

Single/Dual Micropower Zero-Drift Operational Amplifiers

FEATURES

- **Supply Current 150 μ A (Max per Amplifier) Guaranteed from -40°C to 85°C**
- **Offset Voltage 3 μ V (Max, -40°C to 85°C)**
- **Offset Voltage Drift 30nV/ $^{\circ}\text{C}$ (Max, -40°C to 85°C)**
- **Guaranteed Specifications from -55°C to 150°C (LTC2054MP)**
- Common Mode Input Range from V^- to $V^+ - 0.5\text{V}$
- Output Swings Rail-to-Rail
- Voltage Gain: 140dB (Typ)
- PSRR and CMRR: 130dB (Typ)
- Input Bias Current: 1pA (Typ, 25°C)
- Noise: 1.6 μ V_{P-P} (0.01Hz to 10Hz Typ)
- Supply Operation:
 - 2.7V to 6V (LTC2054/LTC2055)
 - 2.7V to $\pm 5.5\text{V}$ (LTC2054HV/LTC2055HV)
- Low Profile (1mm) TSOT-23, MS8 and 3mm \times 3mm \times 0.8mm DFN Packages

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/LTC2055 are low power, low noise, single/dual, zero-drift operational amplifiers with an extended temperature version (LTC2054MP) that has guaranteed specifications from -55°C to 150°C . They are available in TSOT-23 (ThinSOT[™]) and MS8 packages. For space limited applications, the LTC2055 is also available in a 3mm \times 3mm \times 0.8mm dual fine pitch leadless package (DFN). They operate from a single 2.7V minimum supply and support $\pm 5\text{V}$ applications. The current consumption is typically 150 μ A for the LTC2054 and 130 μ A/amp for the LTC2055.

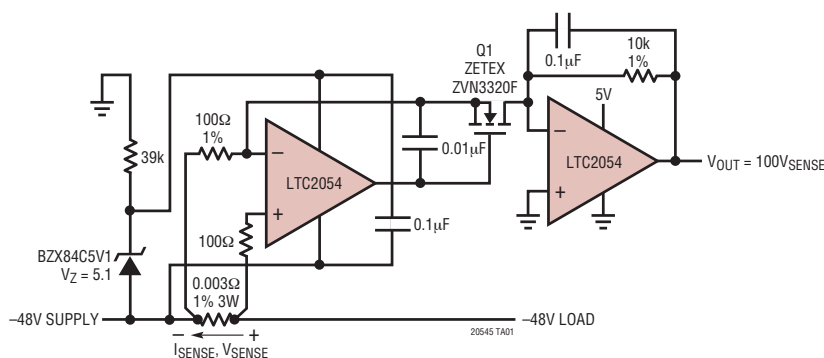
The LTC2054/LTC2055, despite their miniature size, feature uncompromising DC performance. The maximum input offset voltage and offset drift are 3.0 μ V and 30nV/ $^{\circ}\text{C}$ over the -40°C to 85°C industrial temperature range. The almost zero DC offset and drift are supported with a power supply rejection ratio (PSRR) and common mode rejection ratio (CMRR) of 130dB (typ).

The input common mode voltage ranges from the negative supply up to typically 0.5V below the positive supply. The open-loop gain is typically 140dB. The LTC2054/LTC2055 also feature a 1.6 μ V_{P-P} DC to 10Hz noise and a 500kHz gain-bandwidth product.

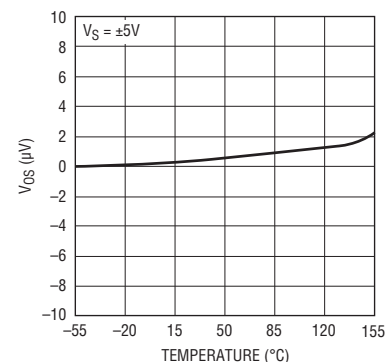
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TYPICAL APPLICATION

-48V Low Side Precision Current Sense



V_{OS} vs Temperature



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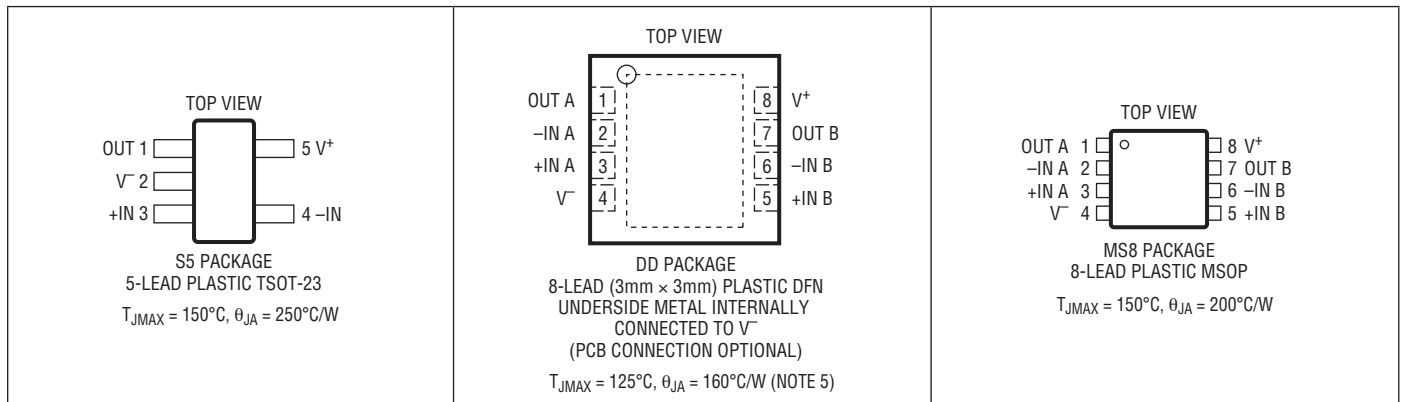
LTC2054/LTC2055

ABSOLUTE MAXIMUM RATINGS (Note 1)

| | |
|---|--|
| Total Supply Voltage (V^+ to V^-) | |
| LTC2054/LTC2055 | 7V |
| LTC2054HV/LTC2055HV | 12V |
| Input Voltage | ($V^+ + 0.3V$) to ($V_S^- - 0.3V$) |
| Input Current | $\pm 10mA$ |
| Output Short-Circuit Duration | Indefinite |

| | |
|--------------------------------------|----------------|
| Specified Temperature Range (Note 2) | |
| LTC2054C/LTC2055C | 0°C to 70°C |
| LTC2054I/LTC2055I | -40°C to 85°C |
| LTC2054H/LTC2055H | -40°C to 125°C |
| LTC2054MP | -55°C to 150°C |
| Storage Temperature Range | -65°C to 150°C |
| DD Package | -65°C to 125°C |
| Lead Temperature (Soldering, 10 sec) | |
| TSOT23 and MS8 Packages | 300°C |

PIN CONFIGURATION



ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING* | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE |
|-------------------|---------------------|---------------|--------------------------------|-----------------------------|
| LTC2054CS5#PBF | LTC2054CS5#TRPBF | LTAGB | 5-Lead Plastic TSOT-23 | 0°C to 70°C |
| LTC2054HVCSS5#PBF | LTC2054HVCSS5#TRPBF | LTAGD | 5-Lead Plastic TSOT-23 | 0°C to 70°C |
| LTC2054IS5#PBF | LTC2054IS5#TRPBF | LTAGB | 5-Lead Plastic TSOT-23 | -40°C to 85°C |
| LTC2054HVIS5#PBF | LTC2054HVIS5#TRPBF | LTAGD | 5-Lead Plastic TSOT-23 | -40°C to 85°C |
| LTC2054HS5#PBF | LTC2054HS5#TRPBF | LTAGB | 5-Lead Plastic TSOT-23 | -40°C to 125°C |
| LTC2054HVHS5#PBF | LTC2054HVHS5#TRPBF | LTAGD | 5-Lead Plastic TSOT-23 | -40°C to 125°C |
| LTC2055CDD#PBF | LTC2055CDD#TRPBF | LBCW | 8-Lead (3mm x 3mm) Plastic DFN | 0°C to 70°C |
| LTC2055HVCDD#PBF | LTC2055HVCDD#TRPBF | LBCX | 8-Lead (3mm x 3mm) Plastic DFN | 0°C to 70°C |
| LTC2055IDD#PBF | LTC2055IDD#TRPBF | LBCW | 8-Lead (3mm x 3mm) Plastic DFN | -40°C to 85°C |
| LTC2055HVIDD#PBF | LTC2055HVIDD#TRPBF | LBCX | 8-Lead (3mm x 3mm) Plastic DFN | -40°C to 85°C |
| LTC2055HDD#PBF | LTC2055HDD#TRPBF | LBCW | 8-Lead (3mm x 3mm) Plastic DFN | -40°C to 125°C |
| LTC2055HVHDD#PBF | LTC2055HVHDD#TRPBF | LBCX | 8-Lead (3mm x 3mm) Plastic DFN | -40°C to 125°C |
| LTC2055CMS8#PBF | LTC2054CMS8#TRPBF | LTBCR | 8-Lead Plastic MSOP | 0°C to 70°C |
| LTC2055HVCMS8#PBF | LTC2055HVCMS8#TRPBF | LTBCT | 8-Lead Plastic MSOP | 0°C to 70°C |
| LTC2055IMS8#PBF | LTC2055IMS8#TRPBF | LTBCR | 8-Lead Plastic MSOP | -40°C to 85°C |

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ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING* | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE |
|-------------------|---------------------|---------------|------------------------|-----------------------------|
| LTC2055HVIMS8#PBF | LTC2055HVIMS8#TRPBF | LTBCT | 8-Lead Plastic MSOP | -40°C to 85°C |
| LTC2055HMS8#PBF | LTC2055HMS8#TRPBF | LTBCR | 8-Lead Plastic MSOP | -40°C to 125°C |
| LTC2055HVHMS8#PBF | LTC2055HVHMS8#TRPBF | LTBCT | 8-Lead Plastic MSOP | -40°C to 125°C |
| LTC2054MPS5#PBF | LTC2054MPS5#TRPBF | LTFFF | 5-Lead Plastic TSOT-23 | -55°C to 150°C |
| LTC2054HVMP5#PBF | LTC2054HVMP5#TRPBF | LTFFG | 5-Lead Plastic TSOT-23 | -55°C to 150°C |

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container. Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreel/>

ELECTRICAL CHARACTERISTICS (LTC2054/LTC2055) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = 3\text{V}, 5\text{V}$ unless otherwise noted. (Note 2)

| SYMBOL | PARAMETER | CONDITIONS | | LTC2054C/LTC2055C LTC2054I/LTC2055I | | | LTC2054H/LTC2055H | | | UNITS |
|--------------------------|--|--|---|--|----------------|------------|-------------------|------------|--|-------|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| I_S | Supply Current (LTC2054) | No Load | ● | | 140 | 175 | 140 | 180 | μA | |
| I_S | Supply Current Per Amplifier (LTC2055) | No Load | ● | | 130 | 150 | 130 | 155 | μA | |
| V_{OS} | Input Offset Voltage | (Note 3) | | | ± 0.5 | ± 3 | ± 0.5 | ± 3 | μV | |
| $\Delta V_{OS}/\Delta T$ | Average Input Offset Drift | (Note 3) | ● | | 0.02 | ± 0.03 | 0.02 | ± 0.05 | $\mu\text{V}/^\circ\text{C}$ | |
| | Long-Term Offset Drift | | | | 50 | | 50 | | $\text{nV}/\sqrt{\text{mo}}$ | |
| I_B | Input Bias Current | (Note 4) | ● | | ± 1 | ± 150 | ± 1 | ± 3000 | pA pA | |
| I_{OS} | Input Offset Current | (Note 4) | ● | | ± 2 | ± 300 | ± 2 | ± 700 | pA pA | |
| e_n | Input Noise Voltage | $R_S = 100\Omega$, DC to 1Hz $R_S = 100\Omega$, DC to 10Hz | | | 0.6 1.6 | | 0.6 1.6 | | μV_{P-P} μV_{P-P} | |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = \text{GND to } V^+ - 0.7\text{V}$ $V_S = 3\text{V}$ | ● | | 115 110 | 130 | 115 110 | 130 | dB dB | |
| | | $V_{CM} = \text{GND to } V^+ - 0.7\text{V}$ $V_S = 5\text{V}$ | ● | | 120 115 | 130 | 120 115 | 130 | dB dB | |
| PSRR | Power Supply Rejection Ratio | $V_S = 2.7\text{V to } 6\text{V}$ | ● | | 120 115 | 130 | 120 115 | 130 | dB dB | |
| A_{VOL} | Large-Signal Voltage Gain | $R_L = 100\text{k}$, $V_S = 3\text{V}$, $V_{OUT} = V_S/2$ | ● | | 120 115 | 135 | 120 115 | 135 | dB dB | |
| | | $R_L = 100\text{k}$, $V_S = 5\text{V}$, $V_{OUT} = V_S/2$ | ● | | 125 120 | 140 | 125 120 | 140 | dB dB | |
| V_{OUT} | Output Voltage Swing High | $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ | ● | | 2.87 2.85 | 2.89 | 2.87 2.84 | 2.89 | V V | |
| | | $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ | ● | | 4.80 4.75 | 4.83 | 4.80 4.70 | 4.83 | V V | |
| | | $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ | ● | | 2.98 2.975 | 2.99 | 2.98 2.97 | 2.99 | V V | |
| | | $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ | ● | | 4.985 4.980 | 4.99 | 4.985 4.970 | 4.99 | V V | |

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LTC2054/LTC2055

ELECTRICAL CHARACTERISTICS (LTC2054/LTC2055) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = 3\text{V}, 5\text{V}$ unless otherwise noted. (Note 2)

| SYMBOL | PARAMETER | CONDITIONS | | LTC2054C/LTC2055C LTC2054I/LTC2055I | | | LTC2054H/LTC2055H | | | UNITS |
|-----------|-----------------------------|--|---|--|-----|-----|-------------------|-----|------------------|----------|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_{OUT} | Output Voltage Swing Low | $R_L = 5\text{k to GND}, V_S = 3\text{V}$ $R_L = 5\text{k to GND}, V_S = 3\text{V}$ | ● | 2 | 8 | 10 | 3 | 8 | 10 | mV mV |
| | | | ● | 2 | 8 | 10 | 3 | 8 | 10 | mV mV |
| | | $R_L = 100\text{k to GND}, V_S = 3\text{V}$ $R_L = 100\text{k to GND}, V_S = 3\text{V}$ | ● | 2 | 8 | 10 | 3 | 8 | 10 | mV mV |
| | | | ● | 2 | 8 | 10 | 3 | 8 | 10 | mV mV |
| SR | Slew Rate | | | 0.5 | | 0.5 | | | V/ μs | |
| GBW | Gain Bandwidth Product | | | 500 | | 500 | | | kHz | |
| f_S | Internal Sampling Frequency | | | 1 | | 1 | | | kHz | |

(LTC2054HV/LTC2055HV) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = \pm 5\text{V}$ unless otherwise noted. (Note 2)

| SYMBOL | PARAMETER | CONDITIONS | | LTC2054HVC/LTC2055HVC LTC2054HVI/LTC2055HVI | | | LTC2054HVH/LTC2055HVH | | | UNITS |
|--------------------------|--------------------------------|---|---|--|------------|-----------|-----------------------|------------|------------------|--|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| I_S | Supply Current | No Load (LTC2054) | ● | 175 | 210 | | 175 | 215 | | μA |
| I_S | Supply Current (Per Amplifier) | No Load (LTC2055) | ● | 150 | 180 | | 150 | 185 | | μA |
| V_{OS} | Input Offset Voltage | (Note 3) | | ± 0.5 | ± 5 | | ± 0.5 | ± 5 | | μV |
| $\Delta V_{OS}/\Delta T$ | Average Input Offset Drift | (Note 3) | ● | 0.025 | ± 0.03 | | 0.025 | ± 0.05 | | $\mu\text{V}/^\circ\text{C}$ |
| | Long-Term Offset Drift | | | 50 | | | 50 | | | $\text{nV}/\sqrt{\text{mo}}$ |
| I_B | Input Bias Current | (Note 4) | ● | ± 3 | | ± 150 | ± 3 | | ± 3000 | pA pA |
| | | | ● | ± 6 | | ± 300 | ± 6 | | ± 700 | pA pA |
| e_n | Input Noise Voltage | $R_S = 100\Omega, \text{DC to } 1\text{Hz}$ $R_S = 100\Omega, \text{DC to } 10\text{Hz}$ | | 0.6 | 1.6 | | 0.6 | 1.6 | | μV_{P-P} μV_{P-P} |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = \text{GND to } V^+ - 0.9$ | ● | 120 | 130 | | 120 | 130 | | dB dB |
| | | | ● | 115 | | | 115 | | | |
| PSRR | Power Supply Rejection Ratio | $V_S = 2.7\text{V to } 11\text{V}$ | ● | 120 | 130 | | 120 | 130 | | dB dB |
| | | | ● | 115 | | | 115 | | | |
| AVOL | Large-Signal Voltage Gain | $R_L = 100\text{k}, V_{OUT} = \text{GND}$ | ● | 125 | 140 | | 125 | 140 | | dB dB |
| | | | ● | 120 | | | 120 | | | |
| V_{OUT} | Maximum Output Voltage Swing | $R_L = 5\text{k to GND}$ $R_L = 5\text{k to GND}$ | ● | ± 4.78 | ± 4.82 | | ± 4.78 | ± 4.82 | | V V |
| | | | ● | ± 4.75 | | | ± 4.70 | | | |
| V_{OUT} | Maximum Output Voltage Swing | $R_L = 100\text{k to GND}$ $R_L = 100\text{k to GND}$ | ● | ± 4.98 | ± 4.99 | | ± 4.98 | ± 4.99 | | V V |
| | | | ● | ± 4.975 | | | ± 4.97 | | | |
| SR | Slew Rate | | | 0.5 | | 0.5 | | | V/ μs | |
| GBW | Gain Bandwidth Product | | | 500 | | 500 | | | kHz | |
| f_S | Internal Sampling Frequency | | | 1 | | 1 | | | kHz | |

ELECTRICAL CHARACTERISTICS (LTC2054MP) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = 3\text{V}, 5\text{V}$ unless otherwise noted. (Note 2)

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--------------------------|------------------------------|--|---|----------------|------------|------------------------|--|
| I_S | Supply Current | No Load | ● | | 145 | 190 | μA |
| V_{OS} | Input Offset Voltage | (Note 3) (Note 3) -55°C to 135°C | ● | | | ± 10 ± 8 | μV μV |
| $\Delta V_{OS}/\Delta T$ | Average Input Offset Drift | (Note 3) | ● | | 0.04 | ± 0.1 | $\mu\text{V}/^\circ\text{C}$ |
| | Long-Term Offset Drift | | | | 50 | | $\text{nV}/\sqrt{\text{mo}}$ |
| I_B | Input Bias Current | (Note 4) | ● | | ± 1 | ± 12 | pA nA |
| I_{OS} | Input Offset Current | (Note 4) | ● | | ± 2 | ± 5 | pA nA |
| e_n | Input Noise Voltage | $R_S = 100\Omega$, DC to 1Hz $R_S = 100\Omega$, DC to 10Hz | | | 0.6 1.6 | | $\mu\text{V}_{\text{P-P}}$ $\mu\text{V}_{\text{P-P}}$ |
| CMRR | Common Mode Rejection Ratio | $V_{\text{CM}} = \text{GND to } V^+ - 0.7\text{V}$ $V_S = 3\text{V}$ | ● | 115 105 | 130 | | dB dB |
| | | $V_{\text{CM}} = \text{GND to } V^+ - 0.7\text{V}$ $V_S = 5\text{V}$ | ● | 120 110 | 130 | | dB dB |
| PSRR | Power Supply Rejection Ratio | $V_S = 2.7\text{V to } 6\text{V}$ | ● | 120 110 | 130 | | dB dB |
| A_{VOL} | Large-Signal Voltage Gain | $R_L = 100\text{k}$, $V_S = 3\text{V}$, $V_{\text{OUT}} = V_S/2$ | ● | 120 110 | 135 | | dB dB |
| | | $R_L = 100\text{k}$, $V_S = 5\text{V}$, $V_{\text{OUT}} = V_S/2$ | ● | 125 115 | 140 | | dB dB |
| V_{OUT} | Output Voltage Swing High | $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ | ● | 2.87 2.84 | 2.89 | | V V |
| | | $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ | ● | 4.80 4.70 | 4.83 | | V V |
| | | $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ | ● | 2.98 2.97 | 2.99 | | V V |
| | | $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ | ● | 4.985 4.970 | 4.99 | | V V |
| | | | | | | | |
| V_{OUT} | Output Voltage Swing Low | $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 3\text{V}$ | ● | | 3 | 8 10 | mV mV |
| | | $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 5\text{k to GND}$, $V_S = 5\text{V}$ | ● | | 3 | 8 10 | mV mV |
| | | $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 3\text{V}$ | ● | | 3 | 8 10 | mV mV |
| | | $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ $R_L = 100\text{k to GND}$, $V_S = 5\text{V}$ | ● | | 3 | 8 10 | mV mV |
| | | | | | | | |
| SR | Slew Rate | | | 0.5 | | $\text{V}/\mu\text{s}$ | |
| GBW | Gain Bandwidth Product | | | 500 | | kHz | |
| f_S | Internal Sampling Frequency | | | 1 | | kHz | |

LTC2054/LTC2055

ELECTRICAL CHARACTERISTICS (LTC2054HVMP) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = \pm 5\text{V}$ unless otherwise noted. (Note 2)

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--------------------------|------------------------------|---|---|---------------------------|------------|-----------|--|
| I_S | Supply Current | No Load | ● | | 175 | 220 | μA |
| V_{OS} | Input Offset Voltage | (Note 3) | ● | | | ± 10 | μV |
| $\Delta V_{OS}/\Delta T$ | Average Input Offset Drift | (Note 3) | ● | | 0.05 | ± 0.1 | $\mu\text{V}/^\circ\text{C}$ |
| | Long-Term Offset Drift | | | | 50 | | $\text{nV}/\sqrt{\text{mo}}$ |
| I_B | Input Bias Current | (Note 4) | ● | | ± 3 | ± 12 | μA nA |
| I_{OS} | Input Offset Current | (Note 4) | ● | | ± 6 | ± 5 | μA nA |
| e_n | Input Noise Voltage | $R_S = 100\Omega$, DC to 1Hz $R_S = 100\Omega$, DC to 10Hz | | | 0.6 1.6 | | μV_{P-P} μV_{P-P} |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = \text{GND to } V^+ - 0.9$ | ● | 120 110 | 130 | | dB dB |
| PSRR | Power Supply Rejection Ratio | $V_S = 2.7\text{V to } 11\text{V}$ | ● | 120 110 | 130 | | dB dB |
| AVOL | Large-Signal Voltage Gain | $R_L = 100\text{k}$, $V_{OUT} = \text{GND}$ | ● | 125 115 | 140 | | dB dB |
| V_{OUT} | Maximum Output Voltage Swing | $R_L = 5\text{k to GND}$ $R_L = 5\text{k to GND}$ | ● | ± 4.78 ± 4.675 | ± 4.82 | | V V |
| | | $R_L = 100\text{k to GND}$ $R_L = 100\text{k to GND}$ | ● | ± 4.98 ± 4.965 | ± 4.99 | | V V |
| | | | | | | | |
| SR | Slew Rate | | | 0.5 | | | $\text{V}/\mu\text{s}$ |
| GBW | Gain Bandwidth Product | | | 500 | | | kHz |
| f_S | Internal Sampling Frequency | | | 1 | | | kHz |

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The LTC2054/LTC2055 are designed, characterized and expected to meet the extended temperature limits of -40°C and 125°C . The LTC2054C/LTC2055C/LTC2054HVC/LTC2055HVC are guaranteed to meet the temperature limits of 0°C and 70°C . The LTC2054I/LTC2055I/LTC2054HVI/LTC2055HVI are guaranteed to meet temperature limits of -40°C and 85°C . The LTC2054H/LTC2055H and LTC2054HVH/LTC2055HVH are guaranteed to meet the temperature limits of -40°C and 125°C . The LTC2054MP/LTC2054HVMP are guaranteed to meet the temperature limits of -55°C and 150°C .

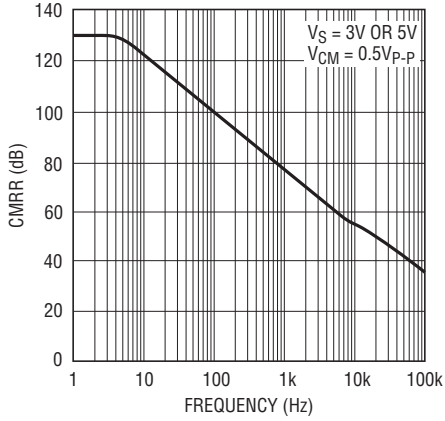
Note 3: These parameters are guaranteed by design. Thermocouple effects preclude measurements of these voltage levels during automated testing.

Note 4: Limit is determined by high speed automated test capability. See Typical Characteristic curves for actual typical performance. For tighter specifications, please consult Linear Technology Marketing.

Note 5: The θ_{JA} specified for the DD package is with minimal PCB heat spreading metal. Using expanded metal area on all layers of a board reduces this value.

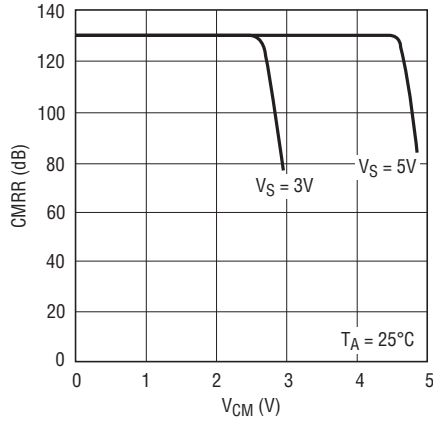
TYPICAL PERFORMANCE CHARACTERISTICS

Common Mode Rejection Ratio vs Frequency



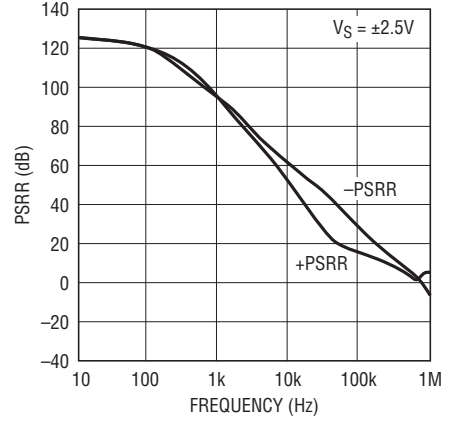
20545 G01

DC CMRR vs Common Mode Input Range



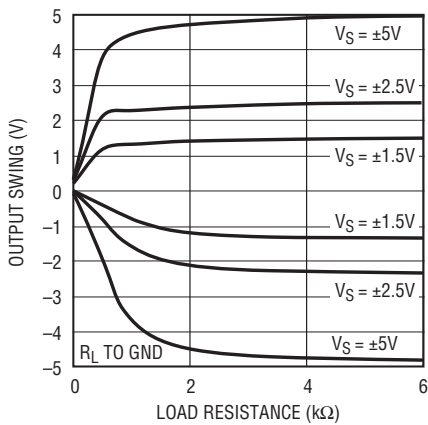
20545 G02

PSRR vs Frequency



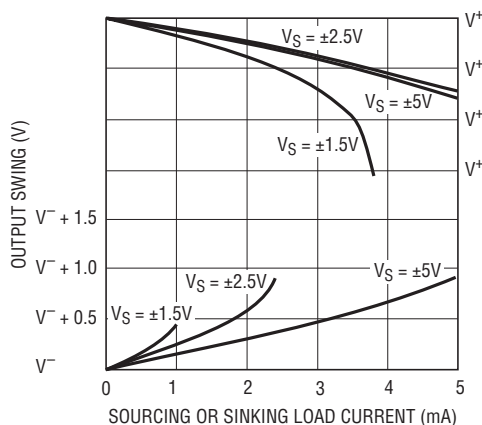
20545 G03

Output Voltage Swing vs Load Resistance



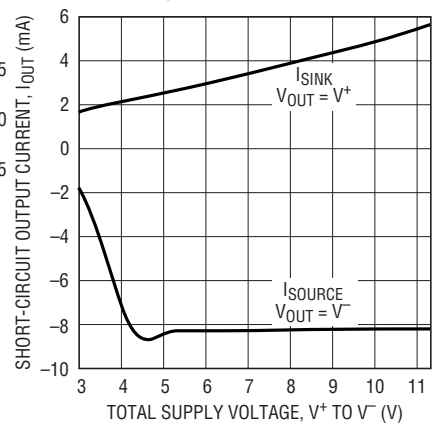
20545 G04

Output Swing vs Load Current



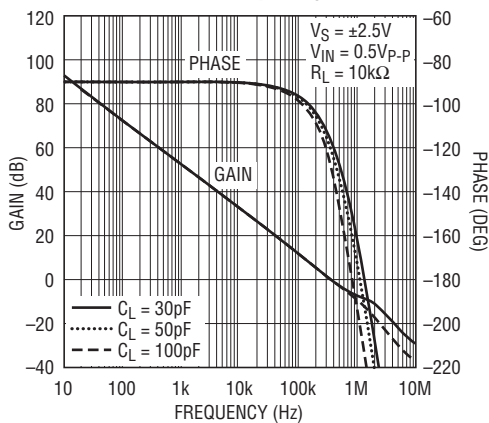
20545 G05

Short-Circuit Output Current vs Supply Voltage



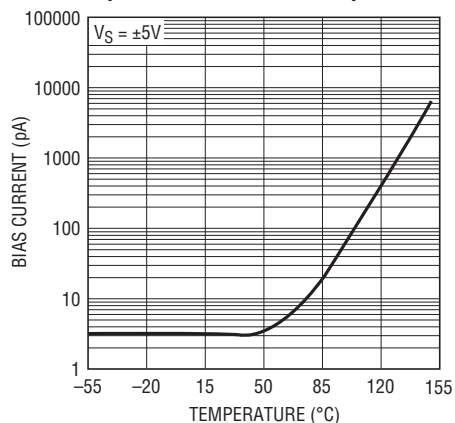
20545 G06

Gain/Phase vs Frequency



20545 G07

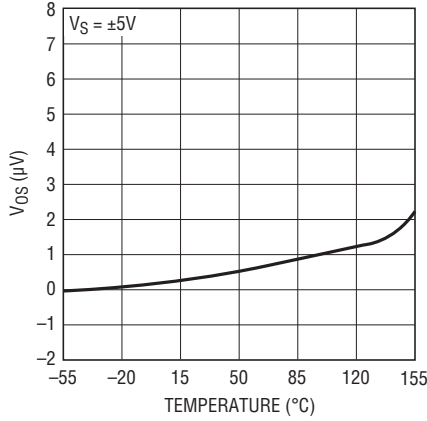
Input Bias Current vs Temperature



20545 G08

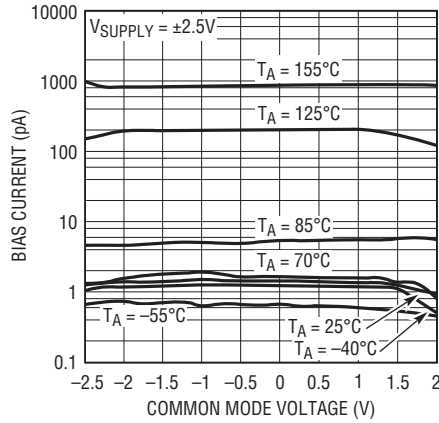
TYPICAL PERFORMANCE CHARACTERISTICS

V_{OS} vs Temperature



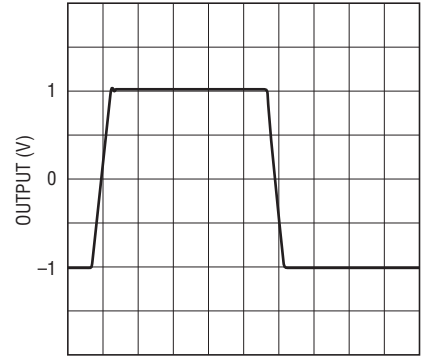
20545 G09

Input Bias Current vs Input Common Mode Voltage



20545 G10

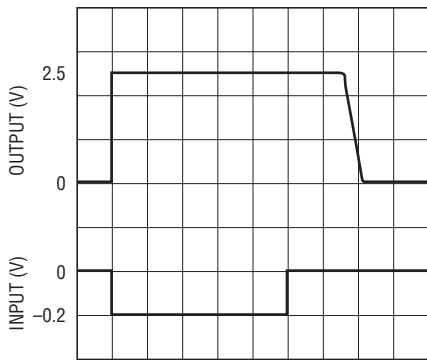
Transient Response



$A_V = 1$
 $R_L = 100k$
 $C_L = 50pF$
 $V_S = \pm 2.5V$
 $V_{IN} = 10kHz\ 2V_{p-p}$

20545 G11

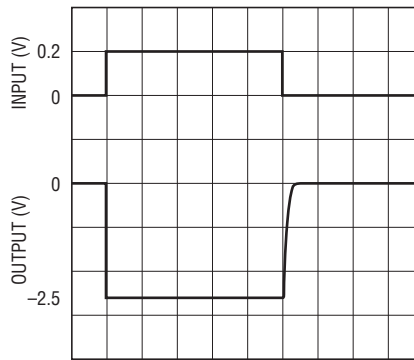
Output Overload Recovery



$A_V = -100$
 $R_L = 100k$
 $V_S = \pm 2.5V$

20545 G12

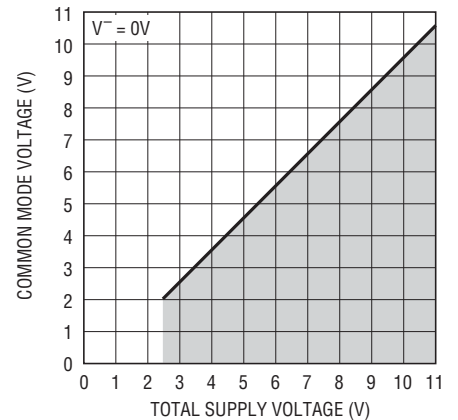
Output Overload Recovery



$A_V = -100$
 $R_L = 100k$
 $V_S = \pm 2.5V$

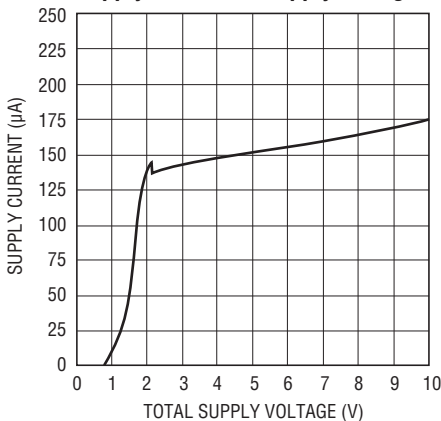
20545 G13

Common Mode Input Range



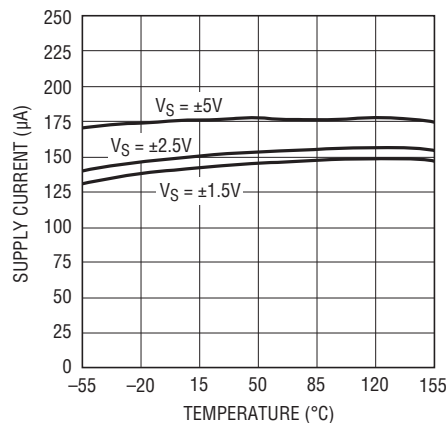
20545 G14

Supply Current vs Supply Voltage



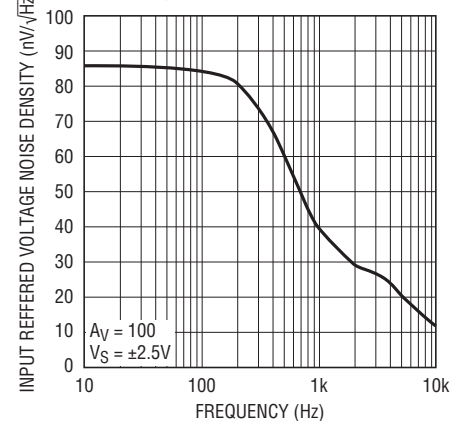
20545 G15

Supply Current vs Temperature



20545 G16

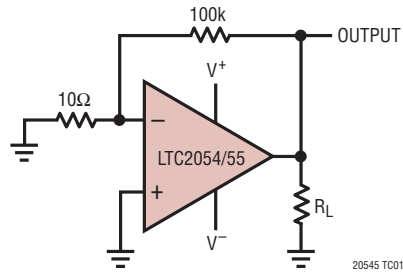
Noise Spectrum



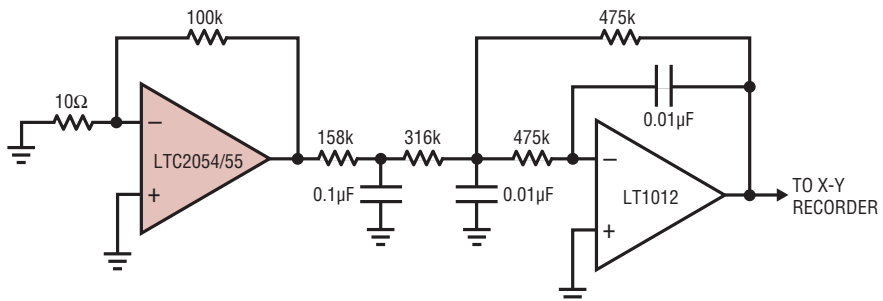
20545 G17

TEST CIRCUITS

Electrical Characteristics Test Circuit



DC-10Hz Noise Test Circuit



FOR 1Hz NOISE BW INCREASE ALL THE CAPACITORS BY A FACTOR OF 10.

APPLICATIONS INFORMATION

Clock Feedthrough, Input Bias Current

The LTC2054 and LTC2055 use 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/LTC2055.

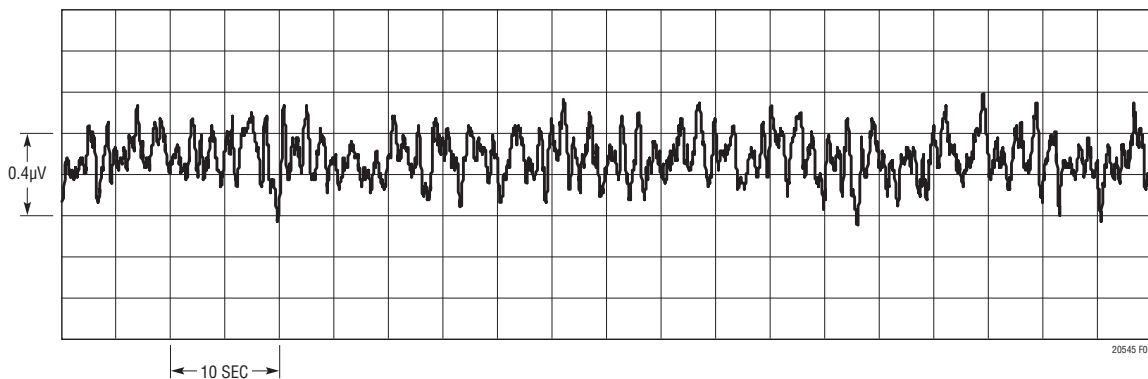
The first form of clock feedthrough is caused by the settling of the internal sampling capacitor and is input referred; that is, it is multiplied by the closed loop gain of the op amp. This form of clock feedthrough is independent of the magnitude of the input source resistance or the magnitude of the gain setting resistors. The LTC2054/LTC2055 have an input referred residue clock feedthrough of less than $0.2\mu\text{V}_{\text{RMS}}$ 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, and the resulting voltage spikes appear 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 $10\text{k}\Omega$, this form of clock feedthrough is less than the amount of residue clock feedthrough from the first form described above.

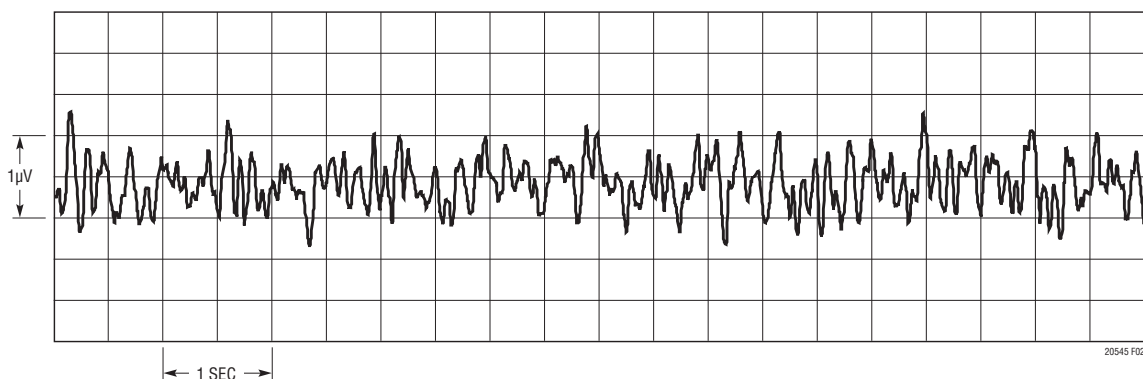
Placing a capacitor across the feedback resistor reduces either form of clock feedthrough by limiting the bandwidth of the closed loop gain.

Input bias current is defined as the DC current into the input pins of the op amp. The same current spikes that

DC to 1Hz Noise



DC to 10Hz Noise



APPLICATIONS INFORMATION

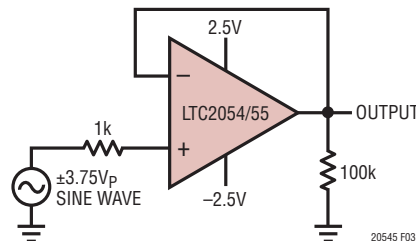
cause the second form of clock feedthrough described above, when averaged, dominate the DC input bias current of the op amp below 70°C.

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 70°C) the leakage current begins to dominate and both the negative and positive pins' input bias currents are in the positive direction (into the pins).

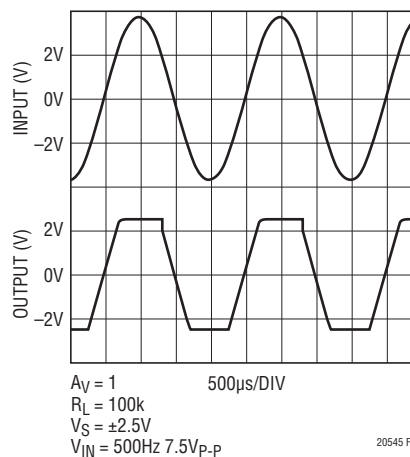
Extended Common Mode Range

The LTC2054/LTC2055 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 phase inversion.

Voltage Follower with Input Exceeding the Common Mode Range

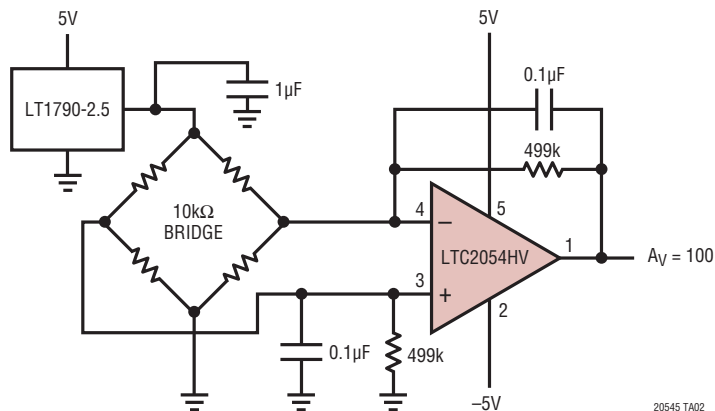


Extended Common Mode Range



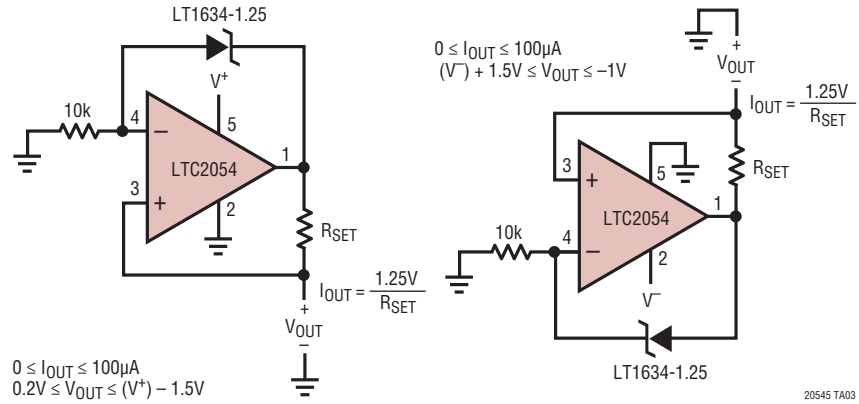
TYPICAL APPLICATIONS

Simple Differential Bridge Amplifier

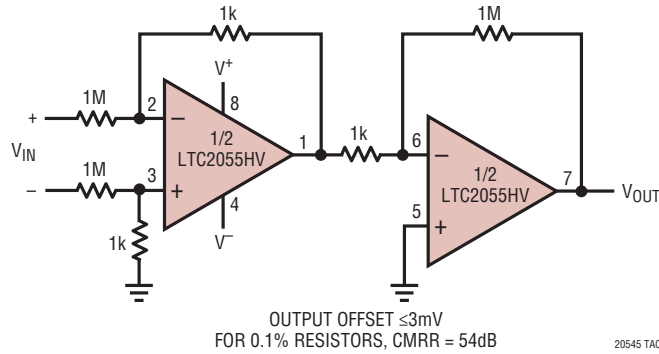


TYPICAL APPLICATIONS

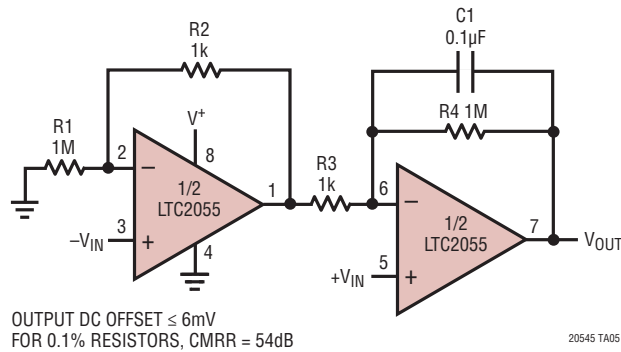
Ground Referred Precision Current Sources



Instrumentation Amplifier with 100V Common Mode Input Voltage

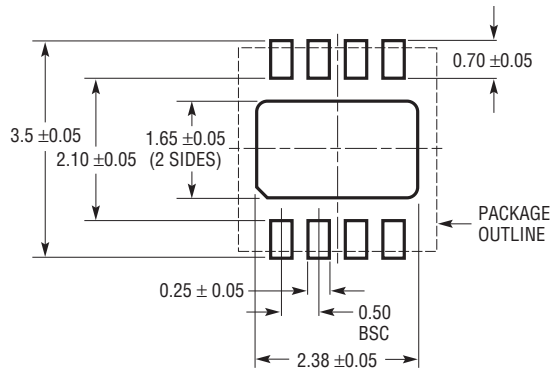


Gain of 1001 Single Supply Instrumentation Amplifier

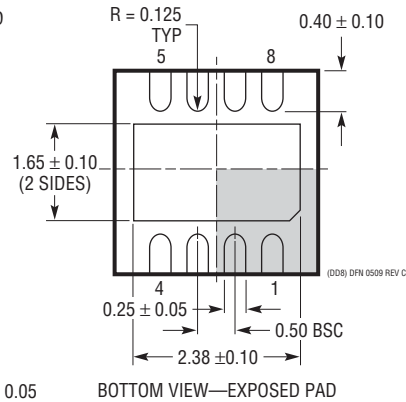
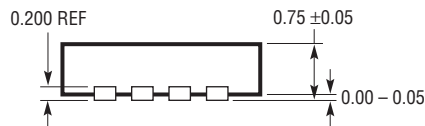
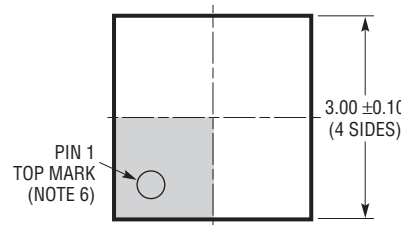


PACKAGE DESCRIPTION

DD Package
8-Lead Plastic DFN (3mm × 3mm)
 (Reference LTC DWG # 05-08-1698 Rev C)



RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS
 APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED



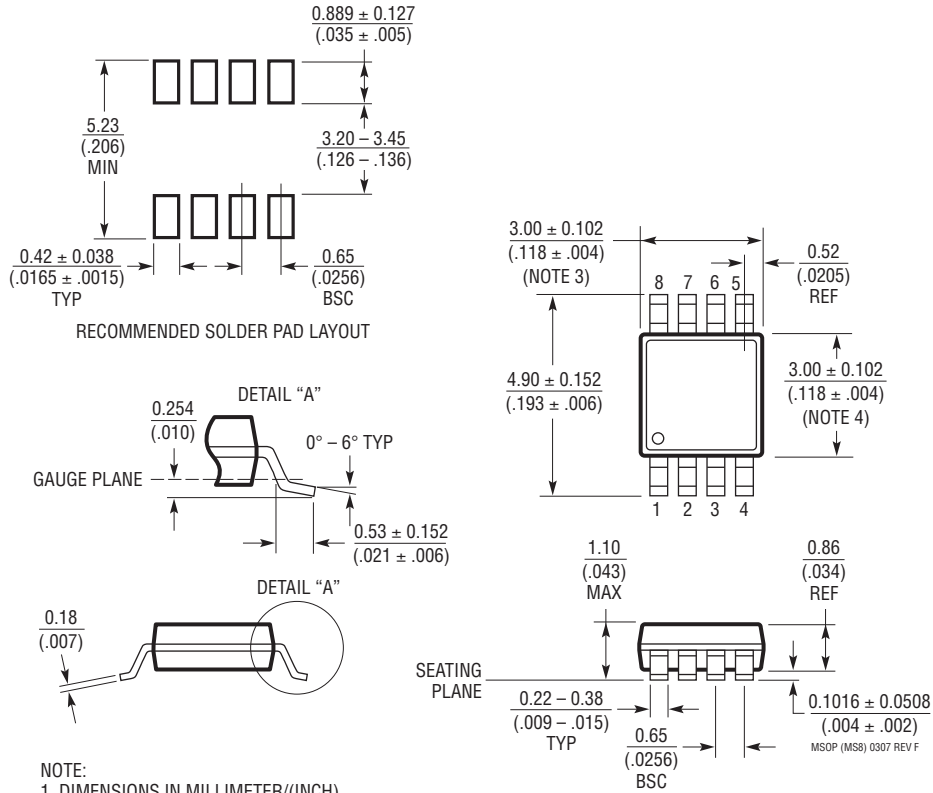
NOTE:

1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON TOP AND BOTTOM OF PACKAGE

PACKAGE DESCRIPTION

MS8 Package 8-Lead Plastic MSOP

(Reference LTC DWG # 05-08-1660 Rev F)

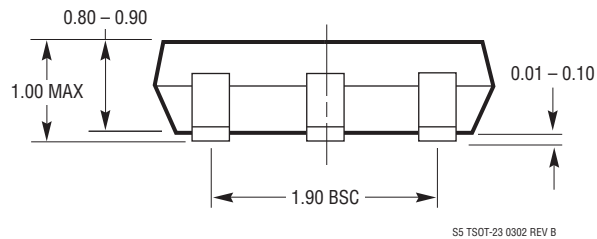
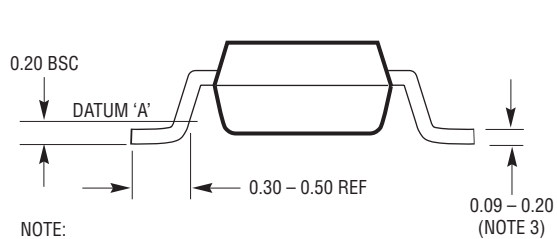
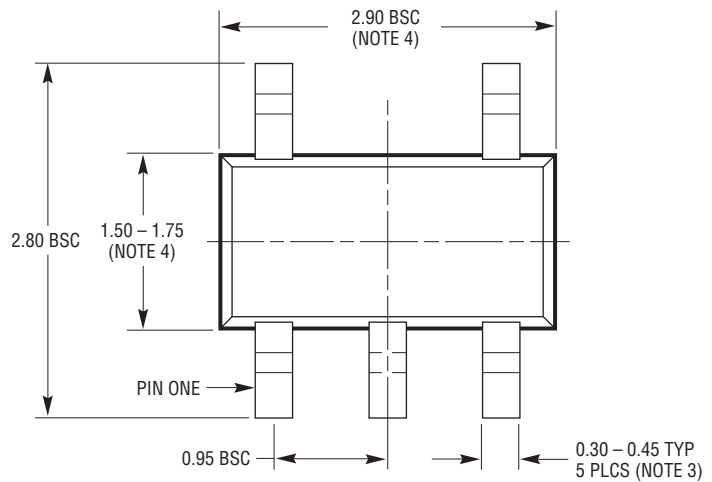
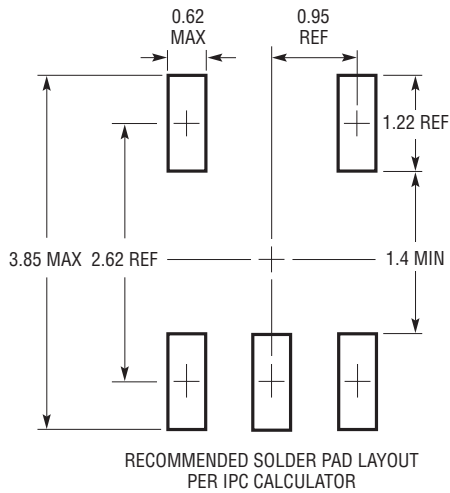


NOTE:

1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

PACKAGE DESCRIPTION

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

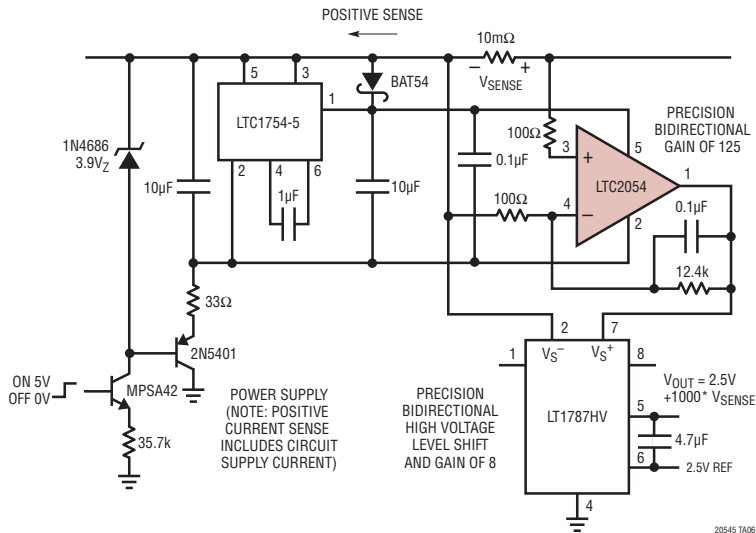


- NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
 2. DRAWING NOT TO SCALE
 3. DIMENSIONS ARE INCLUSIVE OF PLATING
 4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
 5. MOLD FLASH SHALL NOT EXCEED 0.254mm
 6. JEDEC PACKAGE REFERENCE IS MO-193

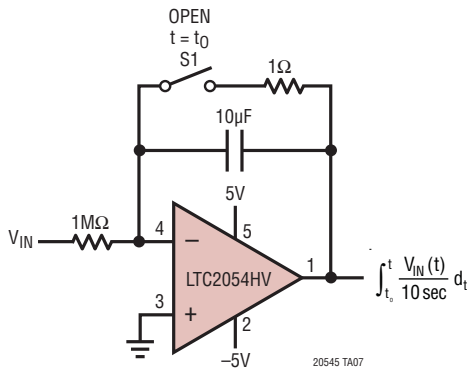
S5 TSOT-23 0302 REV B

TYPICAL APPLICATIONS

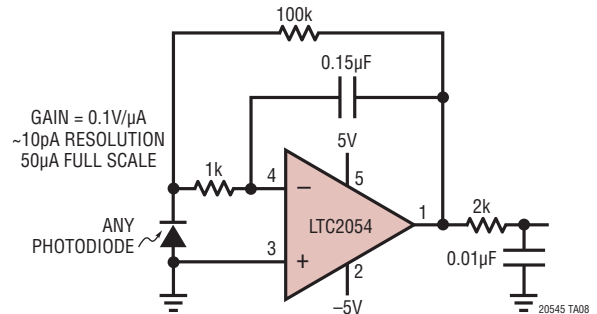
Low Power, Bidirectional 60V Precision Hi Side Current Sense



Precision Low Drift Integrator



Ultra-Precision, Wide Dynamic Range 10Hz Bandwidth 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 Output Precision Op Amp | $V_{OS} = 90\mu V$, $V_S = 2.7V$ to 44V |
| LT1884/LT1885 | Rail-to-Rail Output Precision Op Amp | $V_{OS} = 50\mu V$, $I_B = 400pA$, $V_S = 2.7V$ 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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[LTC2055HVIDD#PBF](#) [LTC2054CS5#TRMPBF](#) [LTC2054IS5#TRPBF](#) [LTC2054HVIS5#TRMPBF](#)
[LTC2055HVHDD#TRPBF](#) [LTC2054HVCS5#TRMPBF](#) [LTC2055HVCDD#PBF](#) [LTC2055HVIMS8#PBF](#)
[LTC2054HVCS5#TRPBF](#) [LTC2055CMS8#TRPBF](#) [LTC2055IDD#PBF](#) [LTC2054MPS5#TRMPBF](#)
[LTC2054MPS5#TRPBF](#) [LTC2055HVCMS8#PBF](#) [LTC2054HVIS5#TRPBF](#) [LTC2054HVHS5#TRMPBF](#)
[LTC2055HDD#TRPBF](#) [LTC2055HVCDD#TRPBF](#) [LTC2055HVIMS8#TRPBF](#) [LTC2055IDD#TRPBF](#)
[LTC2054IS5#TRMPBF](#) [LTC2055HVHMS8#PBF](#) [LTC2054HS5#TRMPBF](#) [LTC2054HVMPS5#TRMPBF](#)
[LTC2055HDD#PBF](#) [LTC2055CDD#TRPBF](#) [LTC2054HVHS5#TRPBF](#) [LTC2055HVHDD#PBF](#) [LTC2054HS5#TRPBF](#)
[LTC2055HVIDD#TRPBF](#) [LTC2055IMS8#TRPBF](#) [LTC2055CMS8#PBF](#) [LTC2054CS5#TRPBF](#)
[LTC2055HVHMS8#TRPBF](#) [LTC2055IMS8#PBF](#) [LTC2055HMS8#TRPBF](#)