Low Power Zero-Drift Operational Amplifiers in SOT-23

FEATURES

- **Supply Current 175µA (Max), Guaranteed Over Temperature**
- **Offset Voltage 3µV (Max)**
- **Offset Voltage Drift 30nV/°C (Max)**
- Noise: 1.6µV_{P-P} (0.01Hz to 10Hz Typ)
- Voltage Gain: 140dB (Typ)
- PSRR: 130dB (Typ)
- CMRR: 130dB (Typ)
- Input Bias Current <1pA (Typ)
- Supply Operation: 2.7V to 6V (LTC2054)
2.7V to ±5.5V (LTC2054HV)
- Common Mode Input Range from V^- to V^+ –0.5V
- Output Swings Rail-to-Rail
- Low Profile (1mm) SOT-23 (ThinSOT™) Package

APPLICATIONS

- Thermocouple Amplifiers
- Electronic Scales
- Medical Instrumentation
- Strain Gauge Amplifiers
- High Resolution Data Acquisition
- DC Accurate RC Active Filters
- Low Side Current Sense
- Battery-Powered Systems

DESCRIPTION

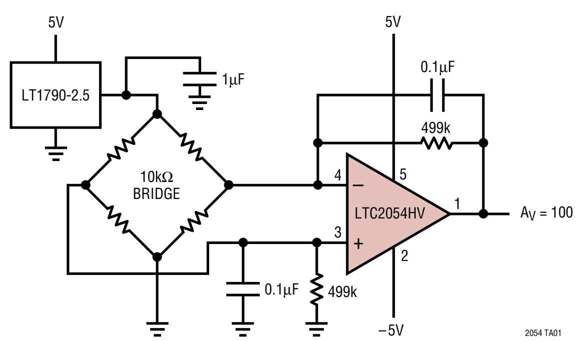
The LTC®2054 and LTC2054HV are low power, low noise zero-drift operational amplifiers available in the 5-lead SOT-23 package. The LTC2054 operates from a single 2.7V to 6V supply. The LTC2054HV operates on supplies from 2.7V to ±5.5V. The current consumption is 150µA (typical), 175µA maximum over temperature.

The LTC2054, despite its miniature size, features uncompromising DC performance. The typical input offset voltage and offset drift are 0.5µV and 25nV/°C. The almost zero DC offset and drift are supported with a power supply rejection ratio (PSRR) and common mode rejection ratio (CMRR) of more than 130dB.

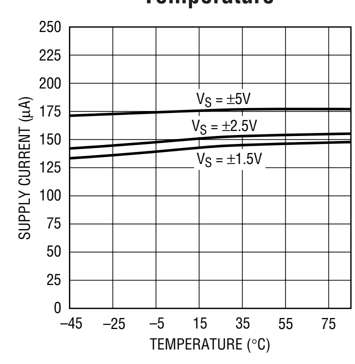
The input common mode voltage ranges from the negative supply up to typically 0.5V from the positive supply. The open-loop gain is typically 140dB. The LTC2054 also features a 1.6µV_{P-P} DC to 10Hz noise and a 500kHz gain bandwidth product.

TYPICAL APPLICATION

Differential Bridge Amplifier



Supply Current vs Temperature



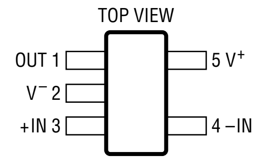
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Total Supply Voltage (V^+ to V^-)
- LTC2054 .... 7V
- LTC2054HV 12V

Input Voltage .... (V^+ + 0.3V) to (V^- – 0.3V)
Output Short-Circuit Duration .... Indefinite
Operating Temperature Range .... –40°C to 85°C
Specified Temperature Range
(Note 4) .... –40°C to 85°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION



S5 PACKAGE
5-LEAD PLASTIC TSOT-23

T_{JMAX} = 150°C, θ_{JA} = 250°C/W

ORDER PART NUMBER	S5 PART MARKING
LTC2054CS5	LTAGB
LTC2054HVCS5	LTAGD
LTC2054IS5	LTAGB
LTC2054HVIS5	LTAGD

Consult LTC Marketing for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

(LTC2054, LTC2054HV) The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 3V unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_S	Supply Current	No Load	●		140	175	µA
V_{OS}	Input Offset Voltage	(Note 2)			±0.5	±3	µV
$\Delta V_{OS}/\Delta T$	Average Input Offset Drift	(Note 2)	●			±0.03	µV/°C
	Long-Term Offset Drift				50		nV/√mo
I_B	Input Bias Current	(Note 3)			±600		fA
			●			±150	pA
I_{OS}	Input Offset Current	(Note 3)			±1.2		pA
			●			±300	pA
e_n	Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.6		μV_{P-P}
CMRR	Common Mode Rejection Ratio	V_{CM} = GND to (V^+ – 0.7V)		115	130		dB
			●	110			dB
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 6V		120	130		dB
			●	115			dB

ELECTRICAL CHARACTERISTICS

(LTC2054, LTC2054HV) The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25°C$. $V_S = 3V$ unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
A_{VOL}	Large-Signal Voltage Gain	R_L = 100k, $V_{OUT} = V_S/2$	 ●	120 115	135		dB dB
V_{OUT}	Output Voltage Swing High	R_L = 5k to GND R_L = 100k to GND	● ●	2.85 2.98			V V
V_{OUT}	Output Voltage Swing Low	R_L = 5k to GND R_L = 100k to GND	● ●			10 10	mV mV
SR	Slew Rate				0.5		V/µs
GBW	Gain Bandwidth Product				500		kHz
f_S	Internal Sampling Frequency				1.0		kHz

(LTC2054, LTC2054HV) $V_S = 5V$ unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_S	Supply Current	No Load	●		150	175	µA
V_{OS}	Input Offset Voltage	(Note 2)				±3	µV
$\Delta V_{OS}/\Delta T$	Average Input Offset Drift	(Note 2)	●			±0.03	µV/°C
	Long-Term Offset Drift				50		$nV/\sqrt{mo}$
I_B	Input Bias Current	(Note 3)	 ●		±800	 ±150	fA pA
I_{OS}	Input Offset Current	(Note 3)	 ●		±1.6	 ±300	pA pA
e_n	Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.6		$µV_{P-P}$
CMRR	Common Mode Rejection Ratio	V_{CM} = GND to (V^+ – 0.7V)	 ●	120 115	130		dB dB
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 6V	 ●	120 115	130		dB dB
A_{VOL}	Large-Signal Voltage Gain	R_L = 100k, $V_{OUT} = V_S/2$	 ●	125 120	140		dB dB
V_{OUT}	Output Voltage Swing High	R_L = 5k to GND R_L = 100k to GND	● ●	4.75 4.98			V V
V_{OUT}	Output Voltage Swing Low	R_L = 5k to GND R_L = 100k to GND	● ●			10 10	mV mV
SR	Slew Rate				0.5		V/µs
GBW	Gain Bandwidth Product				500		kHz
f_S	Internal Sampling Frequency				1.0		kHz

ELECTRICAL CHARACTERISTICS

(LTC2054HV) The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±5V unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_S	Supply Current	No Load	●		175	210	µA
V_{OS}	Input Offset Voltage	(Note 2)			±0.5	±5	µV
$\Delta V_{OS}/\Delta T$	Average Input Offset Drift	(Note 2)	●			±0.03	µV/°C
	Long-Term Offset Drift				50		nV/√mo
I_B	Input Bias Current	(Note 3)			±1		pA
			●			±150	pA
I_{OS}	Input Offset Current	(Note 3)			±2		pA
			●			±300	pA
e_n	Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.6		$µV_{P-P}$
CMRR	Common Mode Rejection Ratio	V_{CM} = V^- to (V^+ – 0.9V)		120	130		dB
			●	115			dB
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 11V		120	130		dB
			●	115			dB
A_{VOL}	Large-Signal Voltage Gain	R_L = 100k, V_{OUT} = GND		125	140		dB
			●	120			dB
V_{OUT}	Maximum Output Voltage Swing	R_L = 5k to GND	●	±4.75			V
		R_L = 100k to GND	●	±4.98			V
SR	Slew Rate				0.5		V/µs
GBW	Gain Bandwidth Product				500		kHz
f_S	Internal Sampling Frequency				1.0		kHz

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

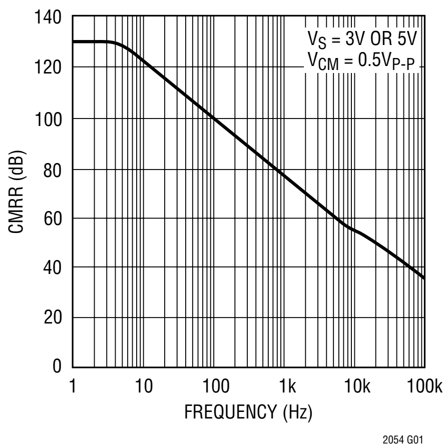
Note 2: These parameters are guaranteed by design. Thermocouple effects preclude measurements of these voltage levels during automated testing.

Note 3: Limit is determined by high speed automated test capability. See characteristic curves for actual typical performance. For tighter specifications, please consult Linear Technology Marketing.

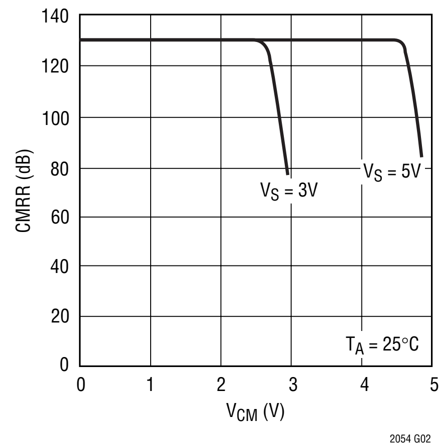
Note 4: The LTC2054C, LTC2054HVC are guaranteed to meet specified performance from 0°C to 70°C and are designed, characterized and expected to meet these extended temperature limits, but are not tested at –40°C and 85°C. The LTC2054I, LTC2054HVI are guaranteed to meet the specified performance from –40°C and 85°C.

TYPICAL PERFORMANCE CHARACTERISTICS

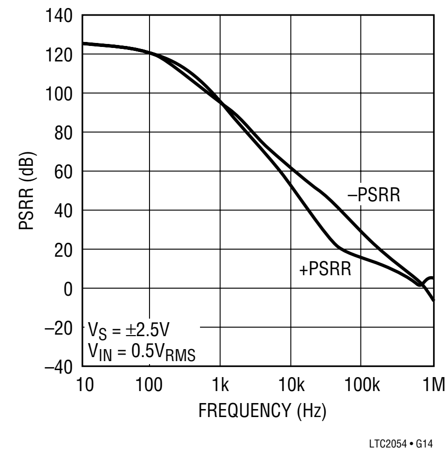
Common Mode Rejection Ratio vs Frequency



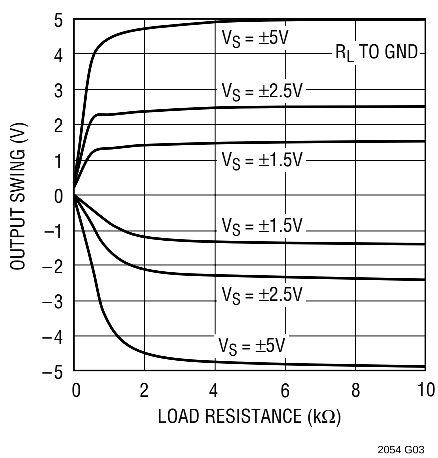
DC CMRR vs Common Mode Input Voltage



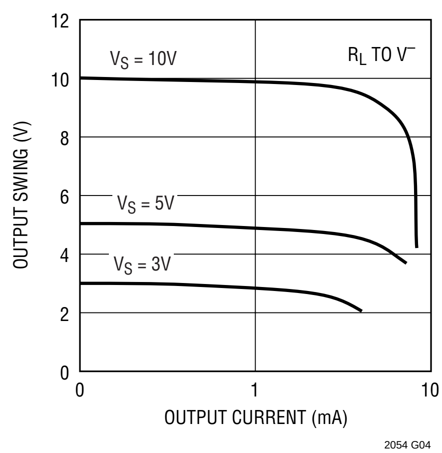
PSRR vs Frequency



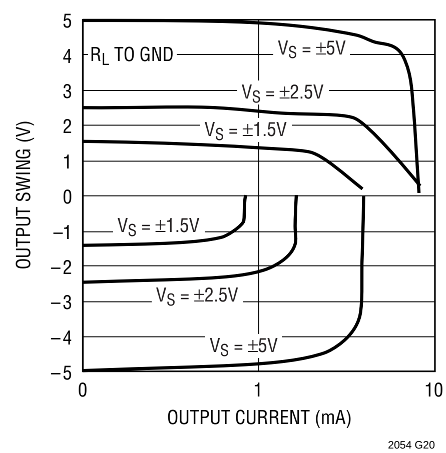
Output Voltage Swing vs Load Resistance



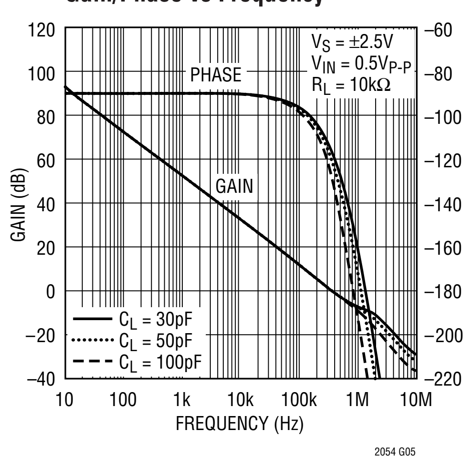
Single Supply Output Swing vs Output Current



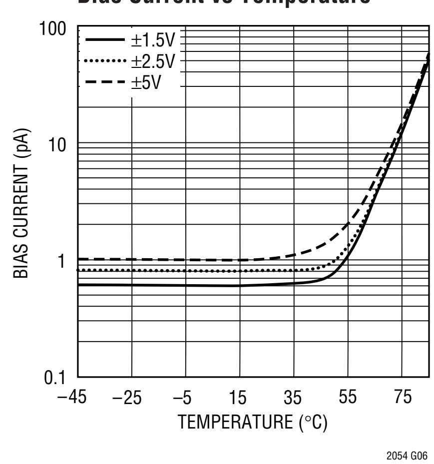
Dual Supply Output Swing vs Output Current



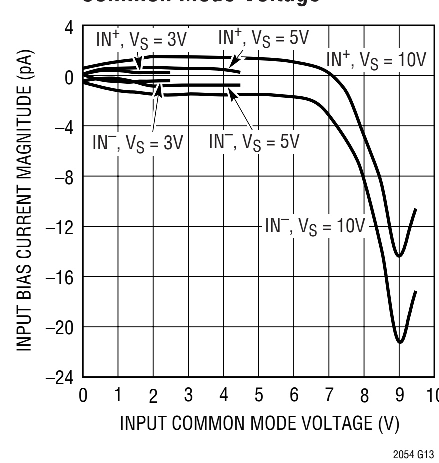
Gain/Phase vs Frequency



Bias Current vs Temperature

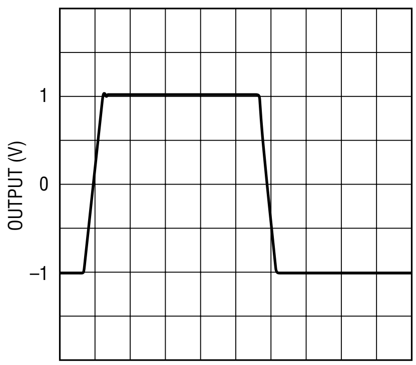


Input Bias Current vs Input Common Mode Voltage



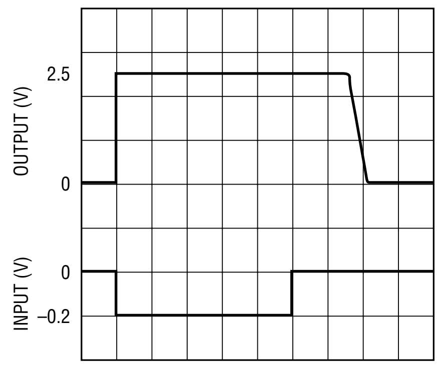
TYPICAL PERFORMANCE CHARACTERISTICS

Transient Response



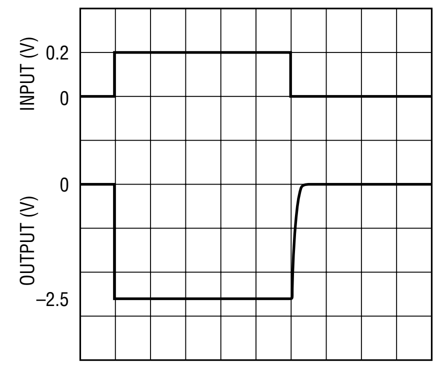
A_V = 1 10µs/DIV
R_L = 100k
C_L = 50pF
V_S = ±2.5V
V_{IN} = 10kHz $2V_{P-P}$
2054 G07

Input Overload Recovery



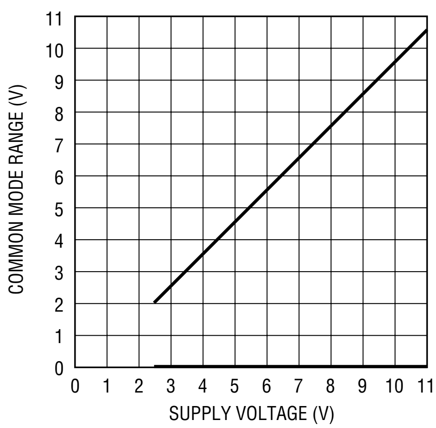
A_V = –100 2ms/DIV
R_L = 100k
V_S = ±2.5V
V_{IN} = 50Hz $200mV_{P-P}$
OFFSET = –100mV
2054 G08

Input Overload Recovery



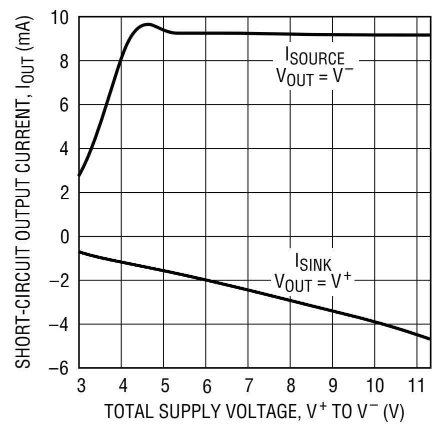
A_V = –100 2ms/DIV
R_L = 100k
V_S = ±2.5V
V_{IN} = 50Hz $200mV_{P-P}$
OFFSET = 100mV
2054 G18

Common Mode Input Range vs Supply Voltage



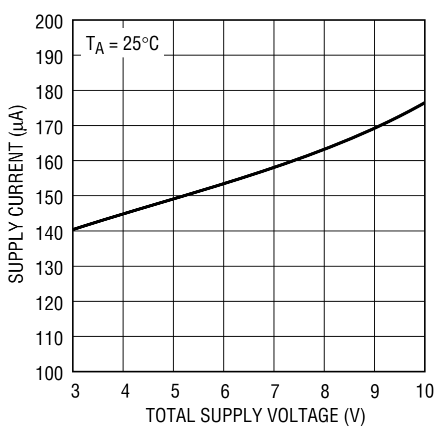
2054 G09

Short-Circuit Output Current vs Supply Voltage



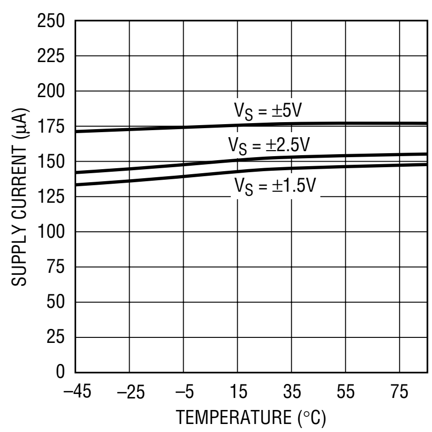
2054 G10

Supply Current vs Supply Voltage



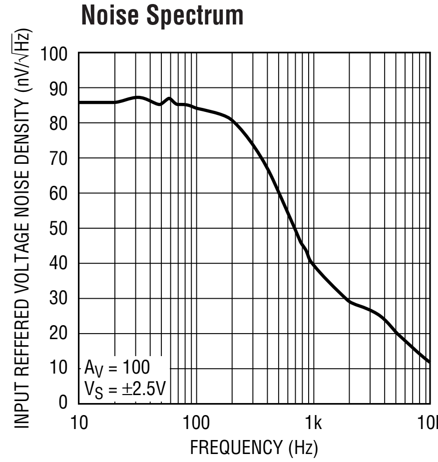
2054 G11

Supply Current vs Temperature



2054 G12

Noise Spectrum

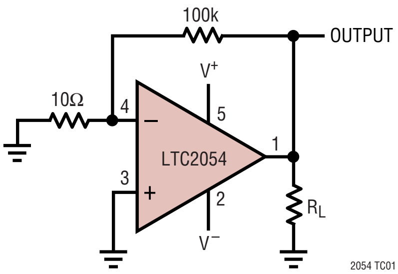


2054 G15

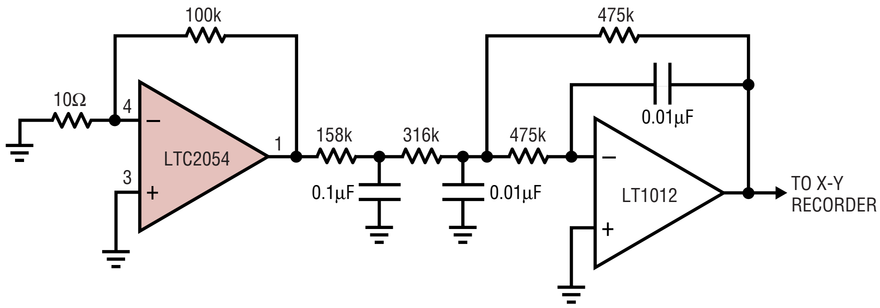
2054f

TEST CIRCUITS

Electrical Characteristics Test Circuit



DC-10Hz Noise Test Circuit



APPLICATIONS INFORMATION

Clock Feedthrough, Input Bias Current

The LTC2054 uses auto-zeroing circuitry to achieve an almost zero DC offset over temperature, common mode voltage, and power supply voltage. The frequency of the clock used for auto-zeroing is typically 1.0kHz. The term clock feedthrough is broadly used to indicate visibility of this clock frequency in the op amp output spectrum. There are typically two types of clock feedthrough in auto zeroed op amps like the LTC2054.

The first form of clock feedthrough is caused by the settling of the internal sampling capacitor and is input referred; that is, it is multiplied by the closed loop gain of the op amp. This form of clock feedthrough is independent of the magnitude of the input source resistance or the magnitude of the gain setting resistors. The LTC2054 has a residue clock feedthrough of less then $0.2\mu V_{RMS}$ input referred at 1.0kHz.

The second form of clock feedthrough is caused by the small amount of charge injection occurring during the sampling and holding of the op amp's input offset voltage. The current spikes are multiplied by the impedance seen at the input terminals of the op amp, appearing at the output multiplied by the closed loop gain of the op amp. To reduce this form of clock feedthrough, use smaller valued gain setting resistors and minimize the source resistance at the input. If the resistance seen at the inputs is less than 10k, this form of clock feedthrough is less than the amount of residue clock feedthrough from the first form described above.

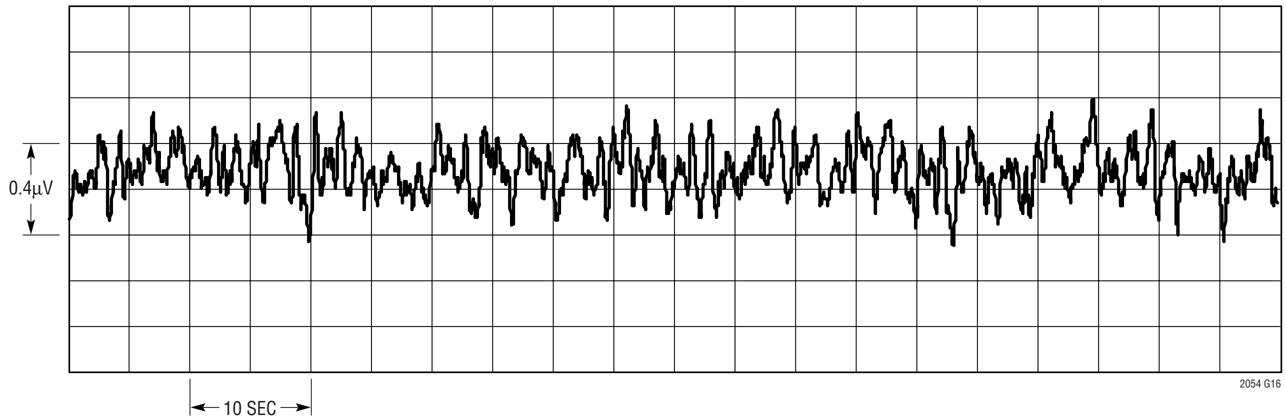
Placing a capacitor across the feedback resistor reduces either form of clock feedthrough by limiting the bandwidth of the closed loop gain.

Input bias current is defined as the DC current into the input pins of the op amp. The same current spikes that cause the second form of clock feedthrough described above, when averaged, dominate the DC input bias current of the op amp below 70°C.

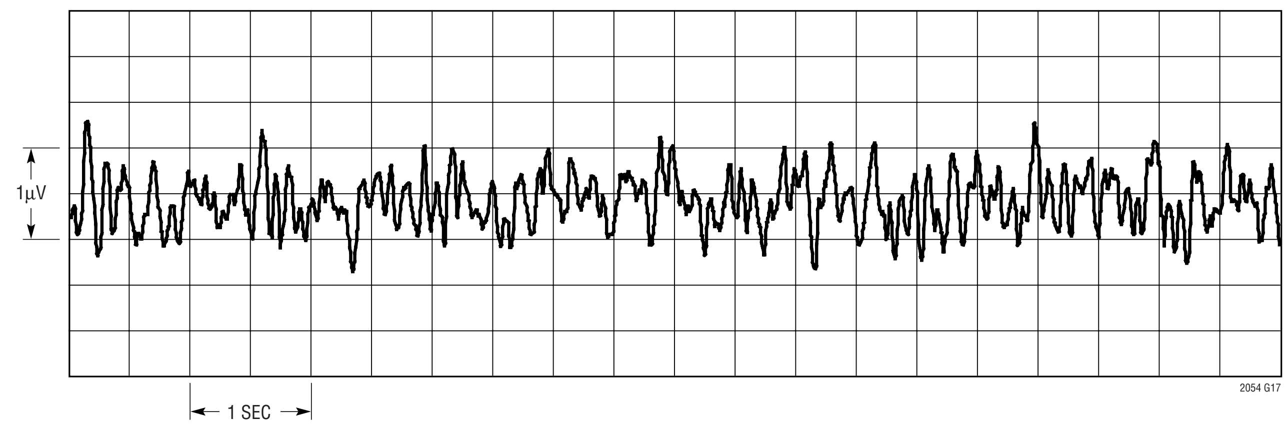
At temperatures above 70°C, the leakage of the ESD protection diodes on the inputs increases the input bias currents of both inputs in the positive direction, while the current caused by the charge injection stays relatively constant. At elevated temperatures (above 85°C) the leakage current begins to dominate and both the negative and positive pin's input bias currents are in the positive direction (into the pins).

APPLICATIONS INFORMATION

LTC2054 DC to 1Hz Noise



LTC2054 DC to 10Hz Noise

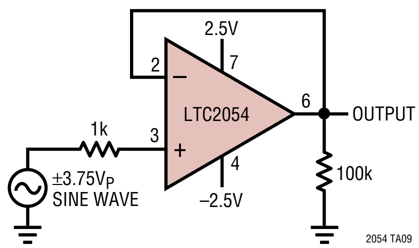


APPLICATIONS INFORMATION

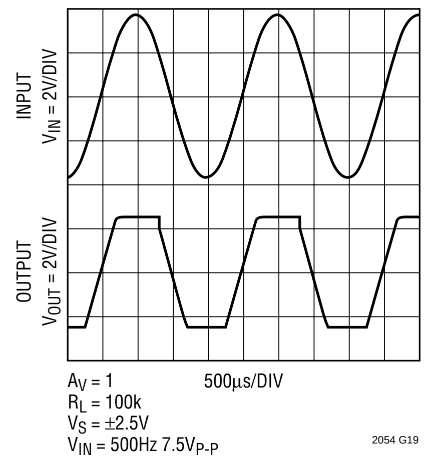
Extended Common Mode Range

The LTC2054 input stage is designed to allow nearly rail-to-rail input common-mode signals. In addition, signals that extend beyond the allowed input common-mode range **do not cause output inversion**.

Voltage Follower with Input Exceeding the Common Mode Range

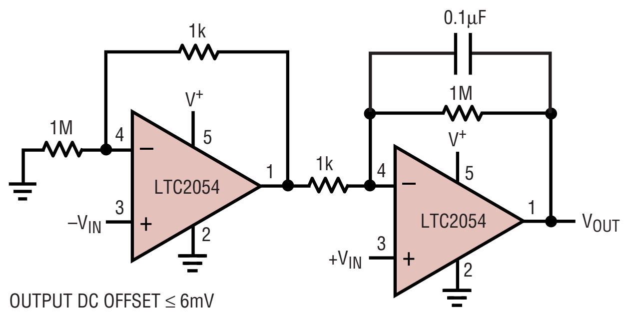


LTC2054 Extended Common Mode Range

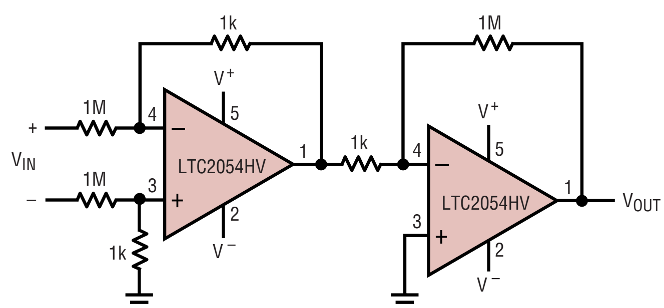


TYPICAL APPLICATIONS

Gain of 1001 Single Supply Instrumentation Amplifier

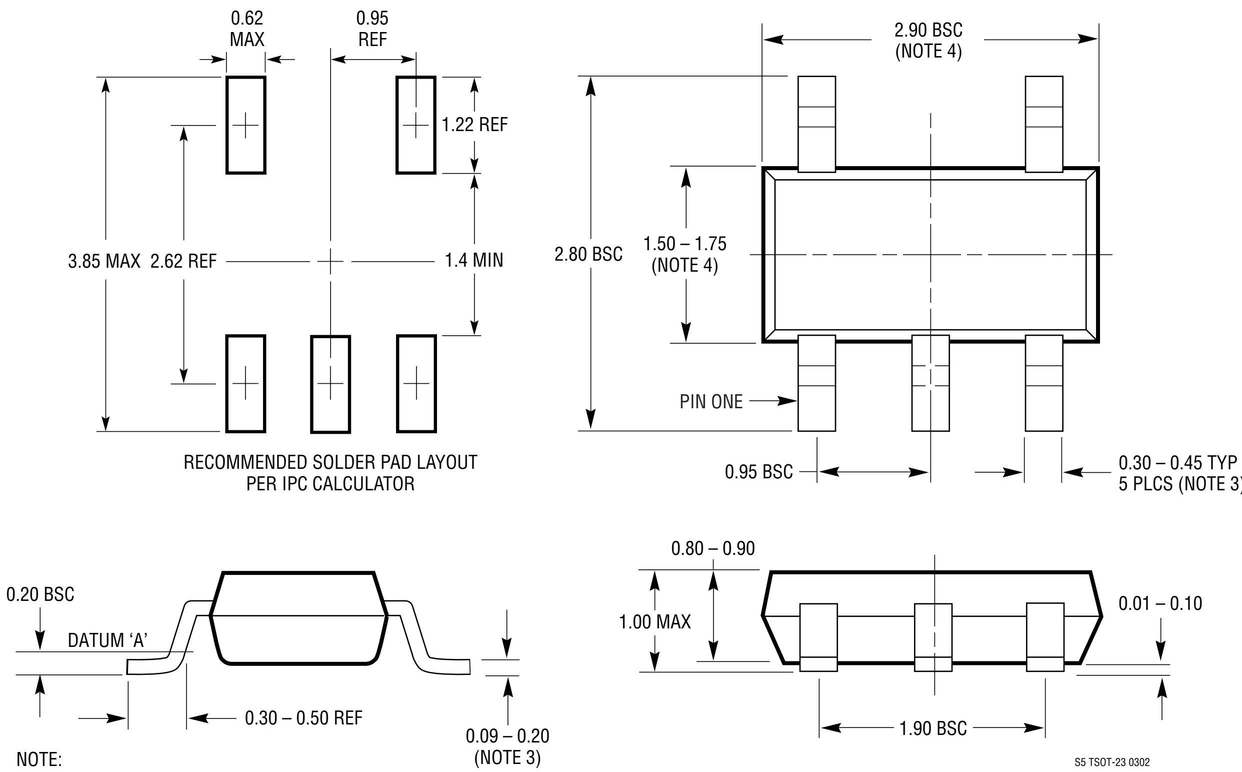


Instrumentation Amplifier with 100V Common Mode Input Voltage



PACKAGE DESCRIPTION

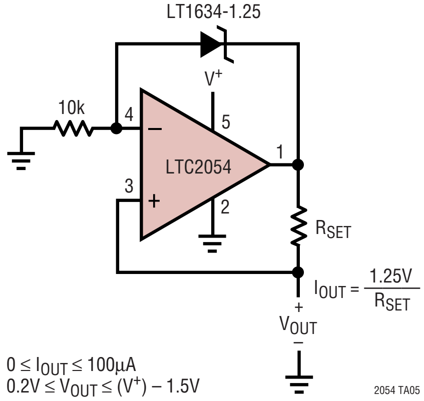
S5 Package
5-Lead Plastic TSOT-23
(Reference LTC DWG # 05-08-1635)



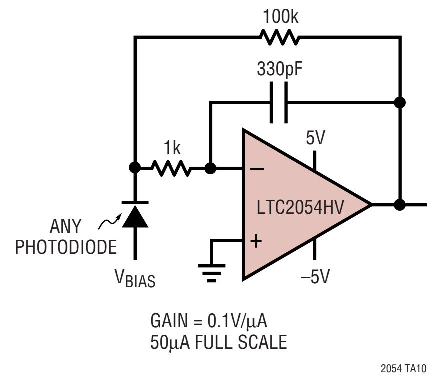
NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
2. DRAWING NOT TO SCALE
3. DIMENSIONS ARE INCLUSIVE OF PLATING
4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
5. MOLD FLASH SHALL NOT EXCEED 0.254mm
6. JEDEC PACKAGE REFERENCE IS MO-193

TYPICAL APPLICATIONS

Ground Referred Precision Current Sources



Ultra-Precision, Wide Dynamic Range Photodiode Amplifier



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1049	Low Power Zero-Drift Op Amp	Low Supply Current 200µA
LTC1050	Precision Zero-Drift Op Amp	Single Supply Operation 4.75V to 16V, Noise Tested and Guaranteed
LTC1051/LTC1053	Precision Zero-Drift Op Amp	Dual/Quad Version of the LTC1050
LTC1150	±15V Zero-Drift Op Amp	High Voltage Operation ±18V
LTC1152	Rail-to-Rail Input and Output Zero-Drift Op Amp	Single Zero-Drift Op Amp with Rail-to-Rail Input and Output and Shutdown
LT1677	Low Noise Rail-to-Rail Input and Ouptput Precision Op Amp	V_{OS} = 90µV, V_S = 2.7V to 44V
LT1884/LT1885	Rail-to-Rail Output Precision Op Amp	V_{OS} = 50µV, I_B = 400pA, V_S = 2.7V to 40V
LTC2050	Zero-Drift Op Amp	Enhanced Output Drive Capability
LTC2051/LTC2052	Dual/Quad Zero-Drift Op Amp	Dual/Quad Version of the LTC2050 in MS8/GN16 Package
LTC2053	Zero-Drift Instrumentation Amp	Rail-to-Rail Input

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