Ultra High Speed Operational Amplifier

FEATURES

- Gain Bandwidth Product, $A_V = +1$ — 50MHz
- Slew Rate — 450V/μs
- Low Cost
- Output Current — ±50mA
- Settling Time — 140ns to 0.1%
- Differential Gain Error — 0.1%, ($R_L = 1k$)
- Differential Phase Error — 0.06°, ($R_L = 1k$)
- High Open Loop Gain — 15V/mV Min
- Single Supply +5V Operation
- Output Shutdown

APPLICATIONS

- Video Cable Drivers
- Video Signal Processing
- Fast Integrators
- Pulse Amplifiers
- D/A Current to Voltage Conversion

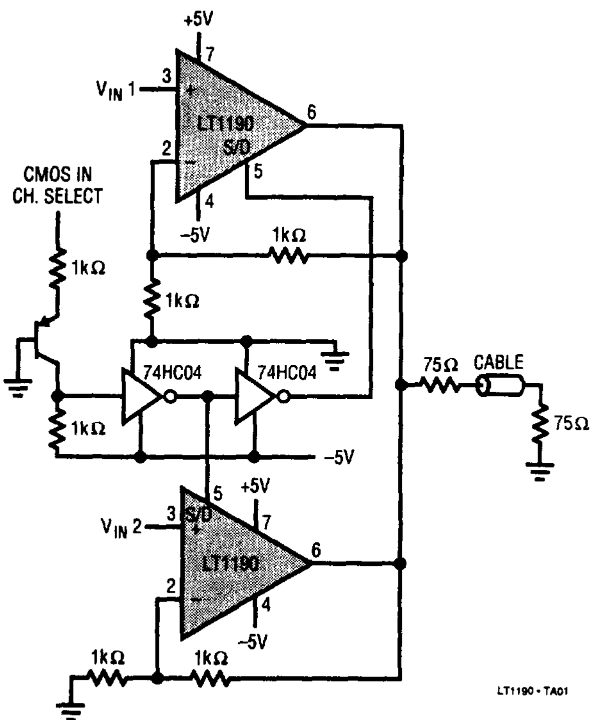
DESCRIPTION

The LT1190 is a video operational amplifier optimized for operation on ±5V, and a single +5V supply. Unlike many high speed amplifiers, this amplifier features high open loop gain, over 85dB, and the ability to drive heavy loads to a full power bandwidth of 20MHz at 7Vp-p. In addition to its very fast slew rate, the LT1190 features a unity gain stable bandwidth of 50MHz, and a 75° phase margin, making it extremely easy to use.

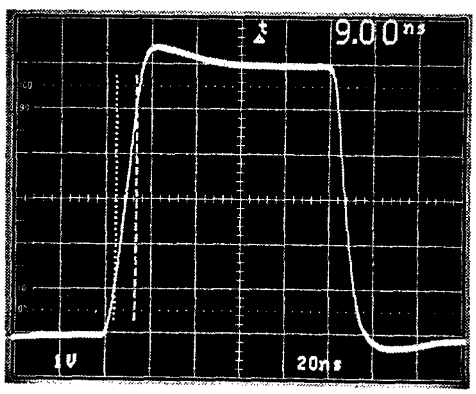
Because the LT1190 is a true operational amplifier, it is an ideal choice for wideband signal conditioning, fast integrators, active filters, and applications requiring speed, accuracy, and low cost.

The LT1190 is available in 8-pin miniDIPs and SO packages with standard pinouts. The normally unused pin 5 is used for a shutdown feature that shuts off the output and reduces power dissipation to a mere 15mW.

Video MUX Cable Driver



Inverter Pulse Response



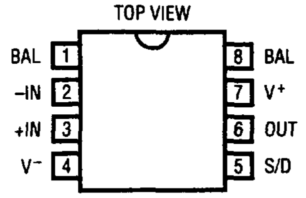
$A_V = -1$, $C_L = 10pF$ SCOPE PROBE

LT1190 • TA02

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V^+ to V^-) 18V
Differential Input Voltage .... ±6V
Input Voltage .... $\pm V_S$
Output Short Circuit Duration (Note 1) .... Continuous
Operating Junction Temperature Range
LT1190M .... −55°C to 150°C
LT1190C .... 0°C to 150°C
Max. Junction Temperature .... See Pkg. Descriptions
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) .... 300°C

PACKAGE/ORDER INFORMATION



J8 PACKAGE
8-LEAD HERMETIC DIP

N8 PACKAGE
8-LEAD PLASTIC DIP

S8 PACKAGE
8-LEAD PLASTIC SOIC

LT1190 • POI01

ORDER PART NUMBER
LT1190MJ8 LT1190CJ8 LT1190CN8 LT1190CS8
S8 PART MARKING
1190

2

ELECTRICAL CHARACTERISTICS $V_S = \pm 5V$, $T_A = 25°C$, $C_L \le 10pF$, pin 5 open circuit unless otherwise noted.

SYMBOL	PARAMETER		CONDITIONS	LT1190M/C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage				3.0	10.0	mV
I_{OS}	Input Offset Current				0.2	1.7	µA
I_B	Input Bias Current				±0.5	±2.5	µA
e_n	Input Noise Voltage		f_O = 10kHz		50		nV/√Hz
i_n	Input Noise Current		f_O = 10kHz		4.0		pA/√Hz
R_{IN}	Input Resistance	Differential Mode			130		kΩ
		Common Mode			5.0		MΩ
C_{IN}	Input Capacitance		A_V = +1		2.2		pF
	Input Voltage Range		(Note 2)	−2.5		+3.5	V
CMRR	Common Mode Rejection Ratio		V_{CM} = −2.5V to +3.5V	60	70		dB
PSRR	Power Supply Rejection Ratio		V_S = ±2.375V to ±8.0V	60	70		dB
A_{VOL}	Large Signal Voltage Gain		R_L = 1k, V_O = ±3.0V	10	22		V/mV
			R_L = 100Ω, V_O = ±3.0V	2.5	6		
			V_S = ±8V, R_L = 100Ω, V_O = ±5V	3.5	12		
V_{OUT}	Output Voltage Swing		V_S = ±5V, R_L = 1k	±3.7	±4.0		V
			V_S = ±8V, R_L = 1k	±6.7	±7.0		
SR	Slew Rate		A_V = −1, R_L = 1k, (Note 3, 8)	325	450		V/µs
FPBW	Full Power Bandwidth		V_O = 6Vp-p, (Note 4)	17.2	23.9		MHz
GBW	Gain Bandwidth Product				50		MHz
t_{r1}, t_{f1}	Rise Time, Fall Time		A_V = +50, V_O = ±1.5V, 20% to 80%, (Note 8)	175	250	325	ns
t_{r2}, t_{f2}	Rise Time, Fall Time		A_V = +1, V_O = ±125mV, 10% to 90%		1.9		ns
t_{PD}	Propagation Delay		A_V = +1, V_O = ±125mV, 50% to 50%		2.4		ns
	Overshoot		A_V = +1, V_O = ±125mV		5		%
t_s	Settling Time		3V Step, 0.1%, (Note 5)		140		ns
Diff A_V	Differential Gain		R_L = 150Ω, A_V = +2, (Note 6)		0.35		%
Diff Ph	Differential Phase		R_L = 150Ω, A_V = +2, (Note 6)		0.16		Deg. p-p

ELECTRICAL CHARACTERISTICS $V_S = \pm5V$, $T_A = 25°C$, $C_L \leq 10pF$, pin 5 open circuit unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1190M/C MIN	LT1190M/C TYP	LT1190M/C MAX	UNITS
I_S	Supply Current			32	38	mA
	Shutdown Supply Current	Pin 5 at V^-		1.3	2.0	mA
$I_{S/D}$	Shutdown Pin Current	Pin 5 at V^-		20	50	µA
t_{on}	Turn On Time	Pin 5 from V^- to Ground, R_L = 1k		100		ns
t_{off}	Turn Off Time	Pin 5 from Ground to V^-, R_L = 1k		400		ns

ELECTRICAL CHARACTERISTICS

$V_S+ = +5V$, $V_S- = 0V$, $V_{CM} = +2.5V$, $T_A = 25°C$, $C_L \leq 10pF$, pin 5 open circuit unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1190M/C MIN	LT1190M/C TYP	LT1190M/C MAX	UNITS
V_{OS}	Input Offset Voltage			3.0	11.0	mV
I_{OS}	Input Offset Current			0.2	1.2	µA
I_B	Input Bias Current			±0.5	±1.5	µA
	Input Voltage Range	(Note 2)	+2.0		+3.5	V
CMRR	Common Mode Rejection Ratio	V_{CM} = +2.0V to +3.5V	55	70		dB
A_{VOL}	Large Signal Voltage Gain	R_L = 100Ω to Ground	[illegible]	[illegible]		[illegible]

ELECTRICAL CHARACTERISTICS $V_S = \pm5V$, $0°C \le T_A \le 70°C$, pin 5 open circuit unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		LT1190C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●		3.0	11.0	mV
$\Delta V_{OS}/\Delta T$	Input V_{OS} Drift		●		16		µV/°C
I_{OS}	Input Offset Current		●		0.2	1.7	µA
I_B	Input Bias Current		●		±0.5	±2.5	µA
CMRR	Common Mode Rejection Ratio	$V_{CM} = -2.5V$ to $+3.5V$	●	58	70		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm2.375V$ to $\pm5.0V$	●	58	70		dB
A_{VOL}	Large Signal Voltage Gain	$R_L = 1k$, $V_O = \pm3.0V$	●	9	20		V/mV
		$R_L = 100\Omega$, $V_O = \pm3.0V$	●	2.0	6.0		
V_{OUT}	Output Voltage Swing	$R_L = 1k$	●	±3.70	±3.9		V
I_S	Supply Current		●		32	38	mA
	Shutdown Supply Current	Pin 5 at V^-, (Note 7)	●		1.4	2.1	mA
$I_{S/D}$	Shutdown Pin Current	Pin 5 at V^-	●		20		µA

The ● denotes the specifications which apply over the full operating temperature range.

Note 1: A heat sink is required to keep the junction temperature below absolute maximum when the output is shorted.

Note 2: Exceeding the input common mode range may cause the output to invert.

Note 3: Slew rate is measured between ±1V on the output, with a ±3V input step.

Note 4: Full power bandwidth is calculated from the slew rate measurement: $FPBW = SR/2\pi Vp$.

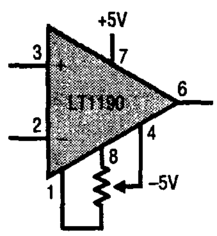
Note 5: Settling time measurement techniques are shown in "Take the Guesswork Out of Settling Time Measurements," EDN, September 19, 1985. $A_V = -1$, $R_L = 1k$.

Note 6: NTSC (3.58MHz). For $R_L = 1k$, Diff $A_V = 0.1\%$, Diff Ph = 0.06°.

Note 7: See Applications section for shutdown at elevated temperatures. Do not operate the shutdown above $T_J > 125°C$.

Note 8: AC parameters are 100% tested on the ceramic and plastic DIP packaged parts (J and N suffix) and are sample tested on every lot of the SO packaged parts (S suffix).

Optional Offset Nulling Circuit

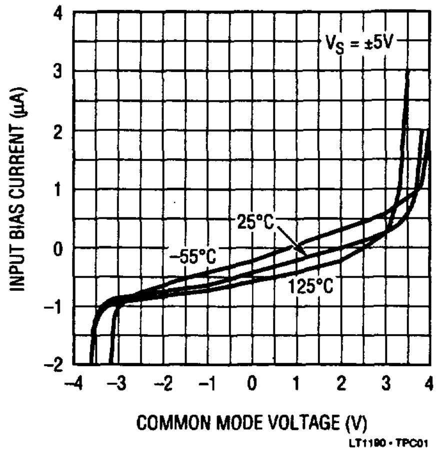


INPUT OFFSET VOLTAGE CAN BE ADJUSTED OVER A ±150mV RANGE WITH A 1kΩ TO 10kΩ POTENTIOMETER.

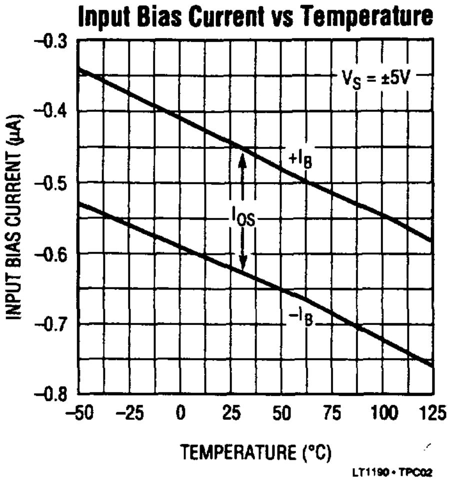
LT1190 • TA03

TYPICAL PERFORMANCE CHARACTERISTICS

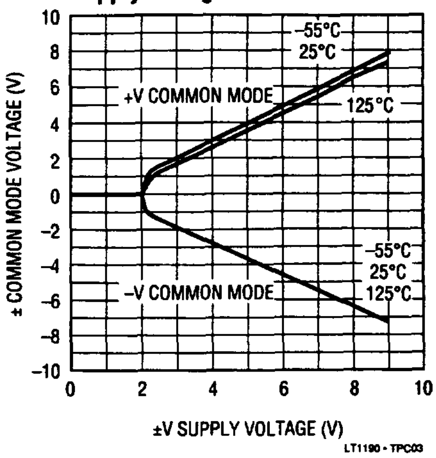
Input Bias Current vs Common Mode Voltage



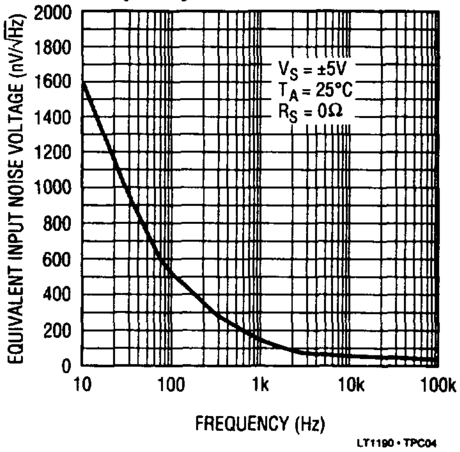
Input Bias Current vs Temperature



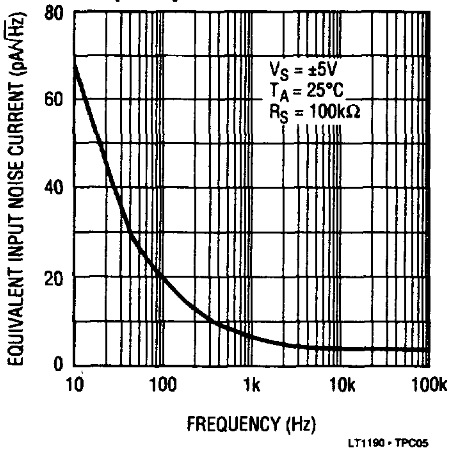
Common Mode Voltage vs Supply Voltage



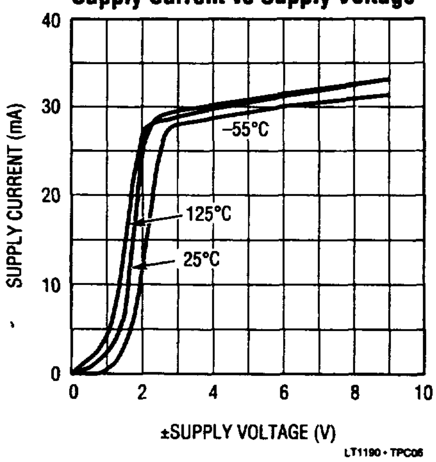
Equivalent Input Noise Voltage vs Frequency



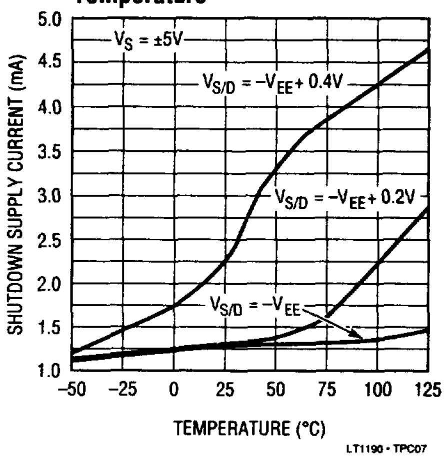
Equivalent Input Noise Current vs Frequency



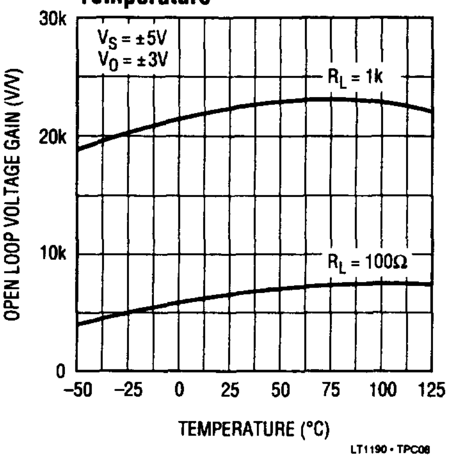
Supply Current vs Supply Voltage



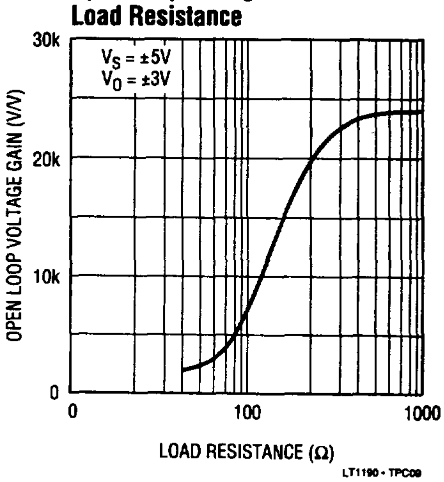
Shutdown Supply Current vs Temperature



Open Loop Voltage Gain vs Temperature



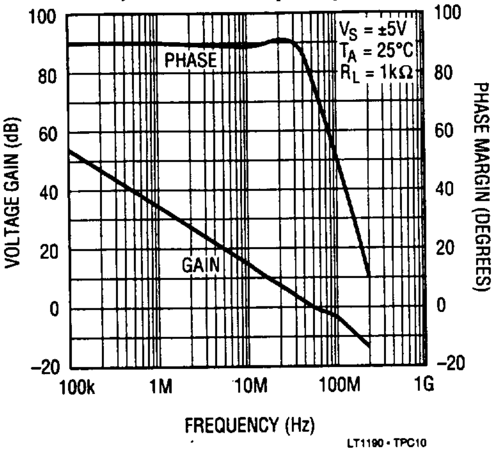
Open Loop Voltage Gain vs Load Resistance



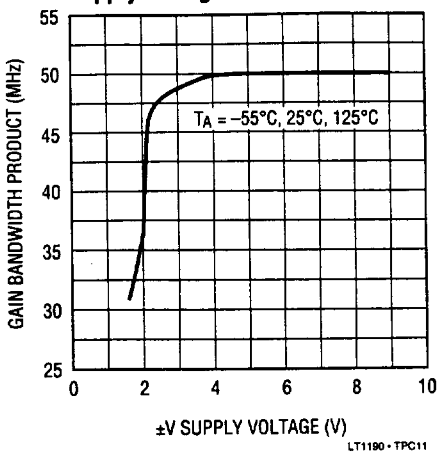
LINEAR TECHNOLOGY

TYPICAL PERFORMANCE CHARACTERISTICS

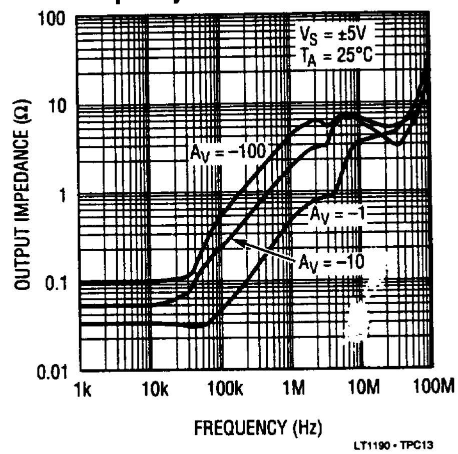
Gain, Phase vs Frequency



Gain Bandwidth Product vs Supply Voltage



Output Impedance vs Frequency



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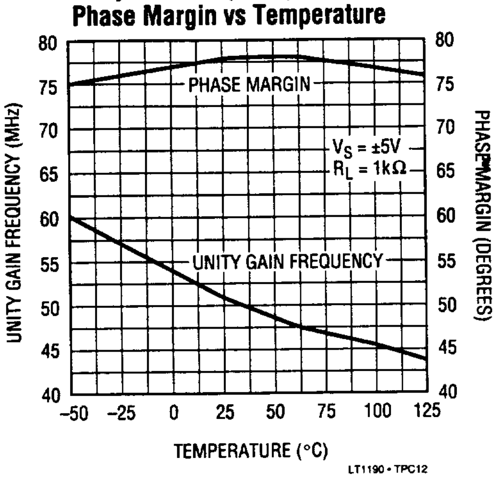
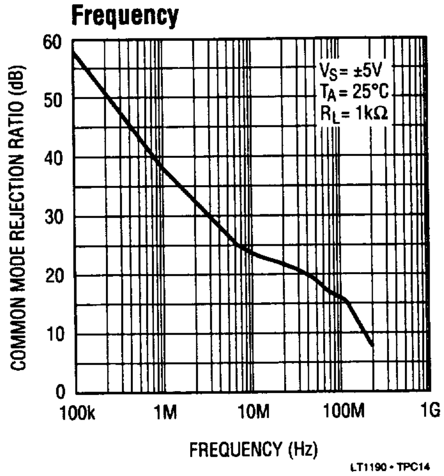
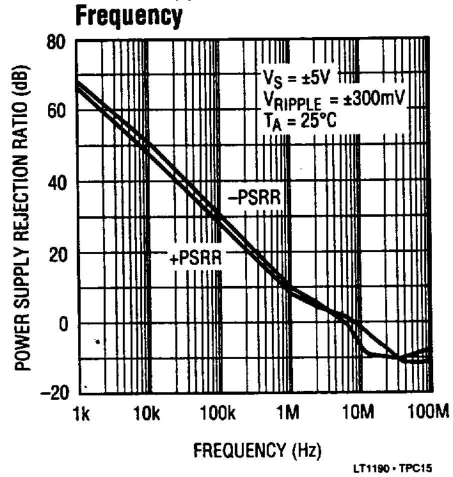
Unity Gain Frequency and Phase Margin vs Temperature



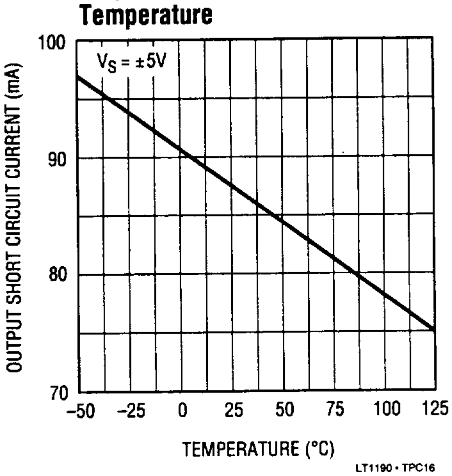
Common Mode Rejection Ratio vs Frequency



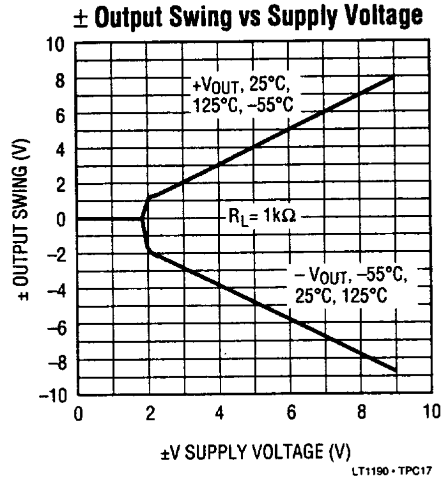
Power Supply Rejection Ratio vs Frequency



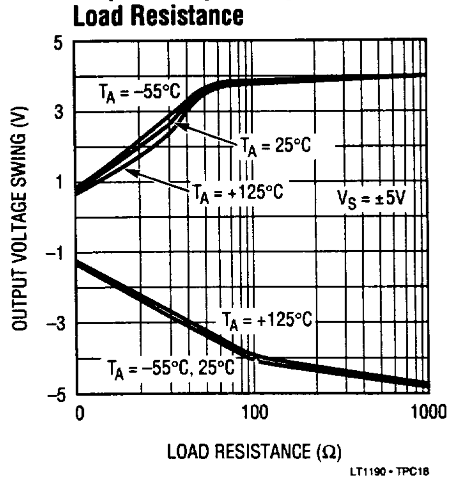
Output Short Circuit Current vs Temperature



± Output Swing vs Supply Voltage

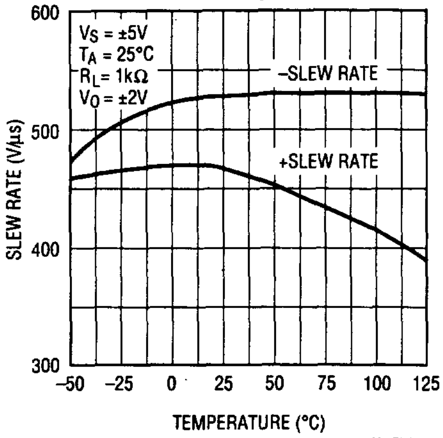


Output Voltage Swing vs Load Resistance



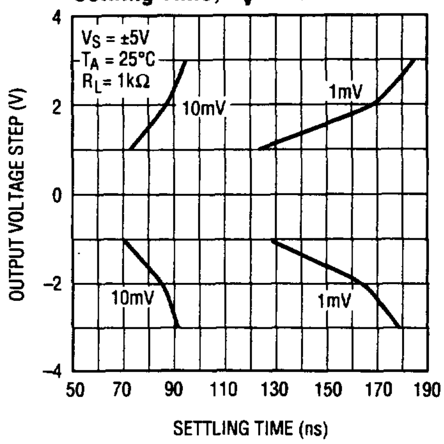
TYPICAL PERFORMANCE CHARACTERISTICS

Slew Rate vs Temperature



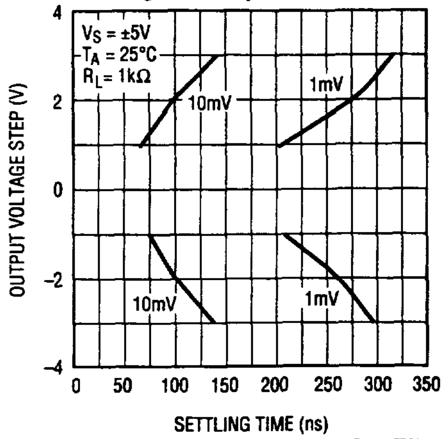
LT1190 • TPC19

Output Voltage Step vs Settling Time, A_V = –1



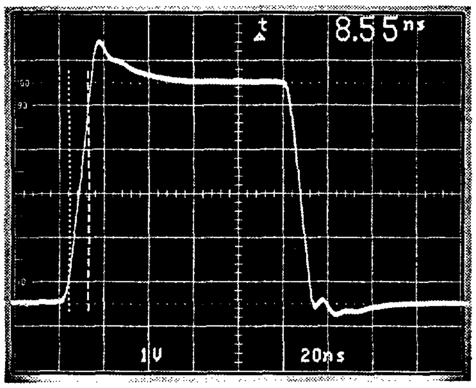
LT1190 • TPC20

Output Voltage Step vs Settling Time, A_V = +1



LT1190 • TPC21

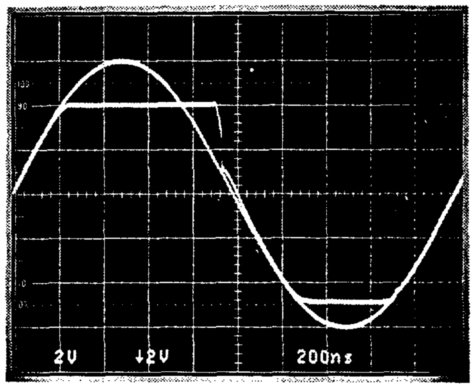
Large Signal Transient Response



A_V = +1, C_L = 10pF SCOPE PROBE

LT1190 • TPC22

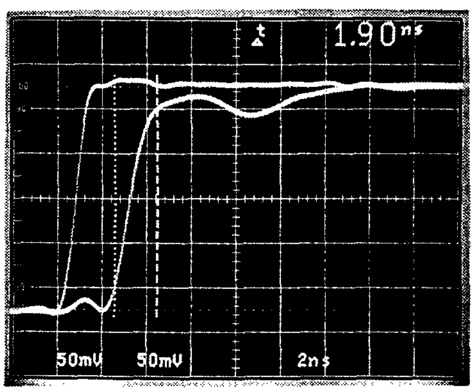
Output Overload



A_V = –1, V_{IN} = 12Vp-p

LT1190 • TPC23

Small Signal Transient Response



A_V = +1, SMALL SIGNAL RISE TIME, WITH FET PROBES

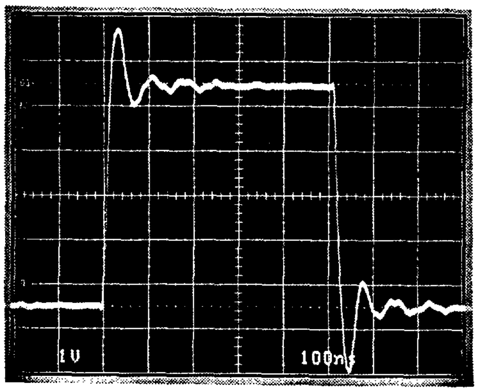
LT1190 • TPC24

APPLICATIONS INFORMATION

Power Supply Bypassing

The LT1190 is quite tolerant of power supply bypassing. In some applications a 0.1µF ceramic disc capacitor placed 1/2 inch from the amplifier is all that is required. A scope photo of the amplifier output with no supply bypassing is used to demonstrate this bypassing tolerance, R_L = 1kΩ.

No Supply Bypass Capacitors

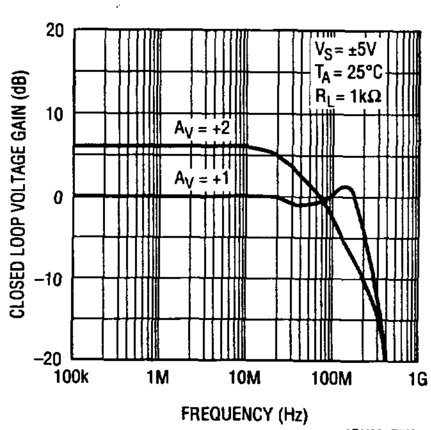


A_V = –1, IN DEMO BOARD, R_L = 1kΩ

LT1190 • TA04

Supply bypassing can also affect the response in the frequency domain. It is possible to see a slight 1dB rise in the frequency response at 130MHz depending on the gain configuration, supply bypass, inductance in the supply leads, and printed circuit board layout. This can be further minimized by not using a socket.

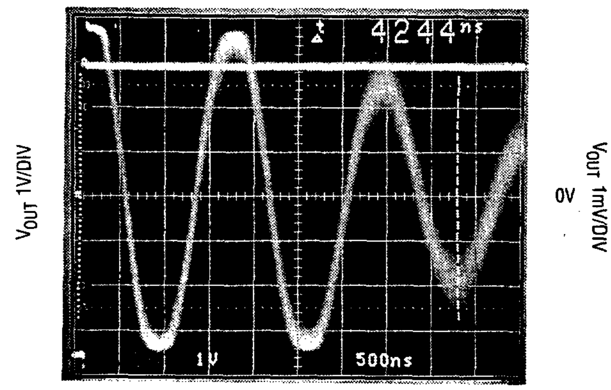
Closed Loop Voltage Gain vs Frequency



LT1190 • TA05

In most applications, and those requiring good settling time, it is important to use multiple bypass capacitors. A 0.1µF ceramic disc in parallel with a 4.7µF tantalum is recommended. Two oscilloscope photos with different bypass conditions are used to illustrate the settling time characteristics of the amplifier. Note that although the output waveform looks acceptable at 1V/div, when amplified to 1mV/div the settling time to 2mV is 4.244µs for the 0.1µF bypass; the time drops to 163ns with multiple bypass capacitors.

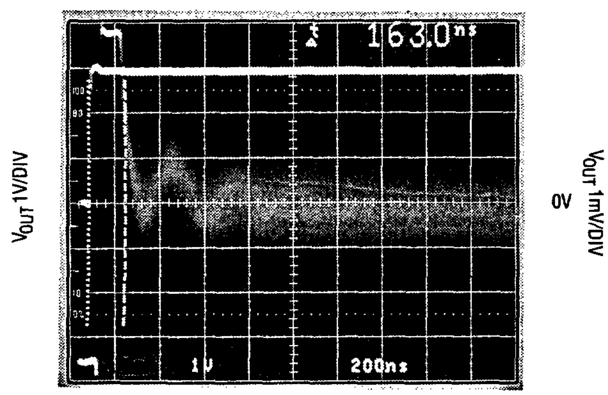
Settling Time Poor Bypass



SETTLING TIME TO 2mV, A_V = –1
SUPPLY BYPASS CAPACITORS = 0.1µF

LT1190 • TA06

Settling Time Good Bypass



SETTLING TIME TO 2mV, A_V = –1
SUPPLY BYPASS CAPACITORS = 0.1µF + 4.7µF TANTALUM

LT1190 • TA07

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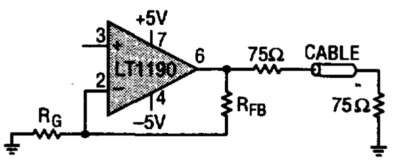
APPLICATIONS INFORMATION

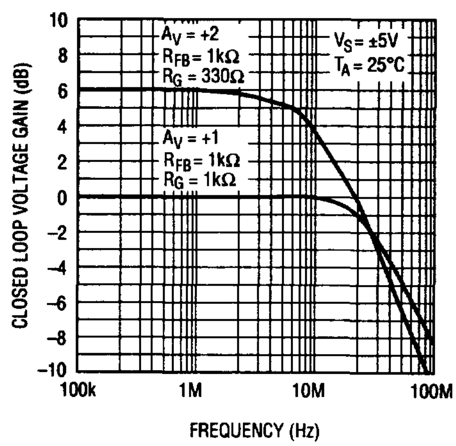
Cable Terminations

The LT1190 operational amplifier has been optimized as a low cost video cable driver. The ±50mA guaranteed output current enables the LT1190 to easily deliver 7.5Vp-p into 100Ω, while operating on ±5V supplies, or 2.6Vp-p on a single 5V supply.

Double Terminated Cable Driver



Cable Driver Voltage Gain vs Frequency

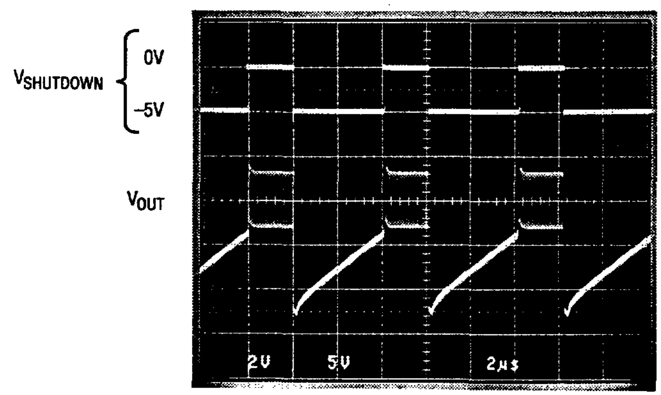


When driving a cable it is important to terminate the cable to avoid unwanted reflections. This can be done in one of two ways: single termination or double termination. With single termination, the cable must be terminated at the receiving end (75Ω to ground) to absorb unwanted energy. The best performance can be obtained by double termination (75Ω in series with the output of the amplifier, and 75Ω to ground at the other end of the cable). This termination is preferred because reflected energy is absorbed at each end of the cable. When using the double termination technique it is important to note that the signal is attenuated by a factor of 2, or 6dB. This can be compensated for by taking a gain of 2, or 6dB in the amplifier. The cable driver has a –3dB bandwidth in excess of 30MHz while driving the 150Ω load.

Using the Shutdown Feature

The LT1190 has a unique feature that allows the amplifier to be shutdown for conserving power, or for multiplexing several amplifiers onto a common cable. The amplifier will shutdown by taking pin 5 to V^-. In shutdown, the amplifier dissipates 15mW while maintaining a true high impedance output state of 15kΩ in parallel with the feedback resistors. The amplifiers must be used in a non-inverting configuration for MUX applications. In inverting configurations the input signal is fed to the output through the feedback components. The following scope photos show that with very high R_L, the output is truly high impedance; the output slowly decays toward ground. Additionally, when the output is loaded with as little as 1kΩ the amplifier shuts off in 400ns. This shutoff can be under the control of HC CMOS operating between 0V and –5V.

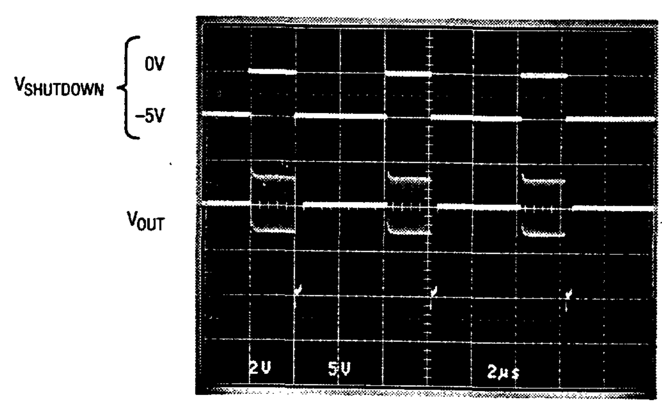
Output Shutdown



1MHz SINE WAVE GATED OFF WITH SHUTDOWN PIN, $A_V = +1$, R_L = SCOPE PROBE

LT1190 • TA09

Output Shutdown



1MHz SINE WAVE GATED OFF WITH SHUTDOWN PIN, $A_V = +1$, $R_L = 1k\Omega$

LT1190 • TA10

APPLICATIONS INFORMATION

The ability to maintain shutoff is shown on the curve Shutdown Supply Current vs Temperature in the Typical Performance Characteristics section. At very high elevated temperatures it is important to hold the shutdown pin close to the negative supply to keep the supply current from increasing.

Murphy Circuits

There are several precautions the user should take when using the LT1190 in order to realize its full capability. Although the LT1190 can drive a 50pF load, isolating the capacitance with 10Ω can be helpful. Precautions primarily have to do with driving large capacitive loads.

Other precautions include:

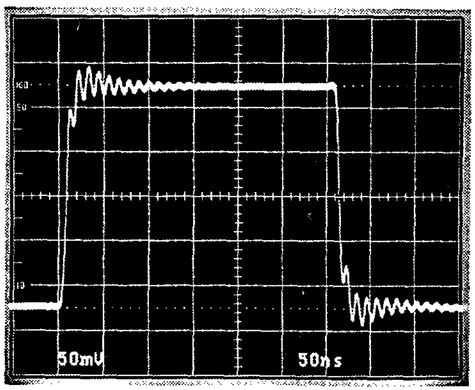
1. Use a ground plane (see Design Note 50, High Frequency Amplifier Evaluation Board).

2. Do not use high source impedances. The input capacitance of 2pF, and R_S = 10kΩ for instance, will give an 8MHz –3dB bandwidth.

3. PC board socket may reduce stability.

4. A feedback resistor of 1kΩ or lower reduces the effects of stray capacitance at the inverting input. (For instance, closed loop gain of +2 can use R_{FB} = 300Ω and R_G = 300Ω.)

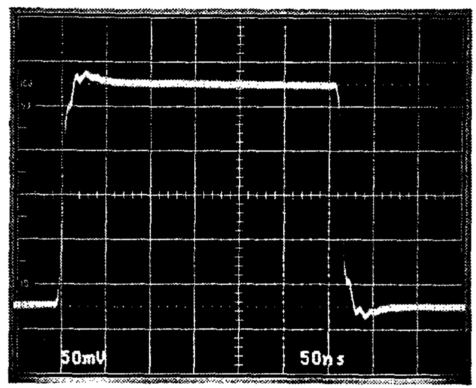
Driving Capacitive Load



A_V = –1, IN DEMO BOARD, C_L = 50pF

LT1190 • TA11

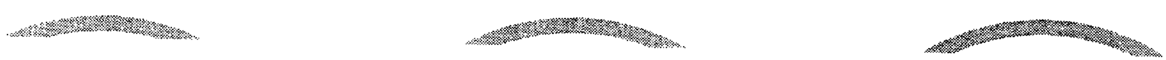
Driving Capacitive Load



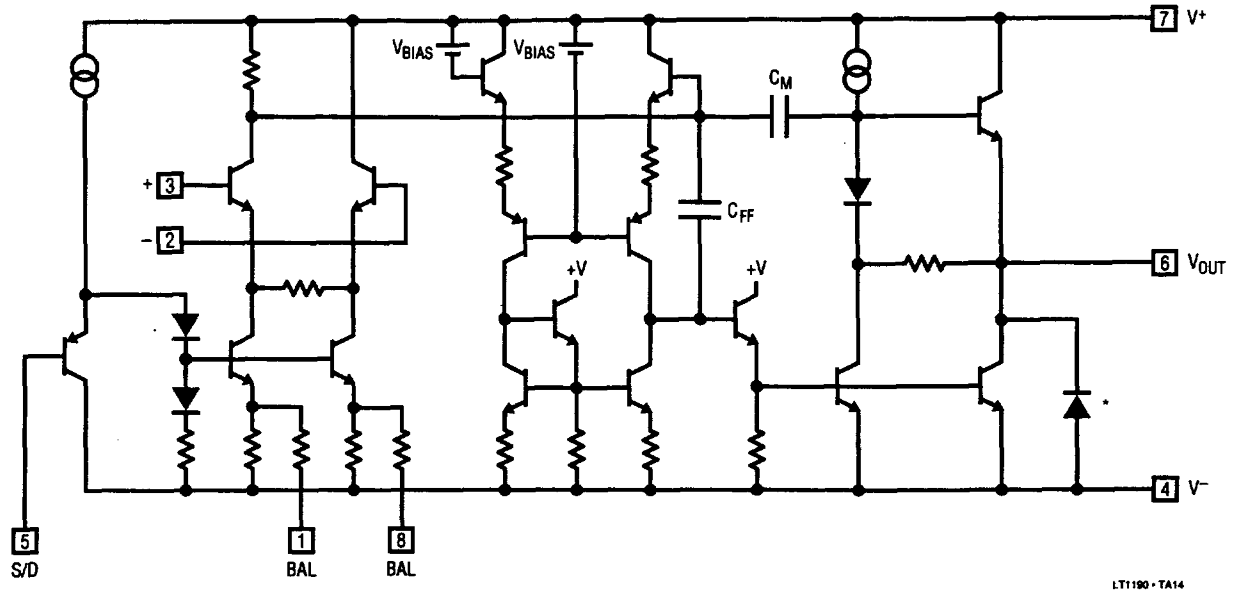
A_V = –1, IN DEMO BOARD, C_L = 50pF WITH 10Ω ISOLATING RESISTOR

LT1190 • TA12

Murphy Circuits



SIMPLIFIED SCHEMATIC



* SUBSTRATE DIODE, DO NOT FORWARD BIAS