



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.

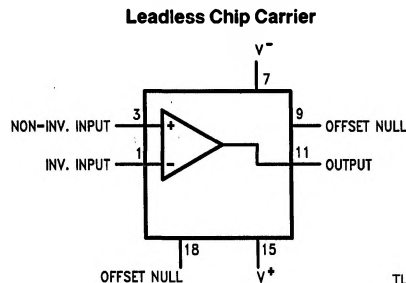
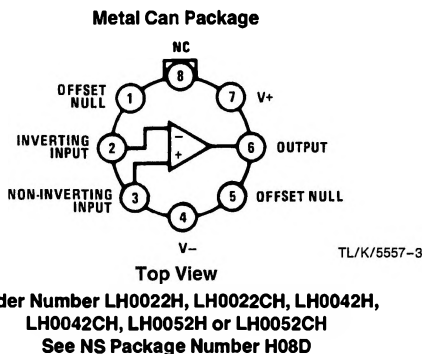
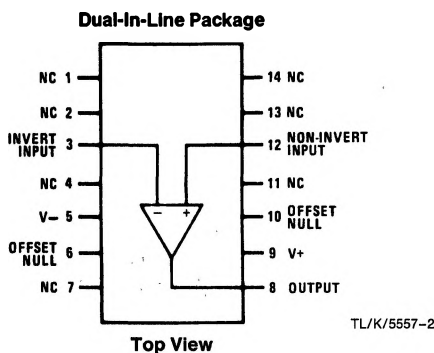
Special electrical parameter selection is available on special request.

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



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	$R_S \leq 10\text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$	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	$R_L = 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$ $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$	100	200		75	160		V/mV
	$R_L = 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$ $V_S = \pm 15\text{V}$	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	$V_{OUT} = \pm 10\text{V}$, $T_A = 25^\circ\text{C}$	± 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	$R_S \leq 10\text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$	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	$R_S \leq 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$	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	$V_{OUT} = \pm 10\text{V}$	± 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/ μ s
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	μ s
Overshoot			10	30		15	40	%
Settling Time (0.1%)	$\Delta V_{IN} = 10V$		4.5			4.5		μ s
Overload Recovery			4.0			4.0		μ s

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/√Hz
	$R_S = 10\text{ k}\Omega$, $f_o = 100\text{ Hz}$		55			55		nV/√Hz
	$R_S = 10\text{ k}\Omega$, $f_o = 1\text{ kHz}$		35			35		nV/√Hz
	$R_S = 10\text{ k}\Omega$, $f_o = 10\text{ kHz}$		30			30		nV/√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

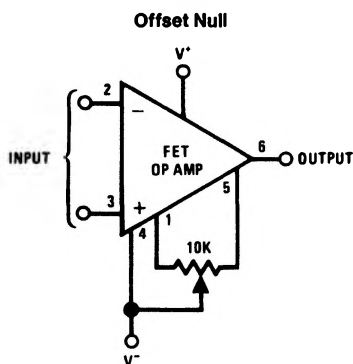
Note 1: For supply voltages less than $\pm 15\text{V}$, the absolute maximum input voltage is equal to the supply voltage.

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 $\pm 5\text{V}$.

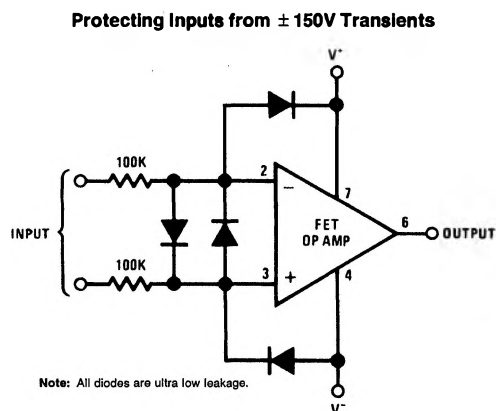
Note 3: Unless otherwise specified, these specifications apply for $\pm 5\text{V} \leq V_S \leq +20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for the LH0022/42/52 and $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for the LH0022C/42C/52C. Typical values are given for $T_A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

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)

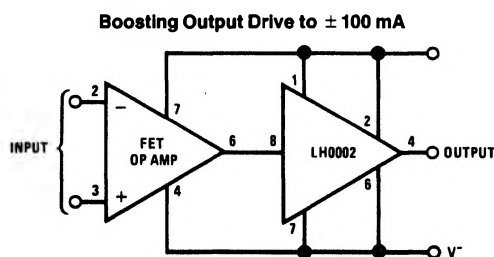


TL/K/5557-5



Note: All diodes are ultra low leakage.

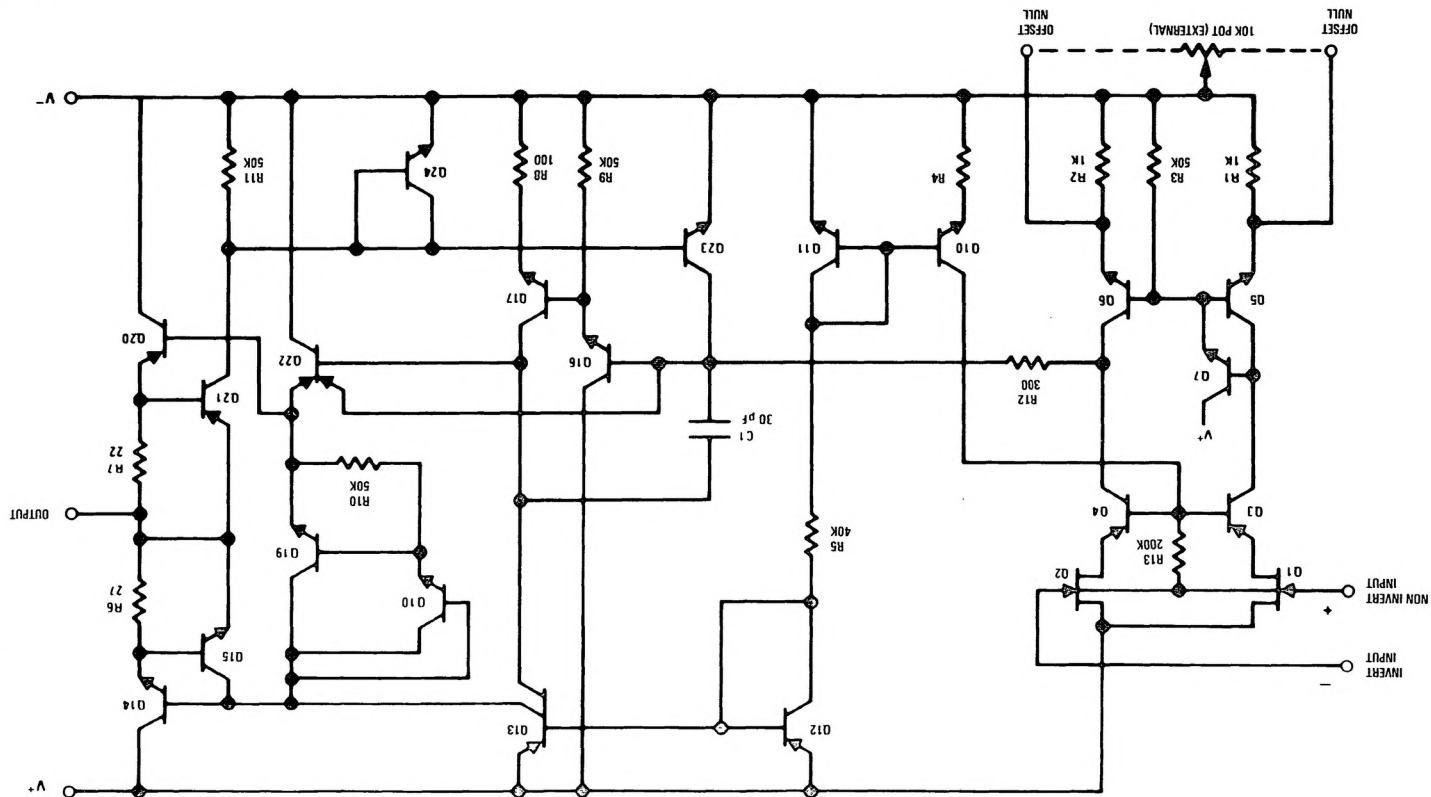
TL/K/5557-6



TL/K/5557-7

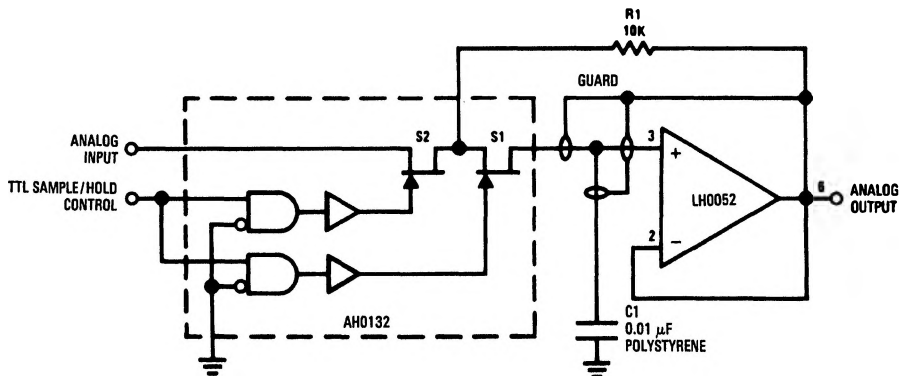
TL/K/5557-1

Schematic Diagram



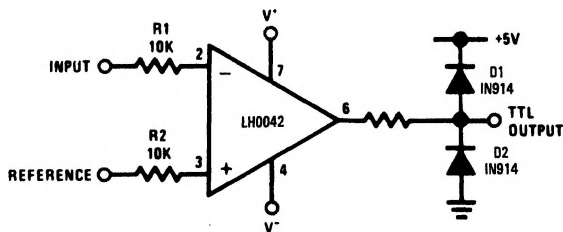
Typical Applications

Low Drift Sample and Hold



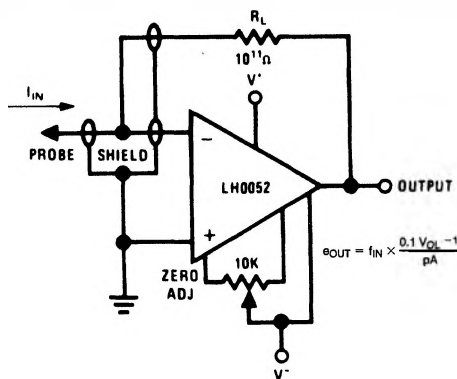
TL/K/5557-8

Precision Voltage Comparator



TL/K/5557-9

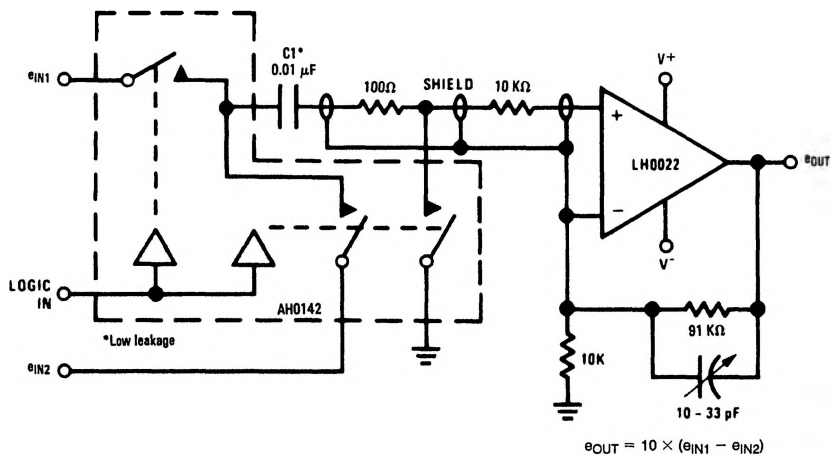
Picoamp Amplifier for pH Meters and Radiation Detectors



TL/K/5557-10

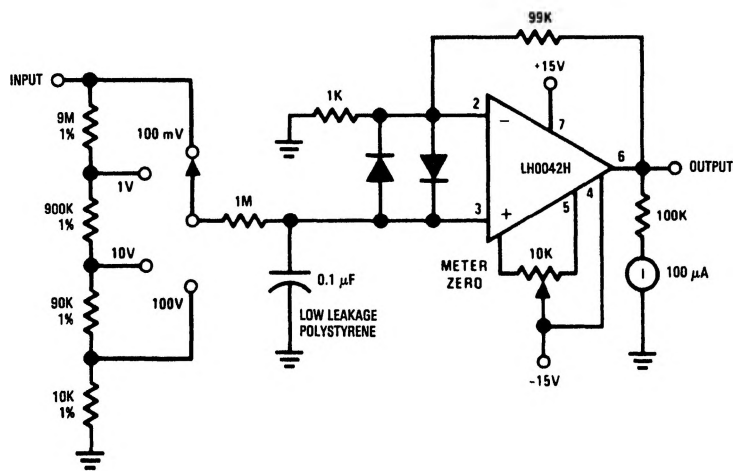
Typical Applications (Continued)

Precision Subtractor for Automatic Test Gear



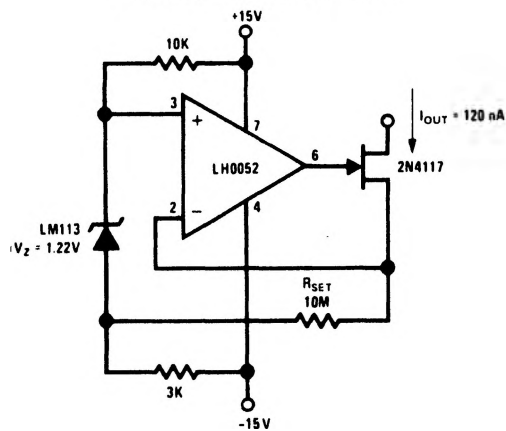
TL/K/5557-11

Sensitive Low Cost "VTVM"



TL/K/5777-12

Ultra Low Level Current Source



TL/K/5557-13

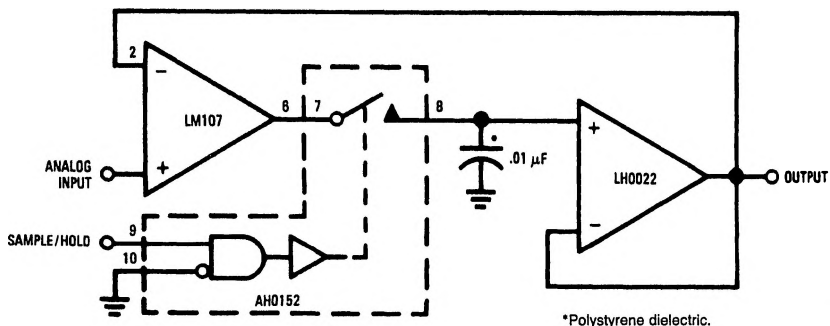
The circuit diagram shows a three-stage differential amplifier. The first stage uses two LM110 op-amp buffers at the inputs, followed by two LH0052 op-amp comparators configured as a differential pair. The second stage consists of two more LH0052 op-amp comparators acting as a differential pair. The final output stage is an LM725 precision centration amplifier, which includes a CMRR adjustment potentiometer labeled "CMRR ADJ TEN TURN 100K". Various resistors are specified with values like 1M, 40K, 10K, 500K, and 450K, along with tolerance percentages (.05%, .1%, 1%). Power supply rails for +15V, -15V, and V+ are indicated.

The diagram shows a Precision Integrator circuit. At the top, a dashed box labeled "Precision Integrator" contains an AH0133 component. The AH0133 has pins 13, 9, 10, 8, 7, 1, and 14. Pin 13 is connected to a "TTL INTEGRATE/RESET CONTROL" input. Pins 9 and 10 are connected to ground. Pins 8 and 14 are connected to the output of the LM0052 op-amp. Pin 7 is connected to a 10K resistor (R4) to ground. Pin 1 is connected to the output of the LM0052 op-amp. The LM0052 op-amp has pins 1, 2, 3, 6, and 7. Pin 1 is connected to the output of the AH0133. Pin 2 is connected to an "INPUT V₁" through a 10⁹Ω resistor (R1) and a resistor (R2). Pin 3 is connected to an "INITIAL CONDITION V₂" through a resistor (R3). Pin 6 is connected to the "OUTPUT". Pin 7 is connected to ground. A capacitor (C1, 1μF) is connected between pins 1 and 2. The output voltage is given by the equation:
$$V_{OUT} = \frac{1}{C1R1} \int -v_1 dt + V_2$$

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Typical Applications (Continued)

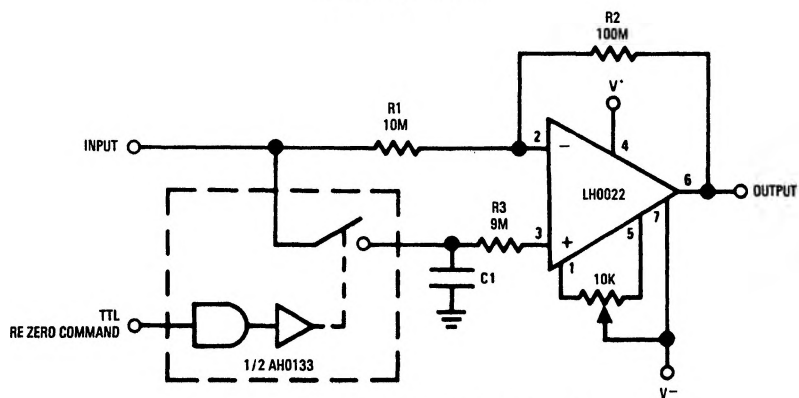
Precision Sample and Hold



*Polystyrene dielectric.

TL/K/5557-16

Re-Zeroing Amplifier

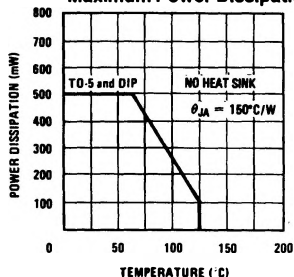


C1—0.01 μF polystyrene.

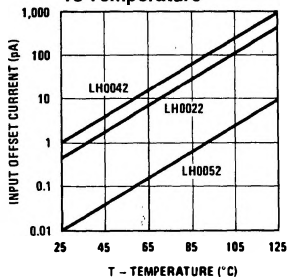
TL/K/5557-17

Typical Performance Characteristics

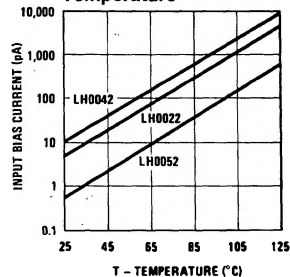
Maximum Power Dissipation



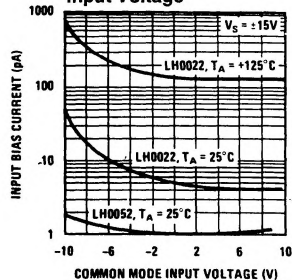
Input Offset Current vs Temperature



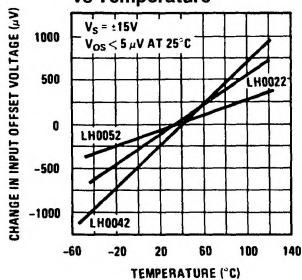
Input Bias Current vs Temperature



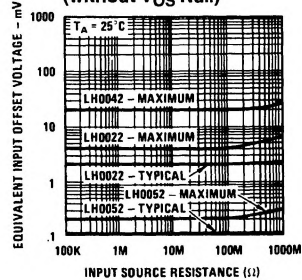
Input Bias Current vs Input Voltage



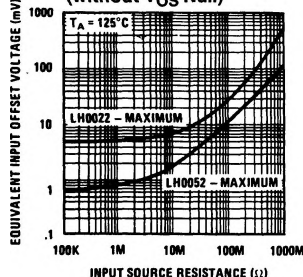
Input Offset Voltage vs Temperature



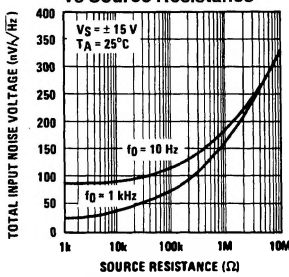
Offset Error (without VOS Null)



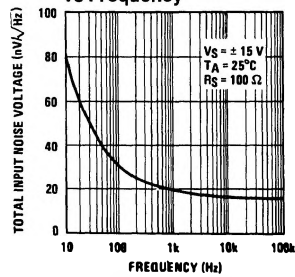
Offset Error (without VOS Null)



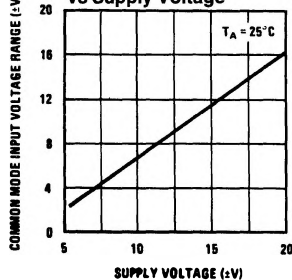
Total Input Noise Voltage* vs Source Resistance



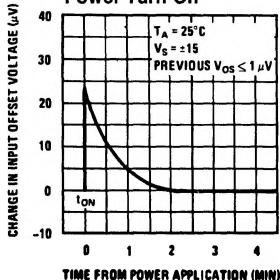
Total Input Noise Voltage* vs Frequency



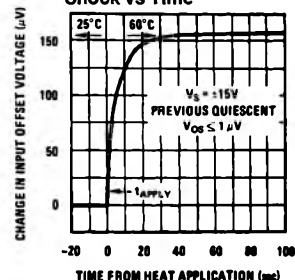
Common Mode Input Voltage vs Supply Voltage



Stabilization Time of Input Offset Voltage from Power Turn-On



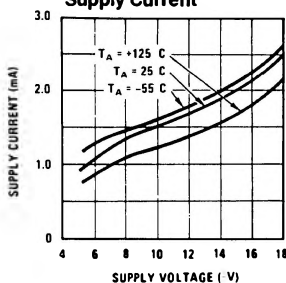
Change in Input Offset Voltage Due to Thermal Shock vs Time



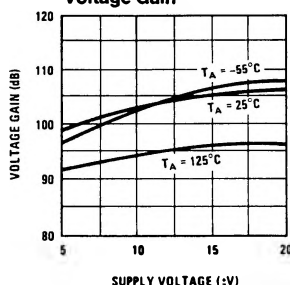
*Noise voltage includes contribution from source resistance.

Typical Performance Characteristics (Continued)

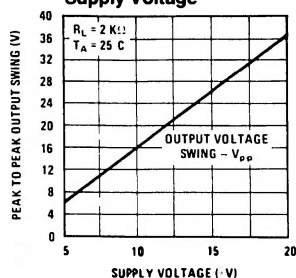
**Supply Voltage vs
Supply Current**



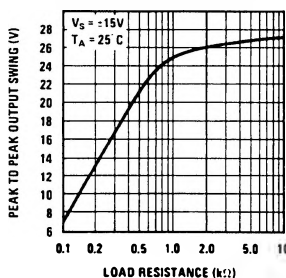
Voltage Gain



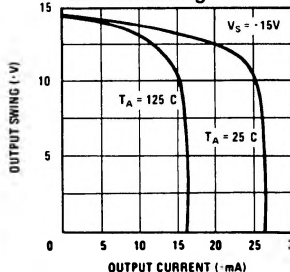
**Output Swing vs
Supply Voltage**



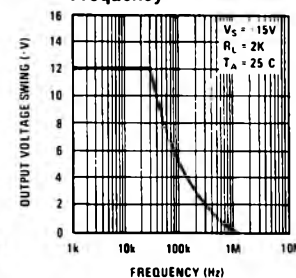
**Output Voltage Swing
vs Load Resistance**



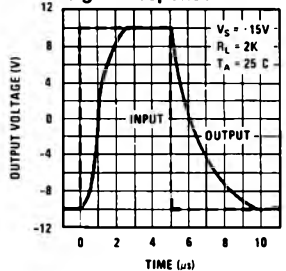
Current Limiting



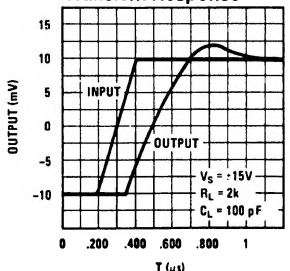
**Output Voltage Swing vs
Frequency**



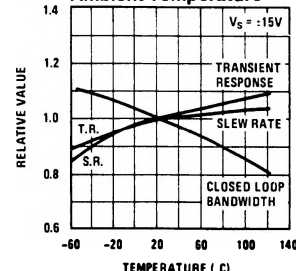
**Voltage Follower Large
Signal Response**



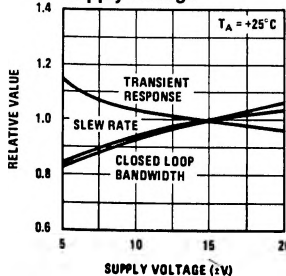
Transient Response



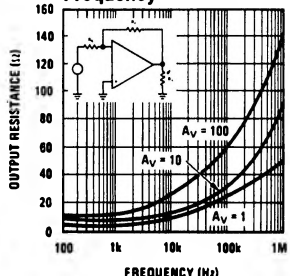
**Frequency Characteristics vs
Ambient Temperature**



**Frequency Characteristics vs
Supply Voltage**



**Output Resistance vs
Frequency**



**Open Loop Transfer
Characteristics vs Frequency**

