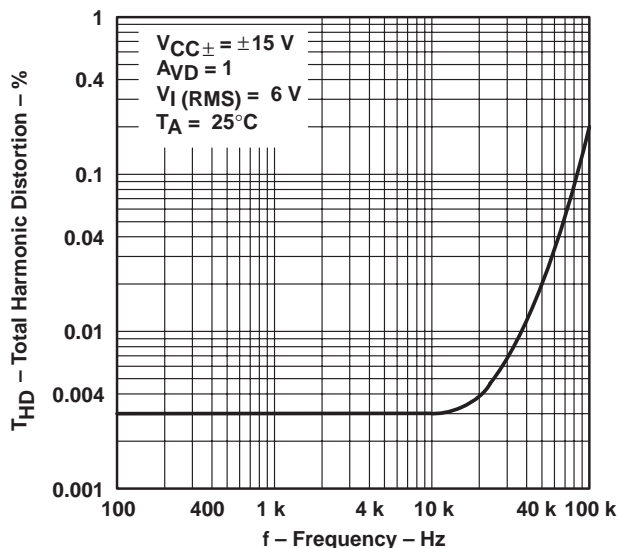


Figure 22

VOLTAGE-FOLLOWER
 LARGE-SIGNAL PULSE RESPONSE

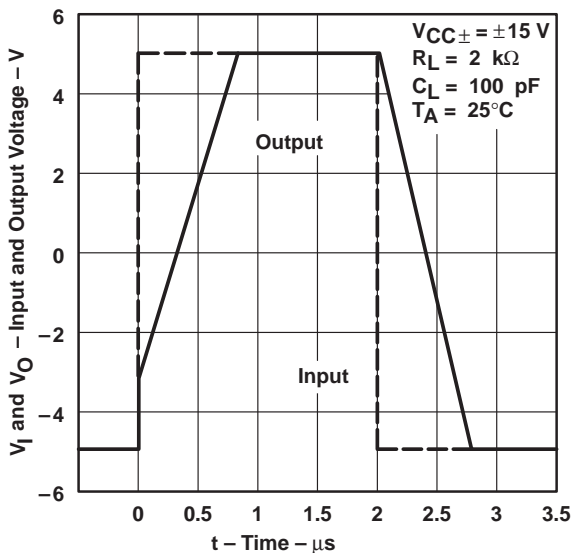


Figure 23

OUTPUT VOLTAGE
 vs
 ELAPSED TIME

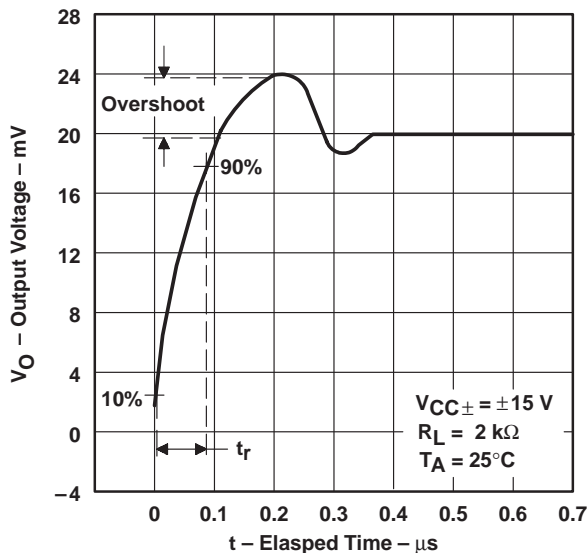


Figure 24

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APPLICATION INFORMATION

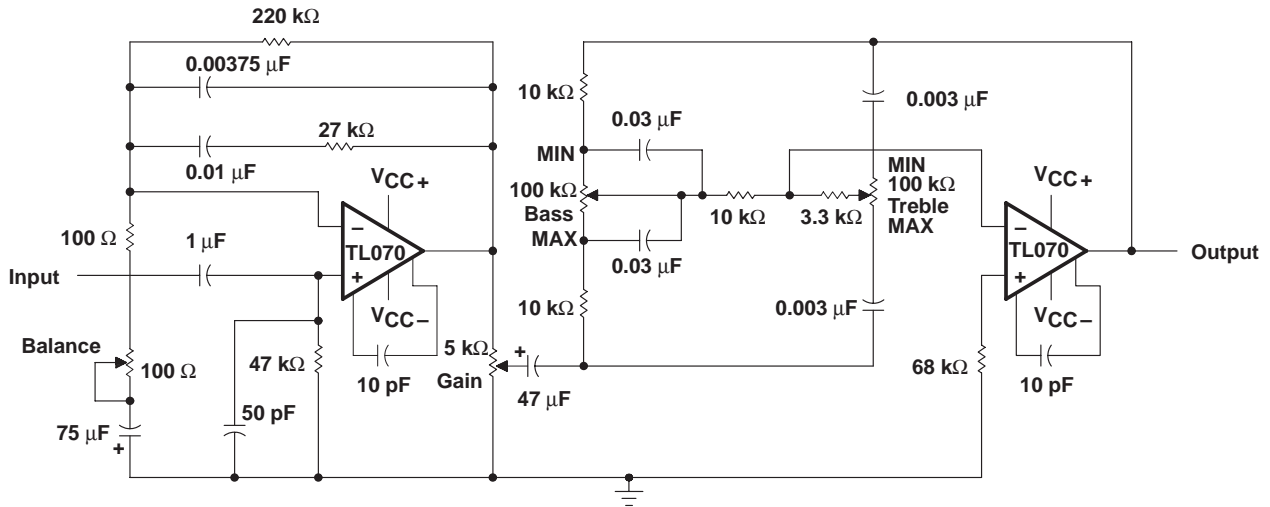


Figure 25. IC Preamplifier

IC PREAMPLIFIER
RESPONSE CHARACTERISTICS

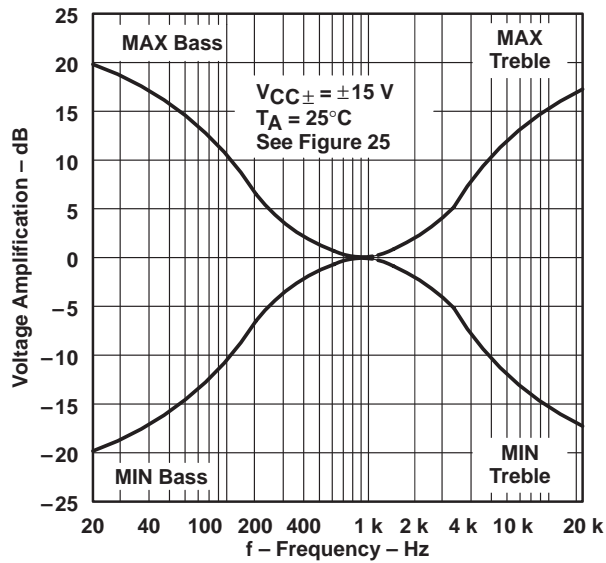


Figure 26

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