# THE DATASHEET OF

# LTC2053IMS8-SYNC#TRPBF

www.win-source.net 0086-755-83957316

# Precision, Rail-to-Rail, Zero-Drift, Resistor-Programmable Instrumentation Amplifier

## FEATURES

- **116dB CMRR Independent of Gain**
- **Maximum Offset Voltage: 10µV**
- **Maximum Offset Voltage Drift: 50nV/°C**
- **Rail-to-Rail Input**
- **Rail-to-Rail Output**
- **2-Resistor Programmable Gain**
- Supply Operation: 2.7V to ±5.5V
- Typical Noise: 2.5µV$_{P-P}$ (0.01Hz to 10Hz)
- Typical Supply Current: 750µA
- LTC2053-SYNC Allows Synchronization to External Clock
- Available in MS8 and 3mm × 3mm × 0.8mm DFN Packages

## APPLICATIONS

- Thermocouple Amplifiers
- Electronic Scales
- Medical Instrumentation
- Strain Gauge Amplifiers
- High Resolution Data Acquisition

## DESCRIPTION

The LTC®2053 is a high precision instrumentation amplifier. The CMRR is typically 116dB with a single or dual 5V supply and is independent of gain. The input offset voltage is guaranteed below 10µV with a temperature drift of less than 50nV/°C. The LTC2053 is easy to use; the gain is adjustable with two external resistors, like a traditional op amp.

The LTC2053 uses charge balanced sampled data techniques to convert a differential input voltage into a single ended signal that is in turn amplified by a zero-drift operational amplifier.

The differential inputs operate from rail-to-rail and the single-ended output swings from rail-to-rail. The LTC2053 can be used in single-supply applications, as low as 2.7V. It can also be used with dual ±5.5V supplies. The LTC2053 requires no external clock, while the LTC2053-SYNC has a CLK pin to synchronize to an external clock.

The LTC2053 is available in an MS8 surface mount package. For space limited applications, the LTC2053 is available in a 3mm × 3mm × 0.8mm dual fine pitch leadless package (DFN).

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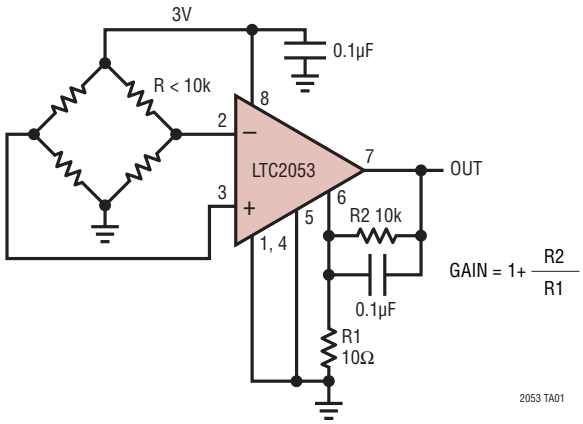
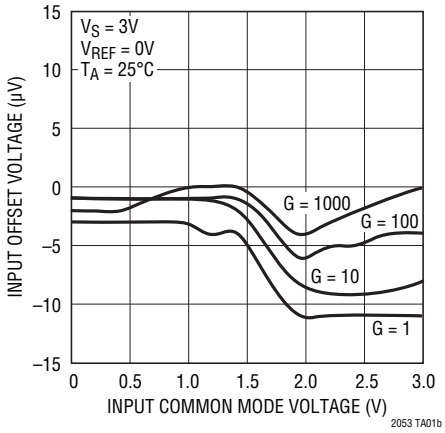
## TYPICAL APPLICATION

**Differential Bridge Amplifier**




**Typical Input Referred Offset vs Input Common Mode Voltage ($V_S$ = 3V)**

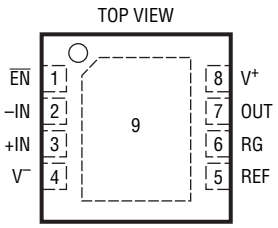


## ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage ($V^+$ to $V^-$) ..... 11V
Input Current ..... ±10mA
$|V_{-IN} - V_{REF}|$ ..... 5.5V
$|V_{+IN} - V_{REF}|$ ..... 5.5V
Output Short-Circuit Duration ..... Indefinite
Operating Temperature Range
LTC2053C, LTC2053C-SYNC ..... 0°C to 70°C
LTC2053I, LTC2053I-SYNC ..... –40°C to 85°C
LTC2053H ..... –40°C to 125°C

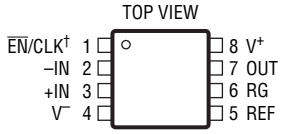
Storage Temperature Range
MS8 Package ..... –65°C to 150°C
DD Package ..... –65°C to 125°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

## PIN CONFIGURATION




DD PACKAGE
8-LEAD (3mm × 3mm) PLASTIC DFN

$T_{JMAX}$ = 125°C, $\theta_{JA}$ = 160°C/W
, UNDERSIDE METAL INTERNALLY CONNECTED TO $V^-$
(PCB CONNECTION OPTIONAL)




MS8 PACKAGE
8-LEAD PLASTIC MSOP

$T_{JMAX}$ = 150°C, $\theta_{JA}$ = 200°C/W
†PIN 1 IS $\overline{EN}$ ON LTC2053, CLK ON LTC2053-SYNC

## ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING* | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|---|---|---|---|---|
| LTC2053CDD#PBF | LTC2053CDD#TRPBF | LAEQ | 8-Lead (3mm × 3mm) Plastic DFN | 0°C to 70°C |
| LTC2053IDD#PBF | LTC2053IDD#TRPBF | LAEQ | 8-Lead (3mm × 3mm) Plastic DFN | –40°C to 85°C |
| LTC2053HDD#PBF | LTC2053HDD#TRPBF | LAEQ | 8-Lead (3mm × 3mm) Plastic DFN | –40°C to 125°C |
| LTC2053CMS8#PBF | LTC2053CMS8#TRPBF | LTVT | 8-Lead Plastic MSOP | 0°C to 70°C |
| LTC2053IMS8#PBF | LTC2053IMS8#TRPBF | LTJY | 8-Lead Plastic MSOP | –40°C to 85°C |
| LTC2053HMS8#PBF | LTC2053HMS8#TRPBF | LTAFB | 8-Lead Plastic MSOP | –40°C to 125°C |
| LTC2053CMS8-SYNC#PBF | LTC2053CMS8-SYNC#TRPBF | LTBNP | 8-Lead Plastic MSOP | 0°C to 70°C |
| LTC2053IMS8-SYNC#PBF | LTC2053IMS8-SYNC#TRPBF | LTBNP | 8-Lead Plastic MSOP | –40°C to 85°C |

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.

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/. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = 3V, $V^-$ = 0V, REF = 200mV. Output voltage swing is referenced to $V^-$. All other specifications reference the OUT pin to the REF pin.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Gain Error | $A_V$ = 1 | ● | | 0.001 | 0.01 | % |
| Gain Nonlinearity | $A_V$ = 1, LTC2053<br>$A_V$ = 1, LTC2053-SYNC | ●<br>● | | 3<br>3 | 12<br>15 | ppm<br>ppm |
| Input Offset Voltage (Note 2) | $V_{CM}$ = 200mV | | | –5 | ±10 | µV |
| Average Input Offset Drift (Note 2) | $T_A$ = –40°C to 85°C<br>$T_A$ = 85°C to 125°C | ●<br>● | | <br>–1 | ±50<br>–2.5 | nV/°C<br>µV/°C |
| Average Input Bias Current (Note 3) | $V_{CM}$ = 1.2V | ● | | 4 | 10 | nA |
| Average Input Offset Current (Note 3) | $V_{CM}$ = 1.2V | ● | | 1 | 3 | nA |
| Input Noise Voltage | DC to 10Hz | | | 2.5 | | $\mu V_{P-P}$ |
| Common Mode Rejection Ratio (Notes 4, 5) | $A_V$ = 1, $V_{CM}$ = 0V to 3V, LTC2053C, LTC2053C-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0.1V to 2.9V, LTC2053I, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0V to 3V, LTC2053I, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0.1V to 2.9V, LTC2053H<br>$A_V$ = 1, $V_{CM}$ = 0V to 3V, LTC2053H | ●<br>●<br>●<br>●<br>● | 100<br>100<br>95<br>100<br>85 | 113<br>113<br>113 | | dB<br>dB<br>dB<br>dB<br>dB |
| Power Supply Rejection Ratio (Note 6) | $V_S$ = 2.7V to 6V | ● | 110 | 116 | | dB |
| Output Voltage Swing High | $R_L$ = 2k to $V^-$<br>$R_L$ = 10k to $V^-$ | ●<br>● | 2.85<br>2.95 | 2.94<br>2.98 | | V<br>V |
| Output Voltage Swing Low | | ● | | | 20 | mV |
| Supply Current | No Load | ● | | 0.75 | 1 | mA |
| Supply Current, Shutdown | $V_{\overline{EN}} \geq$ 2.5V, LTC2053 Only | | | | 10 | µA |
| $\overline{EN}$/CLK Pin Input Low Voltage, $V_{IL}$ | | | | | 0.5 | V |
| $\overline{EN}$/CLK Pin Input High Voltage, $V_{IH}$ | | | 2.5 | | | V |
| $\overline{EN}$/CLK Pin Input Current | $V_{\overline{EN}/CLK} = V^-$ | | | –0.5 | –10 | µA |
| Internal Op Amp Gain Bandwidth | | | | 200 | | kHz |
| Slew Rate | | | | 0.2 | | V/µs |
| Internal Sampling Frequency | | | | 3 | | kHz |

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = 5V, $V^-$ = 0V, REF = 200mV. Output voltage swing is referenced to $V^-$. All other specifications reference the OUT pin to the REF pin.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Gain Error | $A_V$ = 1 | ● | | 0.001 | 0.01 | % |
| Gain Nonlinearity | $A_V$ = 1 | ● | | 3 | 10 | ppm |
| Input Offset Voltage (Note 2) | $V_{CM}$ = 200mV | | | –5 | ±10 | µV |
| Average Input Offset Drift (Note 2) | $T_A$ = –40°C to 85°C<br>$T_A$ = 85°C to 125°C | ●<br>● | | <br>–1 | ±50<br>–2.5 | nV/°C<br>µV/°C |
| Average Input Bias Current (Note 3) | $V_{CM}$ = 1.2V | ● | | 4 | 10 | nA |
| Average Input Offset Current (Note 3) | $V_{CM}$ = 1.2V | ● | | 1 | 3 | nA |
| Common Mode Rejection Ratio (Notes 4, 5) | $A_V$ = 1, $V_{CM}$ = 0V to 5V, LTC2053C<br>$A_V$ = 1, $V_{CM}$ = 0V to 5V, LTC2053C-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0.1V to 4.9V, LTC2053I<br>$A_V$ = 1, $V_{CM}$ = 0.1V to 4.9V, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0V to 5V, LTC2053I, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = 0.1V to 4.9V, LTC2053H<br>$A_V$ = 1, $V_{CM}$ = 0V to 5V, LTC2053H | ●<br>●<br>●<br>●<br>●<br>●<br>● | 105<br>100<br>105<br>100<br>95<br>100<br>85 | 116<br>116<br>116<br>116<br>116 | | dB<br>dB<br>dB<br>dB<br>dB<br>dB<br>dB |
| Power Supply Rejection Ratio (Note 6) | $V_S$ = 2.7V to 6V | ● | 110 | 116 | | dB |

## ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = 5V, $V^-$ = 0V, REF = 200mV. Output voltage swing is referenced to $V^-$. All other specifications reference the OUT pin to the REF pin.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Output Voltage Swing High | $R_L$ = 2k to $V^-$<br>$R_L$ = 10k to $V^-$ | ●<br>● | 4.85<br>4.95 | 4.94<br>4.98 | | V<br>V |
| Output Voltage Swing Low | | ● | | | 20 | mV |
| Supply Current | No Load | ● | | 0.85 | 1.1 | mA |
| Supply Current, Shutdown | $V_{\overline{EN}} \geq$ 4.5V, LTC2053 Only | | | | 10 | µA |
| $\overline{EN}$/CLK Pin Input Low Voltage, $V_{IL}$ | | | | | 0.5 | V |
| $\overline{EN}$/CLK Pin Input High Voltage, $V_{IH}$ | | | 4.5 | | | V |
| $\overline{EN}$/CLK Pin Input Current | $V_{\overline{EN}/CLK} = V^-$ | | | –1 | –10 | µA |
| Internal Op Amp Gain Bandwidth | | | | 200 | | kHz |
| Slew Rate | | | | 0.2 | | V/µs |
| Internal Sampling Frequency | | | | 3 | | kHz |

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = 5V, $V^-$ = –5V, REF = 0V.**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Gain Error | $A_V$ = 1 | ● | | 0.001 | 0.01 | % |
| Gain Nonlinearity | $A_V$ = 1 | ● | | 3 | 10 | ppm |
| Input Offset Voltage (Note 2) | $V_{CM}$ = 0V | | | 10 | ±20 | µV |
| Average Input Offset Drift (Note 2) | $T_A$ = –40°C to 85°C<br>$T_A$ = 85°C to 125°C | ●<br>● | | <br>–1 | ±50<br>–2.5 | nV/°C<br>µV/°C |
| Average Input Bias Current (Note 3) | $V_{CM}$ = 1V | ● | | 4 | 10 | nA |
| Average Input Offset Current (Note 3) | $V_{CM}$ = 1V | ● | | 1 | 3 | nA |
| Common Mode Rejection Ratio (Notes 4, 5) | $A_V$ = 1, $V_{CM}$ = –5V to 5V, LTC2053C<br>$A_V$ = 1, $V_{CM}$ = –5V to 5V, LTC2053C-SYNC<br>$A_V$ = 1, $V_{CM}$ = –4.9V to 4.9V, LTC2053I<br>$A_V$ = 1, $V_{CM}$ = –4.9V to 4.9V, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = –5V to 5V, LTC2053I, LTC2053I-SYNC<br>$A_V$ = 1, $V_{CM}$ = –4.9V to 4.9V, LTC2053H<br>$A_V$ = 1, $V_{CM}$ = –5V to 5V, LTC2053H | ●<br>●<br>●<br>●<br>●<br>●<br>● | 105<br>100<br>105<br>100<br>95<br>100<br>90 | 118<br>118<br>118<br>118<br>118 | | dB<br>dB<br>dB<br>dB<br>dB<br>dB<br>dB |
| Power Supply Rejection Ratio (Note 6) | $V_S$ = 2.7V to 11V | ● | 110 | 116 | | dB |
| Maximum Output Voltage Swing | $R_L$ = 2k to GND, C- and I-Grades<br>$R_L$ = 10k to GND, All Grades<br>$R_L$ = 2k to GND, LTC2053H Only | ●<br>●<br>● | ±4.5<br>±4.6<br>±4.4 | ±4.8<br>±4.9<br>±4.8 | | V<br>V<br>V |
| Supply Current | No Load | ● | | 0.95 | 1.3 | mA |
| Supply Current, Shutdown | $V_{\overline{EN}} \geq$ 4.5V, LTC2053 Only | | | | 20 | µA |
| $\overline{EN}$ Pin Input Low Voltage, $V_{IL}$ | | | | | –4.5 | V |
| CLK Pin Input Low Voltage, $V_{IL}$ | | | | | 0.5 | V |
| $\overline{EN}$/CLK Pin Input High Voltage, $V_{IH}$ | | | 4.5 | | | V |
| $\overline{EN}$/CLK Pin Input Current | $V_{\overline{EN}/CLK} = V^-$ | | | –3 | –20 | µA |
| Internal Op Amp Gain Bandwidth | | | | 200 | | kHz |
| Slew Rate | | | | 0.2 | | V/µs |
| Internal Sampling Frequency | | | | 3 | | kHz |

## ELECTRICAL CHARACTERISTICS

**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:** These parameters are guaranteed by design. Thermocouple effects preclude measurement of these voltage levels in high speed automatic test systems. $V_{OS}$ is measured to a limit determined by test equipment capability.

**Note 3:** If the total source resistance is less than 10k, no DC errors result from the input bias currents or the mismatch of the input bias currents or the mismatch of the resistances connected to –IN and +IN.

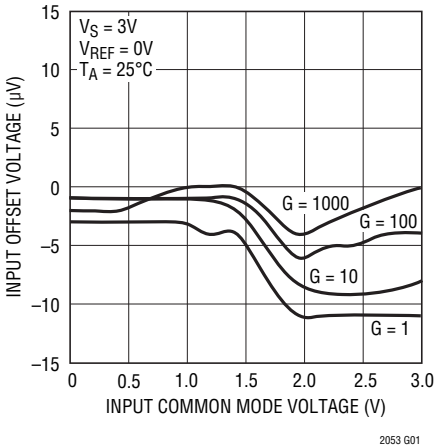
**Note 4:** The CMRR with a voltage gain, $A_V$, larger than 10 is 120dB (typ).

**Note 5:** At temperatures above 70°C, the common mode rejection ratio lowers when the common mode input voltage is within 100mV of the supply rails.

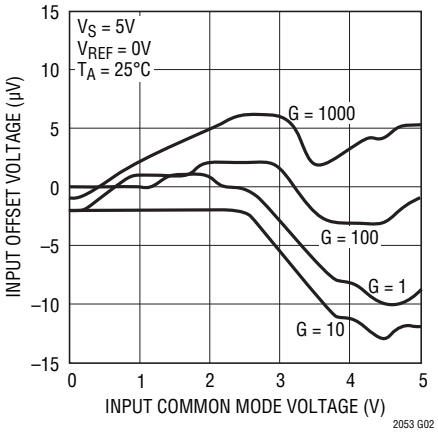
**Note 6:** The power supply rejection ratio (PSRR) measurement accuracy depends on the proximity of the power supply bypass capacitor to the device under test. Because of this, the PSRR is 100% tested to relaxed limits at final test. However, their values are guaranteed by design to meet the data sheet limits.

## TYPICAL PERFORMANCE CHARACTERISTICS

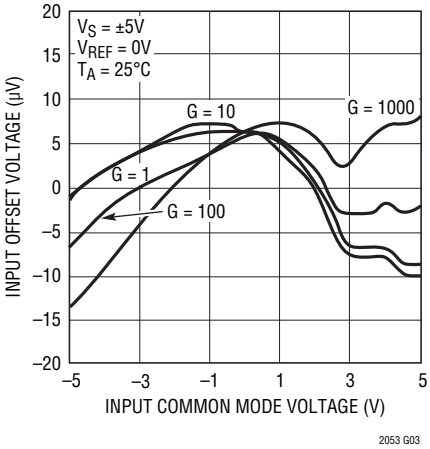
**Input Offset Voltage vs Input Common Mode Voltage**



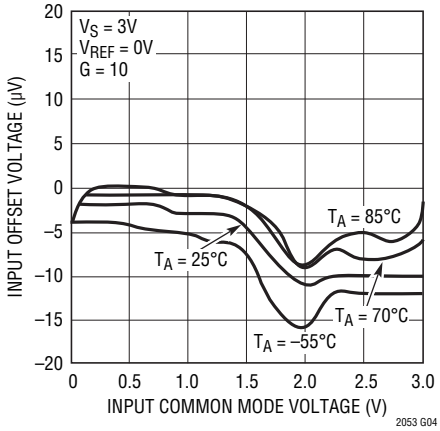

**Input Offset Voltage vs Input Common Mode Voltage**



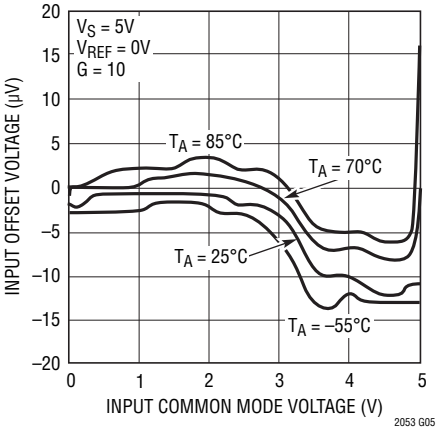

**Input Offset Voltage vs Input Common Mode Voltage**



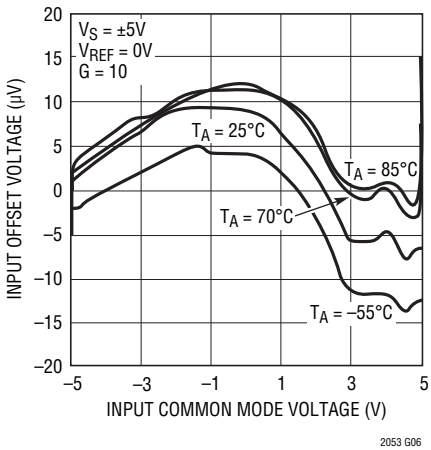

**Input Offset Voltage vs Input Common Mode Voltage**




**Input Offset Voltage vs Input Common Mode Voltage**

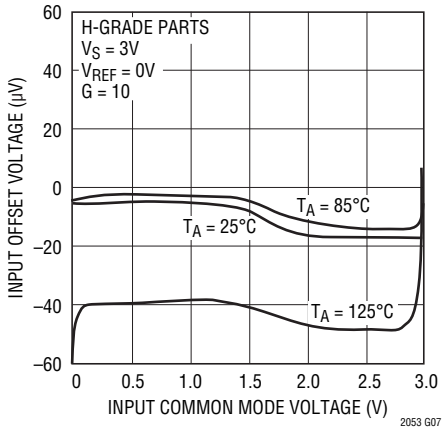



**Input Offset Voltage vs Input Common Mode Voltage**

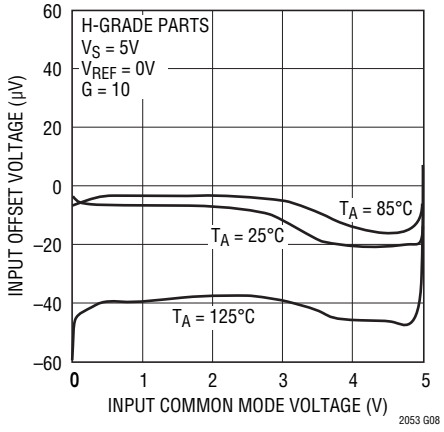


## TYPICAL PERFORMANCE CHARACTERISTICS

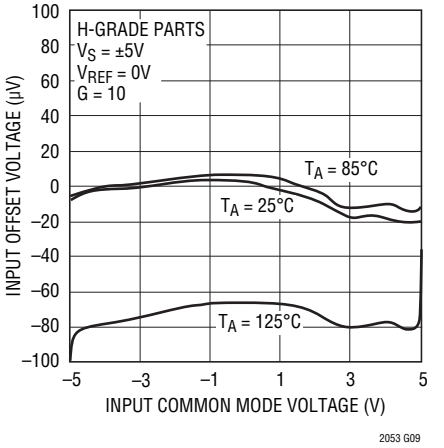
### Input Offset Voltage vs Input Common Mode Voltage



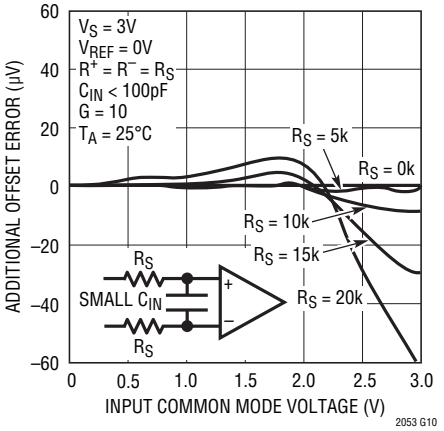

### Input Offset Voltage vs Input Common Mode Voltage



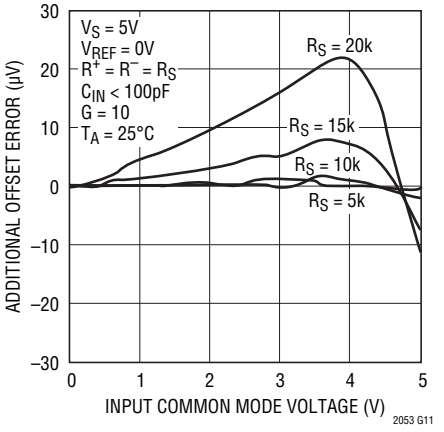

### Input Offset Voltage vs Input Common Mode Voltage



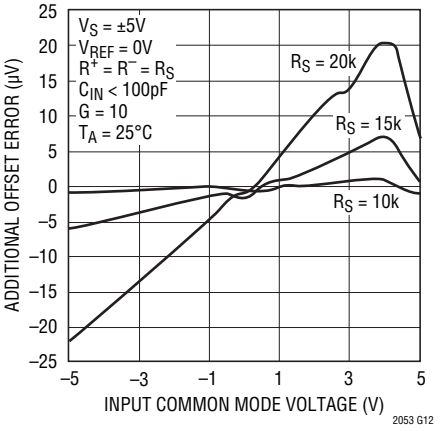

### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ < 100pF)



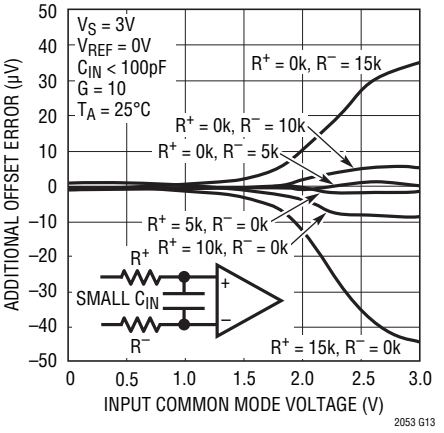

### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ < 100pF)



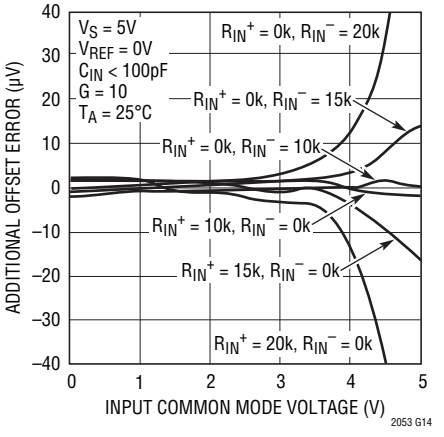

### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ < 100pF)



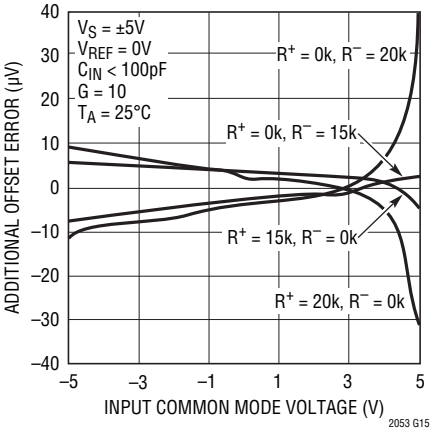

### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ < 100pF)




### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ < 100pF)

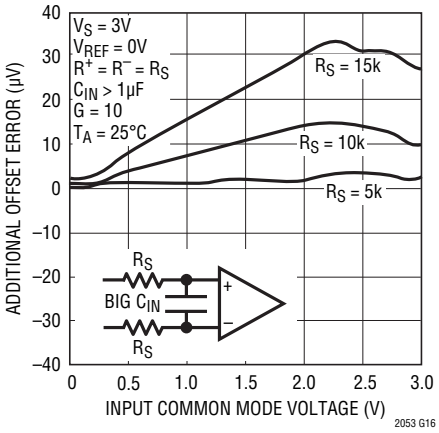



### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ < 100pF)

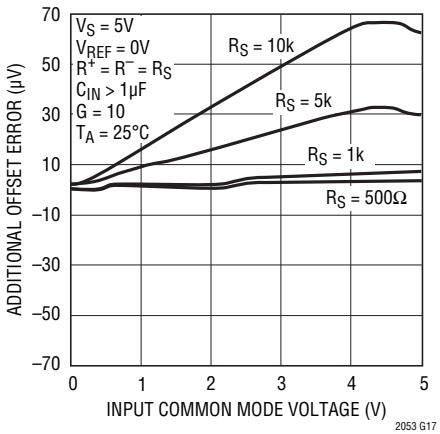


# TYPICAL PERFORMANCE CHARACTERISTICS

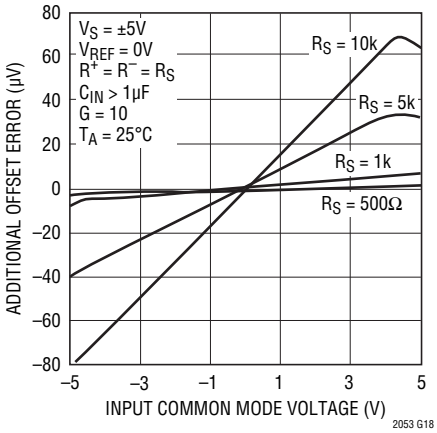
### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ > 1µF)



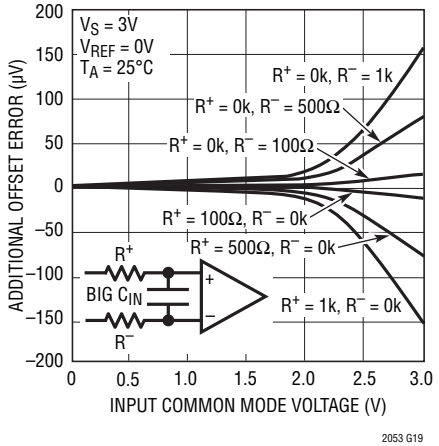

### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ > 1µF)



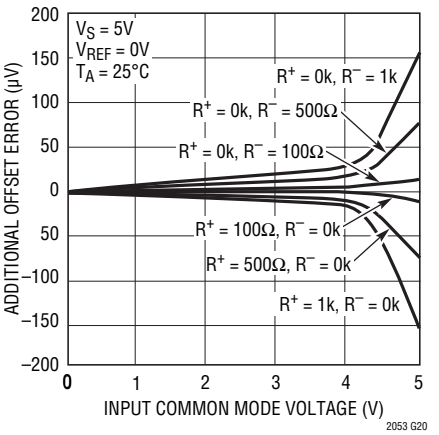

### Error Due to Input $R_S$ vs Input Common Mode ($C_{IN}$ > 1µF)



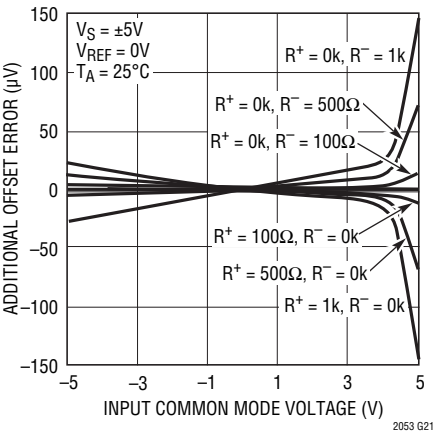

### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ >1µF)



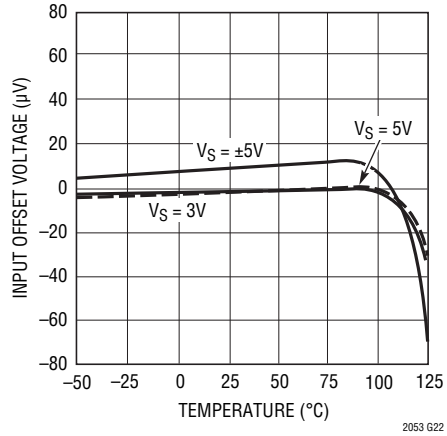

### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ >1µF)



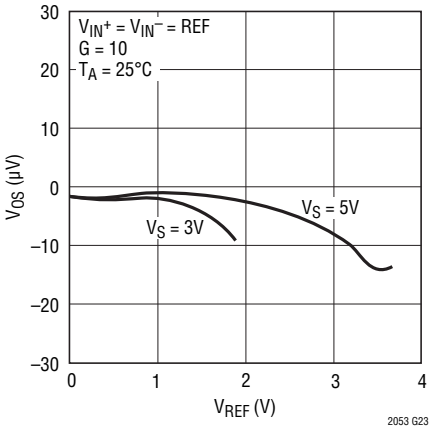

### Error Due to Input $R_S$ Mismatch vs Input Common Mode ($C_{IN}$ >1µF)



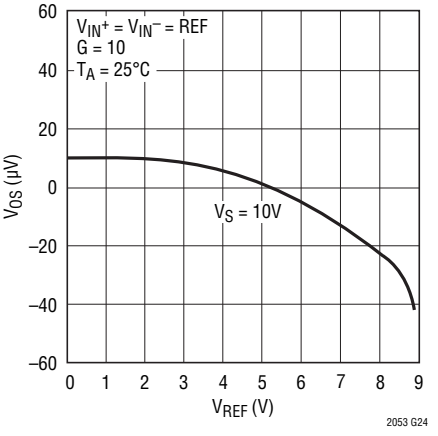

### Offset Voltage vs Temperature




### $V_{OS}$ vs REF (Pin 5)

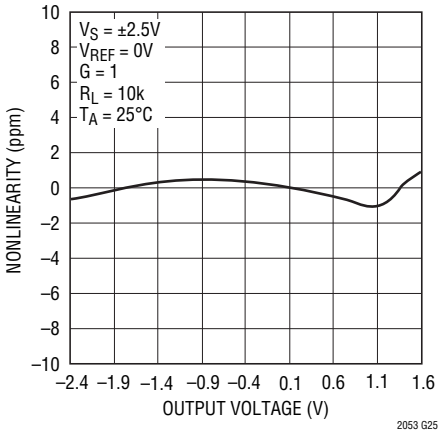



### $V_{OS}$ vs REF (Pin 5)

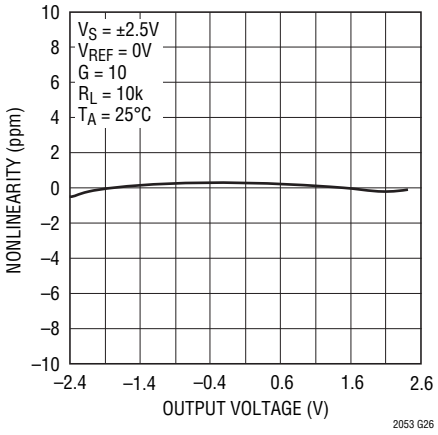


## TYPICAL PERFORMANCE CHARACTERISTICS

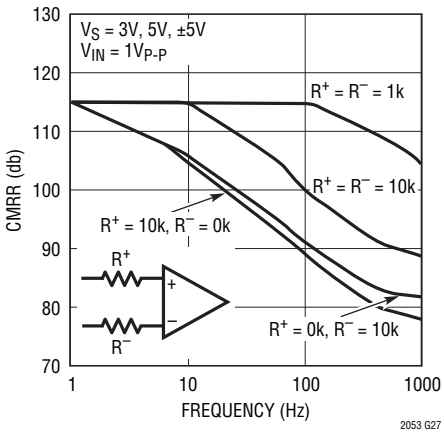
### Gain Nonlinearity, G = 1



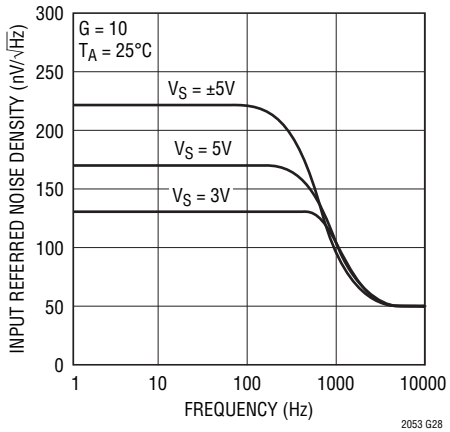

### Gain Nonlinearity, G = 10



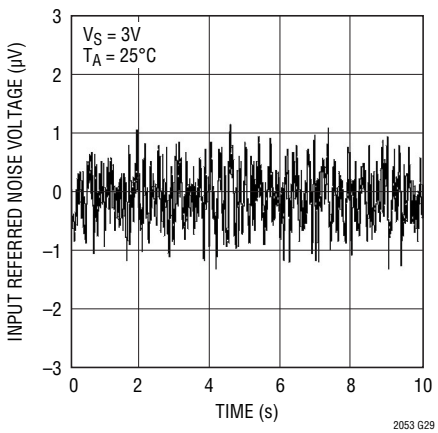

### CMRR vs Frequency



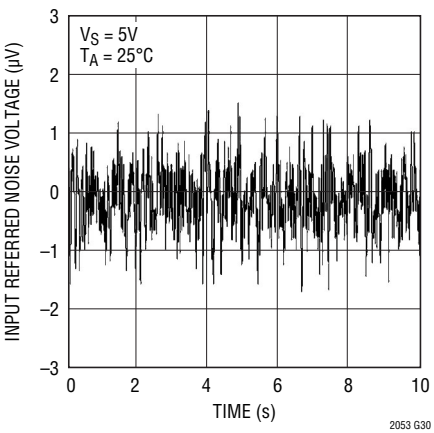

### Input Voltage Noise Density vs Frequency



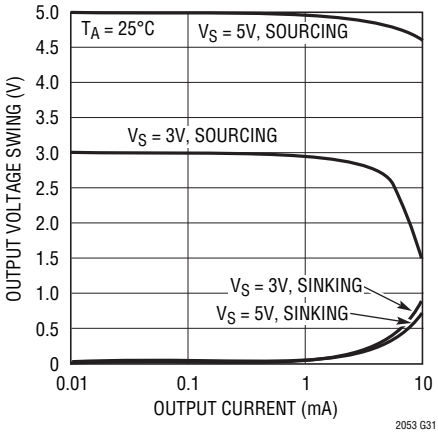

### Input Referred Noise in 10Hz Bandwidth



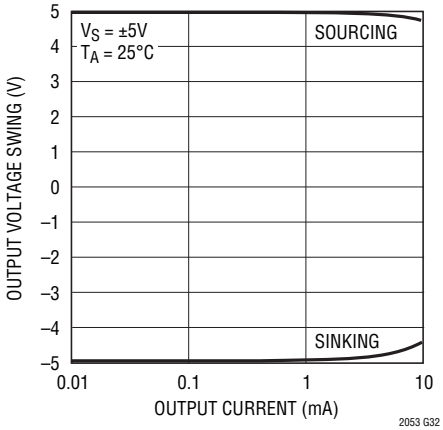

### Input Referred Noise in 10Hz Bandwidth




### Output Voltage Swing vs Output Current

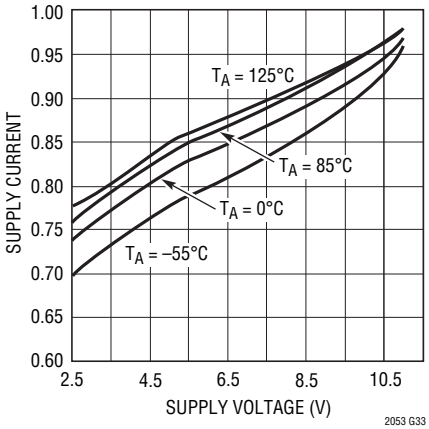



### Output Voltage Swing vs Output Current

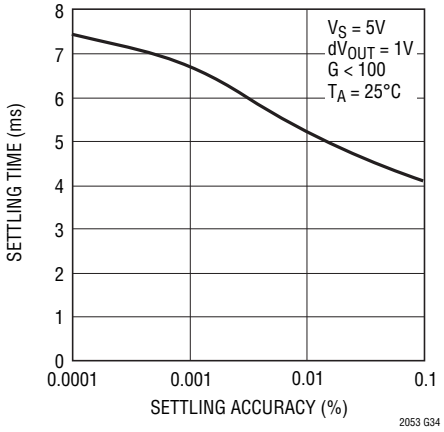


## TYPICAL PERFORMANCE CHARACTERISTICS

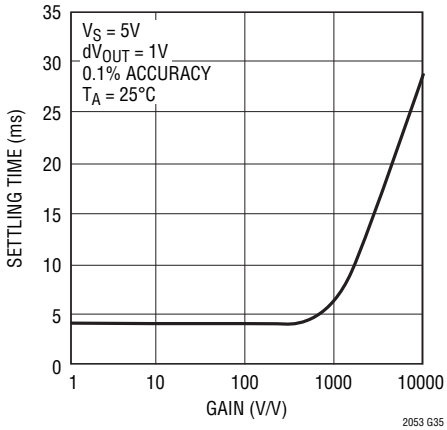
**Supply Current vs Supply Voltage**



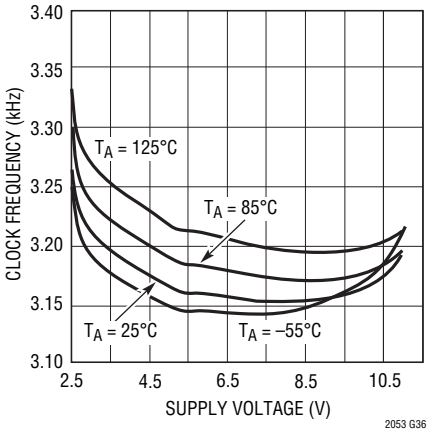

**Low Gain Settling Time vs Settling Accuracy**




**Settling Time vs Gain**




**Internal Clock Frequency vs Supply Voltage**




## PIN FUNCTIONS

**$\overline{EN}$ (Pin 1, LTC2053 Only):** Active Low Enable Pin.

**CLK (Pin 1, LTC2053-SYNC Only):** Clock input for Synchronizing to External System Clock.

**–IN (Pin 2):** Inverting Input.

**+IN (Pin 3):** Noninverting Input.

**$V^-$ (Pin 4):** Negative Supply.

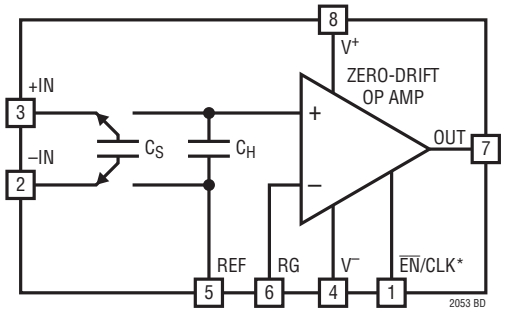
**REF (Pin 5):** Voltage Reference ($V_{REF}$) for Amplifier Output.

**RG (Pin 6):** Inverting Input of Internal Op Amp. See Figure 1.

**OUT (Pin 7):** Amplifier Output. See Figure 1.

**$V^+$ (Pin 8):** Positive Supply.

## BLOCK DIAGRAM




*NOTE: PIN 1 IS $\overline{EN}$ ON THE LTC2053 AND CLK ON THE LTC2053-SYNC

## APPLICATIONS INFORMATION

### Theory of Operation

The LTC2053 uses an internal capacitor ($C_S$) to sample a differential input signal riding on a DC common mode voltage (see the Block Diagram). This capacitor's charge is transferred to a second internal hold capacitor ($C_H$) translating the common mode of the input differential signal to that of the REF pin. The resulting signal is amplified by a zero-drift op amp in the noninverting configuration. The RG pin is the negative input of this op amp and allows external programmability of the DC gain. Simple filtering can be realized by using an external capacitor across the feedback resistor.

### Input Voltage Range

The input common mode voltage range of the LTC2053 is rail-to-rail. However, the following equation limits the size of the differential input voltage:

$$V^- \leq (V_{+IN} - V_{-IN}) + V_{REF} \leq V^+ - 1.3$$

Where $V_{+IN}$ and $V_{-IN}$ are the voltages of the +IN and –IN pins, respectively, $V_{REF}$ is the voltage at the REF pin and $V^+$ is the positive supply voltage.

For example, with a 3V single supply and a 0V to 100mV differential input voltage, $V_{REF}$ must be between 0V and 1.6V.

### ±5 Volt Operation

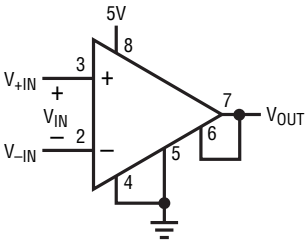
When using the LTC2053 with supplies over 5.5V, care must be taken to limit the maximum difference between any of the input pins (+IN or –IN) and the REF pin to 5.5V; if not, the device will be damaged. For example, if rail-to-rail input operation is desired when the supplies are at ±5V, the REF pin should be 0V, ±0.5V. As a second example, if $V^+$ is 10V and $V^-$ and REF are at 0V, the inputs should not exceed 5.5V.

### Settling Time

The sampling rate is 3kHz and the input sampling period during which $C_S$ is charged to the input differential voltage $V_{IN}$ is approximately 150µs. First assume that on each input sampling period, $C_S$ is charged fully to $V_{IN}$. Since $C_S = C_H$ (= 1000pF), a change in the input will settle to N bits of accuracy at the op amp noninverting input after N clock cycles or 333µs(N). The settling time at the OUT pin is also affected by the settling of the internal op amp. Since the gain bandwidth of the internal op amp is typically 200kHz, the settling time is dominated by the switched capacitor front end for gains below 100 (see the Typical Performance Characteristics section).

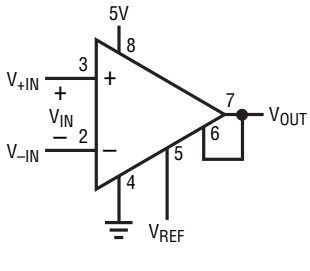
## APPLICATIONS INFORMATION

SINGLE SUPPLY, UNITY GAIN




$0V < V_{+IN} < 5V$
$0V < V_{–IN} < 5V$
$0V < V_{IN} < 3.7V$
$V_{OUT} = V_{IN}$

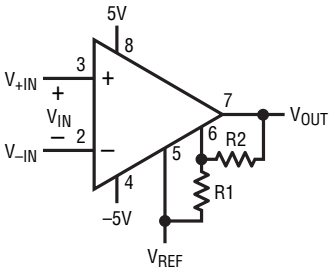
SINGLE SUPPLY, UNITY GAIN




$0V < V_{–IN} < 5V$ AND $|V_{–IN} – V_{REF}| < 5.5V$
$0V < V_{+IN} < 5V$ AND $|V_{+IN} – V_{REF}| < 5.5V$
$0V < V_{IN} + V_{REF} < 3.7V$

$V_{OUT} = V_{IN} + V_{REF}$

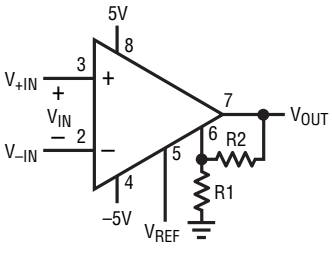
DUAL SUPPLY, NONUNITY GAIN




$–5V < V_{–IN} < 5V$ AND $|V_{–IN} – V_{REF}| < 5.5V$
$–5V < V_{+IN} < 5V$ AND $|V_{+IN} – V_{REF}| < 5.5V$
$–5V < V_{IN} + V_{REF} < 3.7V$

$$V_{OUT} = \left(1 + \frac{R2}{R1}\right) V_{IN} + V_{REF}$$

DUAL SUPPLY, NONUNITY GAIN




$–5V < V_{–IN} < 5V$ AND $|V_{–IN} – V_{REF}| < 5.5V$
$–5V < V_{+IN} < 5V$ AND $|V_{+IN} – V_{REF}| < 5.5V$
$–5V < V_{IN} + V_{REF} < 3.7V$

$$V_{OUT} = \left(1 + \frac{R2}{R1}\right) (V_{IN} + V_{REF})$$

2053 F01

**Figure 1**

### Input Current

Whenever the differential input $V_{IN}$ changes, $C_H$ must be charged up to the new input voltage via $C_S$. This results in an input charging current during each input sampling period. Eventually, $C_H$ and $C_S$ will reach $V_{IN}$ and, ideally, the input current would go to zero for DC inputs.

In reality, there are additional parasitic capacitors which disturb the charge on $C_S$ every cycle even if $V_{IN}$ is a DC voltage. For example, the parasitic bottom plate capacitor on $C_S$ must be charged from the voltage on the REF pin to the voltage on the –IN pin every cycle. The resulting input charging current decays exponentially during each input sampling period with a time constant equal to $R_SC_S$. **If the voltage disturbance due to these currents settles before the end of the sampling period, there will be no errors due to source resistance or the source resistance mismatch between –IN and +IN. With $R_S$ less than 10k, no DC errors occur due to this input current.**

In the Typical Performance Characteristics section of this data sheet, there are curves showing the additional error from non-zero source resistance in the inputs. If there are no large capacitors across the inputs, the amplifier is less sensitive to source resistance and source resistance mismatch. When large capacitors are placed across the inputs, the input charging currents previously described result in larger DC errors, especially with source resistor mismatches.

### Power Supply Bypassing

The LTC2053 uses a sampled data technique and, therefore, contains some clocked digital circuitry. It is, therefore, sensitive to supply bypassing. For single or dual supply operation, a 0.1µF ceramic capacitor must be connected between Pin 8 ($V^+$) and Pin 4 ($V^–$) with leads as short as possible.

### Synchronizing to an External Clock (LTC2053-SYNC Only)

The LTC2053 has an internally generated sample clock that is typically 3kHz. **There is no need to provide the LTC2053 with a clock.** However, in some applications, it may be desirable for the user to control the sampling frequency more precisely to avoid undesirable aliasing. This can be done with the LTC2053-SYNC. This device uses Pin 1 as a clock input whereas the LTC2053 uses Pin 1 as an enable pin. If CLK (Pin 1) is left floating on the LTC2053-SYNC, the device will run on its internal oscillator, similar to the LTC2053. However, if not externally synchronizing to a system clock, it is recommended that the LTC2053 be used instead of the LTC2053-SYNC because the LTC2053-SYNC is sensitive to parasitic capacitance on the CLK pin when left floating. **Clocking the LTC2053-SYNC is accomplished by driving the CLK pin at 8 times the desired sample clock frequency. This completely disables the internal clock. For example, to achieve the nominal LTC2053 sample clock rate of 3kHz, a 24kHz external clock should be applied to the CLK pin of the**

## APPLICATIONS INFORMATION

**LTC2053-SYNC.** If a square wave is used to drive the CLK pin, a 5µs RC time constant should be placed in front of the CLK pin to maintain low offset voltage performance (see Figure 2). This avoids internal and external coupling of the high frequency components of the external clock at the instant the LTC2053-SYNC holds the sampled input.

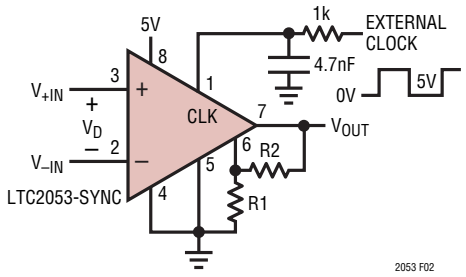



**Figure 2. Driving the CLK Input of the LTC2053-SYNC**

The LTC2053-SYNC is tested with a sample clock of 3kHz ($f_{CLK}$ = 24kHz) to the same specifications as the LTC2053. In addition, the LTC2053-SYNC is tested at one-half and 2x this frequency to verify proper operation. The curves in the Typical Performance Characteristics section of this data sheet apply to the LTC2053-SYNC when driving it with a 24kHz clock at Pin 1 ($f_{CLK}$ = 24kHz, 3kHz sample clock rate). Below are three curves that show the behavior of the LTC2053-SYNC as the clock frequency is varied. The offset is essentially unaffected over a 2:1 increase or decrease of the typical LTC2053 sample clock speed. The bias current is directly proportional to the clock speed. The noise is roughly proportional to the square root of the clock frequency. **For optimum noise and bias current performance, drive the LTC2053-SYNC with a nominal 24kHz external clock (3kHz sample clock).**

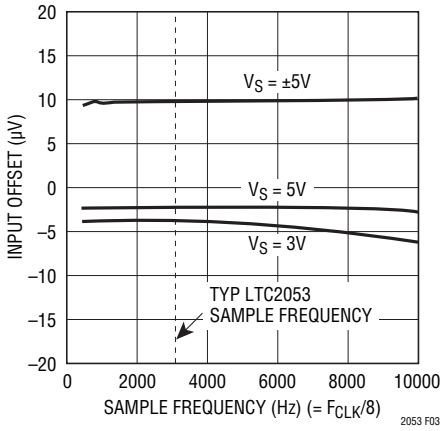



**Figure 3. LTC2053-SYNC Input Offset vs Sample Frequency**

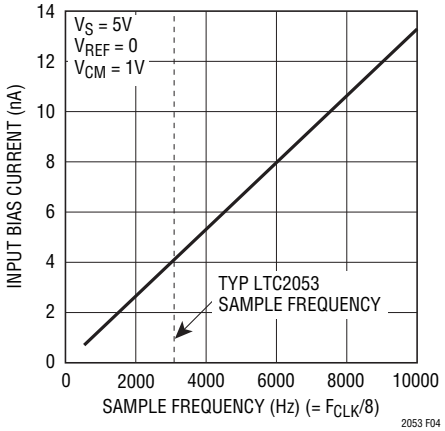



**Figure 4. LTC2053-SYNC Average Input Bias Current vs Sample Frequency**

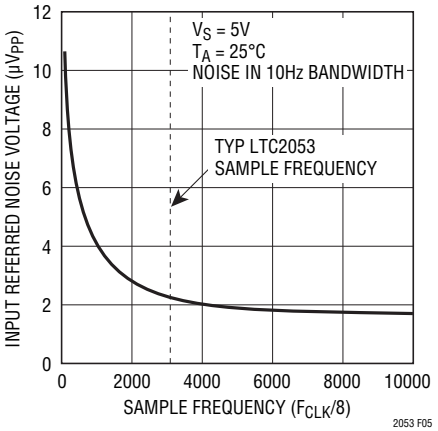
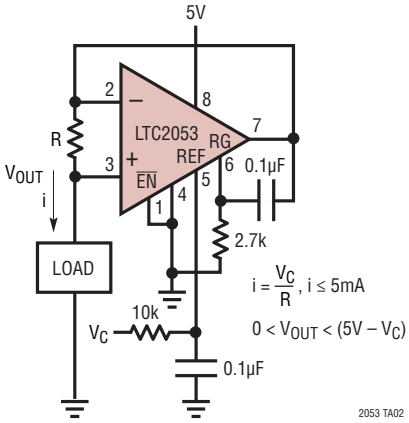


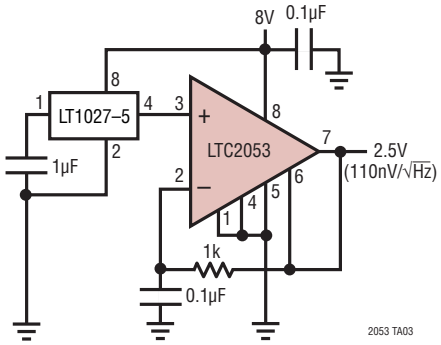

**Figure 5. LTC2053-SYNC Input Referred Noise vs Sample Frequency**

# TYPICAL APPLICATIONS

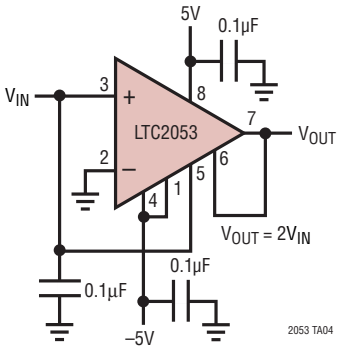
### Precision Current Source



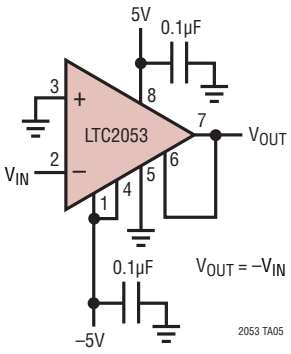

### Precision ÷2 (Low Noise 2.5V Reference)




### Precision Doubler (General Purpose)

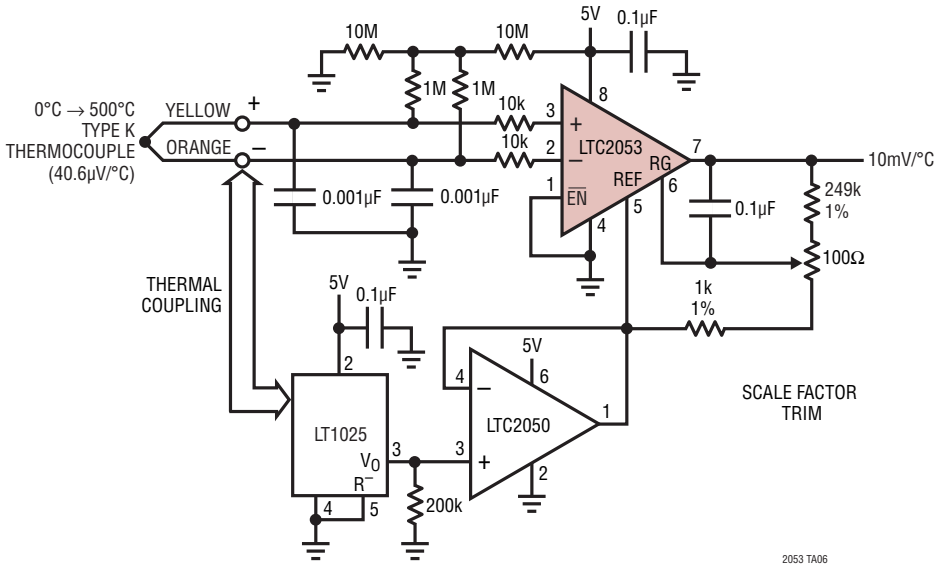



### Precision Inversion (General Purpose)

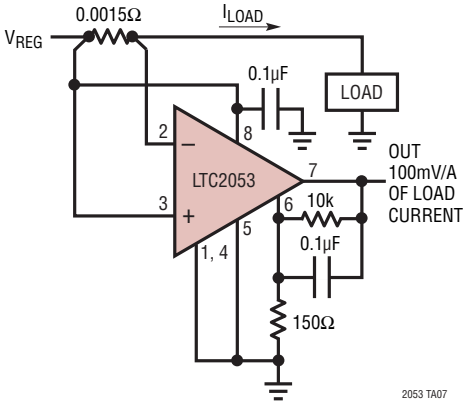


# TYPICAL APPLICATIONS

### Differential Thermocouple Amplifier



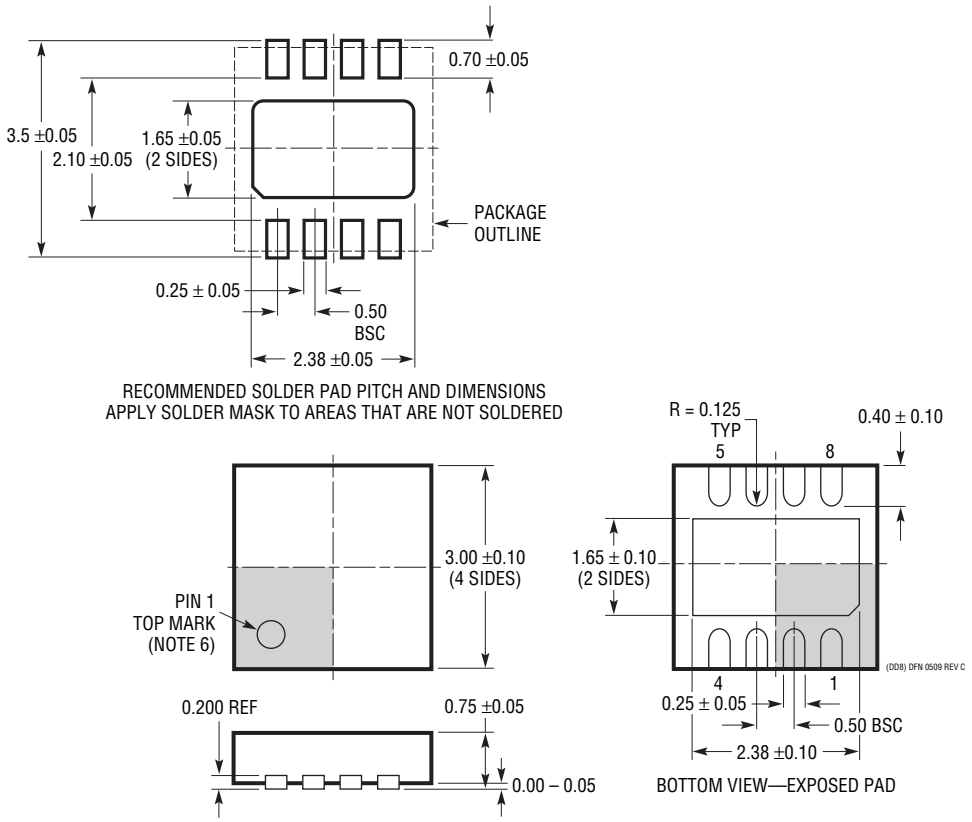

### High Side Power Supply Current Sense



# PACKAGE DESCRIPTION

**Please refer to http://www.linear.com/product/LTC2053#packaging for the most recent package drawings.**

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

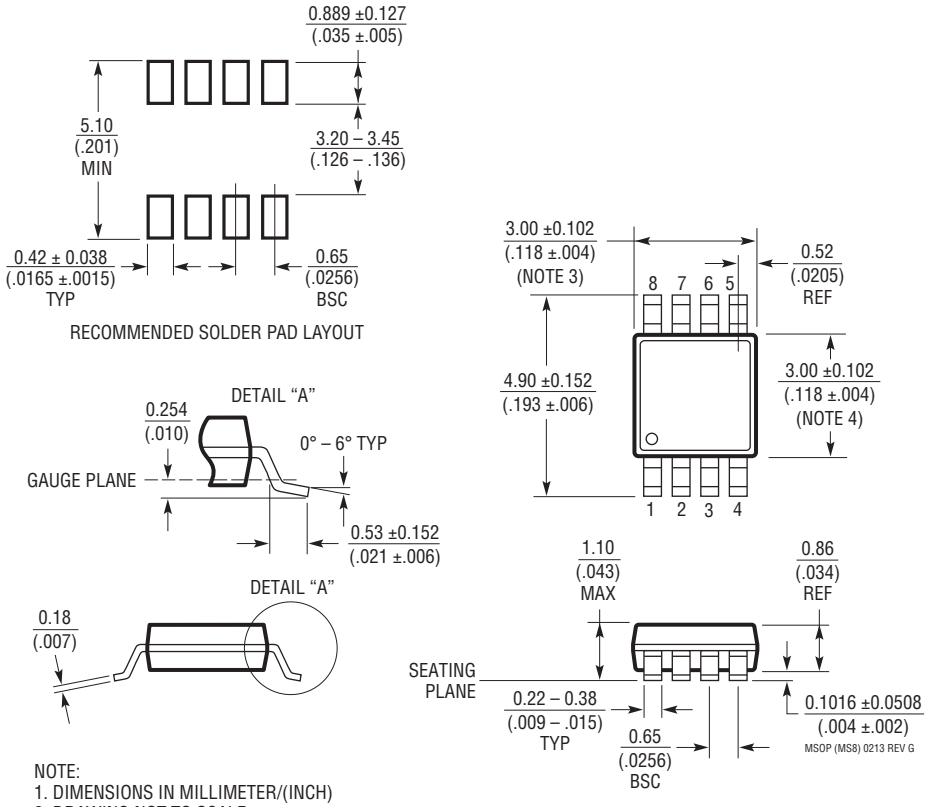



NOTE:
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE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

# PACKAGE DESCRIPTION

**Please refer to http://www.linear.com/product/LTC2053#packaging for the most recent package drawings.**

**MS8 Package**
**8-Lead Plastic MSOP**
(Reference LTC DWG # 05-08-1660 Rev G)




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

## REVISION HISTORY (Revision history begins at Rev C)

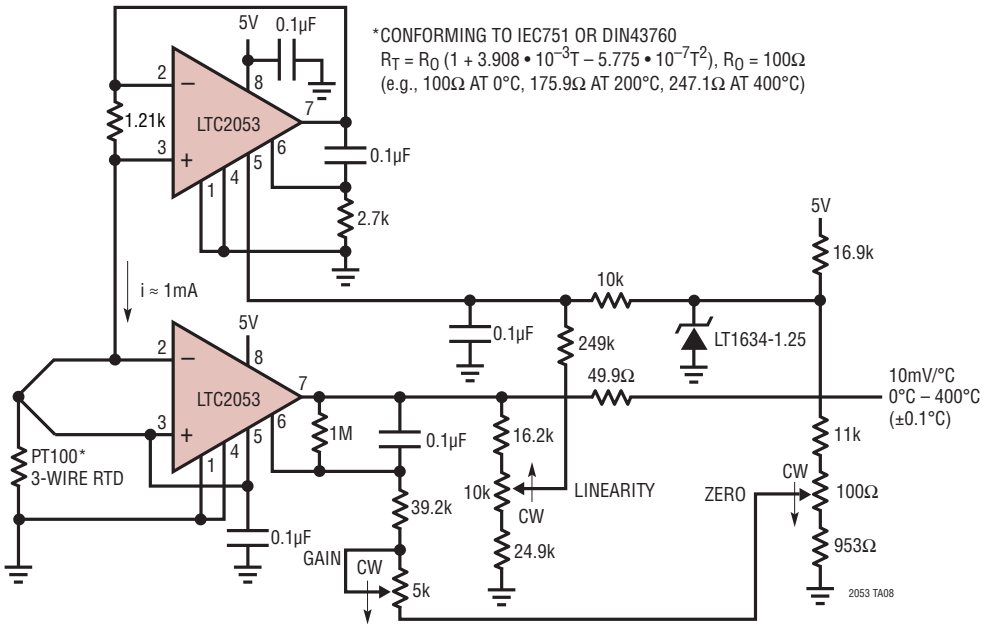
| REV | DATE | DESCRIPTION | PAGE NUMBER |
|---|---|---|---|
| C | 7/10 | Corrected text in the Absolute Maximum Ratings section | 2 |
| | | Updated Pin 6 and Pin 7 text in the Pin Functions section | 9 |
| | | Replaced Figure 1 | 11 |
| D | 12/15 | Corrected title for Figure 2 | 12 |



Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

## TYPICAL APPLICATION

**Linearized Platinum RTD Amplifier**




## RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| LT®1167 | Single Resistor Gain-Programmable, Precision Instrumentation Amplifier | Single-Gain Set Resistor: G = 1 to 10,000, Low Noise: 7.5nV√Hz |
| LTC2050/LTC2051 | Zero-Drift Single/Dual Operation Amplifier | SOT-23 and MS8 Packages |
| LTC2054/LTC2055 | Zero-Drift µPower Operational Amplifier | SOT-23 and MS8 Packages, 150µA/Op Amp |
| LTC6800 | Single-Supply, Zero-Drift, Rail-to-Rail Input and Output Instrumentation Amplifier | MS8 Package, 100µV Max $V_{OS}$, 250nV/°C Max Drift |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