ABSOLUTE MAXIMUM RATINGS

(Note 1)

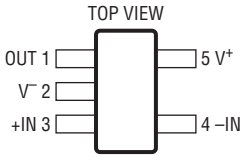
Total Supply Voltage (V^+ to V^-)
- LTC2050 ..... 7V
- LTC2050HV 12V

Input Voltage ..... (V^+ + 0.3V) to (V^- – 0.3V)
Output Short-Circuit Duration ..... Indefinite

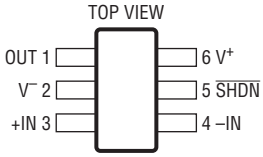
Operating Temperature Range
- LTC2050 ..... –40°C to 125°C
- LTC2050HVMP ..... –55°C to 150°C

Specified Temperature Range (Note 3) ..... –55°C to 150°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

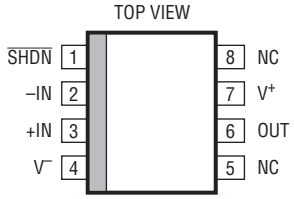
PIN CONFIGURATION



S5 PACKAGE
5-LEAD PLASTIC TSOT-23
T_{JMAX} = 150°C, θ_{JA} = 250°C/W



S6 PACKAGE
6-LEAD PLASTIC TSOT-23



S8 PACKAGE
8-LEAD PLASTIC SO

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE
LTC2050CS5#PBF	LTC2050CS5#TRPBF	LTAEG	5-Lead Plastic TSOT-23	0°C to 70°C
LTC2050IS5#PBF	LTC2050IS5#TRPBF	LTAEG	5-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HS5#PBF	LTC2050HS5#TRPBF	LTAEG	5-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050HVCS5#PBF	LTC2050HVCS5#TRPBF	LTAEH	5-Lead Plastic TSOT-23	0°C to 70°C
LTC2050HVIS5#PBF	LTC2050HVIS5#TRPBF	LTAEH	5-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HVHS5#PBF	LTC2050HVHS5#TRPBF	LTAEH	5-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050CS6#PBF	LTC2050CS6#TRPBF	LTAEJ	6-Lead Plastic TSOT-23	0°C to 70°C
LTC2050IS6#PBF	LTC2050IS6#TRPBF	LTAEJ	6-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HS6#PBF	LTC2050HS6#TRPBF	LTAEJ	6-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050HVMPS6#PBF	LTC2050HVMPS6#TRPBF	LTHGP	6-Lead Plastic TSOT-23	–55°C to 150°C
LTC2050HVCS6#PBF	LTC2050HVCS6#TRPBF	LTAEK	6-Lead Plastic TSOT-23	0°C to 70°C
LTC2050HVIS6#PBF	LTC2050HVIS6#TRPBF	LTAEK	6-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HVHS6#PBF	LTC2050HVHS6#TRPBF	LTAEK	6-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050CS8#PBF	LTC2050CS8#TRPBF	2050	8-Lead Plastic SO	0°C to 70°C
LTC2050IS8#PBF	LTC2050IS8#TRPBF	2050I	8-Lead Plastic SO	–40°C to 85°C
LTC2050HVCS8#PBF	LTC2050HVCS8#TRPBF	2050HV	8-Lead Plastic SO	0°C to 70°C

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE
LTC2050HVIS8#PBF	LTC2050HVIS8#TRPBF	050HVI	8-Lead Plastic SO	–40°C to 85°C
LTC2050CS5	LTC2050CS5#TR	LTAEG	5-Lead Plastic TSOT-23	0°C to 70°C
LTC2050IS5	LTC2050IS5#TR	LTAEG	5-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HS5	LTC2050HS5#TR	LTAEG	5-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050HVCS5	LTC2050HVCS5#TR	LTAEH	5-Lead Plastic TSOT-23	0°C to 70°C
LTC2050HVIS5	LTC2050HVIS5#TR	LTAEH	5-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HVHS5	LTC2050HVHS5#TR	LTAEH	5-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050CS6	LTC2050CS6#TR	LTAEJ	6-Lead Plastic TSOT-23	0°C to 70°C
LTC2050IS6	LTC2050IS6#TR	LTAEJ	6-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HS6	LTC2050HS6#TR	LTAEJ	6-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050HVCS6	LTC2050HVCS6#TR	LTAEK	6-Lead Plastic TSOT-23	0°C to 70°C
LTC2050HVIS6	LTC2050HVIS6#TR	LTAEK	6-Lead Plastic TSOT-23	–40°C to 85°C
LTC2050HVHS6	LTC2050HVHS6#TR	LTAEK	6-Lead Plastic TSOT-23	–40°C to 125°C
LTC2050CS8	LTC2050CS8#TR	2050	8-Lead Plastic SO	0°C to 70°C
LTC2050IS8	LTC2050IS8#TR	2050I	8-Lead Plastic SO	–40°C to 85°C
LTC2050HVCS8	LTC2050HVCS8#TR	2050HV	8-Lead Plastic SO	0°C to 70°C
LTC2050HVIS8	LTC2050HVIS8#TR	050HVI	8-Lead Plastic SO	–40°C to 85°C

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

Tape and reel specifications. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

ELECTRICAL CHARACTERISTICS

(LTC2050/LTC2050HV) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 3V unless otherwise noted. (Note 3)

PARAMETER	CONDITIONS		C, I SUFFIXES MIN	C, I SUFFIXES TYP	C, I SUFFIXES MAX	H SUFFIX MIN	H SUFFIX TYP	H SUFFIX MAX	UNITS
Input Offset Voltage	(Note 2)			±0.5	±3		±0.5	±3	µV
Average Input Offset Drift	(Note 2)	●			±0.03			±0.05	µV/°C
Long-Term Offset Drift				50			50		nV/√mo
Input Bias Current	LTC2050	 ●		±20	±75 ±300		±20	±75 ±4000	pA pA
	LTC2050HV	 ●		±1	±50 ±100		±1	±50 ±4000	pA pA
Input Offset Current	LTC2050	 ●			±150 ±200			±150 ±1000	pA pA
	LTC2050HV	 ●			±100 ±150			±100 ±1000	pA pA
Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.5			1.5		$µV_{P-P}$
Input Capacitance				1.7			1.7		pF
Common Mode Rejection Ratio	LTC2050/LTC2050HV V_{CM} = GND to (V^+ – 1.3) V_{CM} = GND to (V^+ – 1.3)	 ●	 115 110	 130 130	 	 115 110	 130 130	 	 dB dB
Power Supply Rejection Ratio	V_S = 2.7V to 6V	 ●	120 115	130 130		120 115	130 130		dB dB
Large-Signal Voltage Gain	R_L = 10k	 ●	120 115	140 140		120 115	140 140		dB dB
Output Voltage Swing High	R_L = 2k to GND R_L = 10k to GND	● ●	2.85 2.95	2.94 2.98		2.85 2.95	2.94 2.98		V V
Output Voltage Swing Low	R_L = 2k to GND R_L = 10k to GND	● ●		1 1	10 10		1 1	10 10	mV mV
Slew Rate				2			2		V/µs
Gain Bandwidth Product				3			3		MHz
Supply Current	$V_{\overline{SHDN}}$ = V_{IH}, No Load $V_{\overline{SHDN}}$ = V_{IL}	● ●		0.75	1.1 10		0.75	1.2 10	mA µA
Shutdown Pin Input Low Voltage (V_{IL})		●			V^- + 0.5			V^- + 0.5	V
Shutdown Pin Input High Voltage (V_{IH})		●	V^+ – 0.5			V^+ – 0.5			V
Shutdown Pin Input Current	$V_{\overline{SHDN}}$ = GND	●		–0.5	–3		–0.5	–3	µA
Internal Sampling Frequency				7.5			7.5		kHz

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (LTC2050/LTC2050HV) V_S = 5V unless otherwise noted. (Note 3)

PARAMETER	CONDITIONS		C, I SUFFIXES MIN	C, I SUFFIXES TYP	C, I SUFFIXES MAX	H, MP SUFFIX MIN	H, MP SUFFIX TYP	H, MP SUFFIX MAX	UNITS
Input Offset Voltage	(Note 2)			±0.5	±3		±0.5	±3	µV
Average Input Offset Drift	(Note 2) LTC2050HVMP	● ●			±0.03			±0.05 ±0.10	µV/°C µV/°C
Long-Term Offset Drift				50			50		nV/√mo
Input Bias Current	LTC2050	 ●		±75	±150 ±300		±75	±150 ±4000	pA pA
	LTC2050HV	 ●		±7	±50 ±150		±7	±50 ±4000	pA pA
	LTC2050HVMP	 ●					±7	±50 ±8000	pA pA
Input Offset Current	LTC2050	 ●			±300 ±400			±300 ±1000	pA pA
	LTC2050HV	 ●			±100 ±200			±100 ±1000	pA pA
	LTC2050HVMP	●						±2000	pA
Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.5			1.5		μV_{P-P}
Common Mode Rejection Ratio	LTC2050/LTC2050HV V_{CM} = GND to (V^+ – 1.3) V_{CM} = GND to (V^+ – 1.3)	 ●	 120 115	 130 130	 	 120 110	 130 130	 	 dB dB
	LTC2050HVMP V_{CM} = GND to (V^+ – 1.3)	 ●				 107	 130	 	 dB
Power Supply Rejection Ratio	V_S = 2.7V to 6V	 ●	120 115	130 130		120 115	130 130		dB dB
	LTC2050HVMP V_S = 4.5V to 11V	 ●				117 112	130 130		dB dB
Large-Signal Voltage Gain	R_L = 10k	 ●	125 120	140 140		125 115	140 140		dB dB
Output Voltage Swing High	R_L = 2k to GND R_L = 10k to GND	● ●	4.85 4.95	4.94 4.98		4.85 4.95	4.94 4.98		V V
Output Voltage Swing Low	R_L = 2k to GND R_L = 10k to GND	● ●		1 1	10 10		1 1	10 10	mV mV
Slew Rate				2			2		V/µs
Gain Bandwidth Product				3			3		MHz
Supply Current	$V_{\overline{SHDN}}$ = V_{IH}, No Load $V_{\overline{SHDN}}$ = V_{IL}	● ●		0.8	1.2 15		0.8	1.3 15	mA µA
Shutdown Pin Input Low Voltage (V_{IL})		●			V^- + 0.5			V^- + 0.5	V
Shutdown Pin Input High Voltage (V_{IH})		●	V^+ – 0.5			V^+ – 0.5			V
Shutdown Pin Input Current	$V_{\overline{SHDN}}$ = GND	●		–0.5	–7		–0.5	–7	µA
Internal Sampling Frequency				7.5			7.5		kHz

ELECTRICAL CHARACTERISTICS

(LTC2050HV) The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±5V unless otherwise noted. (Note 3)

PARAMETER	CONDITIONS		C, I SUFFIXES MIN	C, I SUFFIXES TYP	C, I SUFFIXES MAX	H, MP SUFFIX MIN	H, MP SUFFIX TYP	H, MP SUFFIX MAX	UNITS
Input Offset Voltage	(Note 2)			±0.5	±3		±0.5	±3	µV
Average Input Offset Drift	(Note 2) LTC2050HVMP	● ●			±0.03			±0.05 ±0.10	µV/°C µV/°C
Long-Term Offset Drift				50			50		nV/√mo
Input Bias Current (Note 4)	LTC2050HV	 ●		±25	±125 ±300		±25	±125 ±4000	pA pA
	LTC2050HVMP	 ●					±25	±125 ±8000	pA pA
Input Offset Current (Note 4)	LTC2050HV	 ●			±250 ±500			±250 ±1000	pA pA
	LTC2050HVMP	●						±2000	pA
Input Noise Voltage	R_S = 100Ω, 0.01Hz to 10Hz			1.5			1.5		$µV_{P-P}$
Common Mode Rejection Ratio	LTC2050HV V_{CM} = V^- to (V^+ – 1.3) V_{CM} = V^- to (V^+ – 1.3)	 ●	 120 115	 130 130		 120 115	 130 130		 dB dB
	LTC2050HVMP V_{CM} = V^- to (V^+ – 1.3)	 ●				 112	 130		 dB
Power Supply Rejection Ratio	V_S = 2.7V to 11V	 ●	120 115	130 130		120 115	130 130		dB dB
	LTC2050HVMP V_S = 4.5 to 11V	 ●				117 112	130 130		dB dB
Large-Signal Voltage Gain	R_L = 10k	 ●	125 120	140 140		125 120	140 140		dB dB
Maximum Output Voltage Swing	R_L = 2k to GND R_L = 10k to GND	● ●	±4.75 ±4.90	±4.94 ±4.98		±4.50 ±4.85	±4.94 ±4.98		V V
Slew Rate				2			2		V/µs
Gain Bandwidth Product				3			3		MHz
Supply Current	$V_{\overline{SHDN}}$ = V_{IH}, No Load $V_{\overline{SHDN}}$ = V_{IL}	● ●		1	1.5 25		1	1.6 25	mA µA
Shutdown Pin Input Low Voltage (V_{IL})		●			V^- + 0.5			V^- + 0.5	V
Shutdown Pin Input High Voltage (V_{IH})		●	V^+ – 0.5			V^+ – 0.5			V
Shutdown Pin Input Current	$V_{\overline{SHDN}}$ = V^-	●		–3	–20		–3	–20	µA
Internal Sampling Frequency				7.5			7.5		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: These parameters are guaranteed by design. Thermocouple effects preclude measurements of these voltage levels during automated testing.

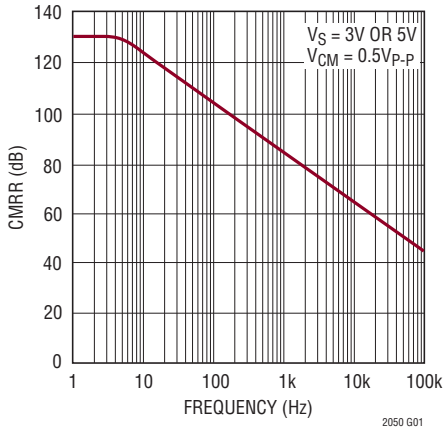
Note 3: All versions of the LTC2050 are designed, characterized and expected to meet the extended temperature limits of –40°C and 125°C.

The LTC2050C/LTC2050HVC are guaranteed to meet the temperature limits of 0°C and 70°C. The LTC2050I/LTC2050HVI are guaranteed to meet the temperature limits of –40°C and 85°C. The LTC2050H/LTC2050HVH are guaranteed to meet the temperature limits of –40°C and 125°C. The are guaranteed to meet the temperature limits of –55°C and 150°C.

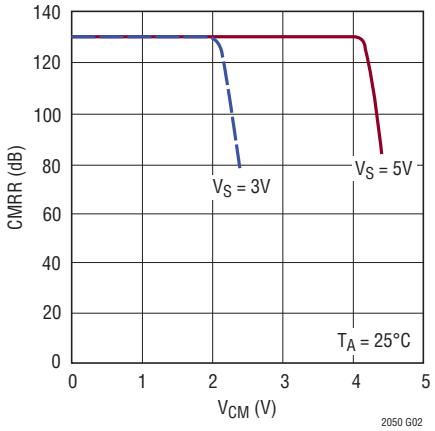
Note 4: The bias current measurement accuracy depends on the proximity of the supply bypass capacitor to the device under test, especially at ±5V supplies. Because of testing limitations on the placement of this bypass capacitor, the bias current at ±5V supplies is guaranteed by design to meet the data sheet limits, but tested to relaxed limits.

TYPICAL PERFORMANCE CHARACTERISTICS

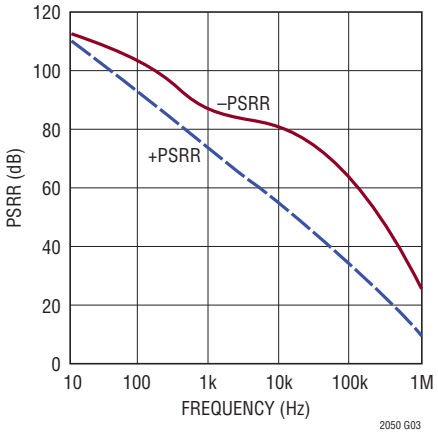
Common Mode Rejection Ratio vs Frequency



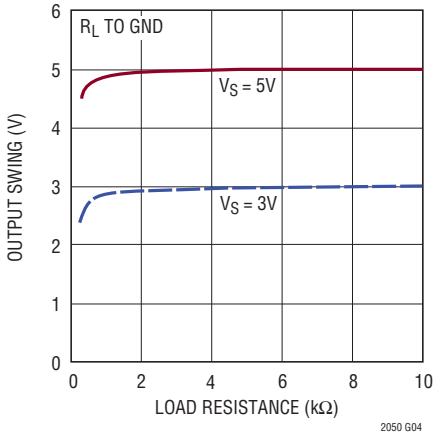
DC CMRR vs Common Mode Input Voltage



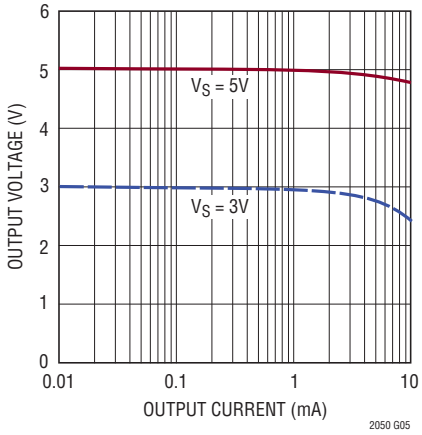
PSRR vs Frequency



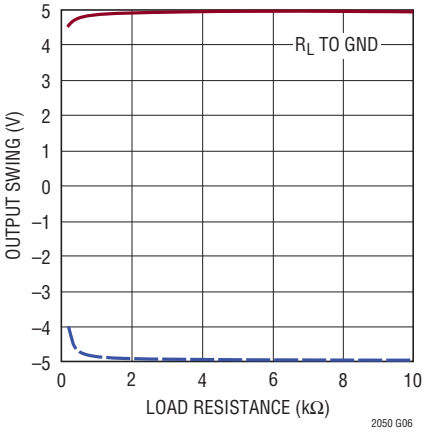
Output Voltage Swing vs Load Resistance



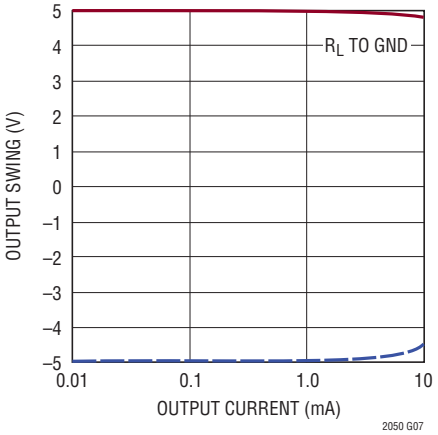
Output Swing vs Output Current



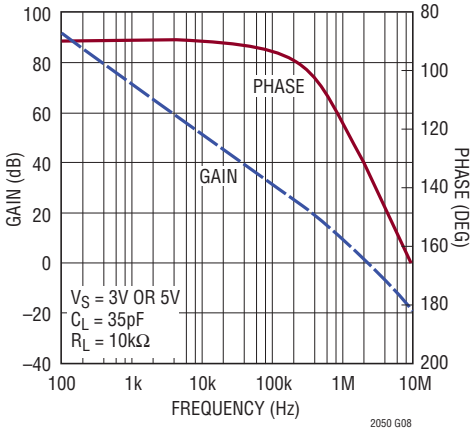
Output Swing vs Load Resistance ±5V Supply



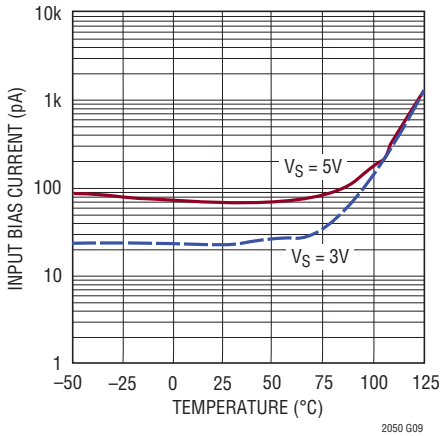
Output Swing vs Output Current ±5V Supply



Gain/Phase vs Frequency

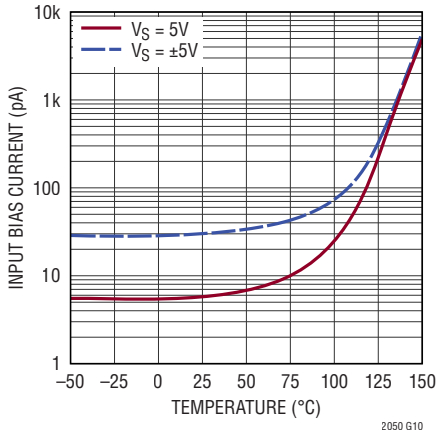


Input Bias Current vs Temperature (LTC2050)

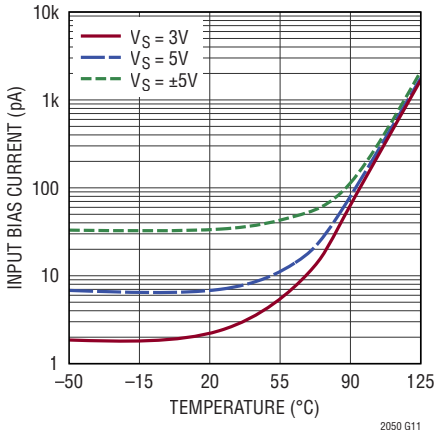


TYPICAL PERFORMANCE CHARACTERISTICS

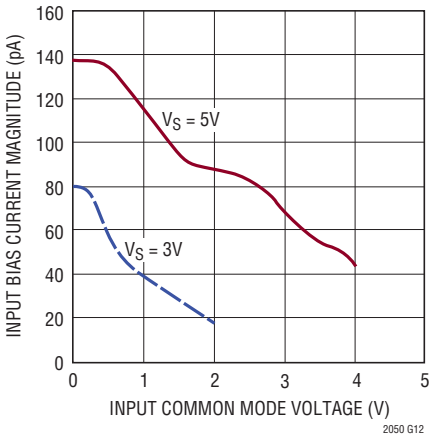
Input Bias Current vs Temperature (LTC2050HVMP)



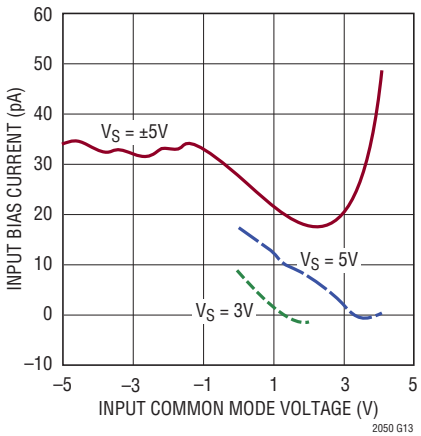
Input Bias Current vs Temperature (LTC2050HV)



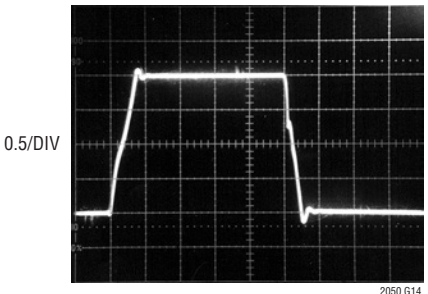
Input Bias Current vs Input Common Mode Voltage



Input Bias Current vs Input Common Mode Voltage (LTC2050HV)

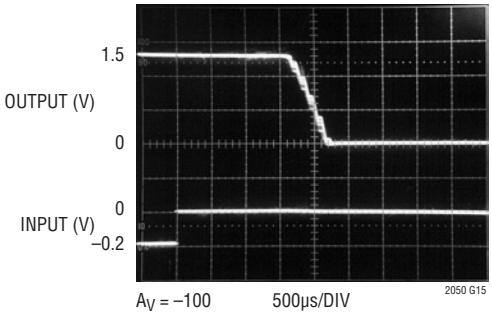


Transient Response



A_V = 1
R_L = 100k
C_L = 50pF
V_S = 5V
1µs/DIV

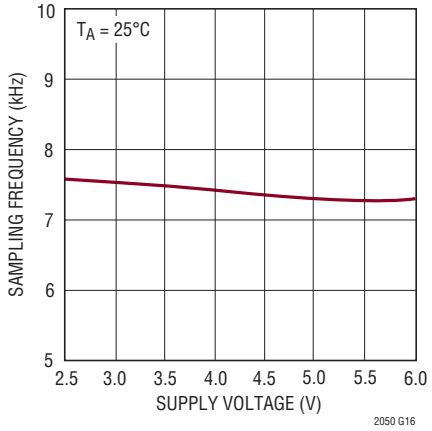
Input Overload Recovery



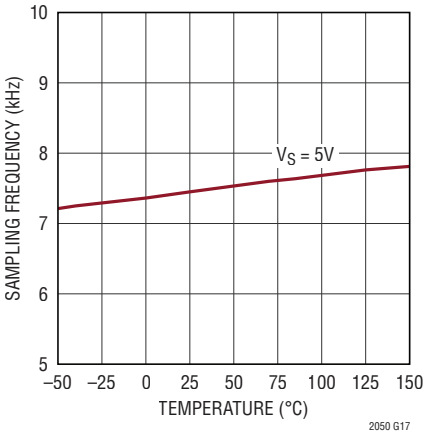
A_V = –100
R_L = 100k
C_L = 10pF
V_S = ±1.5V
500µs/DIV

TYPICAL PERFORMANCE CHARACTERISTICS

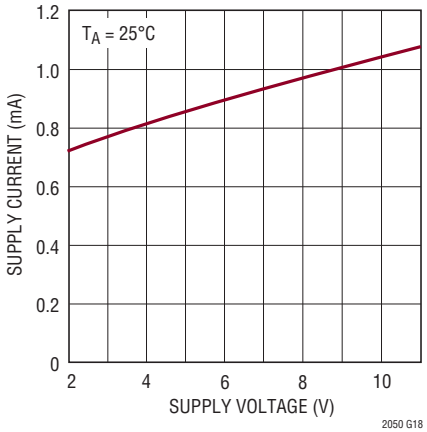
Sampling Frequency vs Supply Voltage



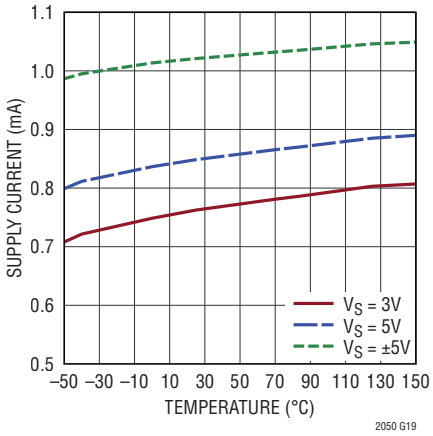
Sampling Frequency vs Temperature



Supply Current vs Supply Voltage

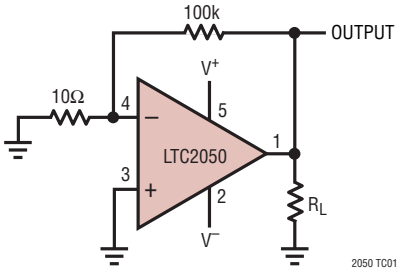


Supply Current vs Temperature

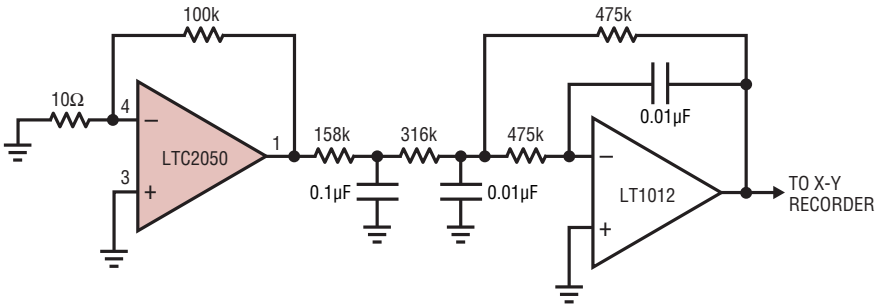


TEST CIRCUITS

Electrical Characteristics Test Circuit



DC–10Hz Noise Test Circuit



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

APPLICATIONS INFORMATION

Shutdown

The LTC2050 includes a shutdown pin in the 6-lead SOT-23 and the SO-8 version. When this active low pin is high or allowed to float, the device operates normally. When the shutdown pin is pulled low, the device enters shutdown mode; supply current drops to 3µA, all clocking stops, and both inputs and output assume a high impedance state.

Clock Feedthrough, Input Bias Current

The LTC2050 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 7.5kHz. 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 LTC2050.

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 LTC2050 has a residue clock feedthrough of less then $1\mu V_{RMS}$ input referred at 7.5kHz.

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 $1\mu V_{RMS}$ input referred at 7.5kHz, or 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.

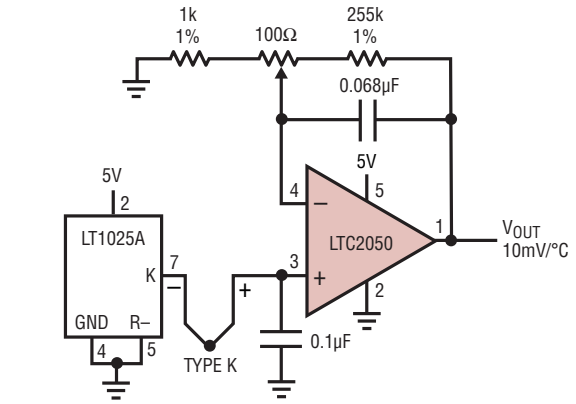
At temperatures above 70°C, the leakage of the ESD protection diodes on the inputs increases the input bias currents of both inputs in the positive direction, while the current caused by the charge injection stays relatively constant. At elevated temperatures (above 85°C) the leakage current begins to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

Input Pins, ESD Sensitivity

ESD voltages above 700V on the input pins of the op amp will cause the input bias currents to increase (more DC current into the pins). At these voltages, it is possible to damage the device to a point where the input bias current exceeds the maximums specified in this data sheet.

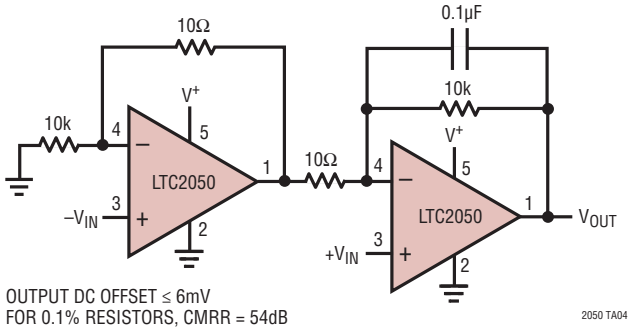
TYPICAL APPLICATIONS

Single Supply Thermocouple Amplifier



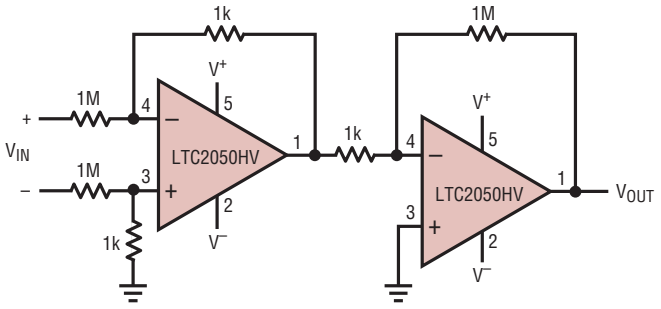
LT1025 COMPENSATES COLD JUNCTION
OVER 0°C TO 100°C TEMPERATURE RANGE

Gain of 1001 Single Supply Instrumentation Amplifier



OUTPUT DC OFFSET ≤ 6mV
FOR 0.1% RESISTORS, CMRR = 54dB

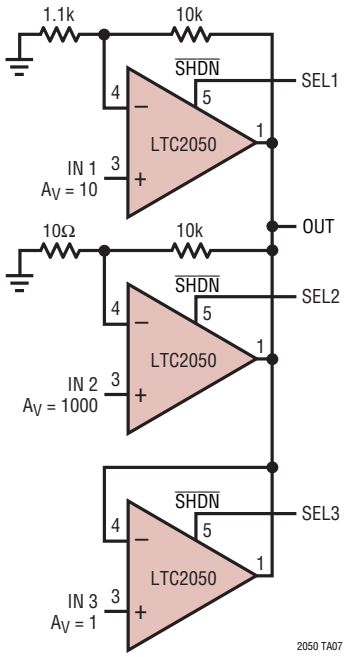
Instrumentation Amplifier with 100V Common Mode Input Voltage



OUTPUT OFFSET ≤3mV
FOR 0.1% RESISTORS, CMRR = 54dB

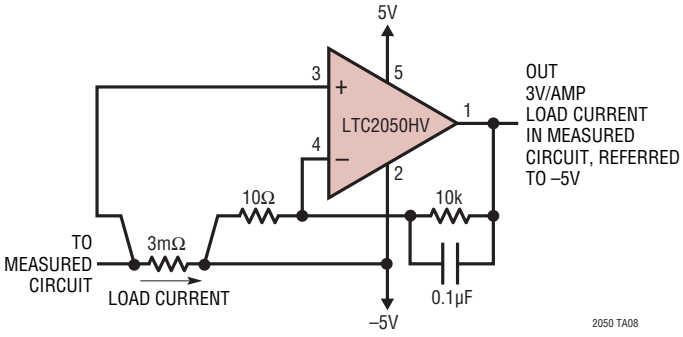
TYPICAL APPLICATIONS

High Precision 3-Input Mux



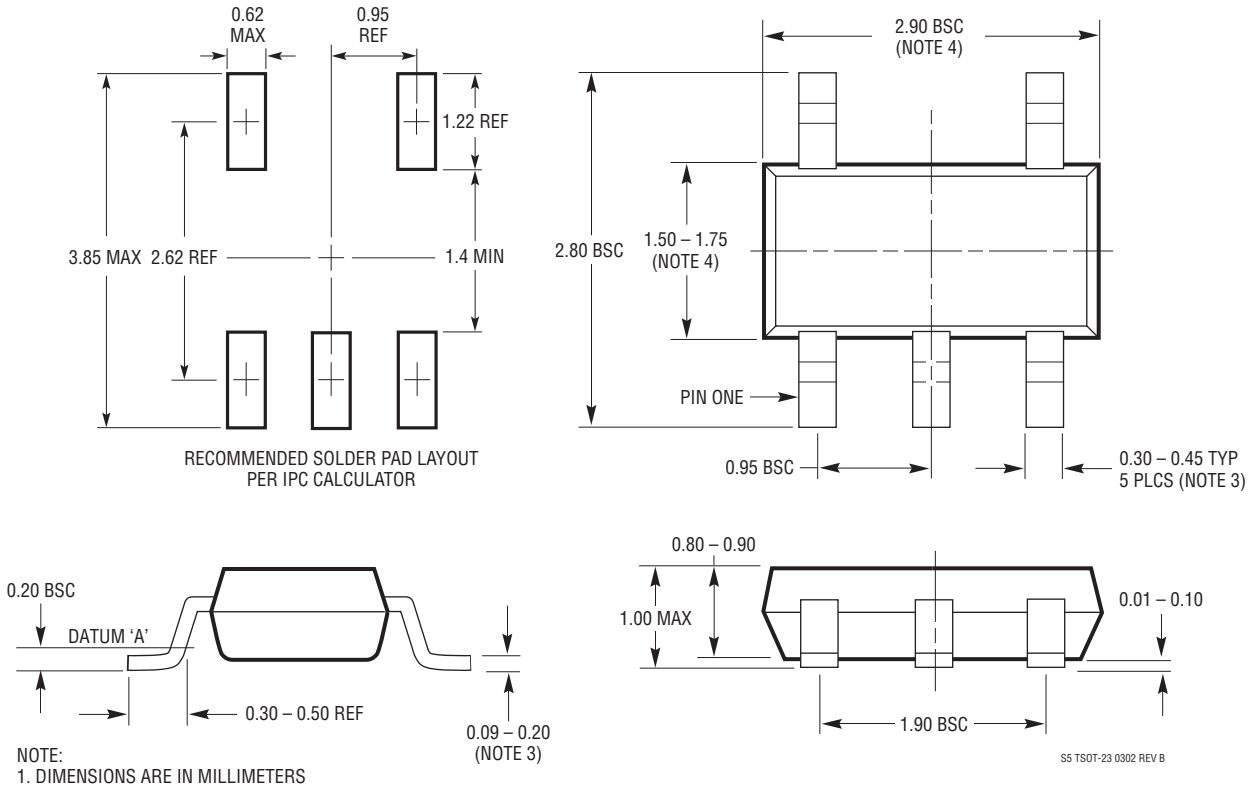
SELECT INPUTS ARE CMOS LOGIC COMPATIBLE

Low Side Power Supply Current Sensing



PACKAGE DESCRIPTION

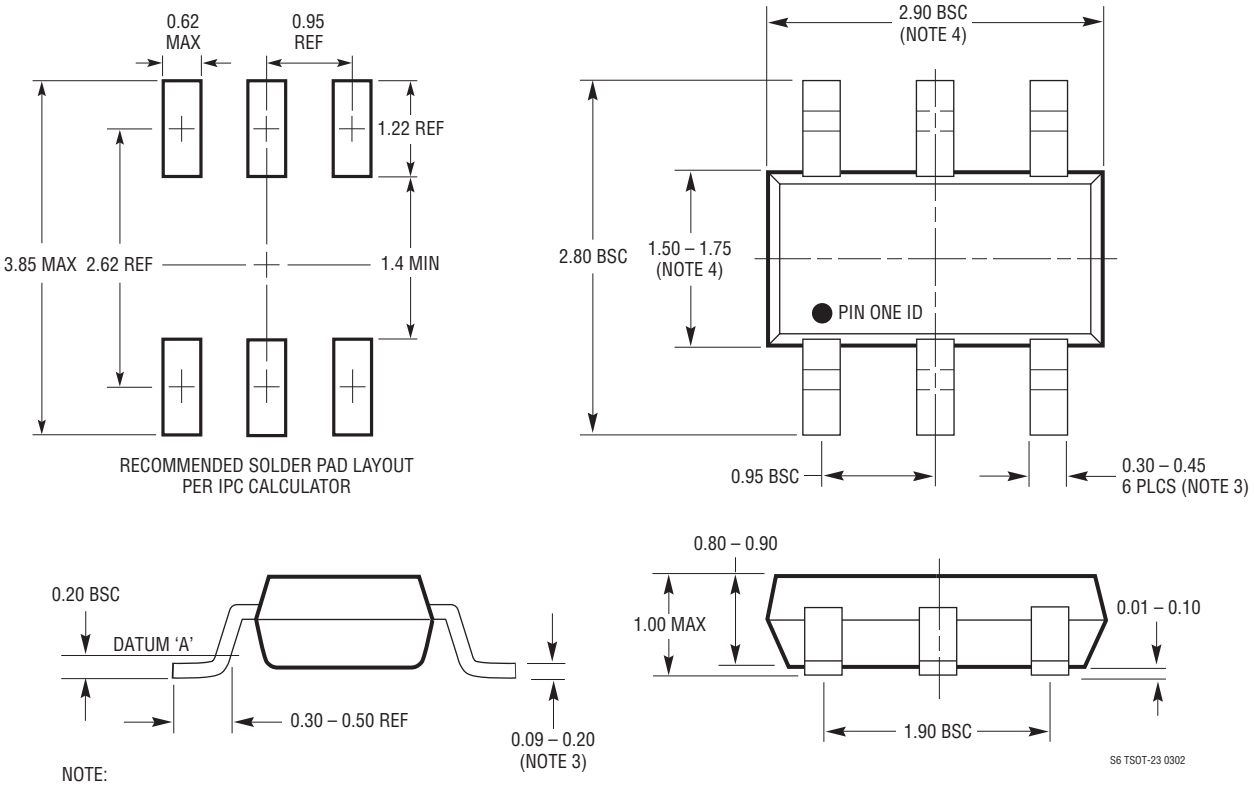
S5 Package
5-Lead Plastic TSOT-23
(Reference LTC DWG # 05-08-1635 Rev B)



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

PACKAGE DESCRIPTION

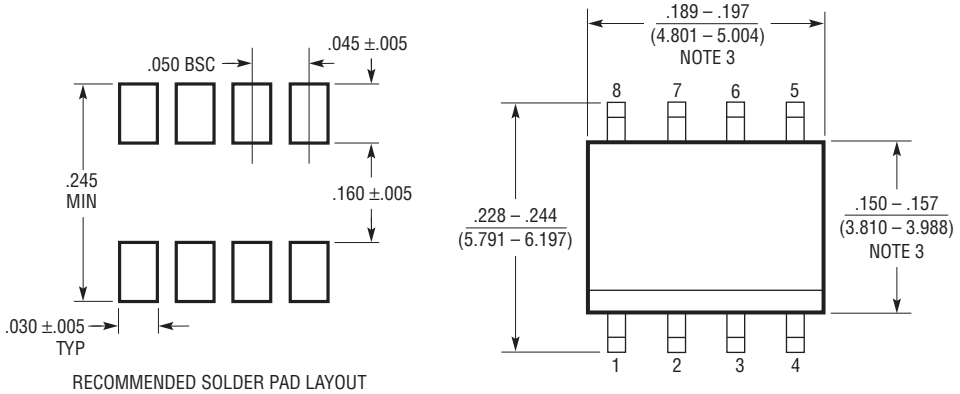
S6 Package
6-Lead Plastic TSOT-23
(Reference LTC DWG # 05-08-1636)



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

PACKAGE DESCRIPTION

S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610 Rev G)



NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{(\text{MILLIMETERS})}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)
4. PIN 1 CAN BE BEVEL EDGE OR A DIMPLE

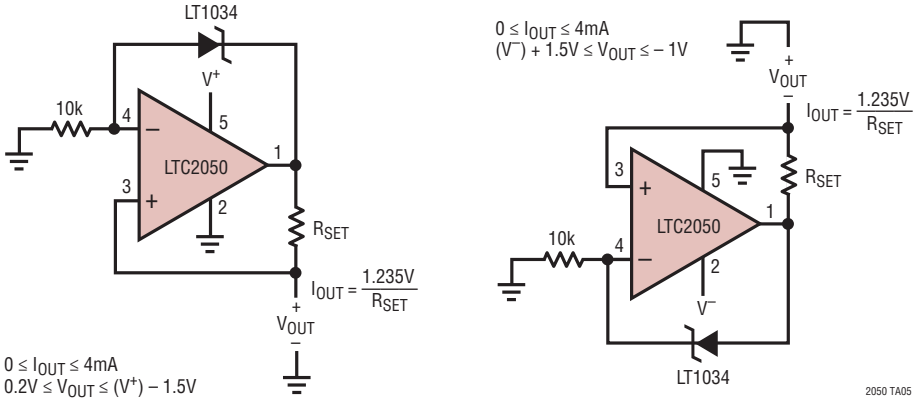
S08 REV G 0212

REVISION HISTORY (Revision history begins at Rev D)

REV	DATE	DESCRIPTION	PAGE NUMBER
D	08/17	Updated T_{JMAX}	2
E	11/18	Added MP option (higher temperature version)	1, 2, 4-6, 7-8

TYPICAL APPLICATION

Ground Referred Precision Current Sources



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
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
LT®1677	Low Noise Rail-to-Rail Input and Output 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
LTC2051	Dual Zero-Drift Op Amp	Dual Version of the LTC2050 in MS8 Package