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

FEATURES

- **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

APPLICATIONS

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

DESCRIPTION

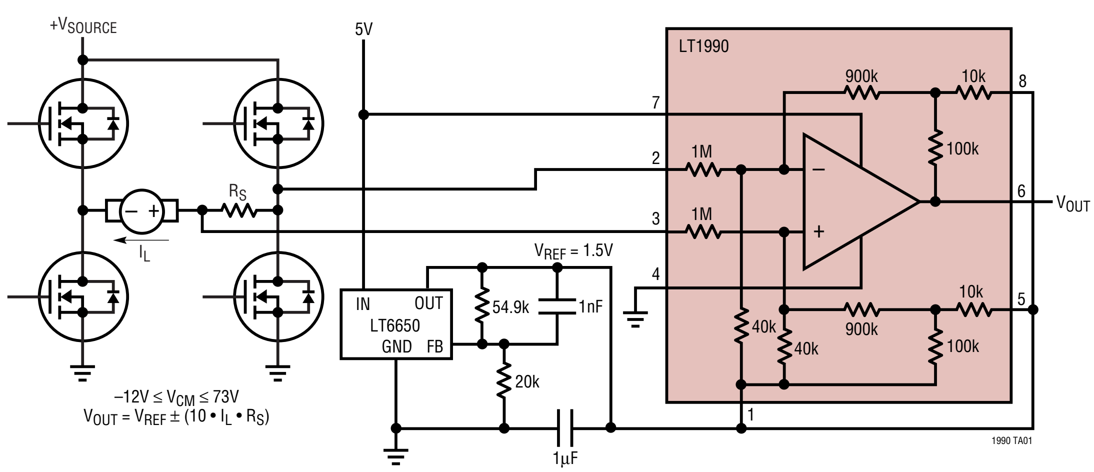
The LT®1990 is a micropower precision difference amplifier with a very high common mode input voltage range. It has pin selectable gains of 1 or 10. The LT1990 operates over a ±250V common mode voltage range on a ±15V supply. The inputs are fault protected from common mode voltage transients up to ±350V 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.

TYPICAL APPLICATION

Full-Bridge Load Current Monitor

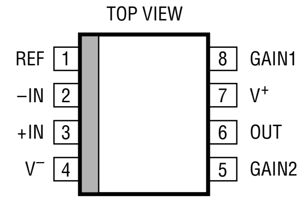


ABSOLUTE MAXIMUM RATINGS

(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)
  LT1990C .... –40°C to 85°C
  LT1990I .... –40°C to 85°C
  LT1990H .... –40°C to 125°C
Specified Temperature Range (Note 5)
  LT1990C .... –40°C to 85°C
  LT1990I .... –40°C to 85°C
  LT1990H .... –40°C to 125°C
Junction Temperature .... 150°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
$T_{JMAX} = 150°C$, $\theta_{JA} = 190°C/W$

ORDER PART NUMBER	S8 PART MARKING
LT1990CS8	1990
LT1990IS8	1990I
LT1990HS8	1990H
LT1990ACS8	1990A
LT1990AIS8	1990AI
LT1990AHS8	1990AH

Order Options Tape and Reel: Add #TR
Lead Free: Add #PBF   Lead Free Tape and Reel: Add #TRPBF
Lead Free Part Marking: http://www.linear.com/leadfree/

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

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 Pins 5 and 8 = V_{REF}		1 10		
ΔG	Gain Error	V_{OUT} = 0.5V to (+Vs) –0.75V LT1990, G = 1 LT1990A, G = 1 G = 10, V_S = 5V, 0V		 0.4 0.07 0.2	 0.6 0.28 0.8	 % % %
GNL	Gain Nonlinearity	V_S = 5V, 0V; V_{OUT} = 0.5V to 4.25V G = 1 G = 10		 0.001 0.01	 0.005	 % %
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 –38		 25 80 47	 V V 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 LT1990A	 60 70	 68 75		 dB dB
		V_S = 5V, 0V V_{CM} = –5V to 80V, V_{REF} = 1.25V LT1990 LT1990A	 60 70	 68 75		 dB dB
		V_S = 5V, 0V (Note 7) V_{CM} = –38V to 47V, V_{REF} = 2.5V LT1990 LT1990A	 60 70	 68 75		 dB dB

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
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		µV/√Hz
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	G = 1 G = 10		1 ± 0.0007 1 ± 0.007		

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		LT1990C/LT1990I 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

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		LT1990C/LT1990I MIN	TYP	MAX	UNITS
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
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		LT1990C/LT1990I 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

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		LT1990C/LT1990I MIN	TYP	MAX	UNITS
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
	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^+ V_S = 5V, 0V, Below V^+	 ● ●			 200 275	 mV mV
I_{SC}	Output Short-Circuit Current	Short to GND (Note 9) Short to V^+ (Note 9)	● ●	2 8			mA mA

3V/5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of –40°C ≤ T_A ≤ 125°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		LT1990H MIN	TYP	MAX	UNITS
∆G	Gain Error	V_{OUT} = 0.5V to (+V_S) – 0.75V LT1990, G = 1 LT1990A, G = 1 G = 10	 ● ● ●			 0.69 0.37 0.97	 % % %
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	 ● ●	 56 66			 dB dB
		V_S = 5V, 0V V_{CM} = –5V to 80V, V_{REF} = 1.25V LT1990 LT1990A	 ● ●	 56 66			 dB dB
		V_S = 5V, 0V (Note 7) V_{CM} = –38V to 47V, V_{REF} = 2.5V LT1990 LT1990A	 ● ●	 56 66			 dB dB

3V/5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of $-40°C \le T_A \le 125°C$. 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		LT1990H MIN	LT1990H TYP	LT1990H MAX	UNITS
V_{OS}	Input Offset Voltage, RTI	V_S = 3V, 0V G = 1, 10	●			5.2	mV
		V_S = 5V, 0V G = 1, 10	●			5.2	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 = 2.7V to 12.7V $V_{CM} = V_{REF}$ = 1.25V	●	75			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●			2.7	V
I_S	Supply Current	(Note 8)	●			200	µA
V_{OL}	Output Voltage Swing LOW	–IN = V^+, +IN = Half Supply (Note 8)	●			80	mV
V_{OH}	Output Voltage Swing HIGH	–IN = 0V, +IN = Half Supply V_S = 3V, 0V, Below V^+ V_S = 5V, 0V, Below V^+	 ● ●			 230 275	 mV mV
I_{SC}	Output Short-Circuit Current	Short to GND (Note 9) Short to V^+ (Note 9)	● ●	1 5			mA 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 Pins 5 and 8 = V_{REF}		1 10		
ΔG	Gain Error	V_{OUT} = ±10V LT1990, G = 1 LT1990A, G = 1 G = 10		 0.4 0.07 0.2	 0.6 0.28 0.8	 % % %
GNL	Gain Nonlinearity	V_{OUT} = ±10V G = 1 G = 10		 0.0008 0.005	 0.002 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 LT1990A	 60 70	 68 75		 dB 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		µV/√Hz
R_{IN}	Input Resistance	Differential Common Mode		2 0.5		MΩ 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

±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
I_{SC}	Output Short-Circuit Current	Short to V^- Short to V^+	6 15	9 22		mA mA
BW	Bandwidth	G = 1 G = 10		105 7		kHz 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	G = 1 G = 10		1 ± 0.0007 1 ± 0.007		

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		LT1990C/LT1990I MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = ±10V LT1990, G = 1 LT1990A, G = 1 G = 10	 ● ● ●			 0.65 0.33 0.9	 % % %
GNL	Gain Nonlinearity	V_{OUT} = ±10V G = 1 G = 10	 ● ●			 0.0025 0.025	 % %
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	●	–250		250	V
CMRR	Common Mode Rejection Ratio, RTI	V_{CM} = –250V to 250V LT1990 LT1990A	 ● ●	 59 68			 dB 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 ±18V	●	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^- Short to V^+	● ●	5 13			mA 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 ≤ T_A ≤ 85°C. V_S = ±15V, R_L = 10k, V_{CM} = V_{REF} = 0V, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		LT1990C/LT1990I MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = ±10V					
		LT1990, G = 1	●			0.67	%
		LT1990A, G = 1	●			0.35	%
		G = 10	●			0.95	%
GNL	Gain Nonlinearity	V_{OUT} = ±10V					
		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 = ±1.35V 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} = ±10V	●	0.2			V/µs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of −40°C ≤ T_A ≤ 125°C. V_S = ±15V, R_L = 10k, V_{CM} = V_{REF} = 0V, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		LT1990H MIN	TYP	MAX	UNITS
ΔG	Gain Error	V_{OUT} = ±10V					
		LT1990, G = 1	●			0.69	%
		LT1990A, G = 1	●			0.37	%
		G = 10	●			0.97	%
GNL	Gain Nonlinearity	V_{OUT} = ±10V					
		G = 1	●			0.0035	%
		G = 10	●			0.035	%
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	●	57			dB
		LT1990A	●	66			dB
V_{OS}	Input Offset Voltage, RTI	G = 1, 10	●			7.4	mV
V_{OS}/T	Input Offset Voltage Drift, RTI	(Note 10)	●		5	22	µV/°C

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of –40°C ≤ T_A ≤ 125°C. V_S = ±15V, R_L = 10k, V_{CM} = V_{REF} = 0V, G = 1, 10, unless otherwise noted. (Notes 4, 6)

SYMBOL	PARAMETER	CONDITIONS		LT1990H MIN	TYP	MAX	UNITS
V_{OSH}	Input Offset Voltage Hysteresis, RTI	(Note 11)	●		250		μV
PSRR	Power Supply Rejection Ratio, RTI	V_S = ±1.35V to ±18V	●	77			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●			±1.35	V
I_S	Supply Current		●			330	μA
V_{OUT}	Output Voltage Swing		●	±14.2			V
I_{SC}	Output Short-Circuit Current	Short to $V^–$ Short to V^+	● ●	1.5 7			mA mA
SR	Slew Rate	G = 1, V_{OUT} = ±10V	●	0.1			V/μs

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: 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. The LT1990H is guaranteed functional over the operating temperature range of –40°C to 125°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. The LT1990H is guaranteed to meet specified performance from –40°C to 125°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 = ±15V tests.

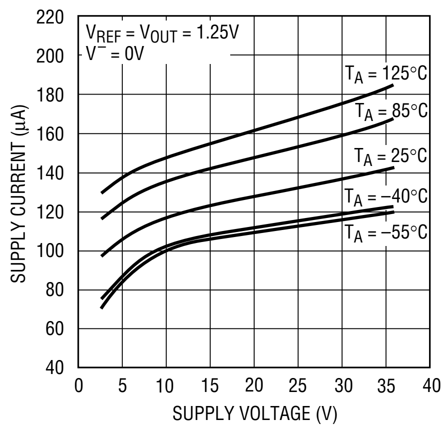
Note 9: V_S = 5V limits are guaranteed by correlation to V_S = 3V and V_S = ±15V tests.

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 (70°C C-grade or 125°C H-grade) or –40°C I/H-grade (0°C C-grade) before successive measurement.

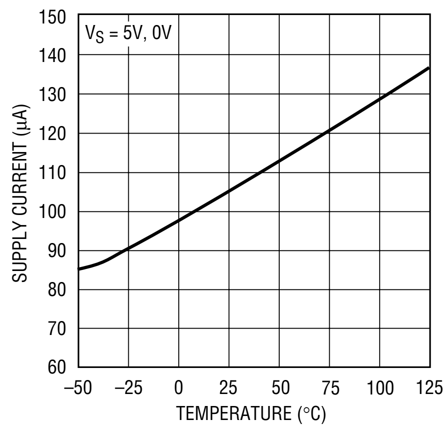
TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Supply Voltage



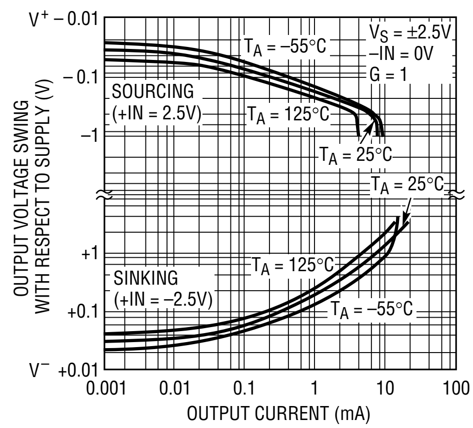
1990 G01

Supply Current vs Temperature



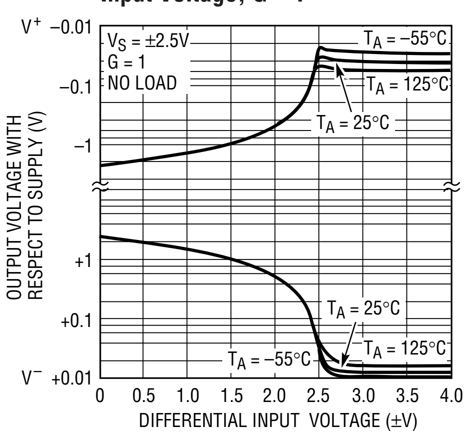
1990 G02

Output Voltage Swing vs Load Current



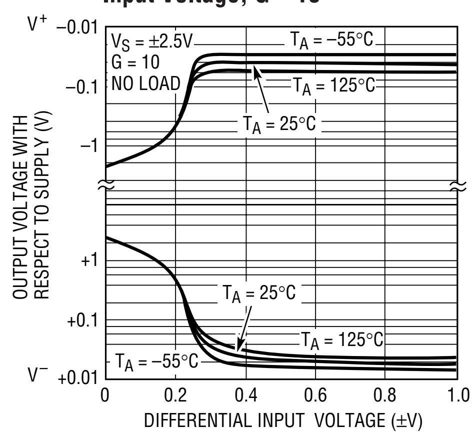
1990 G03

Output Voltage vs Input Voltage, G = 1



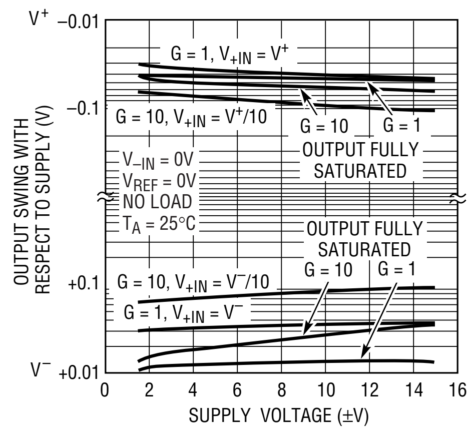
1990 G04

Output Voltage vs Input Voltage, G = 10



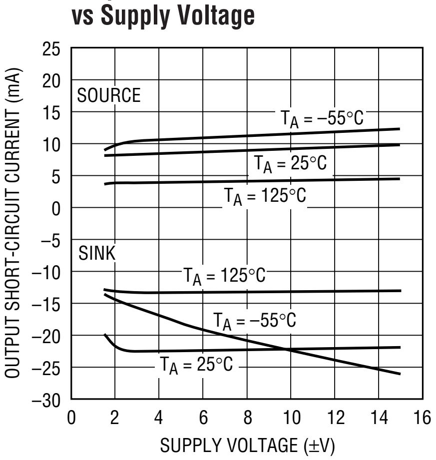
1990 G05

Output Voltage Swing vs Supply Voltage



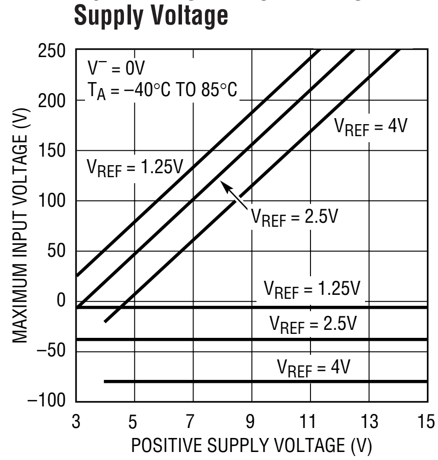
1990 G06

Output Short-Circuit Current vs Supply Voltage



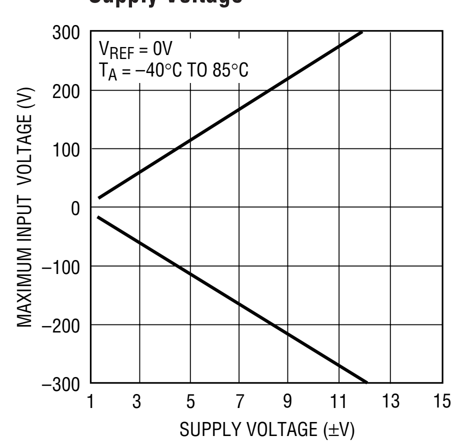
1990 G07

Input Voltage Range vs Single Supply Voltage



1990 G08

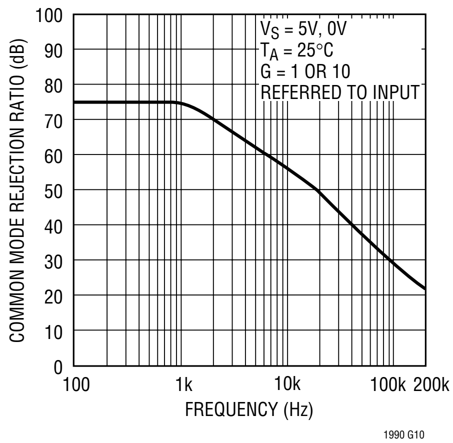
Input Voltage Range vs Split Supply Voltage



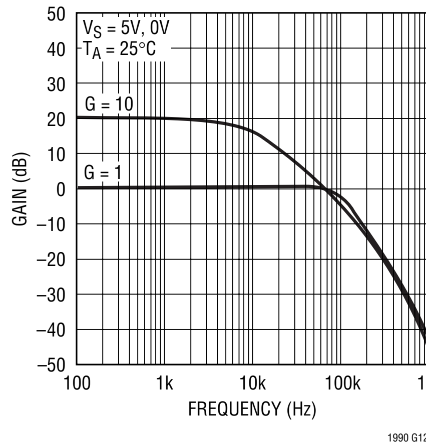
1990 G09

TYPICAL PERFORMANCE CHARACTERISTICS

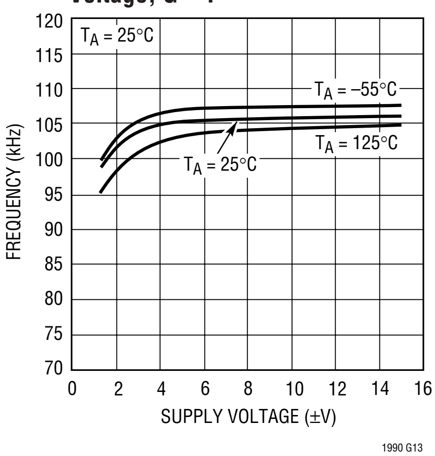
Common Mode Rejection Ratio vs Frequency



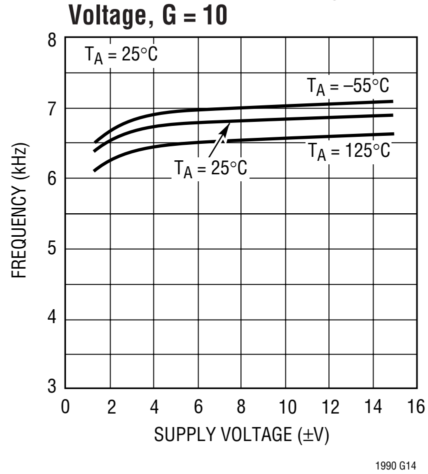
Gain vs Frequency



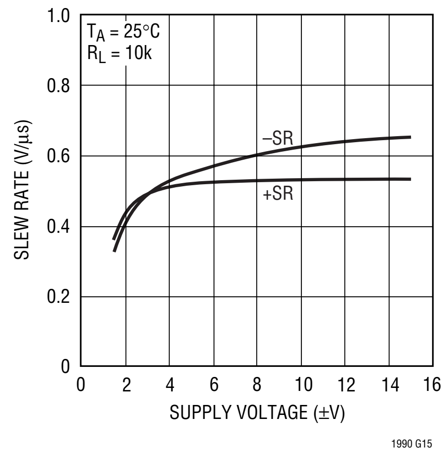
–3dB Bandwidth vs Supply Voltage, G = 1



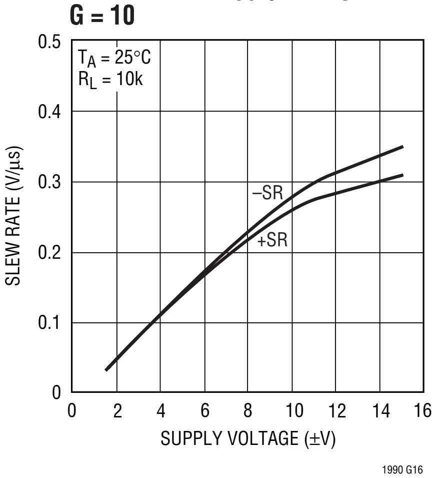
–3dB Bandwidth vs Supply Voltage, G = 10



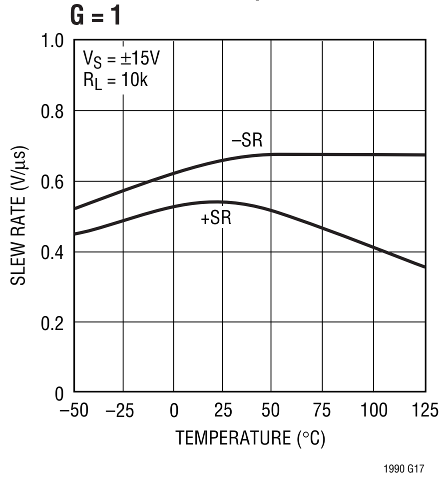
Slew Rate vs Supply Voltage, G = 1



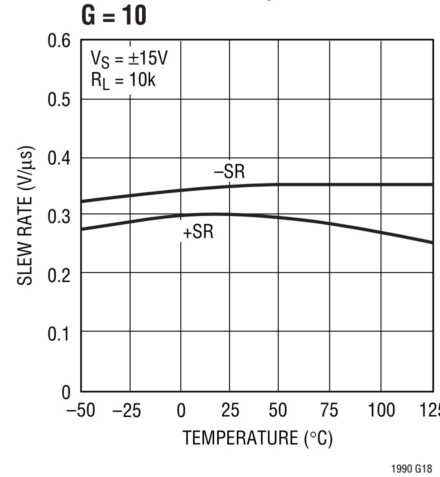
Slew Rate vs Supply Voltage, G = 10



Slew Rate vs Temperature G = 1

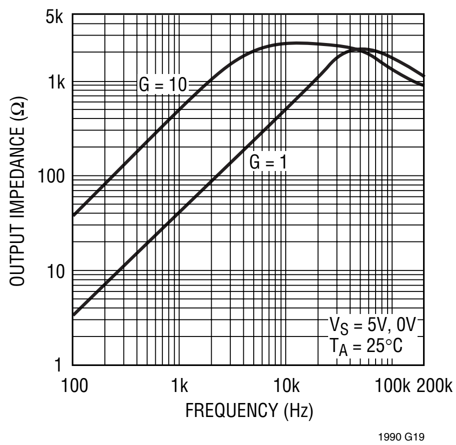


Slew Rate vs Temperature G = 10

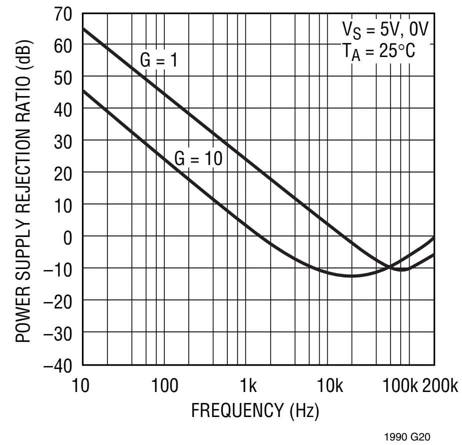


TYPICAL PERFORMANCE CHARACTERISTICS

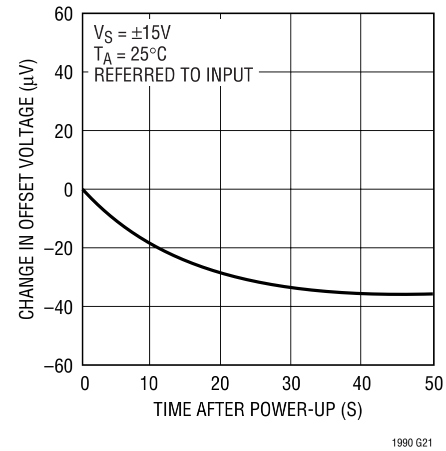
Output Impedance vs Frequency



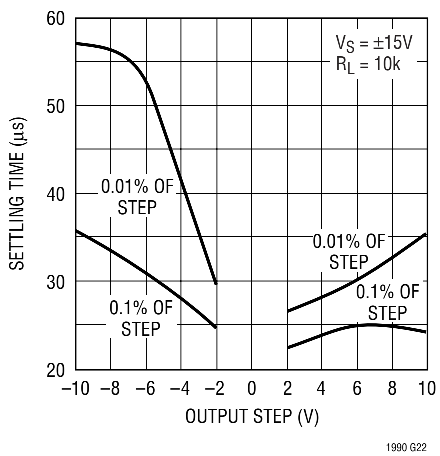
Power Supply Rejection Ratio vs Frequency



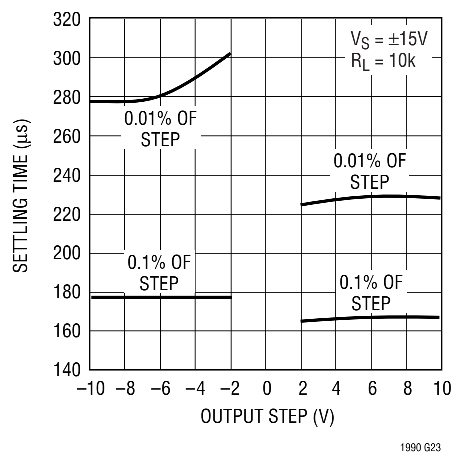
Warm-Up Drift vs Time



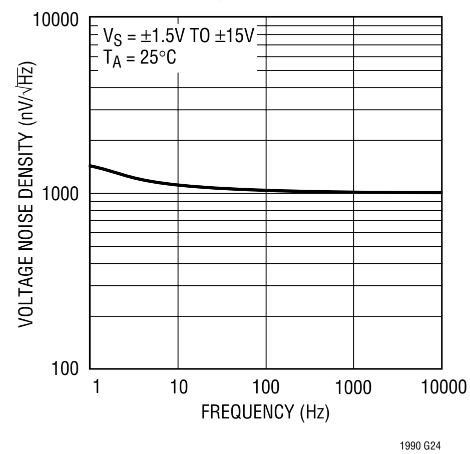
Settling Time vs Output Step, G = 1



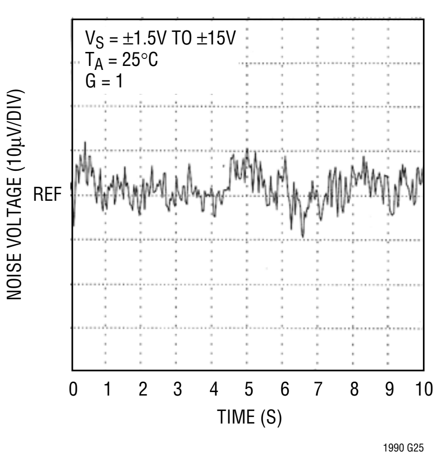
Settling Time vs Output Step, G = 10



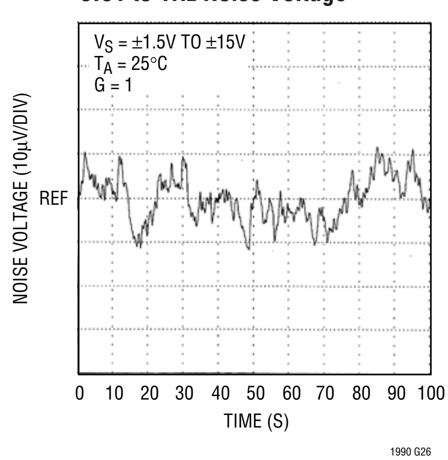
Voltage Noise Density vs Frequency



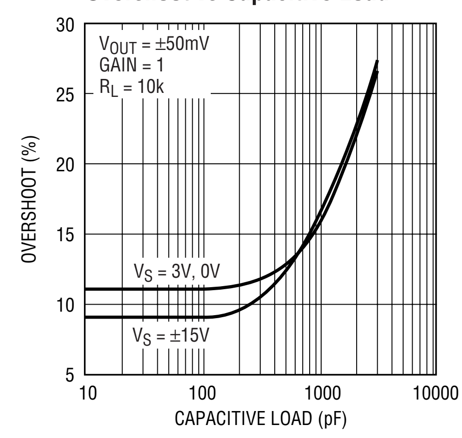
0.1 to 10Hz Noise Voltage



0.01 to 1Hz Noise Voltage

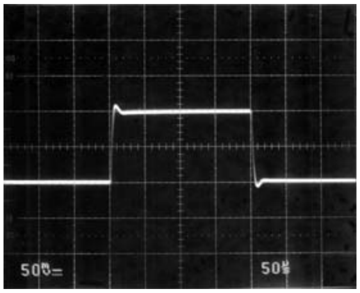


Overshoot vs Capacitive Load



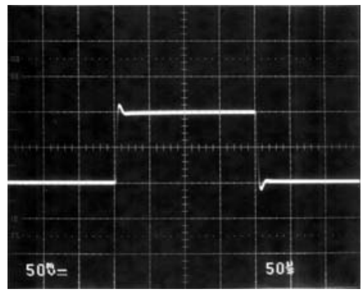
TYPICAL PERFORMANCE CHARACTERISTICS

Small Signal Transient Response



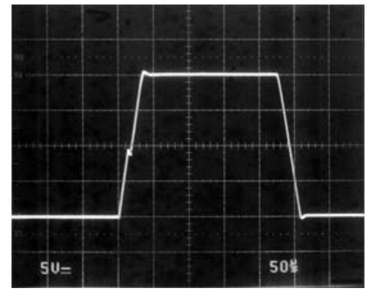
V_S = 3V, 0V
G = 1, –1
R_L = 10k
V_{REF} = 1.5V

Small Signal Transient Response



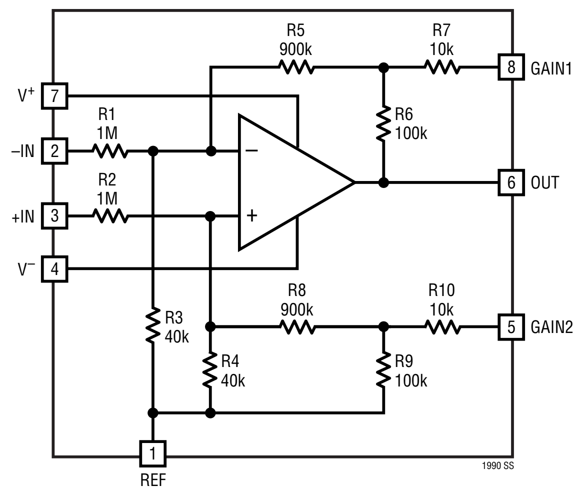
V_S = ±15V
G = 1, –1
R_L = 10k
V_{REF} = GND

Large Signal Transient Response



V_S = ±15V
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 and the REF pin. The gain is equal to one when both GAIN2 and GAIN1 are open. See Applications section for additional functions.

OUT (Pin 6): Output. $V_{OUT} = G \cdot (V_{+IN} - V_{-IN}) + V_{REF}$, 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 and the REF 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 to the REF pin.

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):

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

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

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

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

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

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-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.

APPLICATIONS INFORMATION

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.

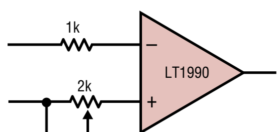


Figure 1. Optional CMRR Trim

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. For best results in this mode of operation the common mode voltage of the GAIN1 and GAIN2 pins should be equal to the REF pin voltage. 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.

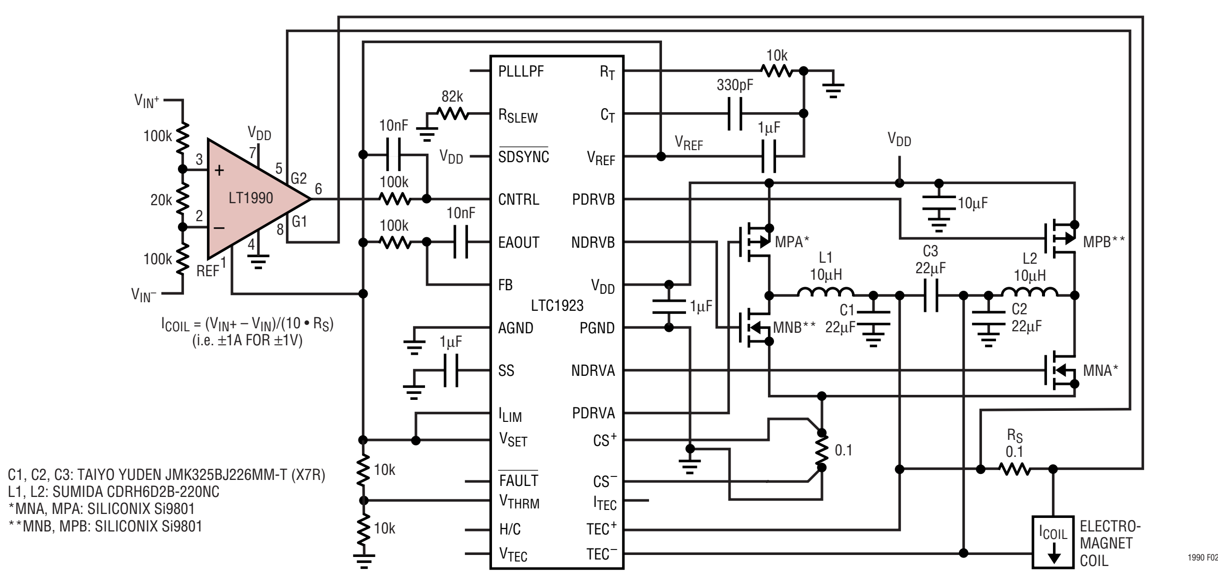
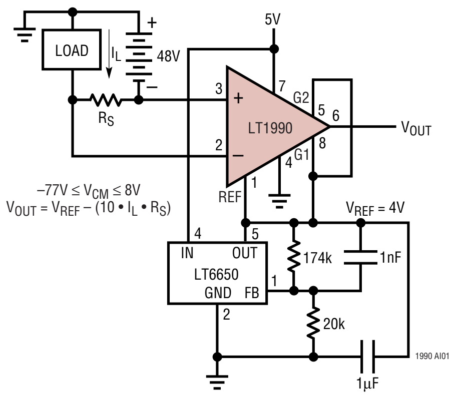


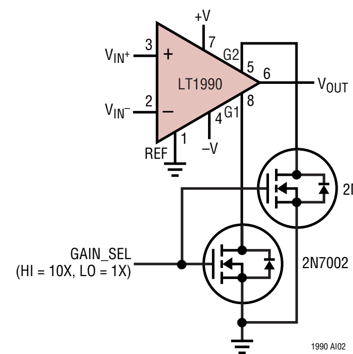
Figure 2. PWM-Based ±1A Electromagnet Current Controller

TYPICAL APPLICATION

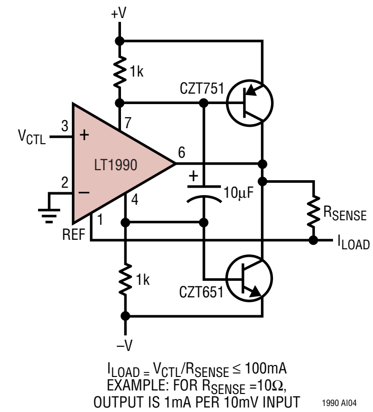
Telecom Supply Current Monitor



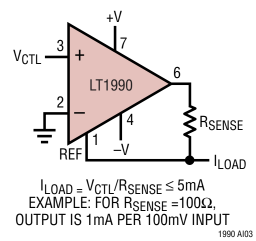
Selectable Gain Amplifier



Boosted Bidirectional Controlled Current Source

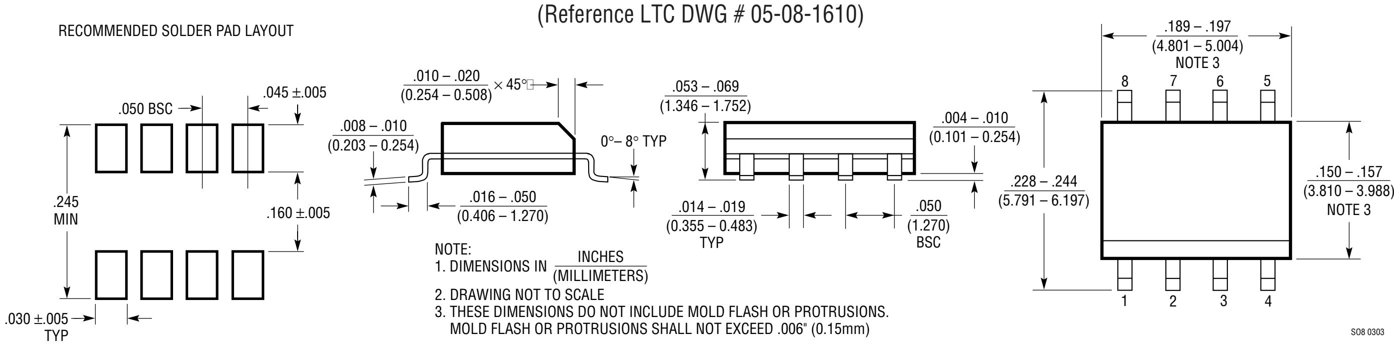


Bidirectional Controlled Current Source



PACKAGE DESCRIPTION

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



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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