National Semiconductor

LH0022/LH0022C High Performance FET Op Amp
LH0042/LH0042C Low Cost FET Op Amp
LH0052/LH0052C Precision FET Op Amp

General Description

The LH0022/LH0042/LH0052 are a family of FET input operational amplifiers with very closely matched input characteristics, very high input impedance, and ultra-low input currents with no compromise in noise, common mode rejection ratio, open loop gain, or slew rate. The internally laser nulled LH0052 offers 500 microvolts maximum offset and 5 $\mu V/^{\circ}C$ offset drift. Input offset current is less than 500 femtoamps at room temperature and 500 pA maximum at 125°C. The LH0022 and LH0042 are not internally nulled but offer comparable matching characteristics. All devices in the family are internally compensated and are free of latch-up and unusual oscillation problems. The devices may be offset nulled with a single 10k trimpot with neglible effect in CMRR.

The LH0022, LH0042 and LH0052 are specified for operation over the -55°C to +125°C military temperature range. The LH0022C, LH0042C and LH0052C are specified for operation over the -25°C to +85°C temperature range.

Features

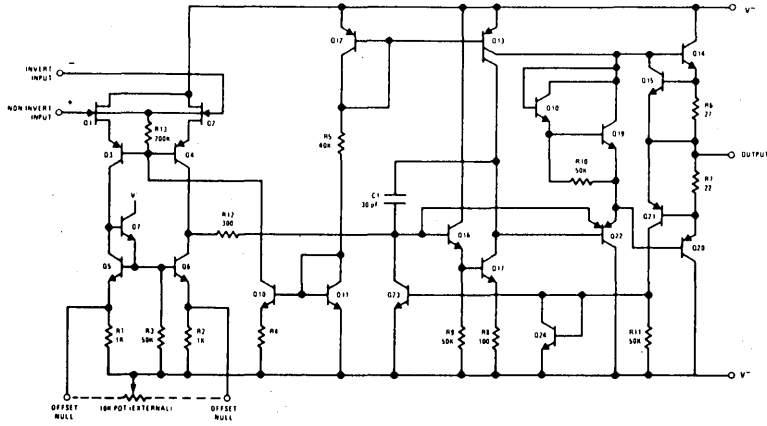
- Low input offset current—500 femtoamps max. (LH0052)
- Low input offset drift—5$\mu V/^{\circ}C$ max (LH0052)
- Low input offset voltage — 100 microvolts-typ.
- High open loop gain — 100 dB typ.
- Excellent slew rate — 3.0 V/μs typ.
- Internal 6 dB/octave frequency compensation
- Pin compatible with standard IC op amps (TO-5 package)

The LH0022/LH0042/LH0052 family of IC op amps are intended to fulfill a wide variety of applications for process control, medical instrumentation, and other systems requiring very low input currents and tightly matched input offsets. The LH0052 is particularly suited for long term high accuracy integrators and high accuracy sample and hold buffer amplifiers. The LH0022 and LH0042 provide low cost high performance for such applications as electrometer and photocell amplification, pico-ammeters, and high input impedance buffers.

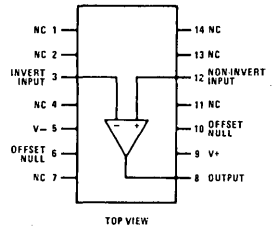
Special electrical parameter selection and custom built circuits are available on special request.

For additional application information and information on other National operational amplifiers, see *Available Linear Applications Literature.*

Schematic and Connection Diagrams



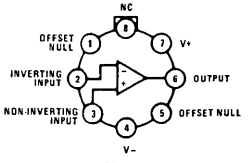
Dual-In-Line Package



TOP VIEW

Order Number LH0022D, LH0022CD, LH0042D, LH0042CD, LH0052D or LH0052CD
See Package D14E

Metal Can Package



TOP VIEW

Order Number LH0022H, LH0022CH, LH0042H, LH0042CH, LH0052H or LH0052CH
See Package H08A

*Previously Called NH0022/NH0022C

Absolute Maximum Ratings

Supply Voltage	±22V
Power Dissipation (see graph)	500 mW
Input Voltage (Note 1)	±15V
Differential Input Voltage (Note 2)	±30V
Voltage Between Offset Null and V^-	±0.5V
Short Circuit Duration	Continuous
Operating Temperature Range	
LH0022, LH0042, LH0052	−55°C to +125°C
LH0022C, LH0042C, LH0052C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

DC Electrical Characteristics for LH0022/LH0022C (Note 3)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0022			LH0022C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 100\ k\Omega$; $T_A = 25°C$, $V_S = \pm 15V$		2.0	4.0		3.5	6.0	mV
	$R_S \leq 100\ k\Omega$, $V_S = \pm 15V$			5.0			7.0	mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\ k\Omega$		5	10		5	15	µV/°C
Offset Voltage Drift with Time			3			4		µV/week
Input Offset Current	(Note 4)		0.2	2.0		1.0	5.0	pA
				2.0			0.5	nA
Temperature Coefficient of Input Offset Current		Doubles every 10°C			Doubles every 10°C			
Offset Current Drift with Time			0.1			0.1		pA/week
Input Bias Current	(Note 4)		5	10		10	25	pA
				10			2.5	nA
Temperature Coefficient of Input Bias Current		Doubles every 10°C			Doubles every 10°C			
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range	$V_S = \pm 15V$	±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$, $V_{IN} = \pm 10V$	80	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$, $\pm 5V \leq V_S \leq \pm 15V$	80	90		70	90		dB
Large Signal Voltage Gain	$R_L = 2\ k\Omega$, $V_{OUT} = \pm 10V$, $T_A = 25°C$, $V_S = \pm 15V$	100	200		75	160		V/mV
	$R_L = 2\ k\Omega$, $V_{OUT} = \pm 10V$, $V_S = \pm 15V$	50			50			V/mV
Output Voltage Swing	$R_L = 1\ k\Omega$, $T_A = 25°C$, $V_S = \pm 15V$	±10	±12.5		±10	±12		V
	$R_L = 2\ k\Omega$, $V_S = \pm 15V$	±10			±10			V
Output Current Swing	$V_{OUT} = \pm 10V$, $T_A = 25°C$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			25			25		mA
Supply Current	$V_S = \pm 15V$		2.0	2.5		2.4	2.8	mA
Power Consumption	$V_S = \pm 15V$			75			85	mW

DC Electrical Characteristics for LH0042/LH0042C (Note 3)

Parameter	Conditions	Limits						Units
		LH0042			LH0042C			
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage	$R_S \leq 100k\Omega$		5.0	20		6.0	20	mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100k\Omega$		5.0			10		µV/°C
Offset Voltage Drift with Time			7.0			10		µV/week
Input Offset Current	(Note 4)		1.0	5.0		2.0	10	pA
Temperature Coefficient of Input Offset Current		Doubles every 10°C			Doubles every 10°C			
Offset Current Drift with Time			0.1			0.1		pA/week
Input Bias Current	(Note 4)		10	25		15	50	pA
Temperature Coeffieient of Input Bias Current		Doubles every 10°C			Doubles every 19°C			
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range		±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$, $V_{IN} = \pm 10V$	70	86		70	80		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$, $\pm 5V \leq V_S \leq \pm 15V$	70	86		70	80		dB
Large Signal Voltage Gain	$R_S \leq 2k\Omega$, $V_{OUT} = \pm 10V$	50	150		25	100		V/mV
Output Voltage Swing	$R_L = 1k\Omega$, $T_A = 25°C$ $R_L = 2k\Omega$	±10 ±10	±12.5		±10 ±10	±12		V V
Output Current Swing	$V_{OUT} = \pm 10V$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			20			20		mA
Supply Current			2.5	3.5		2.8	4.0	mA
Power Consumption				105			120	mW

DC Electrical Characteristics For LH0052/LH0052C (Note 3)

Parameter	Conditions	Limits						Units
		LH0052			LH0052C			
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage	$R_S < 100k\Omega$, $V_S = +15V$ $T_A = 25°C$ $R_S < 100k\Omega$, $V_S = \pm 15V$		0.1	0.5 1.0		0.2	1.0 1.5	mV mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100k\Omega$, $V_S = \pm 15V$		2.0	5.0		5.0	10	µV/°C
Offset Voltage Drift with Time			2.0			4.0		µV/week
Input Offset Current	(Note 4)		0.01	5.0 500		0.02	1.0 100	pA pA
Temperature Coefficient of Input Offset Current		Doubles every 10°C			Doubles every 10°C			
Offset Current Drift with Time		<0.1			<0.1			pA/week
Input Bias Current	(Note 4)		0.5	2.5 2.5		1.0	5.0 0.5	pA nA
Temperature Coefficient of Input Bias Current		Doubles every 10°C			Doubles every 10°C			
Differential Input Resistance			10^{12}			10^{12}		Ω
Common Mode Input Resistance			10^{12}			10^{12}		Ω
Input Capacitance			4.0			4.0		pF
Input Voltage Range	$V_S = \pm 15V$	±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$, $V_{IN} = \pm 10V$	74	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$, $\pm 5V \leq V_S \leq \pm 15V$	74	90		70	90		dB
Large Signal Voltage Gain	$R_L = 2K\Omega$, $V_{OUT} = \pm 10V$ $V_S = \pm 15V$, $T_A = 25°C$	100	200		75	160		V/mV
	$R_L = 2k\Omega$, $V_{OUT} = \pm 10V$ $V_S = \pm 15V$	50			50			V/mV
Output Voltage Swing	$R_L = 1k\Omega$, $T_A = 25°C$ $V_S = \pm 15V$	±10	±12.5		±10	±12		V
	$R_L = 2k\Omega$, $V_S = \pm 15V$	±10			±10			V
Output Current Swing	$V_{OUT} = \pm 10V$, $t_A = 25°C$	±10	±15		±10	±15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			25			25		mA
Supply Current	$V_S = \pm 15V$		3.0	3.5		3.0	3.8	mA
Power Consumption	$V_S = \pm 15V$			105			114	mW

AC Electrical Characteristics For all amplifiers ($T_A = 25°C$, $V_S = \pm 15V$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0022/42/52			LH0022C/42C/52C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	Voltage Follower	1.5	3.0		1.0	3.0		V/μs
Large Signal Bandwidth	Voltage Follower		40			40		kHz
Small Signal Bandwidth			1.0			1.0		MHz
Rise Time			0.3	1.5		0.3	1.5	μs
Overshoot			10	30		15	40	%
Settling Time (0.1 %)	ΔV_{IN} = 10V		4.5			4.5		μs
Overload Recovery			4.0			4.0		μs
Input Noise Voltage	R_S = 10 kΩ, f_o = 10 Hz		150			150		nV/√Hz
Input Noise Voltage	R_S = 10 kΩ, f_o = 100 Hz		55			55		nV/√Hz
Input Noise Voltage	R_S = 10 kΩ, f_o = 1 kHz		35			35		nV/√Hz
Input Noise Voltage	R_S = 10 kΩ, f_o = 10 kHz		30			30		nV/√Hz
Input Noise Voltage	BW = 10 Hz to 10 kHz, R_S = 10 kΩ		12			12		μVrms
Input Noise Current	BW = 10 Hz to 10 kHz		<.1			<.1		pArms

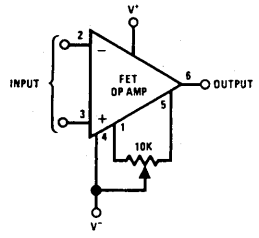
Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 2: Rating applies for minimum source resistance of 10 kΩ, for source resistances less than 10 kΩ, maximum differential input voltage is ±5V.

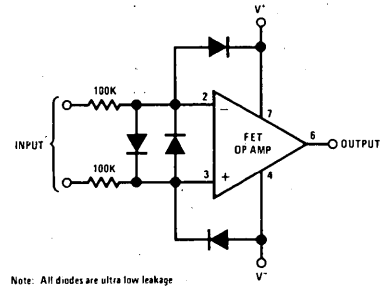
Note 3: Unless otherwise specified, these specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C \leq T_A \leq \pm 125°C$ for the LH0022 and LH0052 and $-25°C \leq T_A \leq +85°C$ for the LH0022C and LH0052C Typical values are given for $T_A = 25°C$.

Note 4: Input currents are a strong function of temperature. Due to high speed testing they are specified a junction temperature $T_j = 25°C$, self heating will cause an increase in current in manual tests.

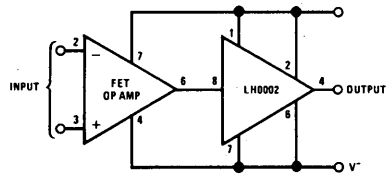
Auxiliary Circuits (Shown for TO-5 pin out)



Offset Null

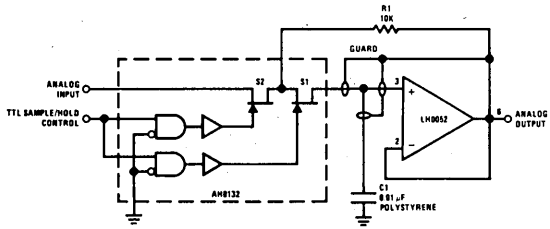


Protecting Inputs From ±150V Transients

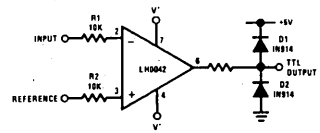


Boosting Output Drive to ±100 mA

Typical Applications

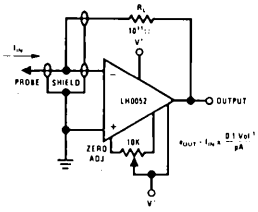


Low Drift Sample and Hold

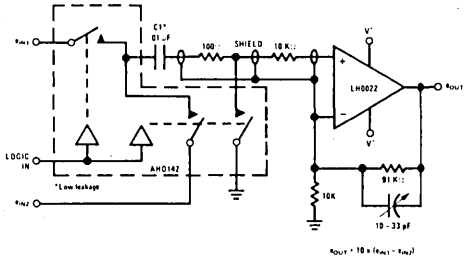


Precision Voltage Comparator

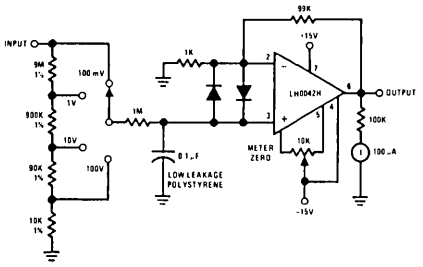
Typical Applications (Cont'd)



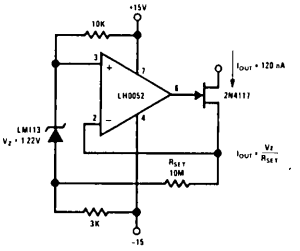
Picoamp Amplifier for pH Meters and Radiation Detectors



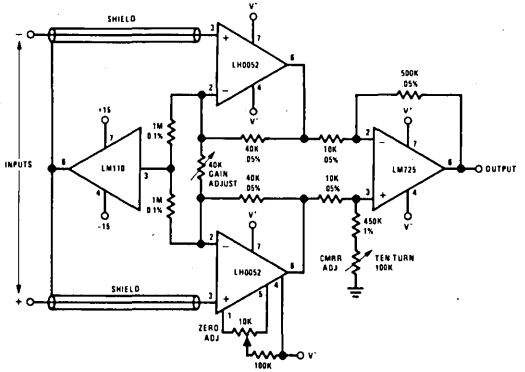
Precision Subtractor for Automatic Test Gear



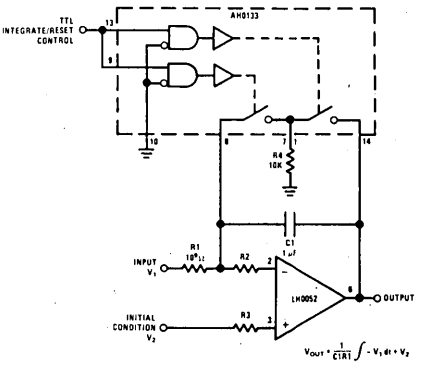
Sensitive Low Cost "VTVM"



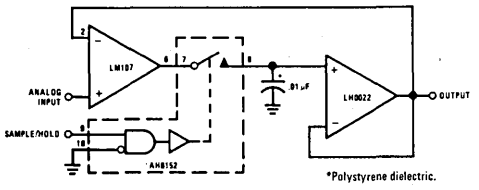
Ultra Low Level Current Source



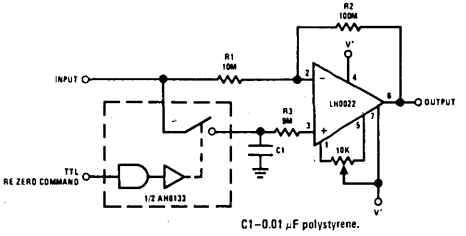
True Instrumentation Amplifier



Precision Integrator



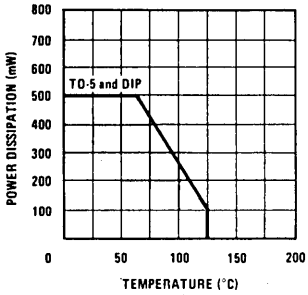
Precision Sample and Hold



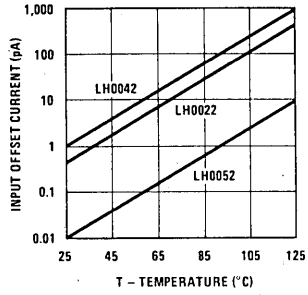
Re-Zeroing Amplifier

Typical Performance Characteristics

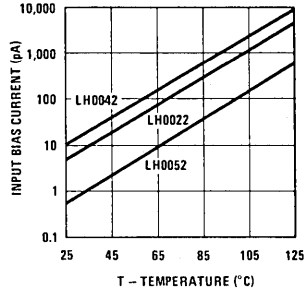
Maximum Power Dissipation



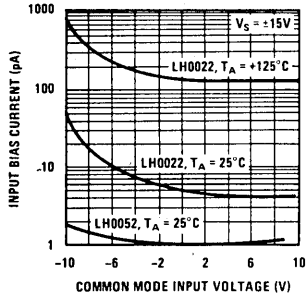
Input Offset Current vs Temperature



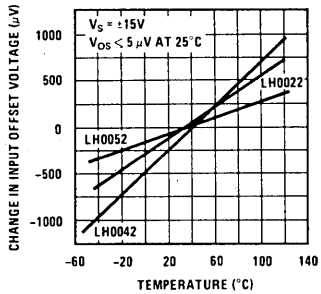
Input Bias Current vs Temperature



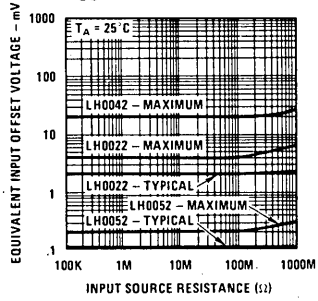
Input Bias Current vs Input Voltage



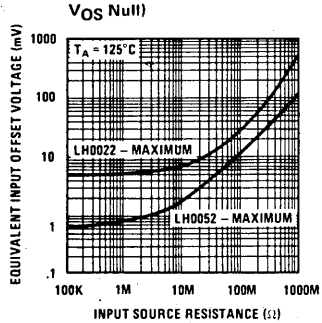
Input Offset Voltage vs Temperature



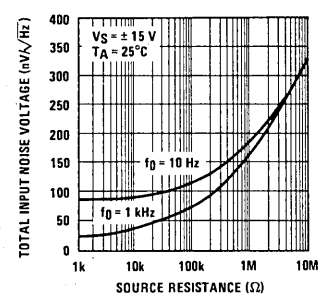
Offset Error (Without V_{OS} Null)



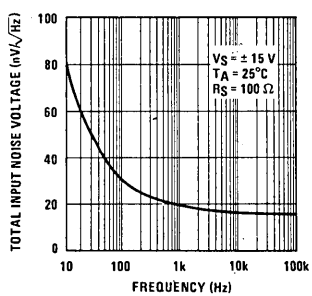
Offset Error (Without V_{OS} Null)



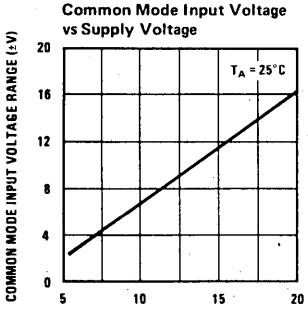
Total Input Noise Voltage* vs Source Resistance



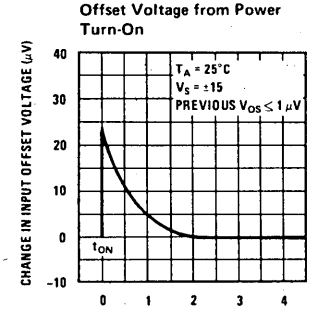
Total Input Noise Voltage* vs Frequency



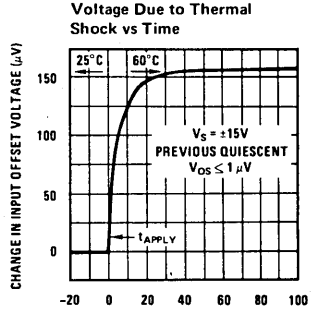
Common Mode Input Voltage vs Supply Voltage



Stabilization Time of Input Offset Voltage from Power Turn-On



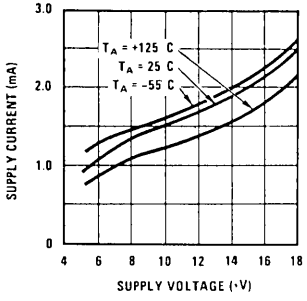
Change in Input Offset Voltage Due to Thermal Shock vs Time



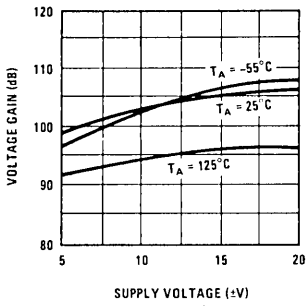
*Noise Voltage Includes Contribution from Source Resistance

Typical Performance Characteristics (Cont'd)

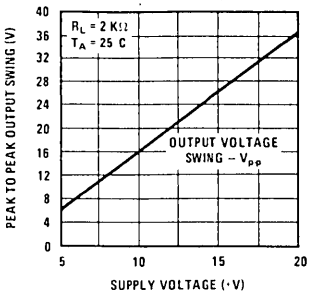
Supply Voltage vs Supply Current



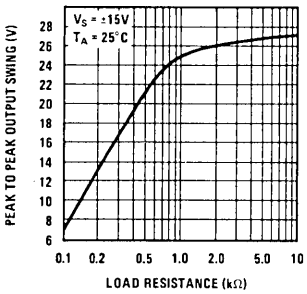
Voltage Gain



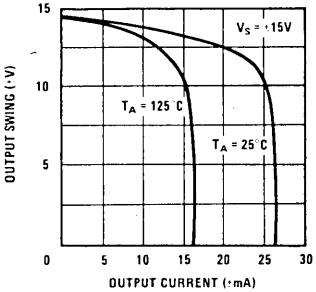
Output Swing vs Supply Voltage



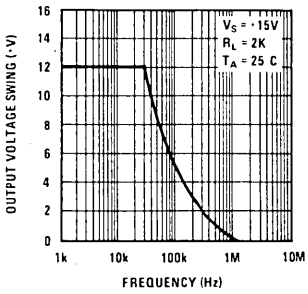
Output Voltage Swing vs Load Resistance



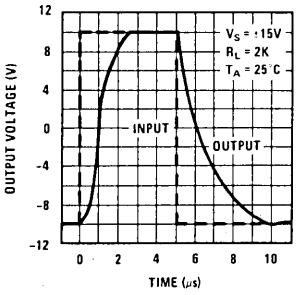
Current Limiting



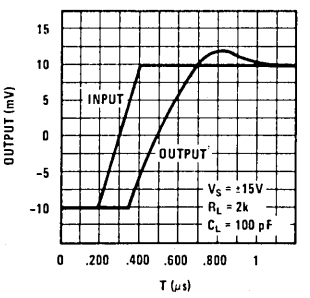
Output Voltage Swing vs Frequency



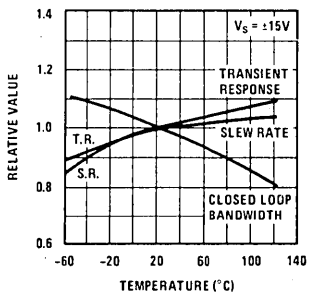
Voltage Follower Large Signal Response



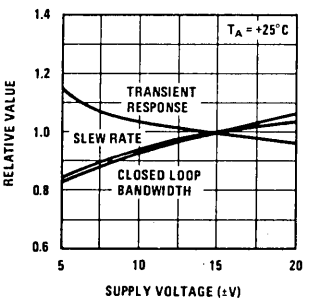
Transient Response



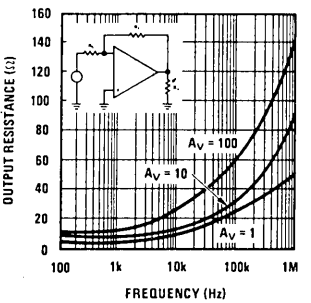
Frequency Characteristics vs Ambient Temperature



Frequency Characteristics vs Supply Voltage



Output Resistance vs Frequency



Open Loop Transfer Characteristics vs Frequency