±250V Input Range G = 1, 10, Micropower, Difference Amplifier

APPLICATIONS

- **Pin Selectable Gain of 1 or 10**
- **High Common Mode Voltage Range:**
  85V Window (V_S = 5V, 0V)
  ±250V (V_S = ±15V)
- **Common Mode Rejection Ratio: 70dB Min**
- Input Protection to ±350V
- Gain Error: 0.28% Max
- PSRR: 82dB Min
- High Input Impedance: 2MΩ Differential, 500kΩ Common Mode
- Micropower: 120µA Max Supply Current
- Wide Supply Range: 2.7V to 36V
- –3dB Bandwidth: 100kHz
- Rail-to-Rail Output
- 8-Pin SO Package

FEATURES

- Battery Cell Voltage Monitoring
- High Voltage Current Sensing
- Signal Acquisition in Noisy Environments
- Input Protection
- Fault Protected Front Ends
- Level Sensing
- Isolation

DESCRIPTION

The LT®1990 is a micropower precision difference amplifier with a very high common mode input voltage range. It has pin selectable gains of 1 or 10. The LT1990 operates over a ±250V common mode voltage range on a ±15V supply. The inputs are fault protected from common mode voltage transients up to ±350V and differential voltages up to ±500V. The LT1990 is ideally suited for both high side and low side current or voltage monitoring.

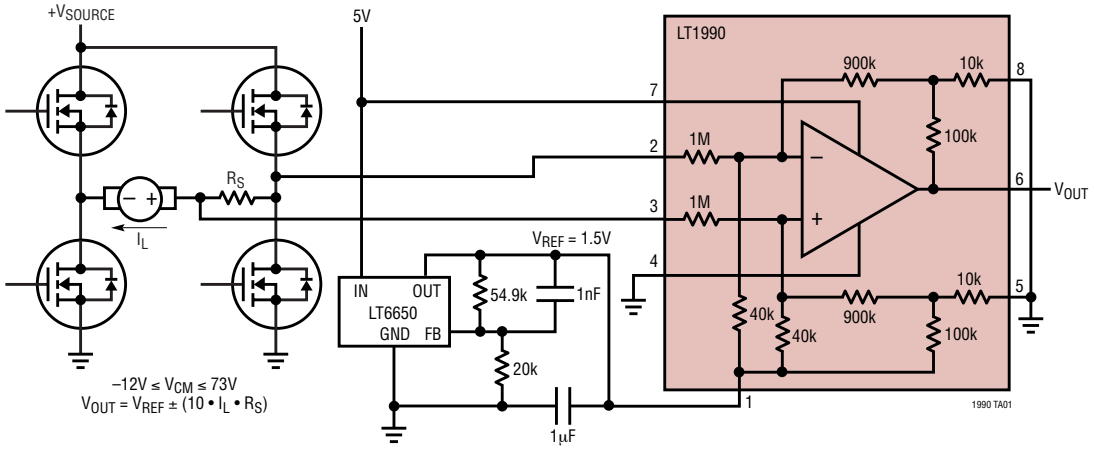
On a single 5V supply, the LT1990 has an adjustable 85V input range, 70dB min CMRR and draws less than 120µA supply current. The rail-to-rail output maximizes the dynamic range, especially important for single supplies as low as 2.7V.

The LT1990 is specified for single 3V, 5V and ±15V supplies over both commercial and industrial temperature ranges. The LT1990 is available in the 8-pin SO package.

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TYPICAL APPLICATION

Full-Bridge Load Current Monitor

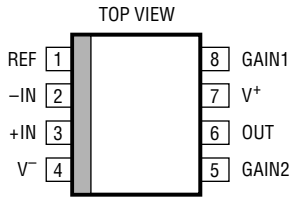


ABSOLUTE MAXIMUM RATINGS

(Notes 1, 2)

Total Supply Voltage (V^+ to V^-) 36V
Input Voltage Range
  Continuous ..... ±250V
  Transient (0.1s) ..... ±350V
  Differential ..... ±500V
Output Short-Circuit Duration (Note 3) ..... Indefinite
Operating Temperature Range (Note 4) ...–40°C to 85°C
Specified Temperature Range (Note 5) ....–40°C to 85°C
Storage Temperature Range .....–65°C to 150°C
Lead Temperature (Soldering, 10 sec.).....300°C

PACKAGE/ORDER INFORMATION



S8 PACKAGE
8-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 190°C/W

ORDER PART NUMBER
LT1990CS8 LT1990IS8 LT1990ACS8 LT1990AIS8
S8 PART MARKING
1990 1990A 1990I 1990AI

3V/5V ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, T_A = 25°C, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
G	Gain	Pins 5 and 8 = Open		1		
		Pins 5 and 8 = GND		10		
ΔG	Gain Error	V_{OUT} = 0.5V to (+Vs) –0.75V				
		LT1990, G = 1		0.4	0.6	%
		LT1990A, G = 1		0.07	0.28	%
		G = 10, V_S = 5V, 0V		0.2	0.8	%
GNL	Gain Nonlinearity	V_S = 5V, 0V; V_{OUT} = 0.5V to 4.25V				
		G = 1		0.001	0.005	%
		G = 10		0.01		%
V_{CM}	Input Voltage Range	Guaranteed by CMRR				
		V_S = 3V, 0V; V_{REF} = 1.25V	–5		25	V
		V_S = 5V, 0V; V_{REF} = 1.25V	–5		80	V
		V_S = 5V, 0V; V_{REF} = 2.5V	–38		47	V
CMRR	Common Mode Rejection Ratio RTI (Referred to Input)	V_S = 3V, 0V (Note 7) V_{CM} = –5V to 25V, V_{REF} = 1.25V				
		LT1990	60	68		dB
		LT1990A	70	75		dB
		V_S = 5V, 0V V_{CM} = –5V to 80V, V_{REF} = 1.25V				
		LT1990	60	68		dB
		LT1990A	70	75		dB
		V_S = 5V, 0V (Note 7) V_{CM} = –38V to 47V, V_{REF} = 2.5V				
		LT1990	60	68		dB
		LT1990A	70	75		dB
V_{OS}	Offset Voltage, RTI	G = 1, 10		0.8	3	mV
e_n	Input Noise Voltage, RTI	f_O = 0.1Hz to 10Hz		22		μV_{P-P}
	Noise Voltage Density, RTI	f_O = 1kHz		1		$\mu V/\sqrt{Hz}$

3V/5V ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, T_A = 25°C, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
R_{IN}	Input Resistance	Differential Common Mode		2 0.5		MΩ MΩ
PSRR	Power Supply Rejection Ratio, RTI	V_S = 2.7V to 12.7V, V_{CM} = V_{REF} = 1.25V	80	92		dB
	Minimum Supply Voltage	Guaranteed by PSRR		2.4	2.7	V
I_S	Supply Current	(Note 8)		105	120	µA
V_{OL}	Output Voltage Swing LOW	–IN = V^+, +IN = Half Supply (Note 8)		30	50	mV
V_{OH}	Output Voltage Swing HIGH	–IN = 0V, +IN = Half Supply V_S = 3V, 0V, Below V^+ V_S = 5V, 0V, Below V^+		 100 120	 150 175	 mV mV
I_{SC}	Output Short-Circuit Current	Short to GND (Note 9) Short to V^+ (Note 9)	4 13	8 20		mA mA
BW	Bandwidth (–3dB)	G = 1 G = 10		100 6.5		kHz kHz
SR	Slew Rate	G = 1, V_S = 5V, 0V, V_{OUT} = 0.5V to 4.5V		0.5		V/µs
	Settling Time to 0.01%	4V Step, G = 1, V_S = 5V, 0V		45		µs
AV_{REF}	Reference Gain to Output			1 ± 0.0007		

The ● denotes the specifications which apply over the temperature range of 0°C ≤ T_A ≤ 70°C. V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = 0.5V to (+V_S) – 0.75V LT1990, G = 1 LT1990A, G = 1 G = 10	 ● ● ●			 0.65 0.33 0.90	 % % %
G/T	Gain vs Temperature	G = 1 (Note 10) G = 10 (Note 10)	● ●		2 7	10 20	ppm/°C ppm/°C
V_{CM}	Input Voltage Range	Guaranteed by CMRR V_S = 3V, 0V, V_{REF} = 1.25V V_S = 5V, 0V, V_{REF} = 1.25V V_S = 5V, 0V, V_{REF} = 2.5V	 ● ● ●	 –5 –5 –37		 25 80 48	 V V V
CMRR	Common Mode Rejection Ratio, RTI	V_S = 3V, 0V (Note 7) V_{CM} = –5V to 25V, V_{REF} = 1.25V LT1990 LT1990A	 ● ●	 58 68		 	 dB dB
		V_S = 5V, 0V V_{CM} = –5V to 80V, V_{REF} = 1.25V LT1990 LT1990A	 ● ●	 58 68		 	 dB dB
		V_S = 5V, 0V (Note 7) V_{CM} = –38V to 47V, V_{REF} = 2.5V LT1990 LT1990A	 ● ●	 58 68		 	 dB dB
V_{OS}	Input Offset Voltage, RTI	V_S = 3V, 0V G = 1, 10	● ●			 4.1	 mV
		V_S = 5V, 0V G = 1, 10	● ●			 4.1	 mV

3V/5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of 0°C ≤ T_A ≤ 70°C. V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}/T	Input Offset Voltage Drift, RTI	(Note 10)	●		5	22	µV/°C
V_{OSH}	Input Offset Voltage Hysteresis, RTI	(Note 11)	●		230		µV
PSRR	Power Supply Rejection Ratio, RTI	V_S = 2.7V to 12.7V V_{CM} = V_{REF} = 1.25V G = 1, 10	●	78			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●			2.7	V
I_S	Supply Current	(Note 8)	●			150	µA
V_{OL}	Output Voltage Swing LOW	–IN = V^+, +IN = Half Supply (Note 8)	●			60	mV
V_{OH}	Output Voltage Swing HIGH	–IN = 0V, +IN = Half Supply V_S = 3V, 0V, Below V^+ V_S = 5V, 0V, Below V^+	 ● ●			 180 205	 mV mV
I_{SC}	Output Short-Circuit Current	Short to GND (Note 9) Short to V^+ (Note 9)	● ●	3 11			mA mA

The ● denotes the specifications which apply over the temperature range of –40°C ≤ T_A ≤ 85°C. V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = 0.5V to (+V_S) – 0.75V LT1990, G = 1 LT1990A, G = 1 G = 10	 ● ● ●			 0.67 0.35 0.95	 % % %
G/T	Gain vs Temperature	G = 1 (Note 10) G = 10 (Note 10)	● ●		2 7	10 20	ppm/°C ppm/°C
V_{CM}	Input Voltage Range	Guaranteed by CMRR V_S = 3V, 0V, V_{REF} = 1.25V V_S = 5V, 0V, V_{REF} = 1.25V V_S = 5V, 0V, V_{REF} = 2.5V	 ● ● ●	 –5 –5 –37		 25 80 48	 V V V
CMRR	Common Mode Rejection Ratio, RTI	V_S = 3V, 0V (Note 7) V_{CM} = –5V to 25V, V_{REF} = 1.25V LT1990 LT1990A	 ● ●	 57 67		 	 dB dB
		V_S = 5V, 0V V_{CM} = –5V to 80V, V_{REF} = 1.25V LT1990 LT1990A	 ● ●	 57 67		 	 dB dB
		V_S = 5V, 0V (Note 7) V_{CM} = –38V to 47V, V_{REF} = 2.5V LT1990 LT1990A	 ● ●	 57 67		 	 dB dB
V_{OS}	Input Offset Voltage, RTI	V_S = 3V, 0V G = 1, 10	● ●			 4.5	 mV
		V_S = 5V, 0V G = 1, 10	● ●			 4.5	 mV
V_{OS}/T	Input Offset Voltage Drift, RTI	(Note 10)	●		5	22	µV/°C
V_{OSH}	Input Offset Voltage Hysteresis, RTI	(Note 11)	●		230		µV
PSRR	Power Supply Rejection Ratio, RTI	V_S = 2.7V to 12.7V V_{CM} = V_{REF} = 1.25V	●	76			dB

3V/5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of –40°C ≤ T_A ≤ 85°C. V_S = 3V, 0V; V_S = 5V, 0V; R_L = 10k, V_{CM} = V_{REF} = half supply, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
	Minimum Supply Voltage	Guaranteed by PSRR	●			2.7	V
I_S	Supply Current	(Note 8)	●			170	µA
V_{OL}	Output Voltage Swing LOW	–IN = V^+, +IN = Half Supply (Note 8)	●			70	mV
V_{OH}	Output Voltage Swing HIGH	–IN = 0V, +IN = Half Supply					
		V_S = 3V, 0V, Below V^+	●			200	mV
		V_S = 5V, 0V, Below V^+	●			225	mV
I_{SC}	Output Short-Circuit Current	Short to GND (Note 9)	●	2			mA
		Short to V^+ (Note 9)	●	8			mA

±15V ELECTRICAL CHARACTERISTICS

V_S = ±15V, R_L = 10k, V_{CM} = V_{REF} = 0V, G = 1, 10, T_A = 25°C, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
G	Gain	Pins 5 and 8 = Open		1		
		Pins 5 and 8 = V_{REF}		10		
ΔG	Gain Error	V_{OUT} = ±10V				
		LT1990, G = 1		0.4	0.6	%
		LT1990A, G = 1		0.07	0.28	%
		G = 10		0.2	0.8	%
GNL	Gain Nonlinearity	V_{OUT} = ±10V				
		G = 1		0.0008	0.002	%
		G = 10		0.005	0.02	%
V_{CM}	Input Voltage Range	Guaranteed by CMRR	–250		250	V
CMRR	Common Mode Rejection Ratio, RTI	V_{CM} = –250V to 250V				
		LT1990	60	68		dB
		LT1990A	70	75		dB
V_{OS}	Offset Voltage, RTI	G = 1, 10		0.9	5.2	mV
e_n	Input Noise Voltage, RTI	f_O = 0.1Hz to 10Hz		22		μV_{P-P}
	Noise Voltage Density, RTI	f_O = 1kHz		1		$\mu V/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		2		MΩ
		Common Mode		0.5		MΩ
PSRR	Power Supply Rejection Ratio, RTI	V_S = ±1.35V to ±18V	82	100		dB
	Minimum Supply Voltage	Guaranteed by PSRR		±1.2	±1.35	V
I_S	Supply Current			140	180	µA
V_{OUT}	Output Voltage Swing		±14.5	±14.79		V
I_{SC}	Output Short-Circuit Current	Short to $V^–$	6	9		mA
		Short to V^+	15	22		mA
BW	Bandwidth	G = 1		105		kHz
		G = 10		7		kHz
SR	Slew Rate	G = 1, V_{OUT} = ±10V	0.3	0.55		V/µs
	Settling Time to 0.01%	10V Step, G = 1		60		µs
AV_{REF}	Reference Gain to Output			1 ± 0.0007		

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of 0°C ≤ T_A ≤ 70°C. V_S = ±15V, R_L = 10k, V_{CM} = V_{REF} = 0V, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = ±10V					
		LT1990, G = 1	●			0.65	%
		LT1990A, G = 1	●			0.33	%
		G = 10	●			0.9	%
GNL	Gain Nonlinearity	V_{OUT} = ±10V					
		G = 1	●			0.0025	%
		G = 10	●			0.025	%
G/T	Gain vs Temperature	G = 1 (Note 10)	●		2	10	ppm/°C
		G = 10 (Note 10)	●		7	20	ppm/°C
V_{CM}	Input Voltage Range	Guaranteed by CMRR	●	–250		250	V
CMRR	Common Mode Rejection Ratio, RTI	V_{CM} = –250V to 250V					
		LT1990	●	59			dB
		LT1990A	●	68			dB
V_{OS}	Input Offset Voltage, RTI	G = 1, 10	●			6.2	mV
V_{OS}/T	Input Offset Voltage Drift, RTI	(Note 10)	●		5	22	μV/°C
V_{OSH}	Input Offset Voltage Hysteresis, RTI	(Note 11)	●		250		μV
PSRR	Power Supply Rejection Ratio, RTI	V_S = ±1.35V to ±16V		80			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●			±1.35	V
I_S	Supply Current		●			230	μA
V_{OUT}	Output Voltage Swing		●	±14.4			V
I_{SC}	Output Short-Circuit Current	Short to V^-	●	5			mA
		Short to V^+	●	13			mA
SR	Slew Rate	G = 1, V_{OUT} = ±10V	●	0.25			V/μs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of $-40°C \le T_A \le 85°C$. $V_S = \pm15V$, $R_L = 10k$, $V_{CM} = V_{REF} = 0V$, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ΔG	Gain Error	$V_{OUT} = \pm10V$					
		LT1990, G = 1	●			0.67	%
		LT1990A, G = 1	●			0.35	%
		G = 10	●			0.9	%
GNL	Gain Nonlinearity	$V_{OUT} = \pm10V$					
		G = 1	●			0.003	%
		G = 10	●			0.03	%
G/T	Gain vs Temperature	G = 1 (Note 10)	●		2	10	ppm/°C
		G = 10 (Note 10)	●		7	20	ppm/°C
V_{CM}	Input Voltage Range	Guaranteed by CMRR	●	–250		250	V
CMRR	Common Mode Rejection Ratio, RTI	$V_{CM} = -250V$ to 250V					
		LT1990	●	58			dB
		LT1990A	●	67			dB
V_{OS}	Input Offset Voltage, RTI	G = 1, 10	●			6.7	mV
V_{OS}/T	Input Offset Voltage Drift, RTI	(Note 10)	●		5	22	μV/°C
V_{OSH}	Input Offset Voltage Hysteresis, RTI	(Note 11)	●		250		μV
PSRR	Power Supply Rejection Ratio, RTI	$V_S = \pm1.35V$ to ±18V	●	78			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●			±1.35	V
I_S	Supply Current					280	μA
V_{OUT}	Output Voltage Swing		●	±14.3			V
I_{SC}	Output Short-Circuit Current	Short to V^-	●	3			mA
		Short to V^+	●	10			mA
SR	Slew Rate	G = 1, $V_{OUT} = \pm10V$	●	0.2			V/μs

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

Note 2: ESD (Electrostatic Discharge) sensitive device. Extensive use of ESD protection devices are used internal to the LT1990, however, high electrostatic discharge can damage or degrade the device. Use proper ESD handling precautions.

Note 3: A heat sink may be required to keep the junction temperature below absolute maximum.

Note 4: The LT1990C/LT1990I are guaranteed functional over the operating temperature range of –40°C to 85°C.

Note 5: The LT1990C is guaranteed to meet the specified performance from 0°C to70°C and is designed, characterized and expected to meet specified performance from –40°C to 85°C but is not tested or QA sampled at these temperatures. The LT1990I is guaranteed to meet specified performance from –40°C to 85°C.

Note 6: G = 10 limits are guaranteed by correlation to G = 1 tests and gain error tests at G = 10.

Note 7: Limits are guaranteed by correlation to –5V to 80V CMRR tests.

Note 8: $V_S = 3V$ limits are guaranteed by correlation to $V_S = 5V$ and $V_S = \pm15V$ tests.

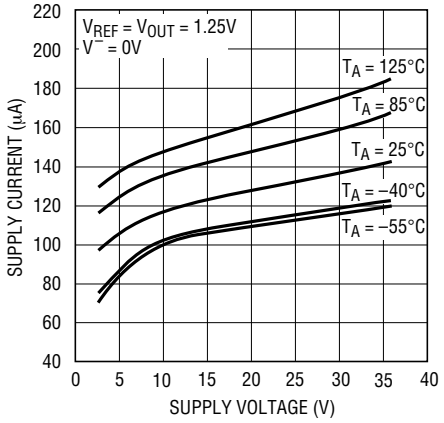
Note 9: $V_S = 5V$ limits are guaranteed by correlation to $V_S = 3V$ and $V_S = \pm15V$ tests.

Note 10: This parameter is not 100% tested.

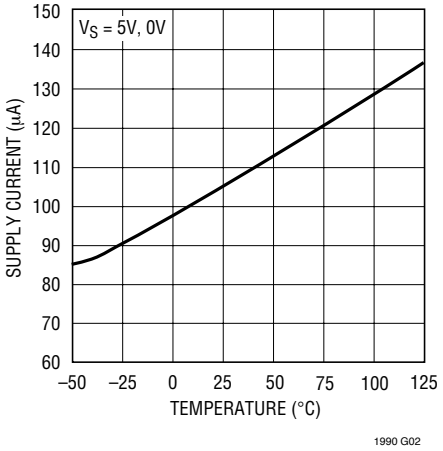
Note 11: Hysteresis in offset voltage is created by package stress that differs depending on whether the IC was previously at a higher or lower temperature. Offset voltage hysteresis is always measured at 25°C, but the IC is cycled to 85°C I-grade (or 70°C C-grade) or –40°C I-grade (0°C C-grade) before successive measurement.

TYPICAL PERFORMANCE CHARACTERISTICS

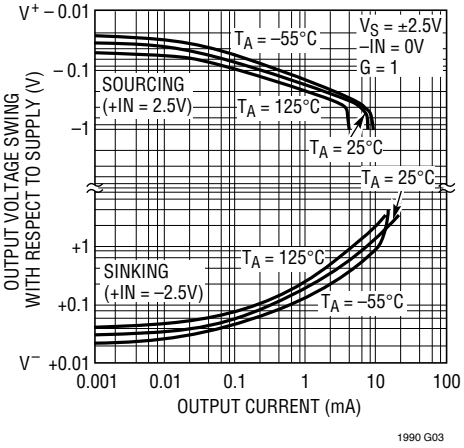
Supply Current vs Supply Voltage



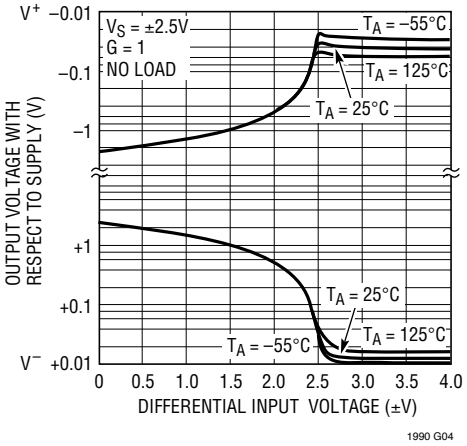
Supply Current vs Temperature



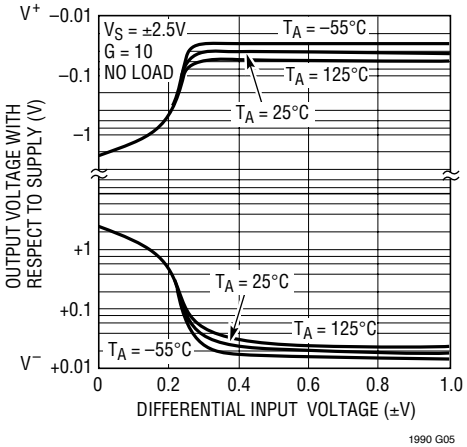
Output Voltage Swing vs Load Current



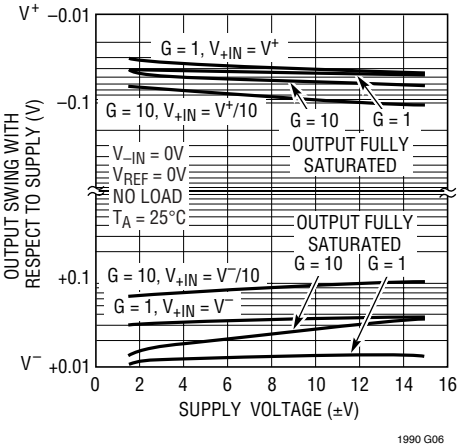
Output Voltage vs Input Voltage, G = 1



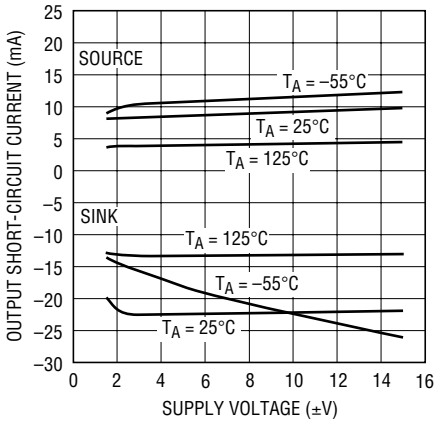
Output Voltage vs Input Voltage, G = 10



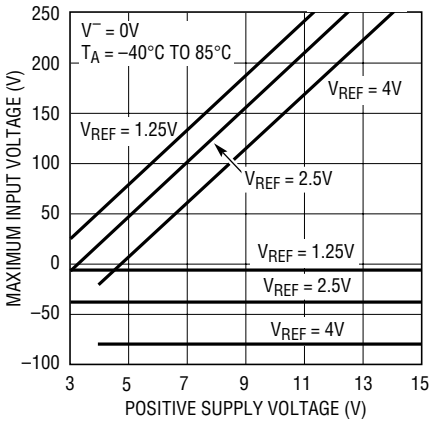
Output Voltage Swing vs Supply Voltage



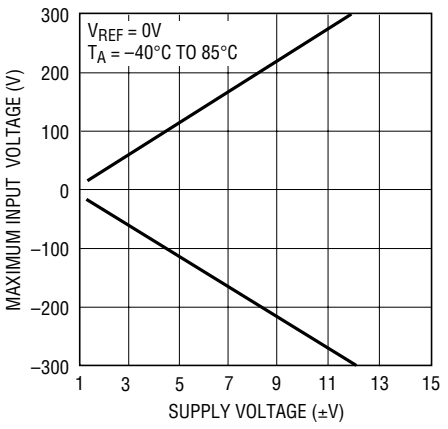
Output Short-Circuit Current vs Supply Voltage



Input Voltage Range vs Single Supply Voltage

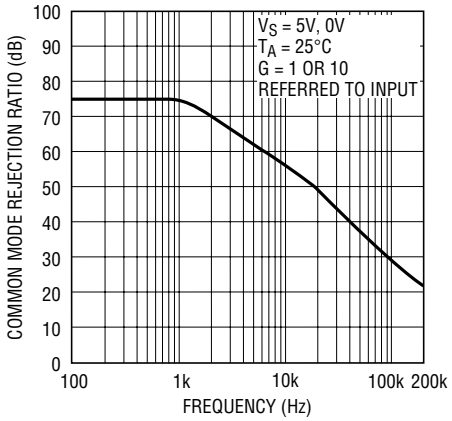


Input Voltage Range vs Split Supply Voltage



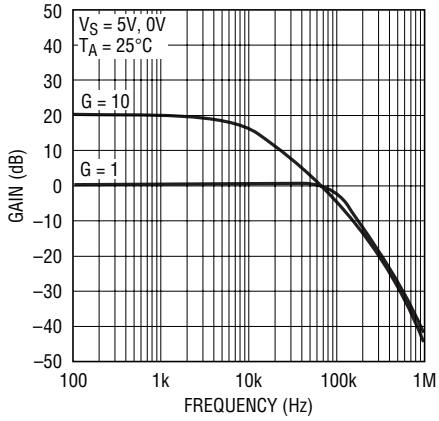
TYPICAL PERFORMANCE CHARACTERISTICS

Common Mode Rejection Ratio vs Frequency



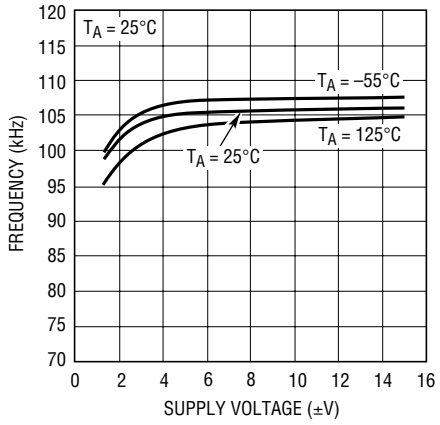
1990 G10

Gain vs Frequency



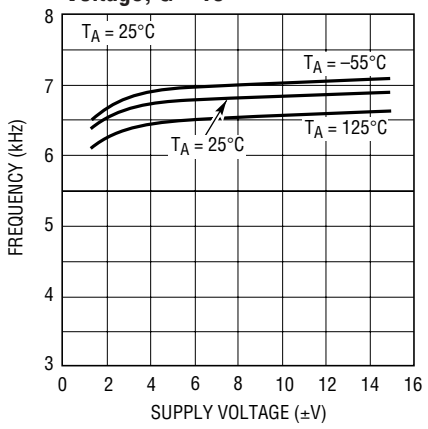
1990 G12

–3dB Bandwidth vs Supply Voltage, G = 1



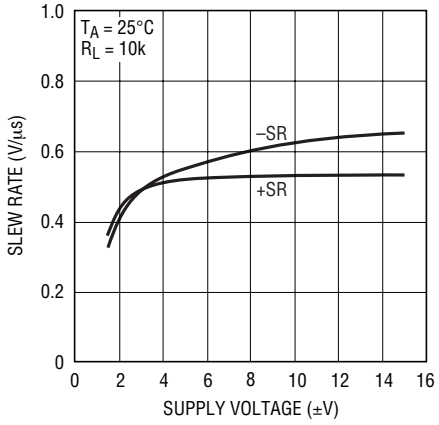
1990 G13

–3dB Bandwidth vs Supply Voltage, G = 10



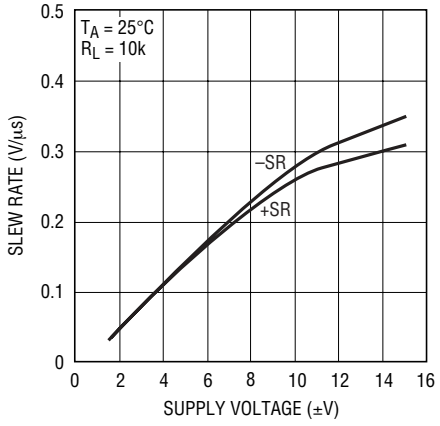
1990 G14

Slew Rate vs Supply Voltage, G = 1



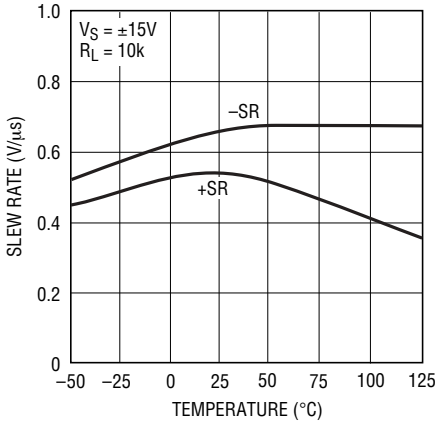
1990 G15

Slew Rate vs Supply Voltage, G = 10



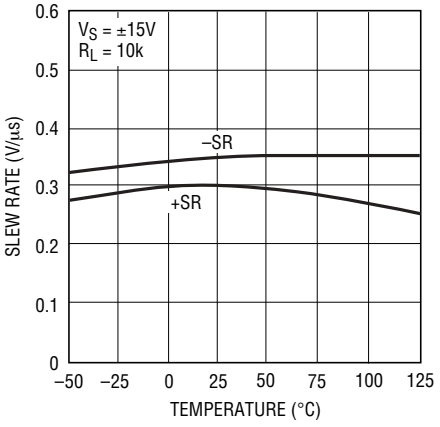
1990 G16

Slew Rate vs Temperature G = 1



1990 G17

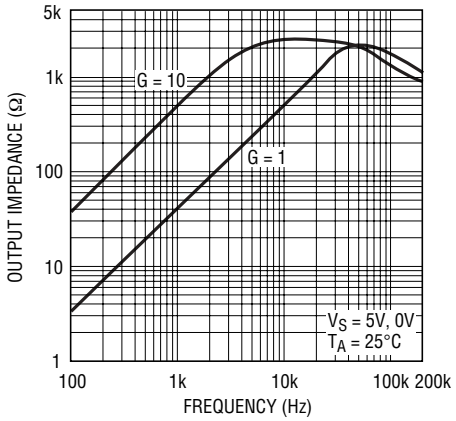
Slew Rate vs Temperature G = 10



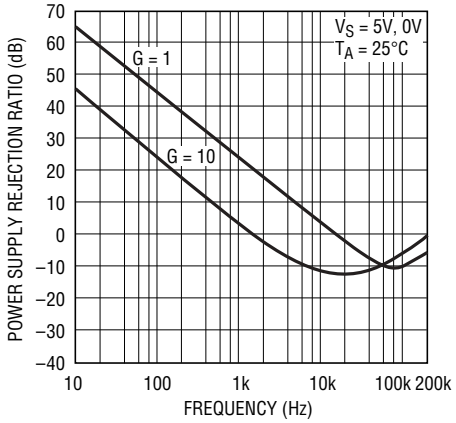
1990 G18

TYPICAL PERFORMANCE CHARACTERISTICS

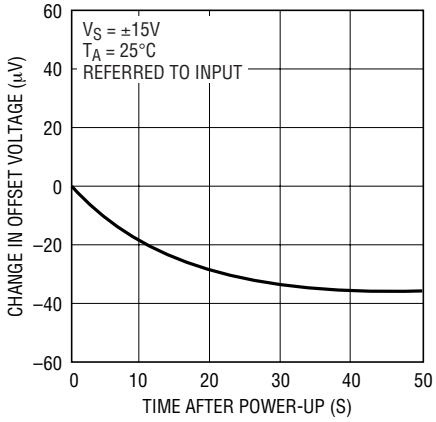
Output Impedance vs Frequency



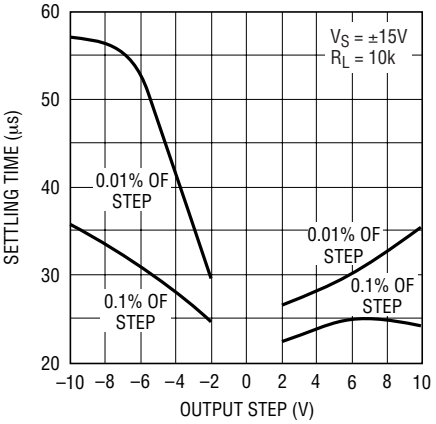
Power Supply Rejection Ratio vs Frequency



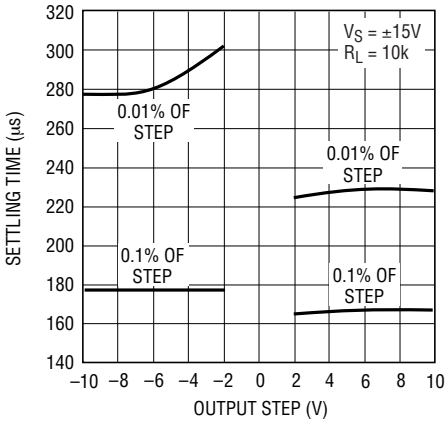
Warm-Up Drift vs Time



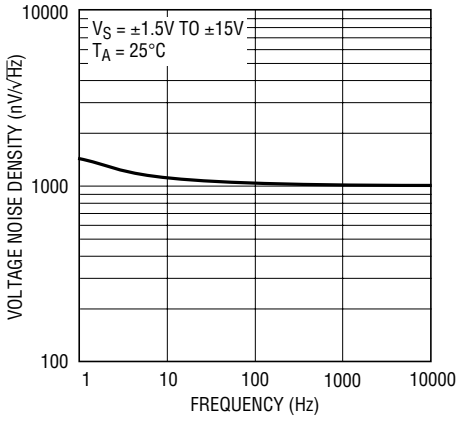
Settling Time vs Output Step, G = 1



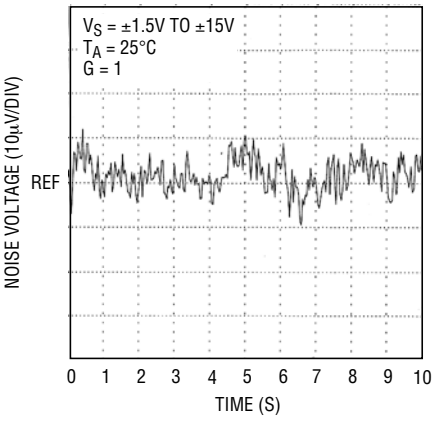
Settling Time vs Output Step, G = 10



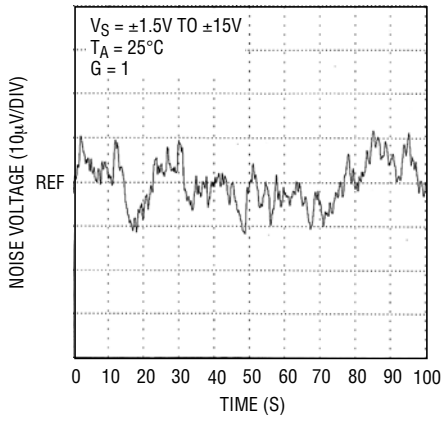
Voltage Noise Density vs Frequency



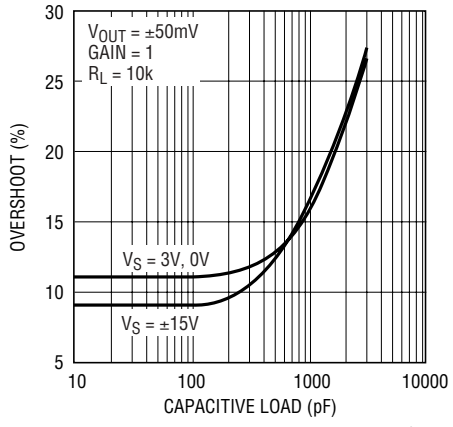
0.1 to 10Hz Noise Voltage



0.01 to 1Hz Noise Voltage

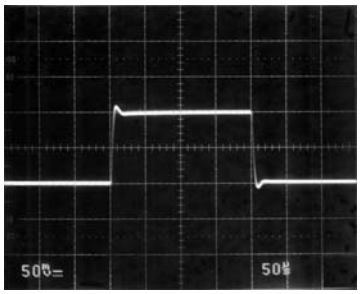


Overshoot vs Capacitive Load



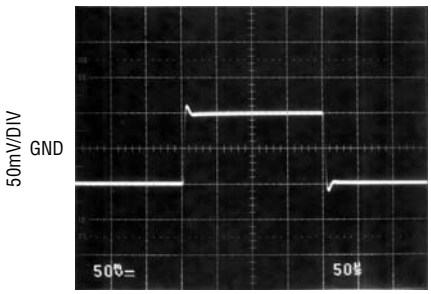
TYPICAL PERFORMANCE CHARACTERISTICS

Small Signal Transient Response



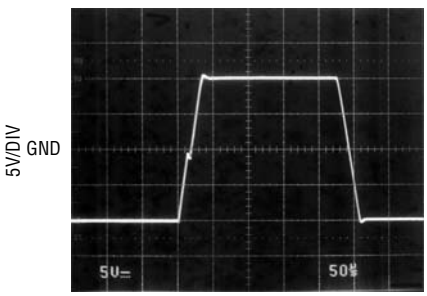
V_S = 3V, 0V 50µs/DIV
G = 1, –1
R_L = 10k
V_{REF} = 1.5V

Small Signal Transient Response



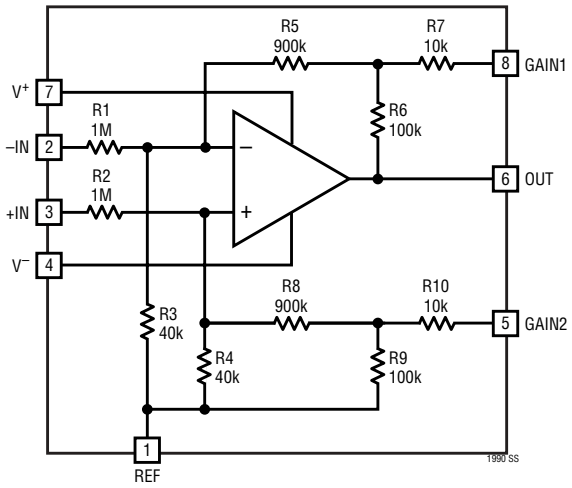
V_S = ±15V 50µs/DIV
G = 1, –1
R_L = 10k
V_{REF} = GND

Large Signal Transient Response



V_S = ±15V 50µs/DIV
G = 1, –1
R_L = 10k
V_{REF} = GND

BLOCK DIAGRAM



PIN FUNCTIONS

REF (Pin 1): Reference Input. Sets the output level when the difference between the inputs is zero.

–IN (Pin 2): Inverting Input. Connects a 1MΩ resistor to the op amp's inverting input. Designed to permit high voltage operation.

+IN (Pin 3): Noninverting Input. Connects a 1MΩ resistor to the op amp's noninverting input. Designed to permit high voltage operation.

V^- (Pin 4): Negative Power Supply. Can be either ground (in single supply applications) or a negative voltage (in split supply applications).

GAIN2 (Pin 5): Gain = 10 Select Input. Configures the amplifier for a gain of 10 when connected to the GAIN1 pin. The gain is equal to one when both GAIN2 and GAIN1 are open. See Applications section for additional functions.

OUT (Pin 6): Output. $V_{OUT} = G \bullet (V_{+IN} - V_{–IN}) + V_{REF}$, in the basic configuration.

V^+ (Pin 7): Positive Power Supply. Can range from 2.7V to 36V above the V^- voltage.

GAIN1 (Pin 8): Gain = 10 Select Input. Configures the amplifier for a gain of 10 when connected to the GAIN2 pin. The gain is equal to one when both GAIN1 and GAIN2 are open. See Applications section for additional functions.

APPLICATIONS INFORMATION

Primary Features

The LT1990 is a complete gain-block solution for high input common mode voltage applications, incorporating a low power precision operational amplifier providing rail-to-rail output swing along with on-chip precision thin-film resistors for high accuracy. The Block Diagram shows the internal architecture of the part. The on-chip resistors form a modified difference amplifier including a reference port for introducing offset or other additive waveforms. With pin-strapping alone either unity gain or gain of 10 is produced with high precision. The resistor network is designed to produce internal common-mode voltage division of 27 so that a very large input range is available compared to the power supply voltage(s) used by the LT1990 itself. The LT1990 is ideally suited to situations where relatively small signals need to be extracted from high voltage circuits, as is the case in many current monitoring instrumentation applications for example. With the ability to accept a range of input voltages well outside the limits of the local power rails and its greater than 1MΩ input impedances, development of precision low power over-the-top and under-the-bottom instrumentation designs is greatly simplified with the LT1990 single chip solution over conventional discrete implementations.

Classic Difference Amplifier

Used in the basic difference amplifier topology where the gain G is pin-strap configurable to be unity or ten, the following relationship is realized:

$$V_O = G \bullet (V_{+IN} - V_{-IN}) + V_{REF}$$

To operate in unity gain, the GAIN1 and GAIN2 pins are left disconnected. For G = 10 operation, the GAIN1 and GAIN2 pins are simply connected together or tied to a common potential such as ground or V^-.

The input common mode range capability is up to ±250V, governed by the following relationships:

For G = 1 and G = 10 where GAIN1 and GAIN2 are only tied together (not grounded,etc):

$$V_{CM+} \leq 27 \bullet V^+ - 26 \bullet V_{REF} - 23$$

$$V_{CM-} \geq 27 \bullet V^- - 26 \bullet V_{REF} + 27$$

For G = 10 where GAIN1 and GAIN2 are tied to a common potential V_{GAIN}:

$$V_{CM+} \leq 27 \bullet V^+ - 26 \bullet V_{REF} - 23 - V_{GAIN}$$

$$V_{CM-} \geq 27 \bullet V^- - 26 \bullet V_{REF} + 27 - V_{GAIN}$$

For split supplies over about ±11V, the full ±250V common mode range is normally available (with V_{REF} a small fraction of the supply). With lower supply voltages, an appropriate selection of V_{REF} can tailor the input common mode range to a specific requirement. As an example, the following low supply voltage scenarios are readily implemented with the LT1990:

Supply	V_{REF}	V_{CM} Range
+3V	1.25V	–5V to 25V (e.g. 12V automotive environment)
+5V	1.25V	–5V to 80V (e.g. 42V automotive environment)
+5V	4.00V	–77V to 8V (e.g. telecom environment; use downward signaling)

Configuring Other Gains

An intermediate gain G ranging between 1 and 10 may be produced by placing an adjustable resistance between the GAIN1 and GAIN2 pins according to the following nominal relationship:

$$R_{GAIN} \approx (180k/(G - 1)) - 20k$$

While the expression is exact, the value is approximate because the absolute resistance of the internal network could vary on a unit-to-unit basis by as much as ±30% from the nominal figures and the external gain resistance is required to accommodate that deviation. Once adjusted, however, the gain stability is excellent by virtue of the –30ppm/°C typical temperature coefficient offered by the on-chip thin-film resistor process.

Preserving and Enhancing Common Mode Rejection

The basic difference amplifier topology of the LT1990 requires that source impedances seen by the input pins +IN and –IN, should be matched to within a few tens of ohms to avoid increasing common mode induced errors beyond the basic production limits of the part. Known source imbalances beyond that level should be compensated for by the addition of series resistance to the lower-

APPLICATIONS INFORMATION

impedance source. Also the source impedance of a signal connected to the REF pin must be on the order of a few ohms or less to preserve the high accuracy of the LT1990.

While the LT1990 comes from the factory with an excellent CMRR, some precision applications with a large applied common mode voltage may require a method to trim out residual common mode error. This is easily accomplished by adding series resistance to each input, +IN and –IN, such that an adjustable resistance difference of ±1kΩ is provided. This is most easily realized by adding a fixed 1kΩ in series with one of the inputs, and a 2kΩ trimmer in series with the other as shown in Figure 1. The trim range of this configuration is ±0.1% for the internal gain resistor matching, so a much more finely resolved correction is available using the LT1990 than is realizable with ordinary discrete solutions. In applications where the input common mode voltage is relatively constant and large (perhaps at or beyond the supply range), this same configuration can be treated as an offset adjustment.

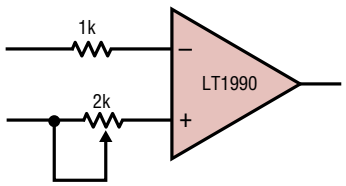


Figure 1. Optional CMRR Trim

Dual Differential-Input Arithmetic Block

The internal resistor network topology of the LT1990 allows the GAIN1 and GAIN2 pins to be used as another differential input in addition to the normal +IN and –IN port. This can be a very useful function for implementing servo-loop differential error amplifiers, for example. In this mode of operation, the output is governed by the following relationship:

$$V_O = 10 \bullet (V_{+IN} - V_{-IN} + V_{GAIN2} - V_{GAIN1}) + V_{REF}$$

Unlike the main inputs, the GAIN1 and GAIN2 pins are clamped by substrate diodes and ESD structures, thus the operating voltage range of these pins is limited to V^- – 0.2V to V^- + 36V. If the GAIN inputs are brought beyond the operating input range, care must be taken to limit the input currents to less than 10mA to prevent damage to the device. Also, since the gain setting resistors associated with the GAIN1 and GAIN2 inputs are in the 10kΩ area, low source impedances are particularly important to preserve the precision of the LT1990.

This dual differential input mode of operation is used in the circuit as shown in Figure 2.

This circuit is a high efficiency H-bridge driver that is PWM modulated to provide a controlled current to an electromagnet coil. Since the common mode voltage of the current sense resistor R_S varies with operating current and the coil properties, a differential feedback is required. In this application, it was desirable to allow the control input to utilize the wide common mode range port (+IN and –IN) so that constraints on input referencing are eliminated. The GAIN1 and GAIN2 pins always operate within the supply range and both ports operate with a gain of 10 to develop the loop error. The LTC1923 provides the loop integrator and PWM functions of the servo.

APPLICATIONS INFORMATION

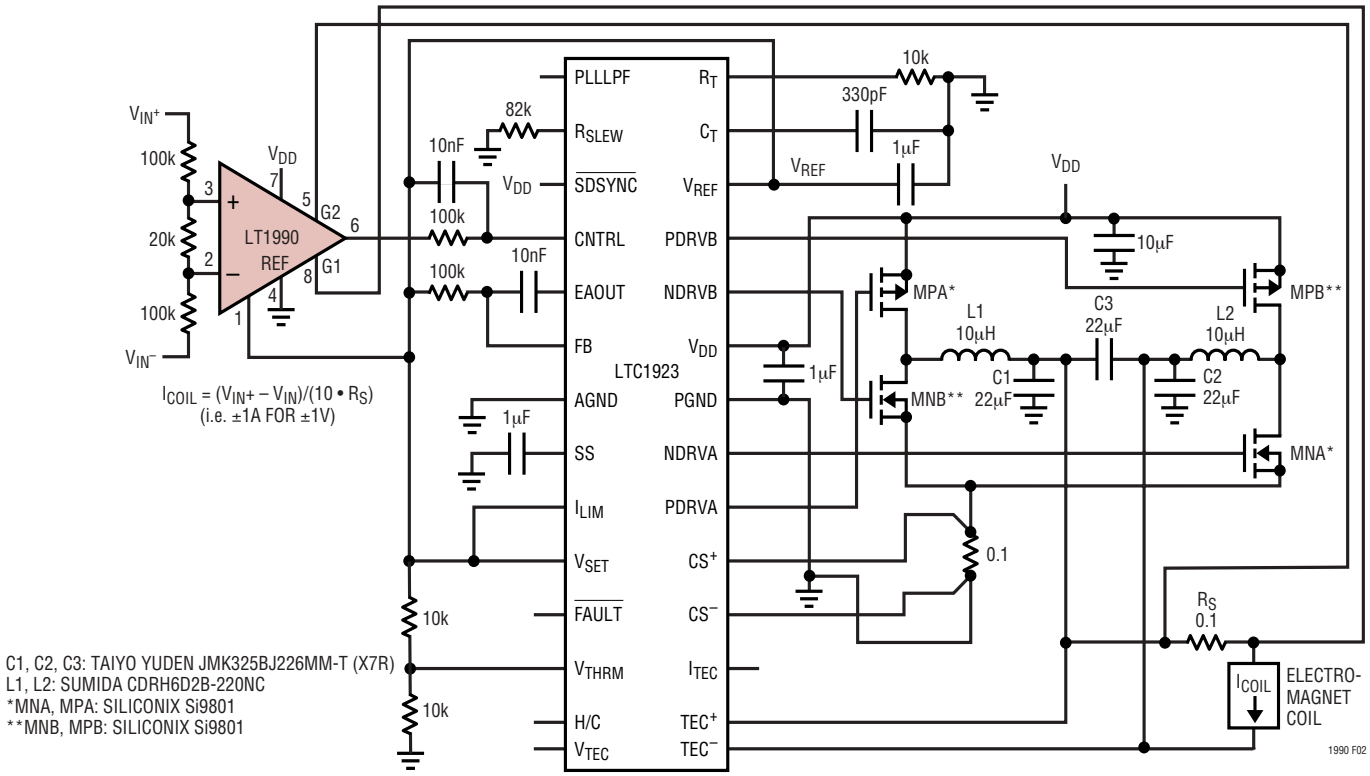
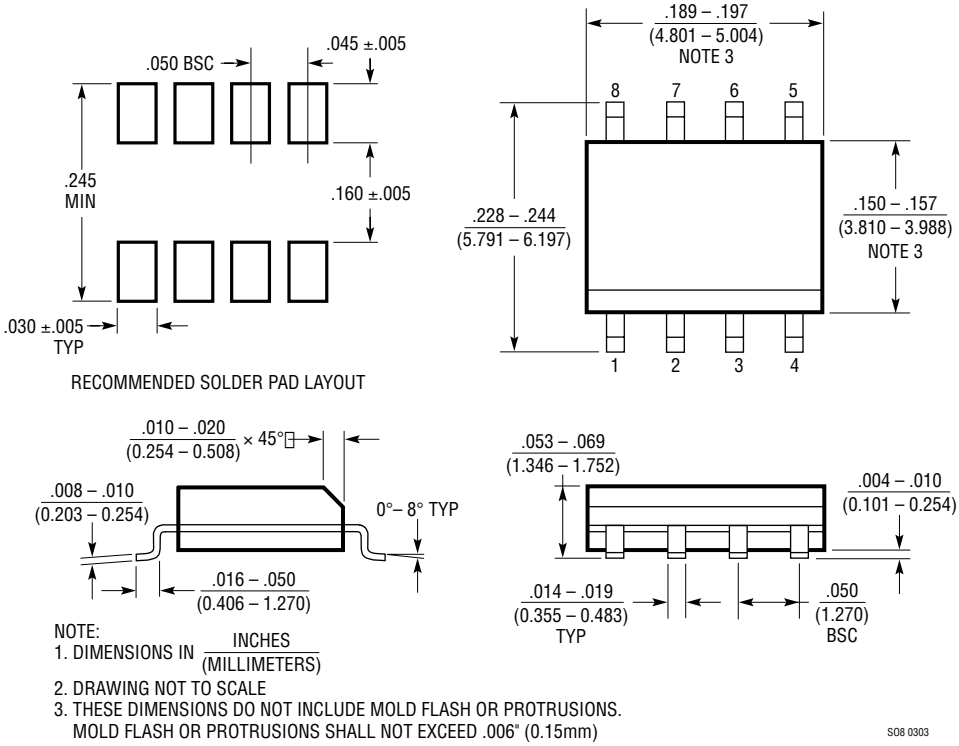


Figure 2. PWM-Based ±1A Electromagnet Current Controller

PACKAGE DESCRIPTION

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



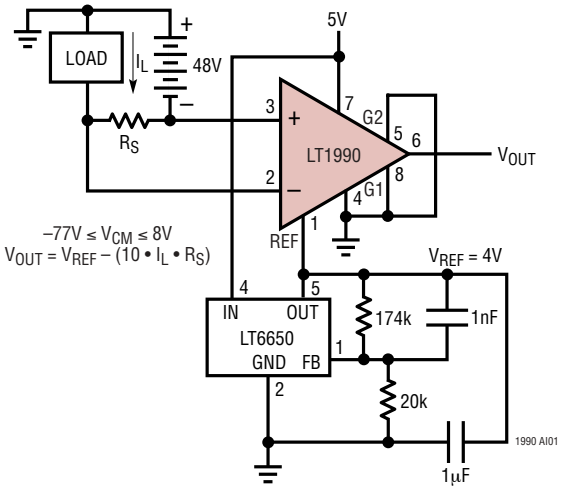
NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{(\text{MILLIMETERS})}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

SO8 0303

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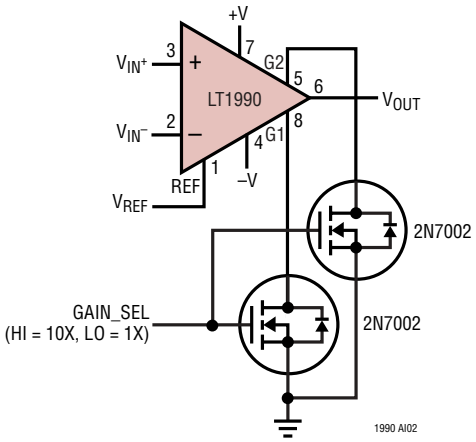
TYPICAL APPLICATION

Telecom Supply Current Monitor

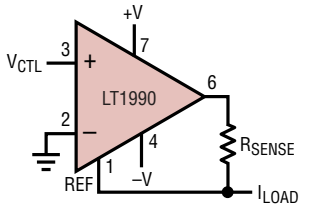


$-77V \le V_{CM} \le 8V$
$V_{OUT} = V_{REF} - (10 \bullet I_L \bullet R_S)$

Selectable Gain Amplifier

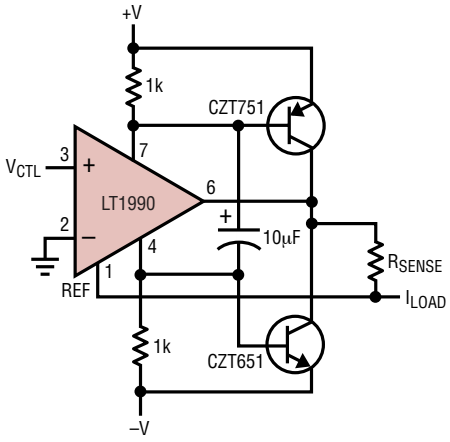


Bidirectional Controlled Current Source



$I_{LOAD} = V_{CTL}/R_{SENSE} \le 5mA$
EXAMPLE: FOR R_{SENSE} =100Ω,
OUTPUT IS 1mA PER 100mV INPUT

Boosted Bidirectional Controlled Current Source



$I_{LOAD} = V_{CTL}/R_{SENSE} \le 100mA$
EXAMPLE: FOR R_{SENSE} =10Ω,
OUTPUT IS 1mA PER 10mV INPUT

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1787	Precision High Side Current Sense Amplifier	On-Chip Precision Resistor Array
LT1789	Micropower Instrumentation Amplifier	Micropower, Precision, G = 1 to 1000
LTC1921	Dual –48V Supply and Fuse Monitor	Withstands ±200V Transients
LT1991	High Accuracy Difference Amplifier	Micropower, Precision, Pin Selectable G = –13 to 14
LT1995	30MHz, 1000V/μs Gain Selectable Amplifier	Pin Selectable G = –7 to 8
LT6910	Single Supply Programmable Gain Amplifier	Digitally Controlled, SOT-23, G = 0 to 100

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