



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 μV maximum offset and 2 $\mu\text{V}/^\circ\text{C}$ 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 negligible effect in CMRR.

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

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 is available on special request.

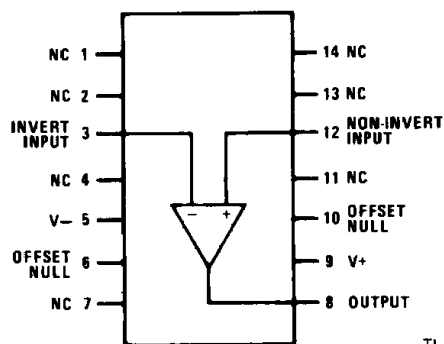
For additional application information and information on other National operational amplifiers, see *Available Linear Applications Literature*.

Features

- Low input offset current—500 femtoamps max (LH0052)
- Low input offset drift—2 $\mu\text{V}/^\circ\text{C}$ typ (LH0052)
- Low input offset voltage—100 μV 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)

Connection Diagrams

Dual-In-Line Package



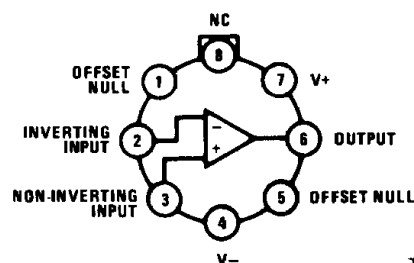
TL/K/5557-2

Top View

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

Order Number LH0042E
See NS Package Number E20A

Metal Can Package

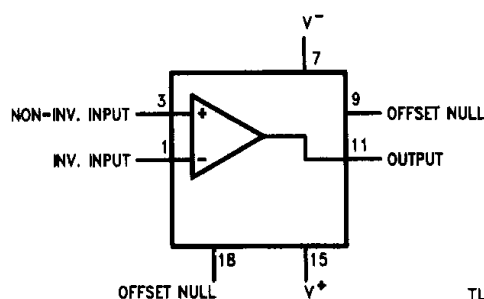


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Top View

Order Number LH0022H, LH0022CH, LH0042H,
LH0042CH, LH0052H or LH0052CH
See NS Package Number H08D

Leadless Chip Carrier



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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

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) T_A = T_J(Max)

Parameter	Conditions	Limits						Units
		LH0022			LH0022C			
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$, $T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$		2.0	4.0		3.5	6.0	mV
	$R_S \leq 100\text{ k}\Omega$, $V_S = \pm 15\text{V}$			5.0			7.0	mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$		10			15		$\mu\text{V}/^\circ\text{C}$
Offset Voltage Drift with Time			3			4		$\mu\text{V}/\text{week}$
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	$V_S = \pm 15\text{V}$	± 12	± 13.5		± 12	± 13.5		V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $V_{\text{IN}} = \pm 10\text{V}$	80	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$	80	90		70	90		dB
Large Signal Voltage Gain	$R_L = 2\text{ k}\Omega$, $V_{\text{OUT}} = \pm 10\text{V}$ $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$	100	200		75	160		V/mV
	$R_L = 2\text{ k}\Omega$, $V_{\text{OUT}} = \pm 10\text{V}$ $V_S = \pm 15\text{V}$	50			50			V/mV
Output Voltage Swing	$R_L = 1\text{ k}\Omega$, $T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$	± 10	± 12.5		± 10	± 12		V
	$R_L = 2\text{ k}\Omega$, $V_S = \pm 15\text{V}$	± 10			± 10			V
Output Current Swing	$V_{\text{OUT}} = \pm 10\text{V}$, $T_A = 25^\circ\text{C}$	± 10	± 15		± 10	± 15		mA
Output Resistance			75			75		Ω
Output Short Circuit Current			25			25		mA
Supply Current	$V_S = \pm 15\text{V}$		2.0	2.5		2.4	2.8	mA
Power Consumption	$V_S = \pm 15\text{V}$			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	$R_S \leq 100\text{ k}\Omega$		5.0	20		6.0	20	mV
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$		10			15		$\mu\text{V}/^\circ\text{C}$
Offset Voltage Drift with Time			7.0			10		$\mu\text{V}/\text{week}$
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 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		± 12	± 13.5		± 12	± 13.5		V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $V_{\text{IN}} = \pm 10\text{V}$	70	86		70	80		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$	70	86		70	86		dB
Large Signal Voltage Gain	$R_S \leq 2\text{ k}\Omega$, $V_{\text{OUT}} = \pm 10\text{V}$	50	150		25	100		V/mV
Output Voltage Swing	$R_L = 1\text{ k}\Omega$, $T_A = 25^\circ\text{C}$	± 10	± 12.5		± 10	± 12		V
	$R_L = 2\text{ k}\Omega$	± 10			± 10			V
Output Current Swing	$V_{\text{OUT}} = \pm 10\text{V}$	± 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	$R_S < 100\text{ k}\Omega$, $V_S = +15\text{V}$ $T_A = 25^\circ\text{C}$		0.1	1.0		0.4	2.0	mV
	$R_S < 100\text{ k}\Omega$, $V_S = \pm 15\text{V}$			2.0			3.0	mV
Temperature Coefficient of Input Offset Voltage	$V_S = 100\text{ k}\Omega$, $V_S = \pm 15\text{V}$		2.0			5.0		$\mu\text{V}/^\circ\text{C}$
Offset Voltage Drift with Time			2.0			4.0		$\mu\text{V}/\text{week}$
Input Offset Current	(Note 4)		0.01	5.0		0.02	1.0	pA
				500			100	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

DC Electrical Characteristics for LH0052/LH0052C (Note 3) (Continued)

Parameter	Conditions	Limits						Units
		LH0052			LH0052C			
		Min	Typ	Max	Min	Typ	Max	
Input Bias Current	(Note 4)		0.5	2.5		1.0	5.0	pA
				2.5			0.5	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 = ±15V	±12	±13.5		±12	±13.5		V
Common Mode Rejection Ratio	R _S ≤ 10 kΩ, V _{IN} = ±10V	74	90		70	90		dB
Supply Voltage Rejection Ratio	R _S ≤ 10 kΩ, ±5V ≤ V _S ≤ ±15V	74	90		70	90		dB
Large Signal Voltage Gain	R _L = 2 kΩ, V _{OUT} = ±10V V _S = ±15V, T _A = 25°C	100	200		75	160		V/mV
	R _L = 2 kΩ, V _{OUT} = ±10V V _S = ±15V	50			50			V/mV
Output Voltage Swing	R _L = 1 kΩ, T _A = 25°C V _S = ±15V	±10	±12.5		±10	±12		V
	R _L = 2 kΩ, V _S = ±15V	±10			±10			V
Output Current Swing	V _{OUT} = ±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 = ±15V		3.0	3.5		3.0	3.8	mA
Power Consumption	V _S = ±15V			105			114	mW

AC Electrical Characteristics for all amplifiers (T_A = 25°C, V_S = ±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

AC Electrical Characteristics for all amplifiers ($T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$) (Continued)

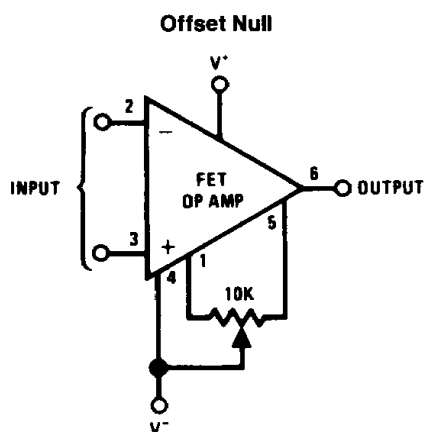
Parameter	Conditions	Limits						Units
		LH0022/42/52			LH0022C/42C/52C			
		Min	Typ	Max	Min	Typ	Max	
Input Noise Voltage	$R_S = 10\text{ k}\Omega$, $f_o = 10\text{ Hz}$		150			150		nV/ $\sqrt{\text{Hz}}$
	$R_S = 10\text{ k}\Omega$, $f_o = 100\text{ Hz}$		55			55		nV/ $\sqrt{\text{Hz}}$
	$R_S = 10\text{ k}\Omega$, $f_o = 1\text{ kHz}$		35			35		nV/ $\sqrt{\text{Hz}}$
	$R_S = 10\text{ k}\Omega$, $f_o = 10\text{ kHz}$		30			30		nV/ $\sqrt{\text{Hz}}$
	$BW = 10\text{ Hz to }10\text{kHz}$, $R_S = 10\text{ k}\Omega$		12			12		μVrms
Input Noise Current	$BW = 10\text{ Hz to }10\text{kHz}$		<0.1			<0.1		pArms

Note 1: For supply voltages less than $\pm 15\text{V}$, the absolute maximum input voltage is equal to the supply voltage.

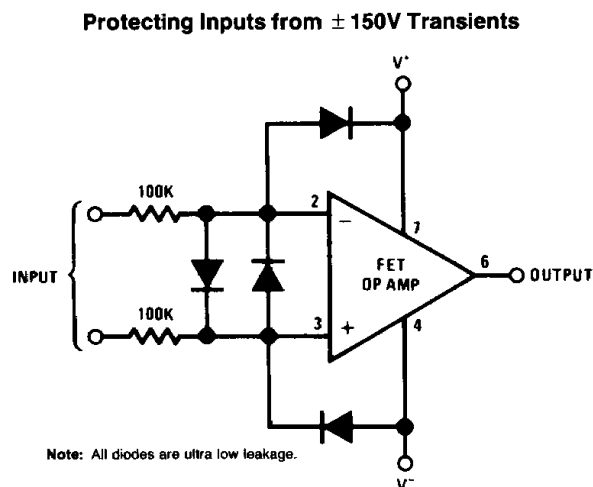
Note 2: Rating applies for minimum source resistance of $10\text{ k}\Omega$, for source resistances less than $10\text{ k}\Omega$, maximum differential input voltage is $\pm 5\text{V}$.

Note 3: Unless otherwise specified, these specifications apply for $\pm 5\text{V} \leq V_S \leq +20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for the LH0022/42/52 and $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for the LH0022C/42C/52C. Typical values are given for $T_A = 25^\circ\text{C}$.

Note 4: Input currents are a strong function of temperature. Due to high speed testing they are specified at a junction temperature $T_J = 25^\circ\text{C}$. Self heating will cause an increase in current in manual tests. 25°C spec is guaranteed by testing at 125°C .

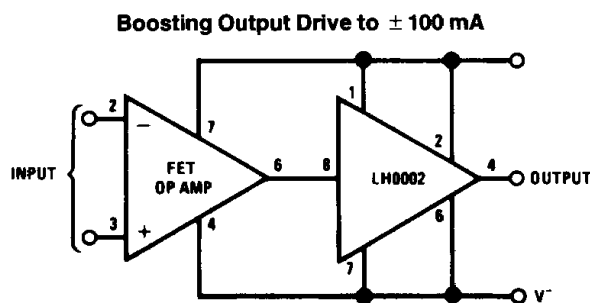
Auxiliary Circuits (Shown for TO-5 pin out)

TL/K/5557-5



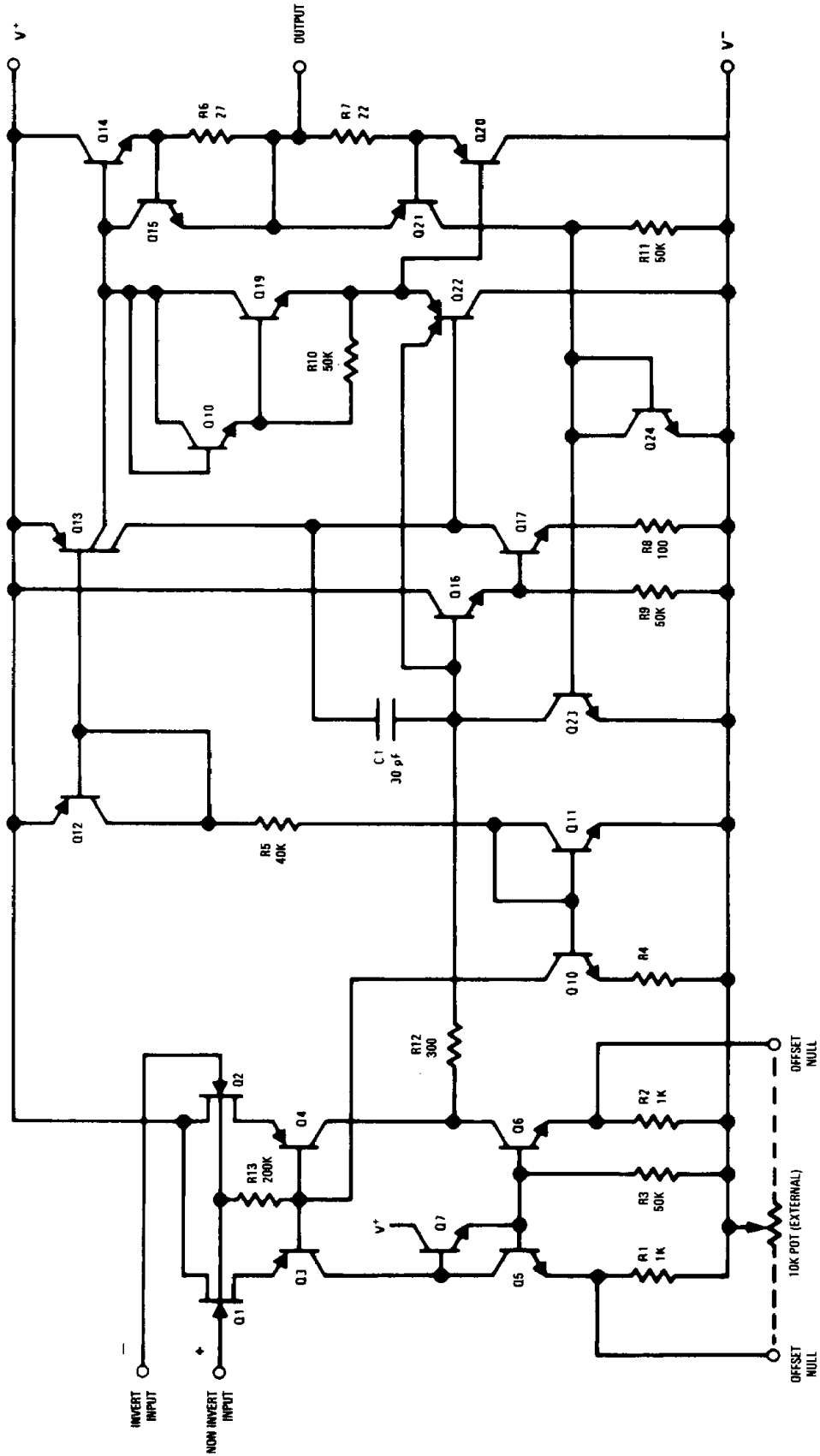
Note: All diodes are ultra low leakage.

TL/K/5557-6



TL/K/5557-7

Schematic Diagram

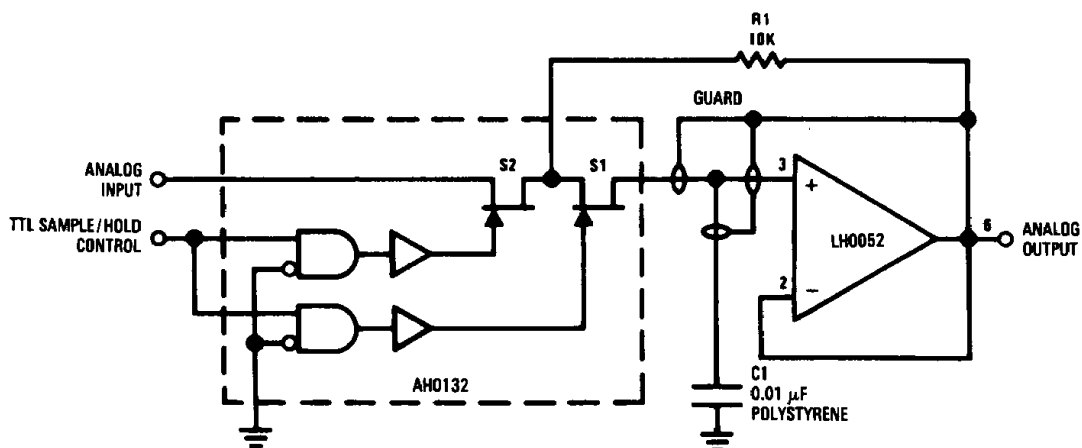


TL/K/5557-1

LH0022/LH0022C/LH0042/LH0042C/LH0052/LH0052C

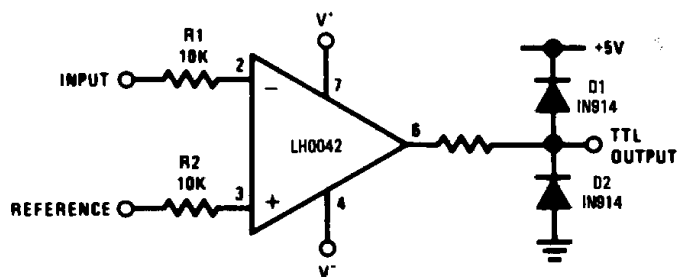
Typical Applications

Low Drift Sample and Hold



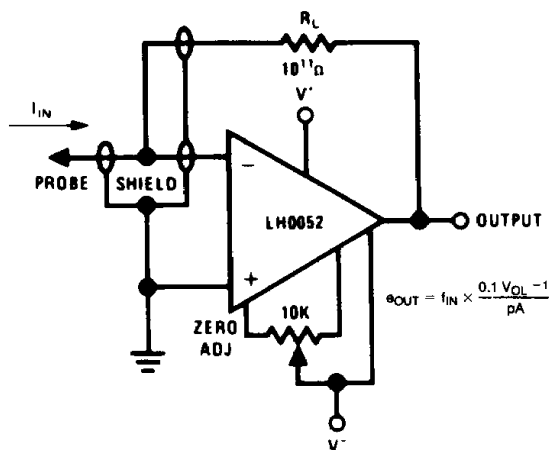
TL/K/5557-8

Precision Voltage Comparator



TL/K/5557-9

Picoamp Amplifier for pH Meters and Radiation Detectors



TL/K/5557-10

LH0022/LH0022C/LH0042/LH0042C/LH0052/LH0052C

The circuit diagram shows a differential amplifier with two inputs, e_{IN1} and e_{IN2} , and a logic input. The e_{IN1} input is connected to a switch that can route the signal to either the non-inverting input (+) or the inverting input (-) of the amplifier. The e_{IN2} input is connected to the inverting input (-). A logic input is connected to a switch that can route the signal to either the non-inverting input (+) or the inverting input (-). The amplifier is an LH0022, which is a dual in-line package (DIP) with pins for V^+ , V^- , and e_{OUT} . The feedback network consists of a $10\text{ K}\Omega$ resistor and a $91\text{ K}\Omega$ resistor in parallel, with a feedback capacitor of $10 - 33\text{ pF}$. The output e_{OUT} is connected to a load resistor of $10\text{ K}\Omega$. The circuit is labeled with component values: $C1^* 0.01\text{ }\mu\text{F}$, $100\text{ }\Omega$, $5\text{ M}\Omega$, $10\text{ K}\Omega$, 10 K , $91\text{ K}\Omega$, $10 - 33\text{ pF}$, and 10 K . The circuit is also labeled with e_{IN1} , e_{IN2} , $LOGIC\ IN$, $*Low\ leakage$, $AH0142$, $LH0022$, V^+ , V^- , and e_{OUT} .

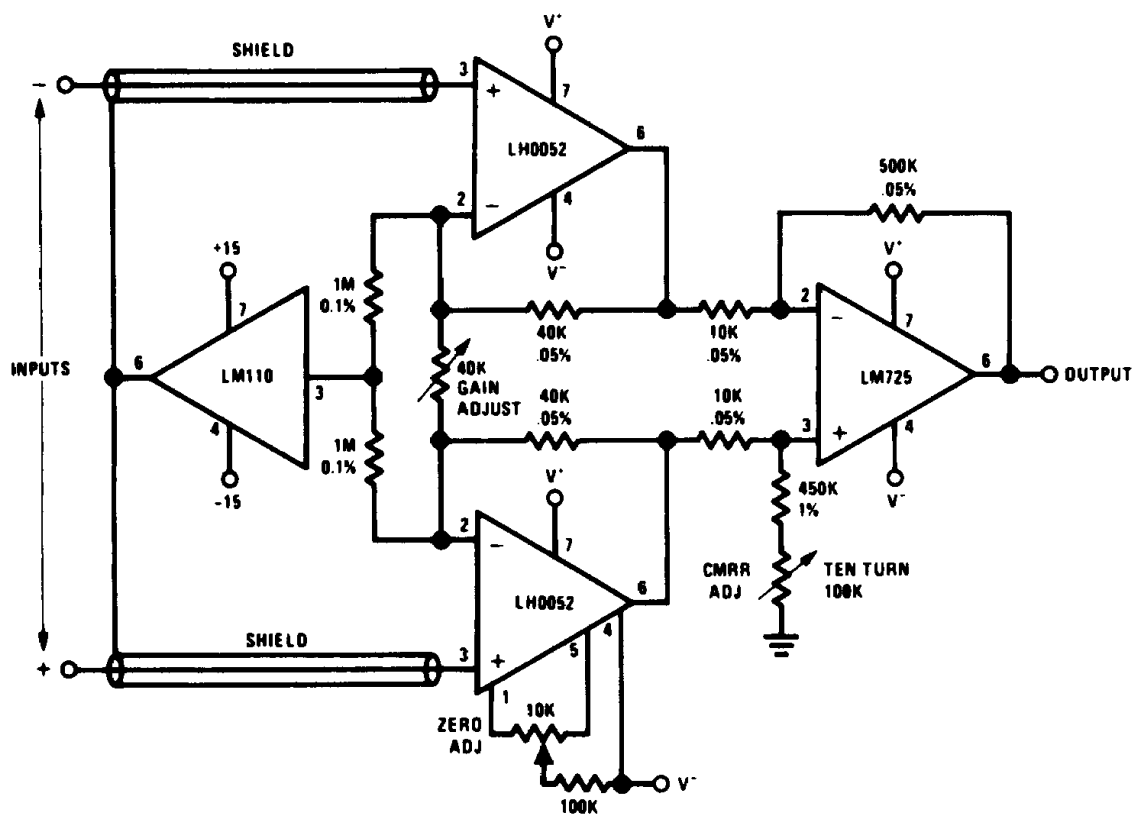
$$e_{OUT} = 10 \times (e_{IN1} - e_{IN2})$$

The circuit diagram shows a precision rectifier using an LHO042H operational amplifier. The input signal is applied to the non-inverting input (pin 3) through a 1M resistor. The inverting input (pin 2) is connected to the output (pin 6) through a 99K resistor and to ground through a 1K resistor. The output (pin 6) is also connected to a 100K resistor and a 100 μA current source. The op-amp is powered by +15V and -15V. The circuit is labeled with component values and a 'METER ZERO' label.

The circuit diagram shows an LM0052 operational amplifier configured as a precision current source. The non-inverting input (pin 3) is connected to a voltage divider consisting of a 10K resistor connected to a +15V supply and a 3K resistor connected to a -15V supply. The inverting input (pin 2) is connected to the cathode of an LM113 diode. The anode of the LM113 diode is connected to the -15V supply, and its voltage is specified as $V_Z = 1.22V$. The output of the op-amp (pin 6) drives the base of a 2N4117 NPN transistor. The emitter of the transistor is connected to the -15V supply through a resistor labeled R_{SET} with a value of 10M. The collector of the transistor provides the output current I_{OUT} , which is specified as 120 nA. The op-amp's supply pins (pin 1 to +15V and pin 7 to -15V) are also shown.

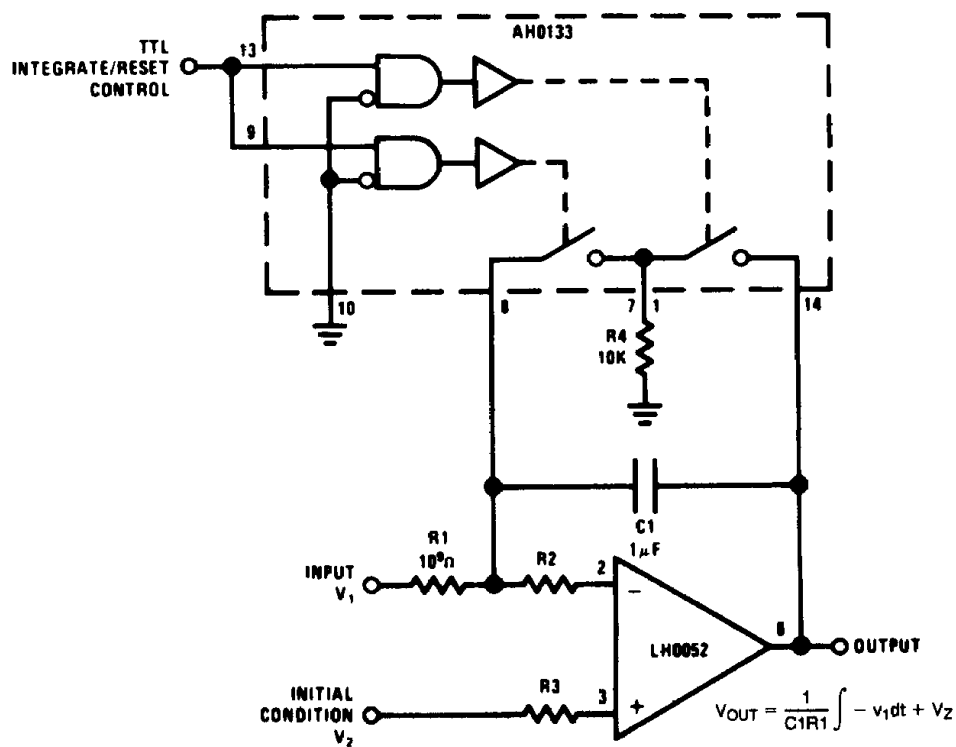
Typical Applications (Continued)

True Instrumentation Amplifier



TL/K/5557-14

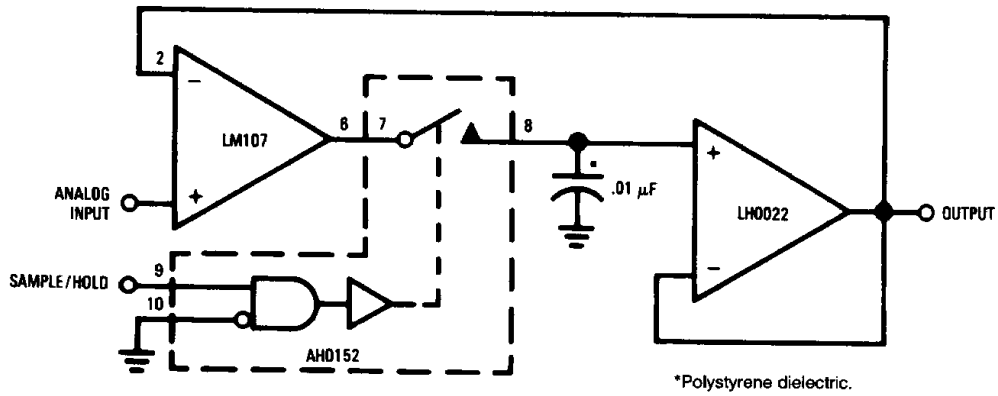
Precision Integrator



TL/K/5557-15

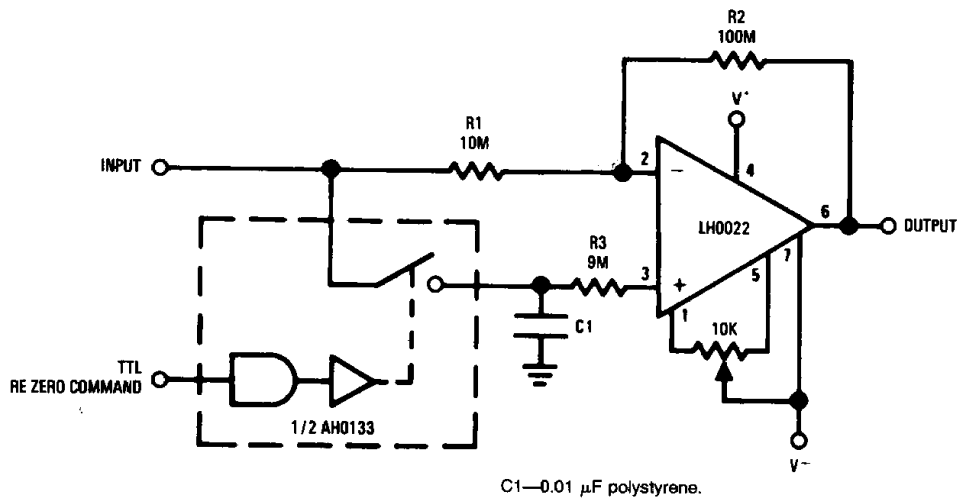
Typical Applications (Continued)

Precision Sample and Hold



TL/K/5557-16

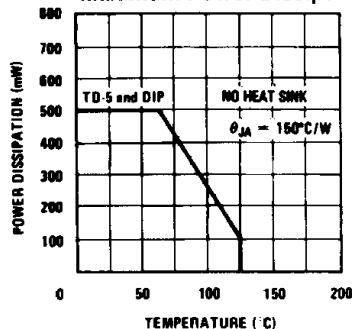
Re-Zeroing Amplifier



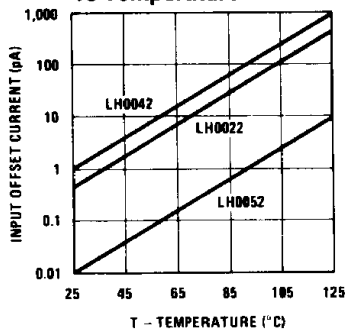
TL/K/5557-17

Typical Performance Characteristics

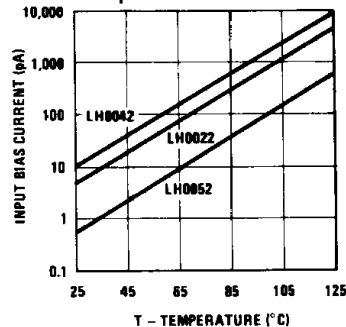
Maximum Power Dissipation



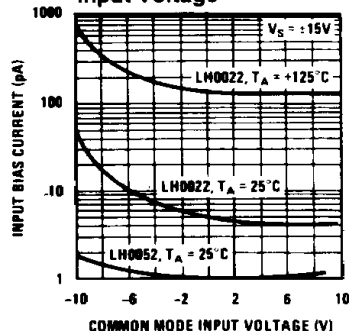
Input Offset Current vs Temperature



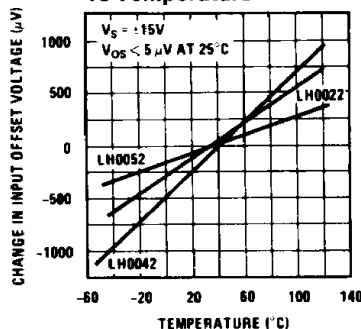
Input Bias Current vs Temperature



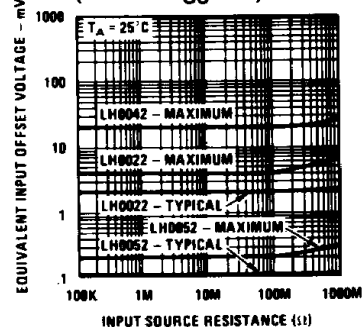
Input Bias Current vs Input Voltage



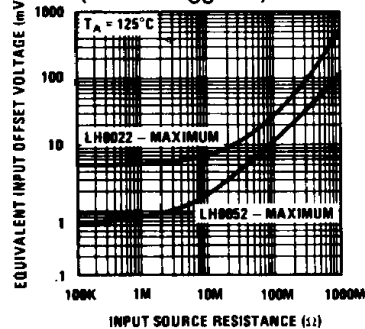
Input Offset Voltage vs Temperature



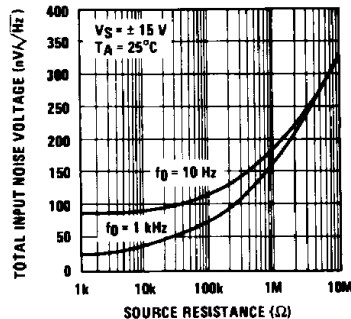
Offset Error (without VOS Null)



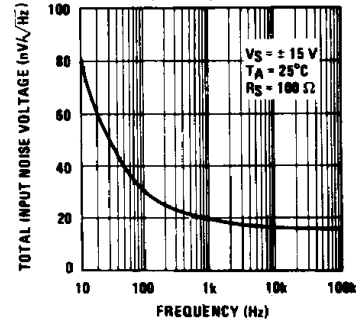
Offset Error (without VOS Null)



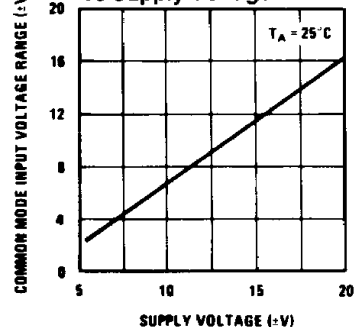
Total Input Noise Voltage* vs Source Resistance



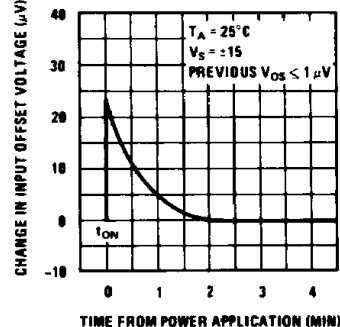
Total Input Noise Voltage* vs Frequency



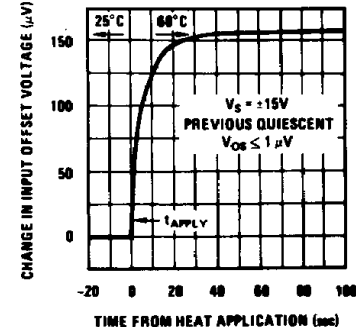
Common Mode Input Voltage vs Supply Voltage



Stabilization Time of Input Offset Voltage from Power Turn-On

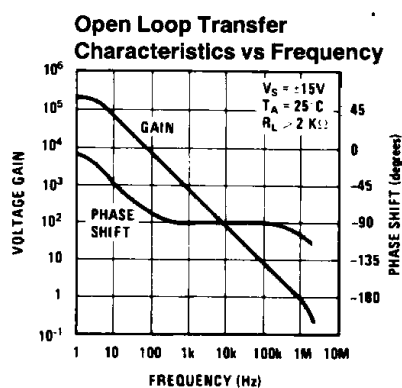
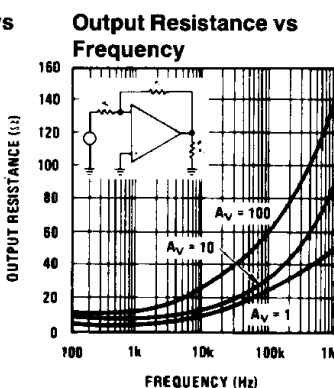
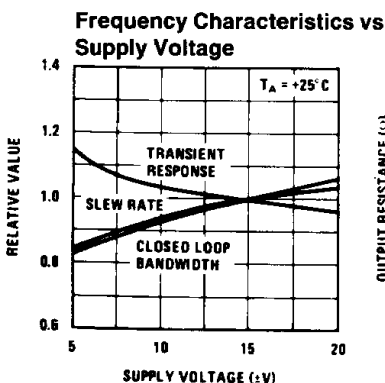
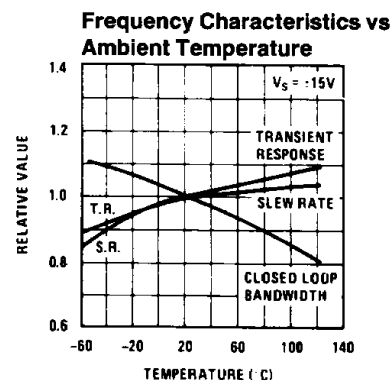
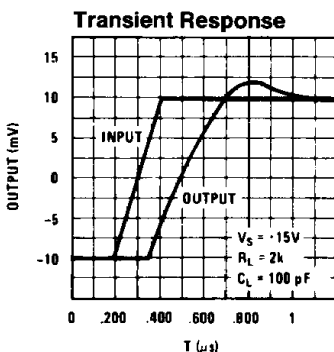
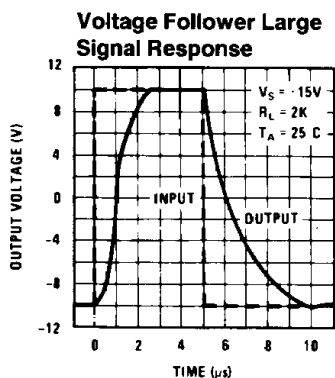
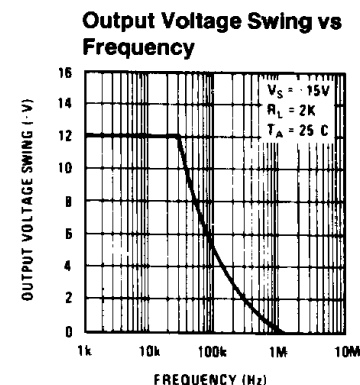
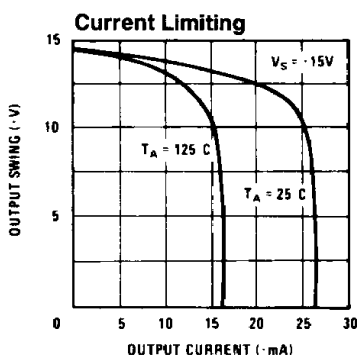
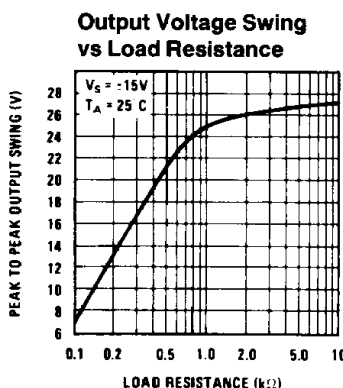
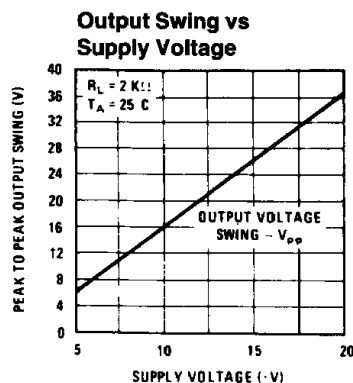
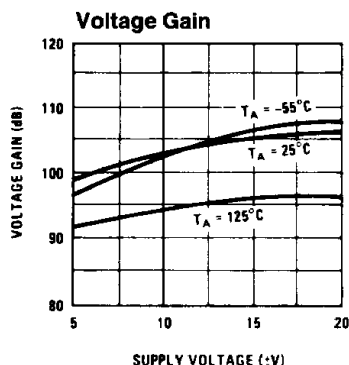
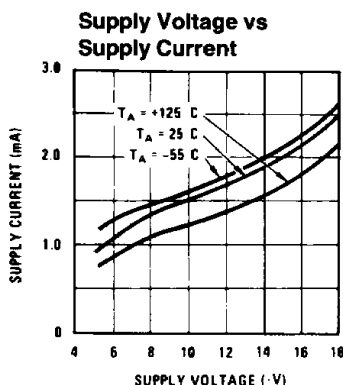


Change in Input Offset Voltage Due to Thermal Shock vs Time



*Noise voltage includes contribution from source resistance.

Typical Performance Characteristics (Continued)



TL/K/5557-19