

# Low Power Video Difference Amplifier

## FEATURES

- Differential or Single-Ended Gain Block (Adjustable)
- -3dB Bandwidth,  $A_V = \pm 2$ : 50MHz
- Slew Rate: 165V/ $\mu$ s
- Low Supply Current: 13mA
- Output Current:  $\pm 20$ mA
- CMRR at 10MHz: 40dB
- LT1193 Pin Compatible
- Low Cost
- Single 5V Operation
- Drives Cables Directly
- Output Shutdown
- Available in 8-Lead PDIP and SO Packages

## APPLICATIONS

- Line Receivers
- Video Signal Processing
- Cable Drivers
- Tape and Disc Drive Systems

## DESCRIPTION

The LT<sup>®</sup>1187 is a difference amplifier optimized for operation on  $\pm 5$ V, or a single 5V supply and gain  $\geq 2$ . This versatile amplifier features uncommitted high input impedance (+) and (-) inputs, and can be used in differential or single-ended configurations. Additionally, a second set of inputs give gain adjustment and DC control to the difference amplifier.

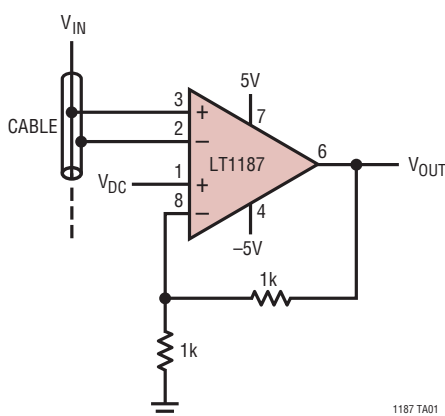
The LT1187's high slew rate, 165V/ $\mu$ s, wide bandwidth, 50MHz, and  $\pm 20$ mA output current require only 13mA of supply current. The shutdown feature reduces the power dissipation to a mere 15mW and allows multiple amplifiers to drive the same cable.

The LT1187 is a low power version of the popular LT1193, and is available in 8-pin miniDIPs and SO packages. For applications with gains of 10 or more, see the LT1189 data sheet.

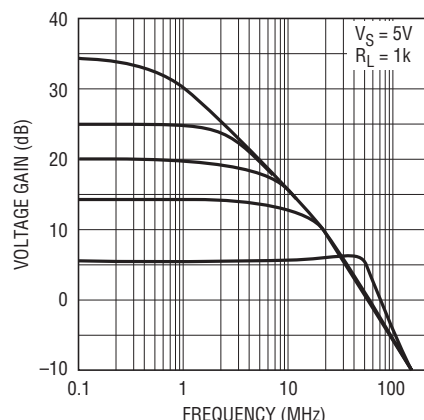
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## TYPICAL APPLICATION

### Cable Sense Amplifier for Loop Through Connections with DC Adjust



### Closed-Loop Gain vs Frequency



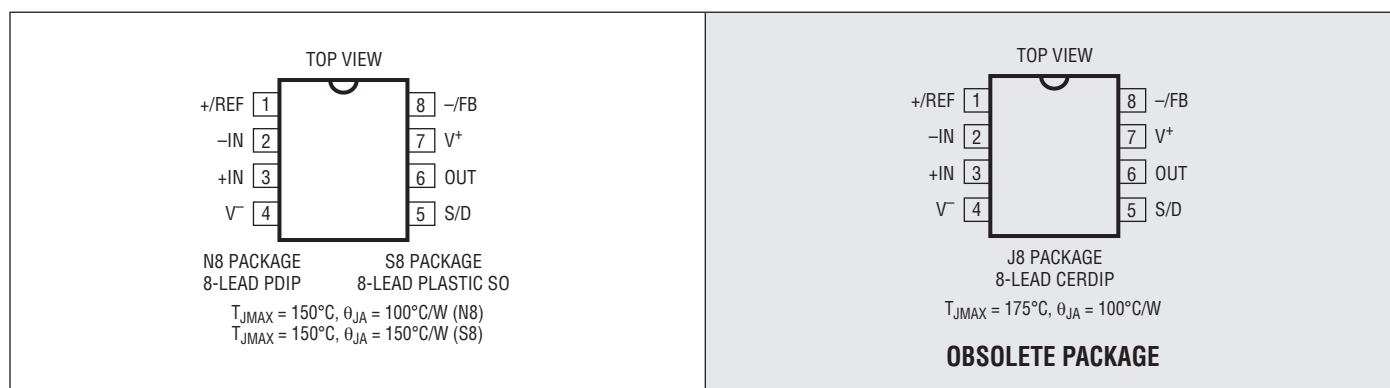
# LT1187

## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                                               |                |
|-----------------------------------------------|----------------|
| Total Supply Voltage ( $V^+$ to $V^-$ ) ..... | 18V            |
| Differential Input Voltage .....              | $\pm 6V$       |
| Input Voltage.....                            | $\pm V_S$      |
| Output Short-Circuit Duration (Note 2) .....  | Continuous     |
| Operating Temperature Range                   |                |
| LT1187C .....                                 | 0°C to 70°C    |
| LT1187I .....                                 | -40°C to 85°C  |
| LT1187M ( <b>OBSOLETE</b> ).....              | -55°C to 150°C |

|                                                      |                |
|------------------------------------------------------|----------------|
| Junction Temperature (Note 3)                        |                |
| Plastic Packages (CN8, CS8) .....                    | 150°C          |
| Ceramic Packages (CJ8, MJ8) ( <b>OBSOLETE</b> )..... | 175°C          |
| Storage Temperature Range .....                      | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec).....            | 300°C          |

## PIN CONFIGURATION



## ORDER INFORMATION <http://www.linear.com/product/LT1187#orderinfo>

| LEAD FREE FINISH        | TAPE AND REEL   | PART MARKING* | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|-------------------------|-----------------|---------------|---------------------|-------------------|
| LT1187CN8#PBF           | LT1187CN8#TRPBF | 1187          | 8-Lead PDIP         | 0°C to 70°C       |
| LT1187CS8#PBF           | LT1187CS8#TRPBF | 1187          | 8-Lead Plastic SO   | 0°C to 70°C       |
| LT1187IN8#PBF           | LT1187IN8#TRPBF | 1187          | 8-Lead PDIP         | -40°C to 85°C     |
| <b>OBSOLETE PACKAGE</b> |                 |               |                     |                   |
| LT1187MJ8#PBF           | LT1187MJ8#TRPBF | 1187          | 8-Lead CERDIP       | -55°C to 150°C    |
| LT1187CJ8#PBF           | LT1187CJ8#TRPBF | 1187          | 8-Lead CERDIP       | 175°C             |
| LEAD BASED FINISH       | TAPE AND REEL   | PART MARKING* | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
| LT1187CN8               | LT1187CN8#TR    | 1187          | 8-Lead PDIP         | 0°C to 70°C       |
| LT1187CS8               | LT1187CS8#TR    | 1187          | 8-Lead Plastic SO   | 0°C to 70°C       |
| LT1187IN8               | LT1187IN8#TR    | 1187          | 8-Lead PDIP         | -40°C to 85°C     |
| <b>OBSOLETE PACKAGE</b> |                 |               |                     |                   |
| LT1187MJ8               | LT1187MJ8#TR    | 1187          | 8-Lead CERDIP       | -55°C to 150°C    |
| LT1187CJ8               | LT1187CJ8#TR    | 1187          | 8-Lead CERDIP       | 175°C             |

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

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreel/>. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

**±5V ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ\text{C}$  (Note 4) $V_S = \pm 5\text{V}$ ,  $V_{\text{REF}} = 0\text{V}$ ,  $R_{\text{FB1}} = 900\Omega$  from Pins 6 to 8,  $R_{\text{FB2}} = 100\Omega$  from Pin 8 to ground,  $R_L = R_{\text{FB1}} + R_{\text{FB2}} = 1\text{k}$ ,  $C_L \leq 10\text{pF}$ , Pin 5 open.

| SYMBOL              | PARAMETERS                   | CONDITIONS                                                        | LT1187C/I/M |            |           | UNITS                        |
|---------------------|------------------------------|-------------------------------------------------------------------|-------------|------------|-----------|------------------------------|
|                     |                              |                                                                   | MIN         | MAX        | MAX       |                              |
| $V_{\text{OS}}$     | Input Offset Voltage         | Either Input (Note 5)<br>S8 Package                               |             | 2.0<br>2.0 | 10<br>11  | mV                           |
| $I_{\text{OS}}$     | Input Offset Current         | Either Input                                                      |             | 0.2        | 1.0       | $\mu\text{A}$                |
| $I_{\text{B}}$      | Input Bias Current           | Either Input                                                      |             | $\pm 0.5$  | $\pm 2.0$ | $\mu\text{A}$                |
| $e_n$               | Input Noise Voltage          | $f_0 = 10\text{kHz}$                                              |             | 65         |           | $\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$               | Input Noise Current          | $f_0 = 10\text{kHz}$                                              |             | 1.5        |           | $\text{pA}/\sqrt{\text{Hz}}$ |
| $R_{\text{IN}}$     | Input Resistance             | Differential                                                      |             | 100        |           | $\text{k}\Omega$             |
| $C_{\text{IN}}$     | Input Capacitance            | Either Input                                                      |             | 2.0        |           | pF                           |
| $V_{\text{IN LIM}}$ | Input Voltage Limit          | (Note 6)                                                          |             | $\pm 380$  |           | mV                           |
|                     | Input Voltage Range          |                                                                   | -2.5        |            | 3.5       | V                            |
| CMRR                | Common Mode Rejection Ratio  | $V_{\text{CM}} = -2.5\text{V}$ to $3.5\text{V}$                   | 70          | 100        |           | dB                           |
| PSRR                | Power Supply Rejection Ratio | $V_S = \pm 2.375\text{V}$ to $\pm 8\text{V}$                      | 70          | 85         |           | dB                           |
| $V_{\text{OUT}}$    | Output Voltage Swing         | $V_S = \pm 5\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$            | $\pm 3.8$   | $\pm 4.0$  |           | V                            |
|                     |                              | $V_S = \pm 8\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$            | $\pm 6.7$   | $\pm 7.0$  |           | V                            |
|                     |                              | $V_S = \pm 8\text{V}$ , $R_L = 300\Omega$ , $A_V = 50$ , (Note 4) | $\pm 6.4$   | $\pm 6.8$  |           | V                            |
| $G_E$               | Gain Error                   | $V_0 = \pm 1\text{V}$ , $A_V = 10$ , $R_L = 1\text{k}$            |             | 0.2        | 1.0       | %                            |
| SR                  | Slew Rate                    | (Notes 7, 11)                                                     | 100         | 165        |           | $\text{V}/\mu\text{s}$       |
| FPBW                | Full Power Bandwidth         | $V_0 = 1V_{\text{P-P}}$ (Note 8)                                  |             | 53         |           | MHz                          |
| BW                  | Small-Signal Bandwidth       | $A_V = 10$                                                        |             | 5.7        |           | MHz                          |
| $t_r$ , $t_f$       | Rise Time, Fall Time         | $A_V = 50$ , $V_0 = \pm 1.5\text{V}$ , 20% to 80% (Note 11)       | 150         | 230        | 325       | ns                           |
| $t_{\text{PD}}$     | Propagation Delay            | $R_L = 1\text{k}$ , $V_0 = \pm 125\text{mV}$ , 50% to 50%         |             | 26         |           | ns                           |
|                     | Overshoot                    | $V_0 = \pm 50\text{mV}$                                           |             | 0          |           | %                            |
| $t_s$               | Settling Time                | 3V Step, 0.1% (Note 9)                                            |             | 100        |           | ns                           |
| Diff AV             | Differential Gain            | $R_L = 1\text{k}$ , $A_V = 4$ (Note 10)                           |             | 0.6        |           | %                            |
| Diff Ph             | Differential Phase           | $R_L = 1\text{k}$ , $A_V = 4$ (Note 10)                           |             | 0.8        |           | DEG <sub>P-P</sub>           |
| $I_S$               | Supply Current               |                                                                   |             | 13         | 16        | mA                           |
|                     | Shutdown Supply Current      | Pin 5 at $V^-$                                                    |             | 0.8        | 1.5       | mA                           |
| $I_{\text{S/D}}$    | Shutdown Pin Current         | Pin 5 at $V^-$                                                    |             | 5          | 25        | $\mu\text{A}$                |
| $t_{\text{ON}}$     | Turn-On Time                 | Pin 5 from $V^-$ to Ground, $R_L = 1\text{k}$                     |             | 500        |           | ns                           |
| $t_{\text{OFF}}$    | Turn-On Time                 | Pin 5 from Ground to $V^-$ , $R_L = 1\text{k}$                    |             | 600        |           | ns                           |

**5V ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ\text{C}$  (Note 4)

$V_S^+ = 5\text{V}$ ,  $V_S^- = 0\text{V}$ ,  $V_{\text{REF}} = 2.5\text{V}$ ,  $R_{\text{FB1}} = 900\Omega$  from Pins 6 to 8,  $R_{\text{FB2}} = 100\Omega$  from Pin 8 to  $V_{\text{REF}}$ ,  $R_L = R_{\text{FB1}} + R_{\text{FB2}} = 1\text{k}$ ,  $C_L \leq 10\text{pF}$ , Pin 5 open.

| SYMBOL           | PARAMETER                   | CONDITIONS                                  |                       | LT1187C/I/M |      |      | UNITS |
|------------------|-----------------------------|---------------------------------------------|-----------------------|-------------|------|------|-------|
|                  |                             |                                             |                       | MIN         | TYP  | MAX  |       |
| V <sub>OS</sub>  | Input Offset Voltage        | Either Input (Note 5)<br>SO Package         |                       |             | 2.0  | 10   | mV    |
|                  |                             |                                             |                       |             | 2.0  | 12   | mV    |
| I <sub>OS</sub>  | Input Offset Current        | Either Input                                |                       |             | 0.2  | 1.0  | μA    |
| I <sub>B</sub>   | Input Bias Current          | Either Input                                |                       |             | ±0.5 | ±2.0 | μA    |
|                  | Input Voltage Range         |                                             |                       | 2.0         |      | 3.5  | V     |
| CMRR             | Common Mode Rejection Ratio | V <sub>CM</sub> = 2.0V to 3.5V              |                       | 70          | 100  |      | dB    |
| V <sub>OUT</sub> | Output Voltage Swing        | R <sub>L</sub> = 300Ω to Ground<br>(Note 4) | V <sub>OUT</sub> High | 3.6         | 4.0  |      | V     |
|                  |                             |                                             | V <sub>OUT</sub> Low  |             | 0.15 | 0.4  | V     |
| SR               | Slew Rate                   | V <sub>O</sub> = 1.5V to 3.5V               |                       |             | 130  |      | V/μs  |
| BW               | Small-Signal Bandwidth      | A <sub>V</sub> = 10                         |                       |             | 5.3  |      | MHz   |
| I <sub>S</sub>   | Supply Current              |                                             |                       |             | 12   | 15   | mA    |
|                  | Shutdown Supply Current     | Pin 5 at V–                                 |                       |             | 0.8  | 1.5  | mA    |
| I <sub>S/D</sub> | Shutdown Pin Current        | Pin 5 at V–                                 |                       |             | 5    | 25   | μA    |

 **$\pm 5\text{V}$  ELECTRICAL CHARACTERISTICS**  $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$  (Note 4)

$V_S = \pm 5\text{V}$ ,  $V_{\text{REF}} = 0\text{V}$ ,  $R_{\text{FB1}} = 900\Omega$  from Pins 6 to 8,  $R_{\text{FB2}} = 100\Omega$  from Pin 8 to ground,  $R_L = R_{\text{FB1}} + R_{\text{FB2}} = 1\text{k}$ ,  $C_L \leq 10\text{pF}$ , Pin 5 open.

| SYMBOL                          | PARAMETER                    | CONDITIONS                                                      | LT1187M   |           |           | UNITS                |
|---------------------------------|------------------------------|-----------------------------------------------------------------|-----------|-----------|-----------|----------------------|
|                                 |                              |                                                                 | MIN       | TYP       | MAX       |                      |
| $V_{\text{OS}}$                 | Input Offset Voltage         | Either Input (Note 5)                                           |           | 2.0       | 15        | mV                   |
| $\Delta V_{\text{OS}}/\Delta T$ | Input $V_{\text{OS}}$ Drift  |                                                                 |           | 8.0       |           | mV/ $^\circ\text{C}$ |
| $I_{\text{OS}}$                 | Input Offset Current         | Either Input                                                    |           | 0.2       | 1.5       | $\mu\text{A}$        |
| $I_{\text{B}}$                  | Input Bias Current           | Either Input                                                    |           | $\pm 0.5$ | $\pm 3.5$ | $\mu\text{A}$        |
|                                 | Input Voltage Range          |                                                                 | -2.5      |           | 3.5       | V                    |
| CMRR                            | Common Mode Rejection Ratio  | $V_{\text{CM}} = -2.5\text{V}$ to $3.5\text{V}$                 | 70        | 100       |           | dB                   |
| PSRR                            | Power Supply Rejection Ratio | $V_S = \pm 2.375\text{V}$ to $\pm 8\text{V}$                    | 60        | 85        |           | dB                   |
| $V_{\text{OUT}}$                | Output Voltage Swing         | $V_S = \pm 5\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$          | $\pm 3.7$ | $\pm 4.0$ |           | V                    |
|                                 |                              | $V_S = \pm 8\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$          | $\pm 6.6$ | $\pm 7.0$ |           | V                    |
|                                 |                              | $V_S = \pm 8\text{V}$ , $R_L = 300\Omega$ , $A_V = 50$ (Note 4) | $\pm 6.4$ | $\pm 6.8$ |           | V                    |
| $G_E$                           | Gain Error                   | $V_O = \pm 1\text{V}$ , $A_V = 10$ , $R_L = 1\text{k}$          |           | 0.2       | 1.2       | %                    |
| $I_S$                           | Supply Current               |                                                                 |           | 13        | 17        | mA                   |
|                                 | Shutdown Supply Current      | Pin 5 at $V^-$ (Note 12)                                        |           | 0.8       | 1.5       | mA                   |
| $I_{\text{S/D}}$                | Shutdown Pin Current         | Pin 5 at $V^-$                                                  |           | 5         | 25        | $\mu\text{A}$        |

# **±5V ELECTRICAL CHARACTERISTICS** $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ (LT1187C) $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ (LT1187I) (Note 4) $V_S = \pm 5\text{V}$ , $V_{\text{REF}} = 0\text{V}$ , $R_{\text{FB1}} = 900\Omega$ from Pins 6 to 8, $R_{\text{FB2}} = 100\Omega$ from Pin 8 to ground, $R_L = R_{\text{FB1}} + R_{\text{FB2}} = 1\text{k}$ , $C_L \leq 10\text{pF}$ , Pin 5 open.

| SYMBOL                          | PARAMETER                    | CONDITIONS                                                      | LT1187C/I |           |           | UNITS                  |
|---------------------------------|------------------------------|-----------------------------------------------------------------|-----------|-----------|-----------|------------------------|
|                                 |                              |                                                                 | MIN       | TYP       | MAX       |                        |
| $V_{\text{OS}}$                 | Input Offset Voltage         | Either Input (Note 5)                                           |           | 2.0       | 12        | mV                     |
| $\Delta V_{\text{OS}}/\Delta T$ | Input $V_{\text{OS}}$ Drift  |                                                                 |           | 9.0       |           | mV/ $^{\circ}\text{C}$ |
| $I_{\text{OS}}$                 | Input Offset Current         | Either Input                                                    |           | 0.2       | 1.5       | $\mu\text{A}$          |
| $I_{\text{B}}$                  | Input Bias Current           | Either Input                                                    |           | $\pm 0.5$ | $\pm 3.5$ | $\mu\text{A}$          |
|                                 | Input Voltage Range          |                                                                 | -2.5      |           | 3.5       | V                      |
| CMRR                            | Common Mode Rejection Ratio  | $V_{\text{CM}} = -2.5\text{V}$ to $3.5\text{V}$                 | 70        | 100       |           | dB                     |
| PSRR                            | Power Supply Rejection Ratio | $V_S = \pm 2.375\text{V}$ to $\pm 8\text{V}$                    | 65        | 85        |           | dB                     |
| $V_{\text{OUT}}$                | Output Voltage Swing         | $V_S = \pm 5\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$          | $\pm 3.7$ | $\pm 4.0$ |           | V                      |
|                                 |                              | $V_S = \pm 8\text{V}$ , $R_L = 1\text{k}$ , $A_V = 50$          | $\pm 6.6$ | $\pm 7.0$ |           | V                      |
|                                 |                              | $V_S = \pm 8\text{V}$ , $R_L = 300\Omega$ , $A_V = 50$ (Note 4) | $\pm 6.4$ | $\pm 6.8$ |           | V                      |
| $G_E$                           | Gain Error                   | $V_0 = \pm 1\text{V}$ , $A_V = 10$ , $R_L = 1\text{k}$          |           | 0.2       | 1.0       | %                      |
| $I_S$                           | Supply Current               |                                                                 |           | 13        | 17        | mA                     |
|                                 | Shutdown Supply Current      | Pin 5 at $V^-$ (Note 12)                                        |           | 0.8       | 1.5       | mA                     |
| $I_{\text{S/D}}$                | Shutdown Pin Current         | Pin 5 at $V^-$                                                  |           | 5         | 25        | $\mu\text{A}$          |

# **5V ELECTRICAL CHARACTERISTICS** $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ (LT1187C) $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ (LT1187I) (Note 4) $V_S^+ = 5\text{V}$ , $V_S^- = 0\text{V}$ , $V_{\text{REF}} = 2.5\text{V}$ , $R_{\text{FB1}} = 900\Omega$ from Pins 6 to 8, $R_{\text{FB2}} = 100\Omega$ from Pin 8 to $V_{\text{REF}}$ , $R_L = R_{\text{FB1}} + R_{\text{FB2}} = 1\text{k}$ , $C_L \leq 10\text{pF}$ , Pin 5 open.

| SYMBOL                          | PARAMETER                   | CONDITIONS                                     | LT1187C/I |           |           | UNITS                          |
|---------------------------------|-----------------------------|------------------------------------------------|-----------|-----------|-----------|--------------------------------|
|                                 |                             |                                                | MIN       | TYP       | MAX       |                                |
| $V_{\text{OS}}$                 | Input Offset Voltage        | Either Input (Note 5)                          |           | 2.0       | 12.0      | mV                             |
|                                 |                             | SO Package                                     |           | 2.0       | 13.0      | mV                             |
| $\Delta V_{\text{OS}}/\Delta T$ | Input $V_{\text{OS}}$ Drift |                                                |           | 9.0       |           | $\mu\text{V}/^{\circ}\text{C}$ |
| $I_{\text{OS}}$                 | Input Offset Current        | Either Input                                   |           | 0.2       | 1.5       | $\mu\text{A}$                  |
| $I_{\text{B}}$                  | Input Bias Current          | Either Input                                   |           | $\pm 0.5$ | $\pm 3.5$ | $\mu\text{A}$                  |
|                                 | Input Voltage Range         |                                                | 2.0       |           | 3.5       | V                              |
| CMRR                            | Common Mode Rejection Ratio | $V_{\text{CM}} = 2.0\text{V}$ to $3.5\text{V}$ | 70        | 100       |           | dB                             |
| $V_{\text{OUT}}$                | Output Voltage Swing        | $R_L = 300\Omega$ to Ground (Note 4)           |           |           |           |                                |
|                                 |                             | $V_{\text{OUT}}$ High                          | 3.5       | 4.0       |           | V                              |
|                                 |                             | $V_{\text{OUT}}$ Low                           |           | 0.15      | 0.4       | V                              |
| $I_S$                           | Supply Current              |                                                |           | 12        | 16        | mA                             |
|                                 | Shutdown Supply Current     | Pin 5 at $V^-$ (Note 12)                       |           | 0.8       | 1.5       | mA                             |
| $I_{\text{S/D}}$                | Shutdown Pin Current        | Pin 5 at $V^-$                                 |           | 5         | 25        | $\mu\text{A}$                  |

**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:** A heat sink may be required to keep the junction temperature below absolute maximum when the output is shorted continuously.

**Note 3:**  $T_J$  is calculated from the ambient temperature  $T_A$  and power dissipation  $P_D$  according to the following formulas:

$$\text{LT1187MJ8, LT1187CJ8: } T_J = T_A + (P_D \cdot 100^{\circ}\text{C/W})$$

$$\text{LT1187CN8: } T_J = T_A + (P_D \cdot 100^{\circ}\text{C/W})$$

$$\text{LT1187CS8: } T_J = T_A + (P_D \cdot 150^{\circ}\text{C/W})$$

**Note 4:** When  $R_L = 1\text{k}$  is specified, the load resistor is  $R_{\text{FB1}} + R_{\text{FB2}}$ , but when  $R_L = 300\Omega$  is specified, then an additional  $430\Omega$  is added to the output such that  $(R_{\text{FB1}} + R_{\text{FB2}})$  in parallel with  $430\Omega$  is  $R_L = 300\Omega$ .

**Note 5:**  $V_{\text{OS}}$  measured at the output (Pin 6) is the contribution from both input pair and is input referred.

**Note 6:**  $V_{\text{IN LIM}}$  is the maximum voltage between  $-V_{\text{IN}}$  and  $+V_{\text{IN}}$  (Pin 2 and Pin 3) for which the output can respond.

**Note 7:** Slew rate is measured between  $\pm 0.5\text{V}$  on the output, with a  $V_{\text{IN}}$  step of  $\pm 0.75\text{V}$ ,  $A_V = 3$  and  $R_L = 1\text{k}$ .

**Note 8:** Full power bandwidth is calculated from the slew rate measurement:  $\text{FPBW} = \text{SR}/2\pi V_p$ .

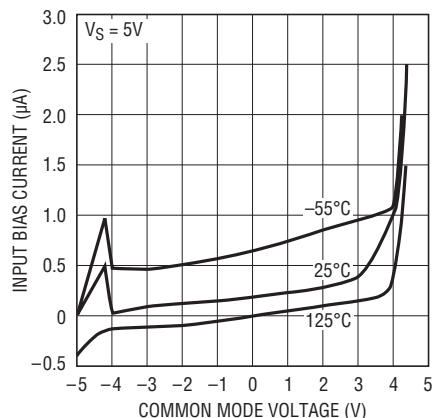
**Note 9:** Settling time measurement techniques are shown in "Take the Guesswork Out of Settling Time Measurements," EDN, September 19, 1985.

**Note 10:** NTSC (3.58MHz).

**Note 11:** AC parameters are 100% tested on the ceramic and plastic DIP packaged parts (J8 and N8 suffix) and are sample tested on every lot of the SO packaged parts (S8 suffix).

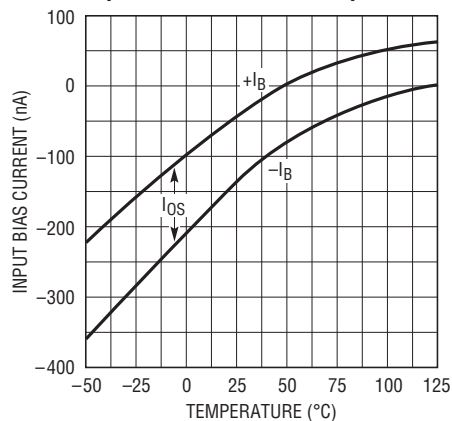
**Note 12:** See Application section for shutdown at elevated temperatures. Do not operate shutdown above  $T_J > 125^{\circ}\text{C}$ .

## TYPICAL PERFORMANCE CHARACTERISTICS

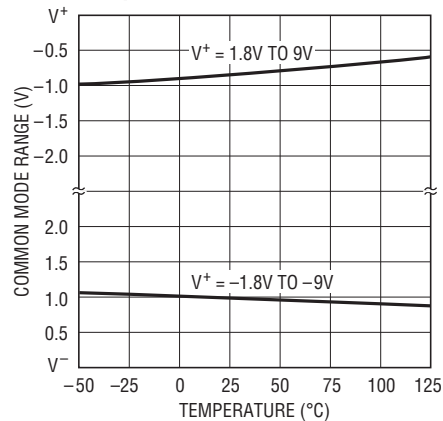
Input Bias Current vs  
Common Mode Voltage

1187 G01

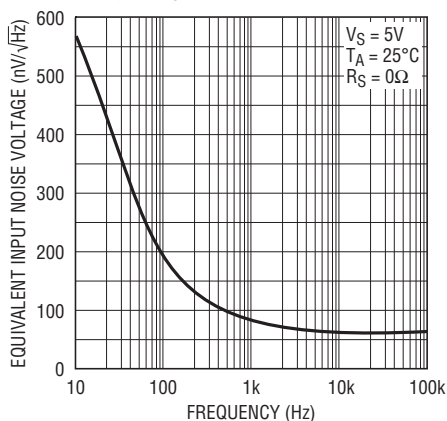
Input Bias Current vs Temperature



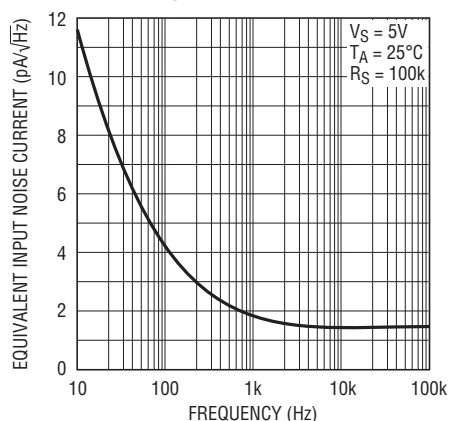
1187 G02

Common Mode Voltage vs  
Temperature

1187 G03

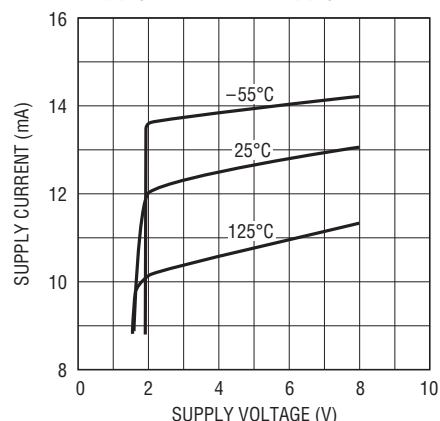
Equivalent Input Noise Voltage vs  
Frequency

1187 G04

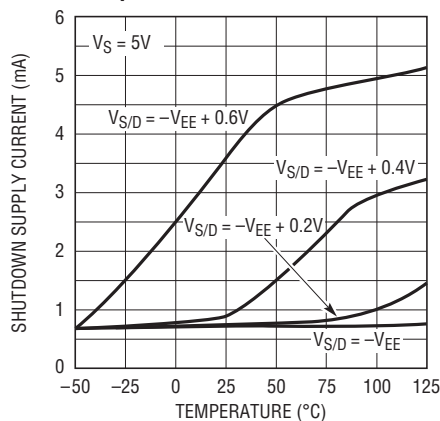
Equivalent Input Noise Current vs  
Frequency

1187 G05

Supply Current vs Supply Voltage

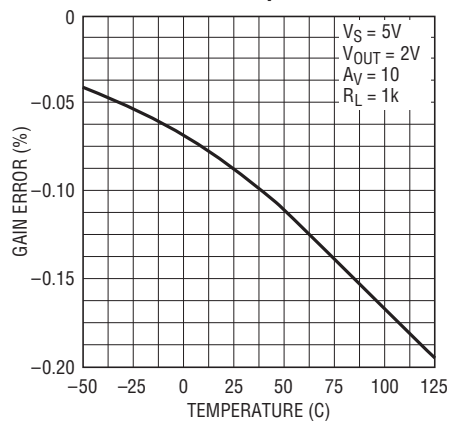


1187 G06

Shutdown Supply Current vs  
Temperature

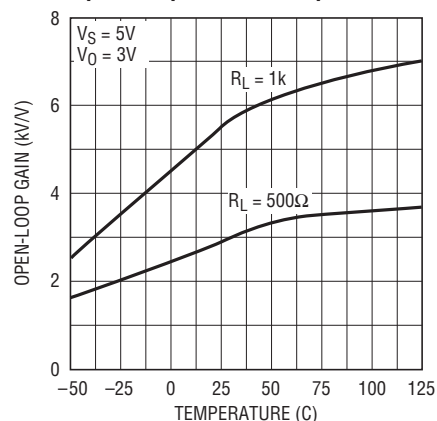
1187 G07

Gain Error vs Temperature



1187 G08

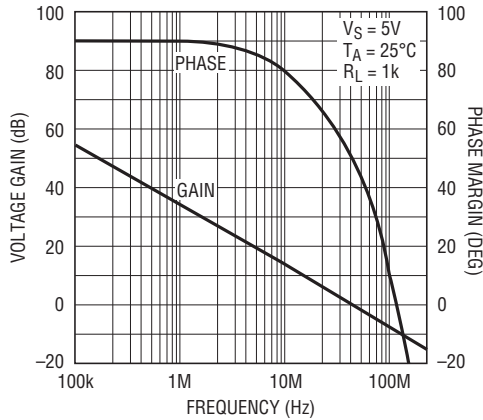
Open-Loop Gain vs Temperature



1187 G09

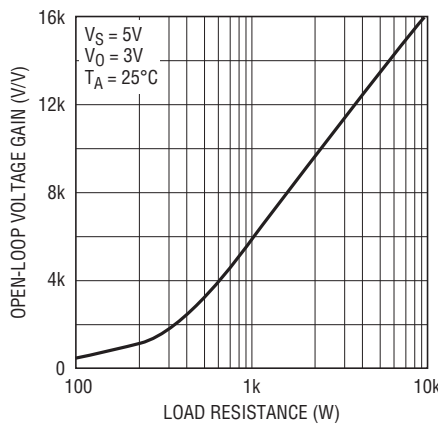
# TYPICAL PERFORMANCE CHARACTERISTICS

Gain, Phase vs Frequency



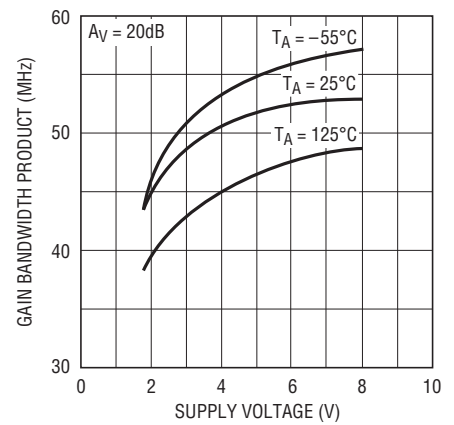
1187 G10

Open-Loop Voltage Gain vs Load Resistance



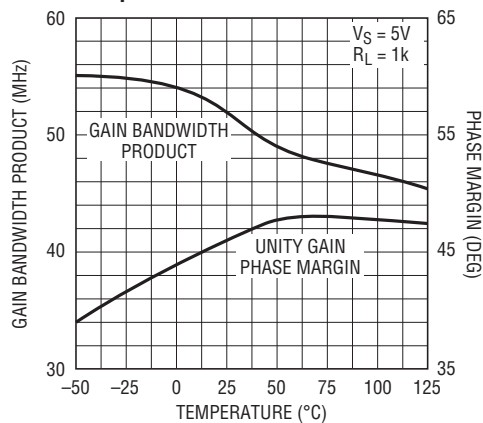
1187 G11

Gain Bandwidth Product vs Supply Voltage



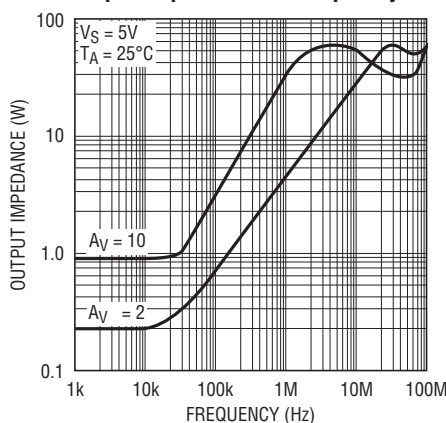
1187 G12

Gain Bandwidth Product and Unity Gain Phase Margin vs Temperature



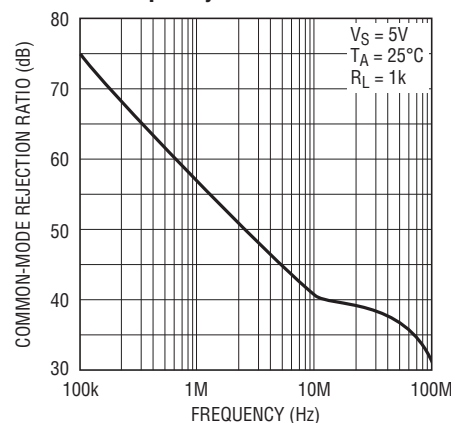
1187 G13

Output Impedance vs Frequency



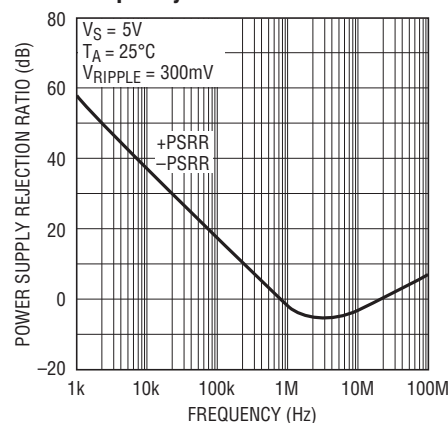
1187 G14

Common Mode Rejection Ratio vs Frequency



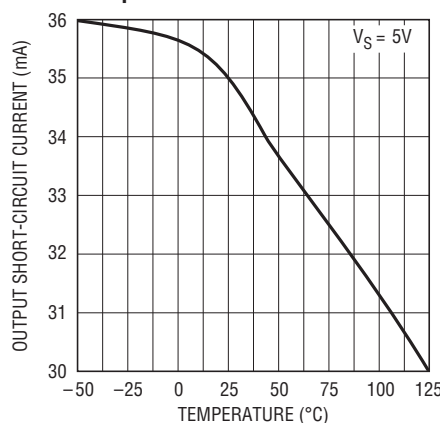
1187 G15

Power Supply Rejection Ratio vs Frequency



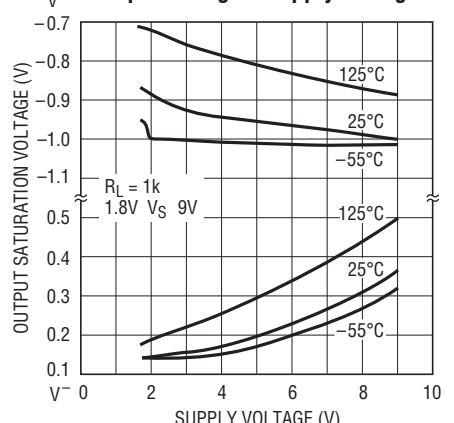
1187 G16

Output Short-Circuit Current vs Temperature



1187 G17

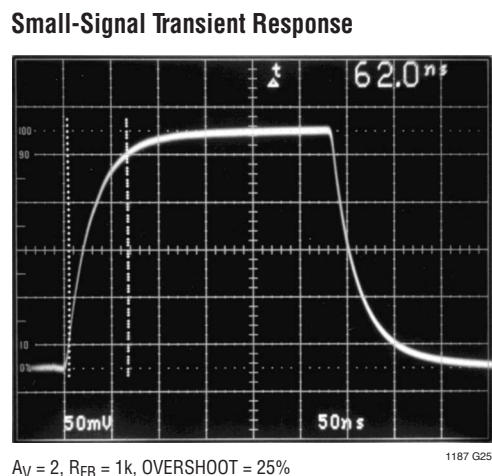
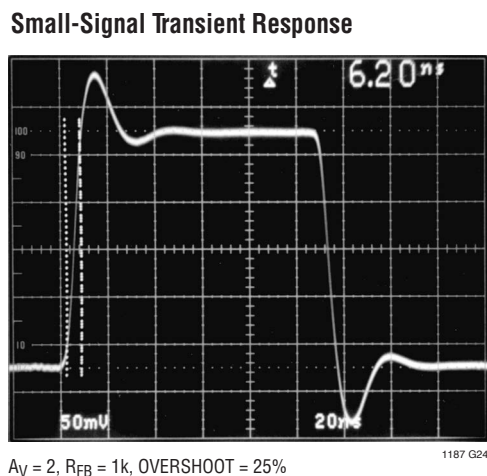
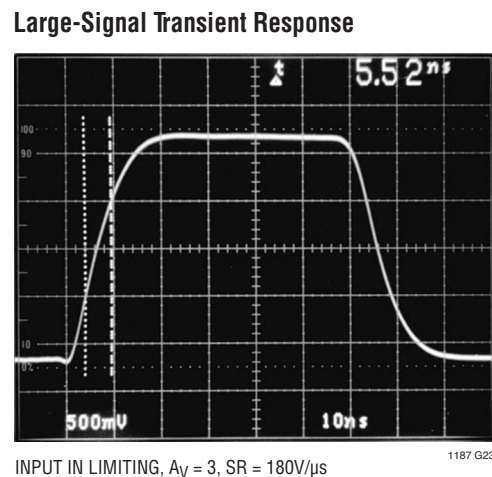
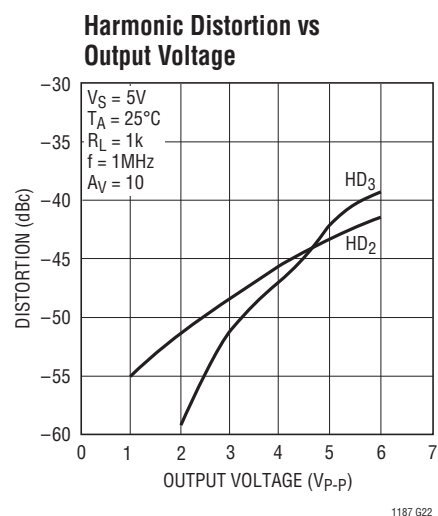
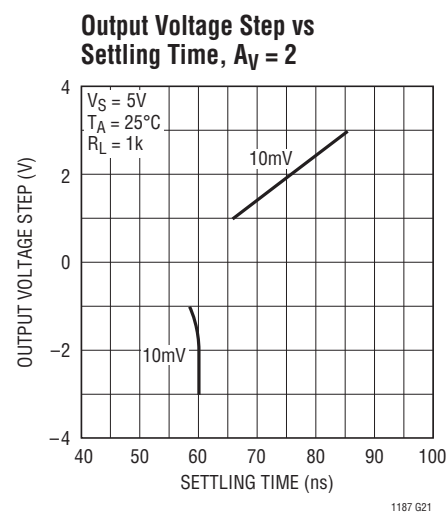
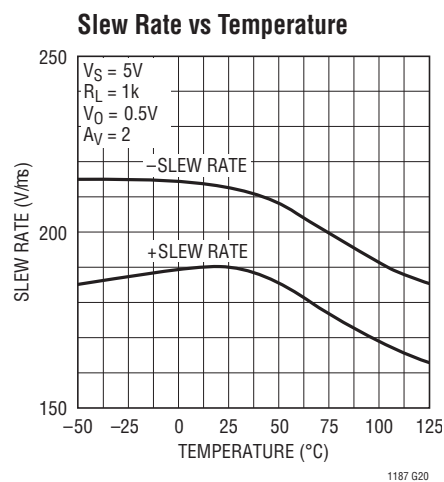
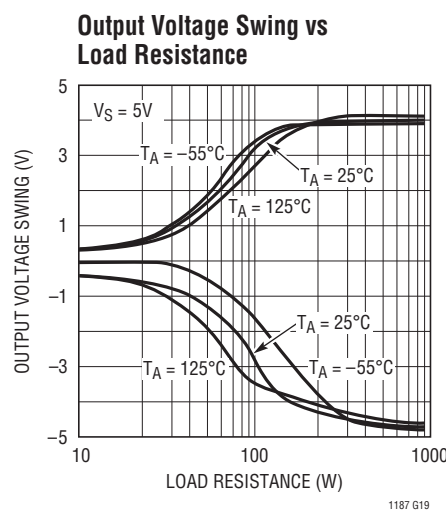
±Output Swing vs Supply Voltage



1187 G18

1187fb

TYPICAL PERFORMANCE CHARACTERISTICS



## APPLICATIONS INFORMATION

The primary use of the LT1187 is in converting high speed differential signals to a single-ended output. The LT1187 video difference amplifier has two uncommitted high input impedance (+) and (–) inputs. The amplifier has another set of inputs which can be used for reference and feedback. Additionally, this set of inputs give gain adjust and DC control to the difference amplifier. The voltage gain of the LT1187 is set like a conventional operational amplifier. Feedback is applied to Pin 8, and it is optimized for gains of 2 or greater. The amplifier can be operated single-ended by connecting either the (+) or (–) inputs to the +/REF (Pin 1). The voltage gain is set by the resistors:  $(R_{FB} + R_G)/R_G$ .

Like the single-ended case, the differential voltage gain is set by the external resistors:  $(R_{FB} + R_G)/R_G$ . The maximum input differential signal for which the output will respond is approximately  $\pm 0.38V$ .

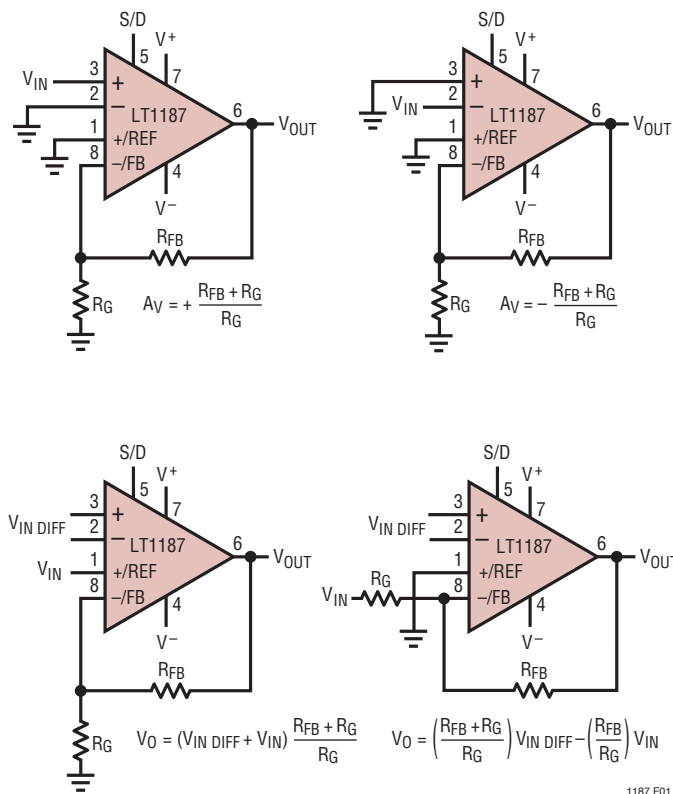


Figure 1.

### Power Supply Bypassing

The LT1187 is quite tolerant of power supply bypassing. In some applications a  $0.1\mu F$  ceramic disc capacitor placed 1/2 inch from the amplifier is all that is required. In applications requiring good settling time, it is important to use multiple bypass capacitors. A  $0.1\mu F$  ceramic disc in parallel with a  $4.7\mu F$  tantalum is recommended.

### Calculating the Output Offset Voltage

Both input stages contribute to the output offset voltage at Pin 6. The feedback correction forces balance in the input stages by introducing an input  $V_{OS}$  at Pin 8. The complete expression for the output offset voltage is:

$$V_{OUT} = (V_{OS} + I_{OS}(R_S) + I_B(R_{REF})) \cdot (R_{FB} + R_G)/R_G + I_B(R_{FB})$$

$R_S$  represents the input source resistance, typically  $75\Omega$ , and  $R_{REF}$  represents the finite source impedance from the DC reference voltage, for  $V_{REF}$  grounded,  $R_{REF} = 0\Omega$ . The  $I_{OS}$  is normally a small contributor and the expression simplifies to:

$$V_{OUT} = V_{OS}(R_{FB} + R_G)/R_G + I_B(R_{FB})$$

If  $R_{FB}$  is limited to  $1k$  the last term of the equation contributes only  $2mV$ , since  $I_B$  is less than  $2\mu A$ .

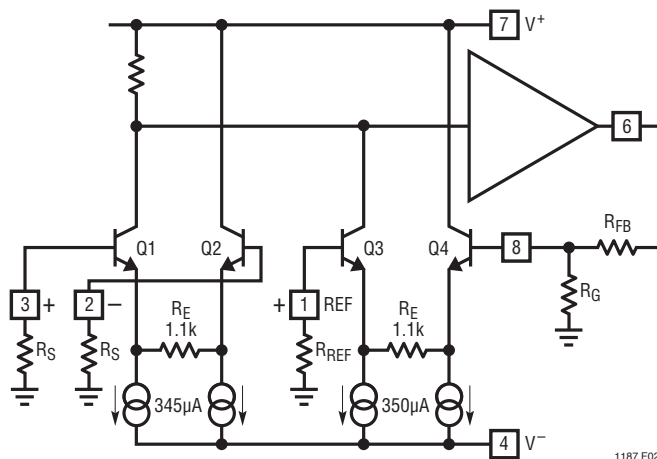


Figure 2. Simplified Input Stage Schematic

# APPLICATIONS INFORMATION

## Operating with Low Closed-Loop Gains

The LT1187 has been optimized for closed-loop gains of 2 or greater. For a closed-loop gain of 2 the response peaks about 2dB. Peaking can be eliminated by placing a capacitor across the feedback resistor, (feedback zero). This peaking shows up as time domain overshoot of about 25%.

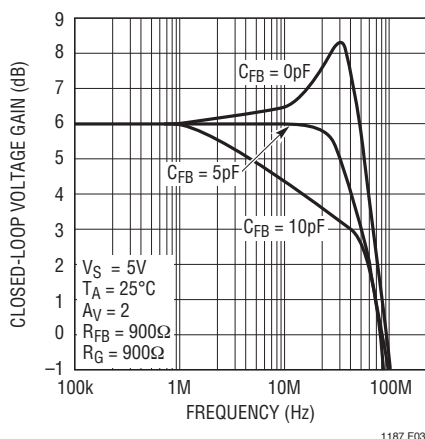
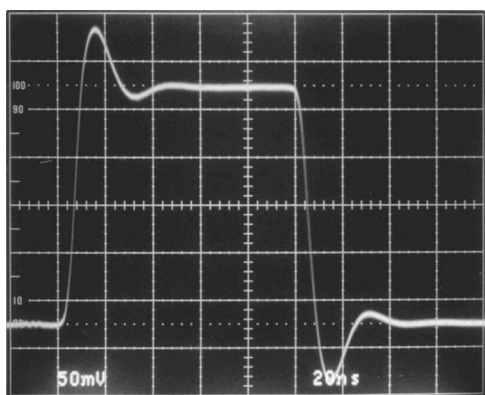
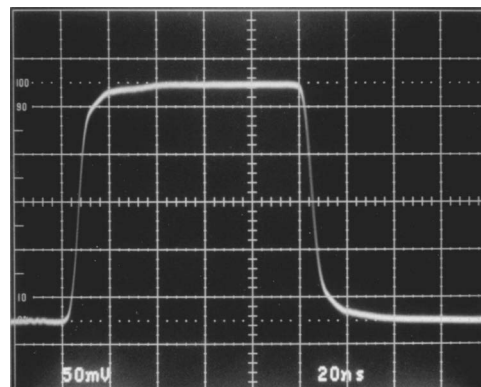


Figure 3. Closed-Loop Voltage Gain vs Frequency



$A_V = 2$ , OVERSHOOT = 25%,  $R_{FB} = R_G = 1\text{k}$

Figure 4. Small-Signal Transient Response



$A_V = 2$ , WITH  $8\mu\text{F}$  FEEDBACK CAPACITOR

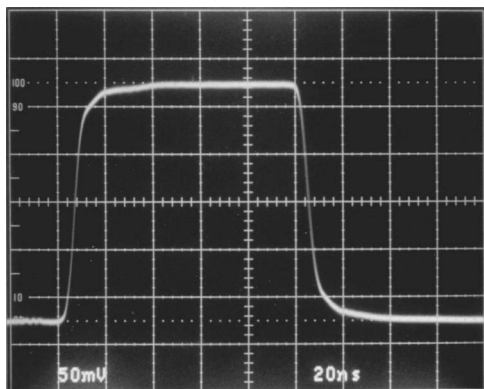
Figure 5. Small-Signal Transient Response

## Extending the Input Range

Figure 2 shows a simplified schematic of the LT1187. In normal operation REF, Pin 1, is grounded or taken to a DC offset control voltage and differential signals are applied between Pins 2 and 3. The input responds linearly until all of the 345 $\mu\text{A}$  current flows through the 1.1k resistor and Q1 (or Q2) turns off. Therefore the maximum input swing is 380mV<sub>P</sub> or 760mV<sub>P-P</sub>. The second differential pair, Q3 and Q4, is running at slightly larger current so that when the first input stage limits, the second stage remains biased to maintain the feedback.

Occasionally it is necessary to handle signals larger than 760mV<sub>P-P</sub> at the input. The LT1187 input stage can be tricked to handle up to 1.5V<sub>P-P</sub>. To do this, it is necessary to ground Pin 3 and apply the differential input signal between Pins 1 and 2. The input signal is now applied across two 1.1k resistors in series. Since the input signal is applied to both input pairs, the first pair will run out of bias current before the second pair, causing the amplifier to go open loop. The results of this technique are shown in the following scope photo.

## APPLICATIONS INFORMATION



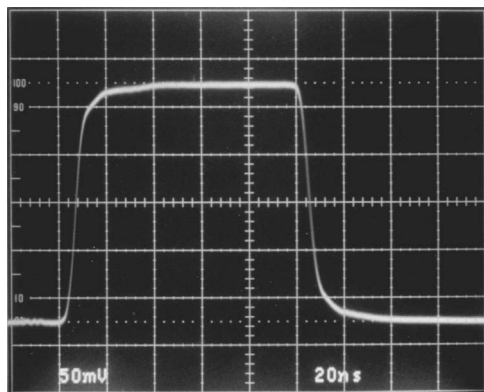
(A) STANDARD INPUTS, PINS 2 TO 3,  $V_{IN} = 1.0V_{P-P}$   
 (B) EXTENDED INPUTS, PINS 2 TO 2,  $V_{IN} = 1.0V_{P-P}$   
 (C) EXTENDED INPUTS, PINS 1 TO 2,  $V_{IN} = 2.0V_{P-P}$

1187 F06

Figure 6. LT1187 in Unity Gain

### Using the Shutdown Feature

The LT1187 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 shut down by taking Pin 5 to  $V^-$ . In shutdown, the amplifier dissipates 15mW while maintaining a true high impedance output state of 20k in parallel with the feedback resistors. For MUX applications, the amplifiers may be configured inverting, noninverting or differential. When the output is loaded with as little 1k from the amplifier's feedback resistors, the amplifier shuts off in 600ns. This shutoff can be under the control of HC CMOS operating between 0V and -5V.



$A_V = 2$ ,  $R_{FB} = R_G = 1k$

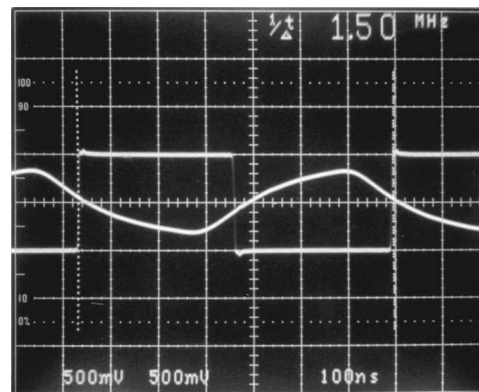
1187 F07

Figure 7. 1MHz Sine Wave Gated Off with Shutdown Pin

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 temperature it is important to hold the shutdown pin close to the negative supply to keep the supply current from increasing.

### Send Color Video Over Twisted-Pair

With an LT1187 it is possible to send and receive color composite video signals more than 1000 feet on a low cost twisted-pair. A bidirectional "video bus" consists of the LT1195 op amp and the LT1187 video difference amplifier. A pair of LT1195s at Transmit 1 is used to generate differential signals to drive the line which is back-terminated in its characteristic impedance. The LT1187 twisted-pair receiver converts signals from differential to single-ended. Topology of the LT1187 provides for cable compensation at the amplifier's feedback node as shown. In this case, 1000 feet of twisted-pair is compensated with 1000pF and 50Ω to boost the 3dB bandwidth of the system from 750kHz to 4MHz. This bandwidth is adequate to pass a 3.58MHz chroma subcarrier and the 4.5MHz sound subcarrier. Attenuation in the cable can be compensated by lowering the gain set resistor  $R_G$ . At Transmit 2, another pair of LT1195s serve the dual function to provide cable termination via low output impedance, and generate differential signals for Transmit 2. Cable termination is made up of a 15Ω and 33Ω attenuator to reduce the differential input signal to the LT1187. Maximum input signal for the LT1187 is 760mV<sub>P-P</sub>.

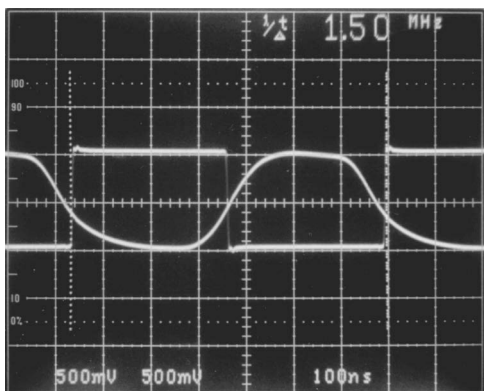


1187 F08

Figure 8. 1.5MHz Square Wave Input and Unequalized Response Through 1000 Feet of Twisted-Pair

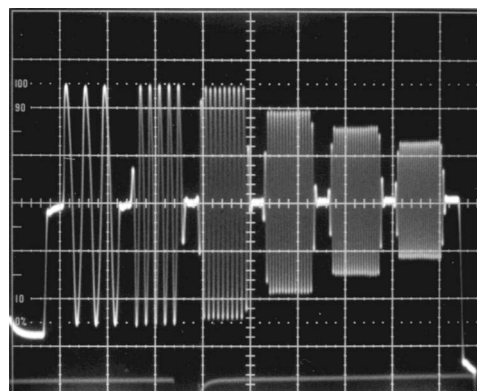
1187fb

## APPLICATIONS INFORMATION



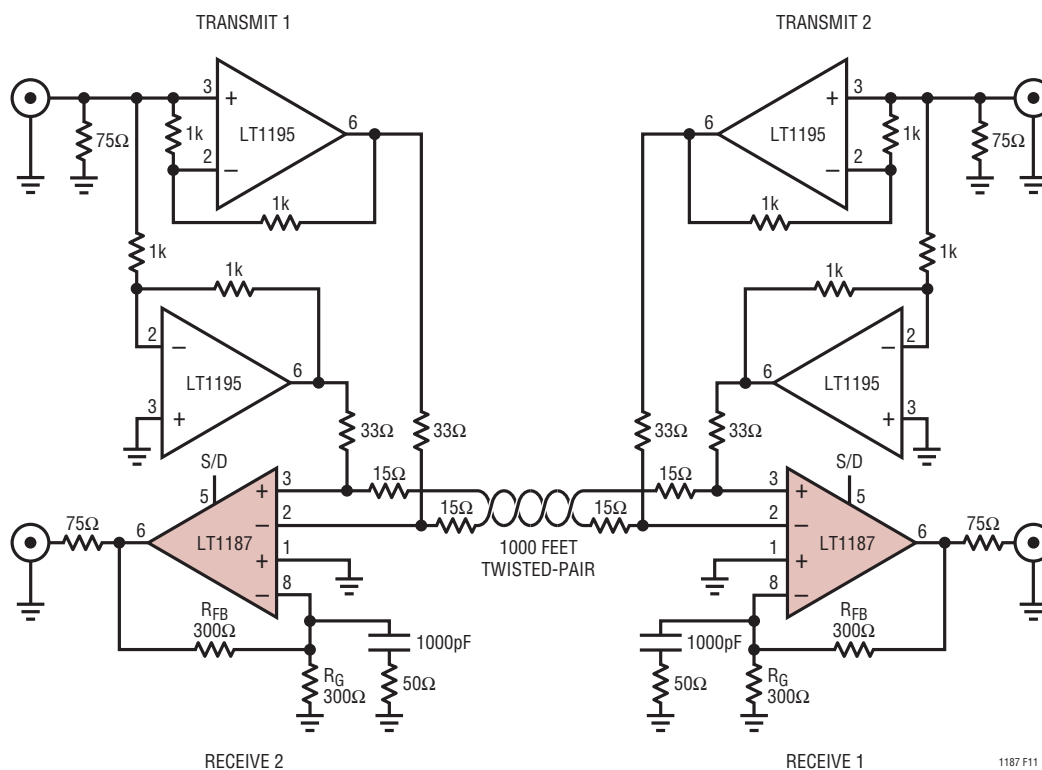
1187 F09

**Figure 9. 1.5MHz Square Wave Input and Equalized Response Through 1000 Feet of Twisted-Pair**



1187 F10

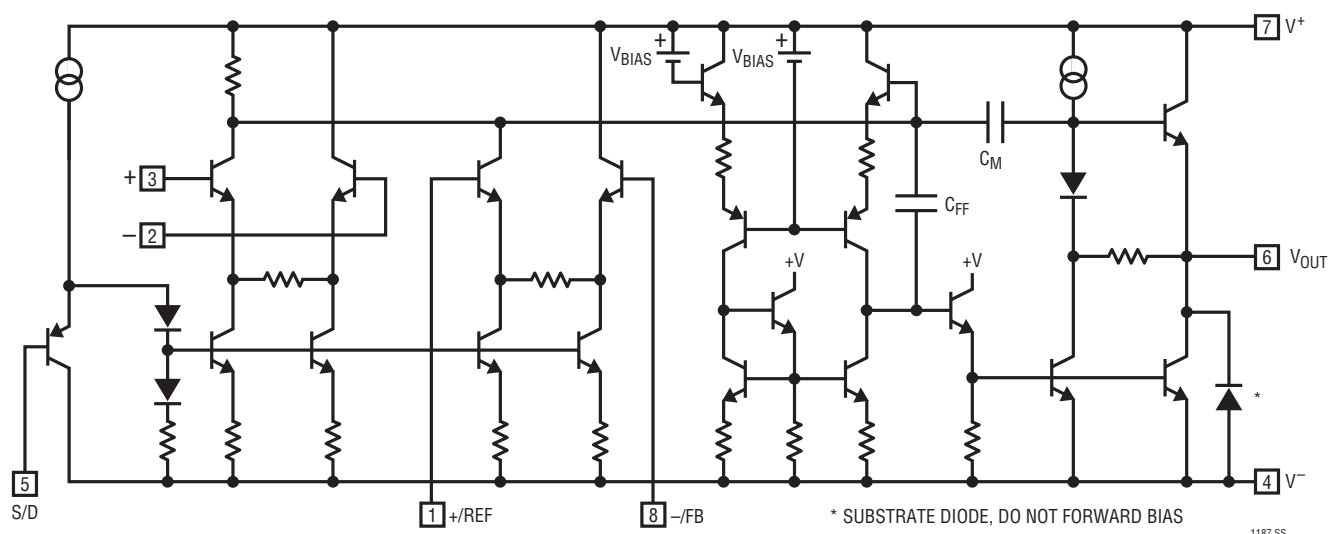
**Figure 10. Multiburst Pattern Passed Through 1000 Feet of Twisted-Pair**



1187 F11

**Figure 11. Bidirectional Video Bus**

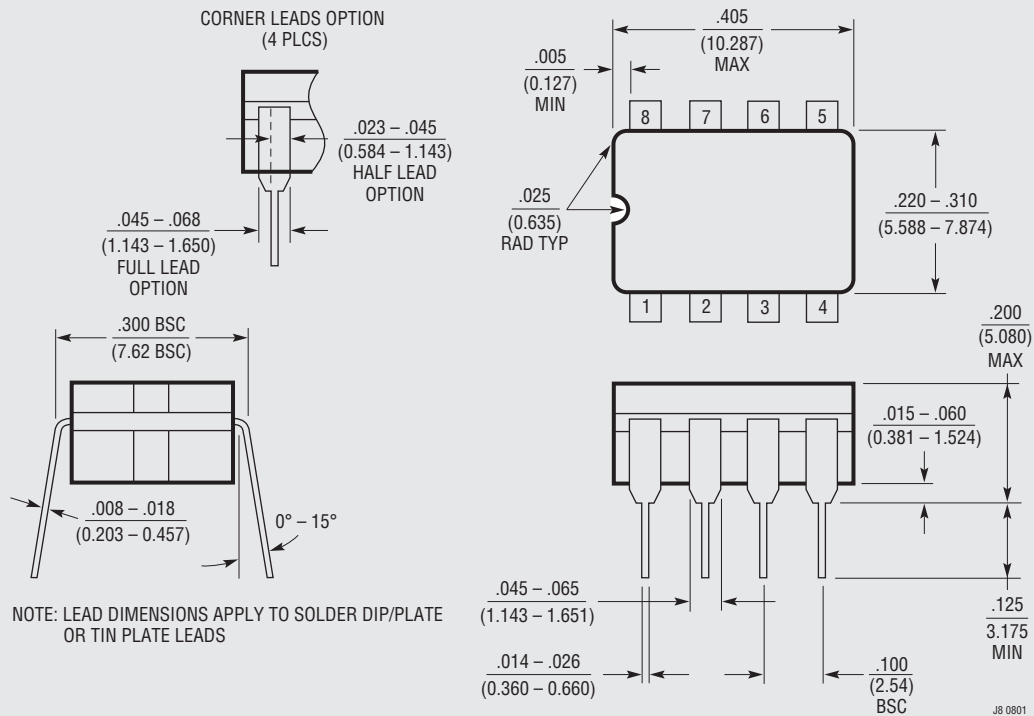
# SIMPLIFIED SCHEMATIC



## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/product/LT1187#packaging> for the most recent package drawings.

### J8 Package 8-Lead CERDIP (Narrow .300 Inch, Hermetic) (Reference LTC DWG # 05-08-1110)

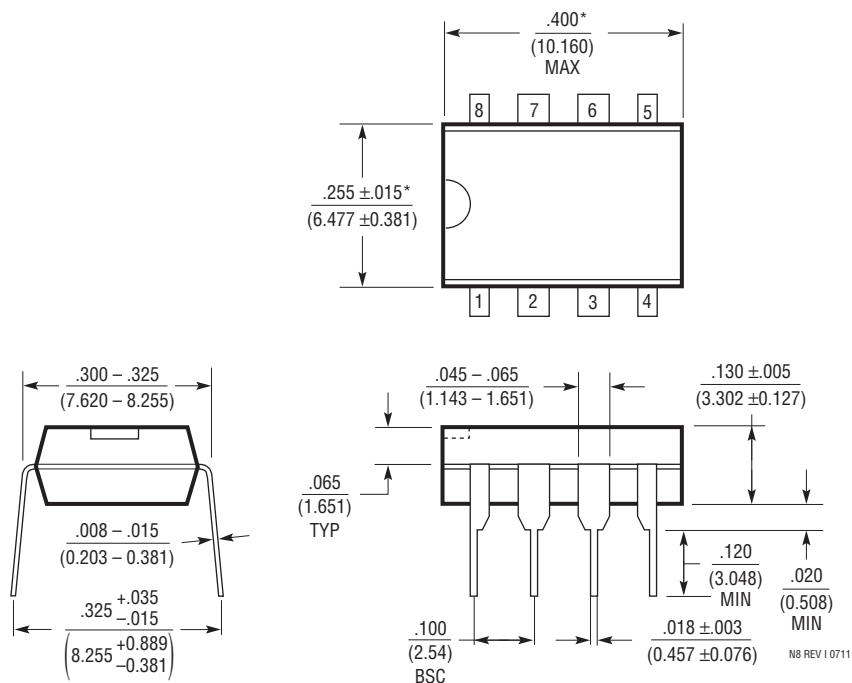


**OBSOLETE PACKAGE**

## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/product/LT1187#packaging> for the most recent package drawings.

### N8 Package 8-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510 Rev I)



#### NOTE:

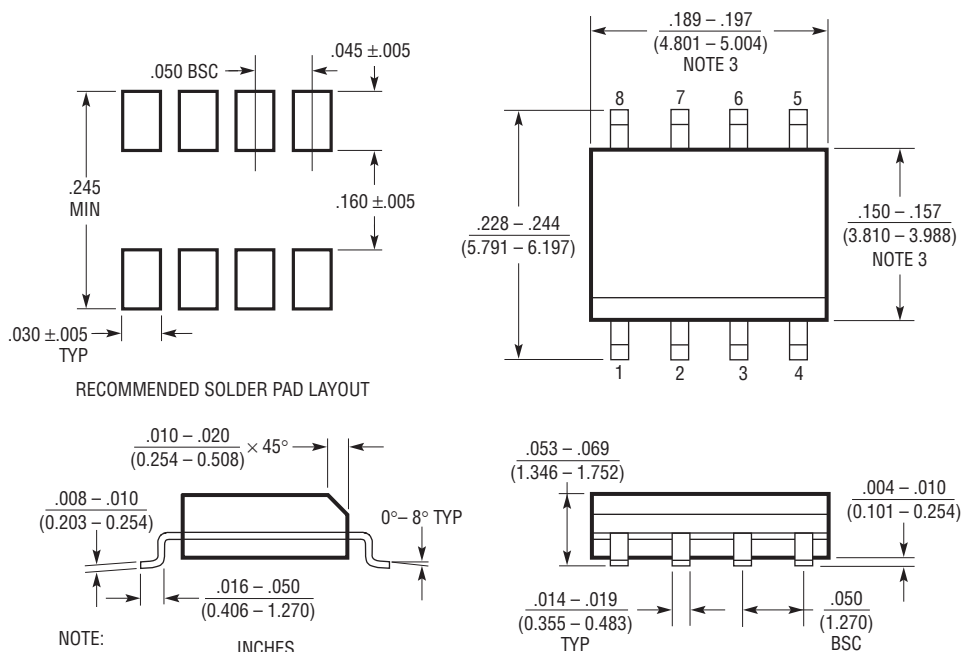
1. DIMENSIONS ARE  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/product/LT1187#packaging> for the most recent package drawings.

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



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

S08 REV G 0212

**REVISION HISTORY** (Revision history begins at Rev B)

| REV | DATE  | DESCRIPTION                               | PAGE NUMBER |
|-----|-------|-------------------------------------------|-------------|
| B   | 12/17 | Corrected slew rate.<br>Added hyperlinks. | 1<br>All    |

**RELATED PARTS**

| PART NUMBER            | DESCRIPTION                                                |
|------------------------|------------------------------------------------------------|
| <a href="#">LT1189</a> | Low Power Video Difference Amplifier                       |
| <a href="#">LT1193</a> | Adjustable Gain Video Difference Amplifier                 |
| <a href="#">LT1194</a> | Gain = 10 Video Difference Amplifier                       |
| <a href="#">LT1206</a> | 250mA Out, 900V/ $\mu$ s, 60MHz CFA                        |
| <a href="#">LT1354</a> | 1mA, 12MHz 400V/ $\mu$ s Op Amplifier                      |
| <a href="#">LT6552</a> | 3.3V Video Difference Amplifier                            |
| <a href="#">LT6559</a> | Low Cost 5V/ $\pm$ 5V Triple Video Amplifier with Shutdown |

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