

## FEATURES

- Excellent noise performance through the entire gain range
- Exceptionally low THD+N over the full audio bandwidth
- Low power consumption: 7mA typ.
- Wide bandwidth: 3MHz typ. @ G=1000 (THAT 1510)
- High Slew Rate: 28 V/μs @ G=10 and C<sub>L</sub>=50pF (THAT 1510)
- Wide Output Swing: ±13V typ. on ±15V supplies
- Gain adjustable from 1 to >1000 with a single external resistor
- Drop-in compatible with SSM-2017 (THAT 1510)

## APPLICATIONS

- Mixing Consoles
- Public Address Systems
- Analog and Digital Snakes
- Breakout Boxes for Digital Systems
- Sonar
- Paging and Intercom systems
- Instrumentation

## Description

The THAT 1510 and 1512 are high performance audio preamplifiers suitable for microphone preamp and bus summing applications. The ICs are pin compatible with the Analog Devices SSM2017 in both the 8-pin DIP and 16-pin SOIC packages.

The THAT1512 follows a different gain equation than the 1510, but exhibits significantly lower noise at lower gain settings and is recommended for new designs.

Designed from the ground up in THAT's complementary bipolar, dielectric isolation

process, the THAT 1510 and 1512 improve on existing integrated microphone preamps by offering lower noise at low gains, better distortion characteristics, lower power consumption, higher slew rate and bandwidth, and increased output voltage swing. The parts are fully protected against ESD on all critical pins, and reliability is further enhanced by their reduced power requirements.

In short, the THAT 1510 and 1512 provide superior performance in a popular format at an affordable price.

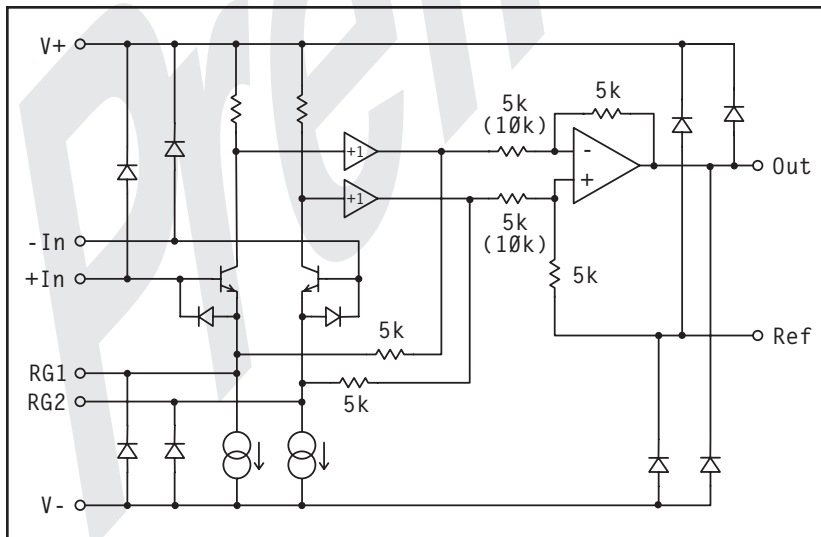


Figure 1. THAT 1510 / 1512 Equivalent Circuit Diagram  
(THAT 1512 values shown in parentheses)

| Pin Name | DIP | SO16 |
|----------|-----|------|
| RG1      | 1   | 2    |
| -In      | 2   | 4    |
| +In      | 3   | 5    |
| V-       | 4   | 7    |
| Ref      | 5   | 10   |
| Out      | 6   | 11   |
| V+       | 7   | 13   |
| RG2      | 8   | 15   |

Table 1. 1510 / 1512 pin assignments

| Gain Equation                   | DIP-8 | SO16  |
|---------------------------------|-------|-------|
| $G = 1 + \frac{10k\Omega}{RG}$  | 1510P | 1510S |
| $G = 0.5 + \frac{5k\Omega}{RG}$ | 1512P | 1512S |

Table 2. Ordering Information

**SPECIFICATIONS<sup>1</sup>****Absolute Maximum Ratings ( $T_A = 25^\circ\text{C}$ )**

|                                              |            |                                          |               |
|----------------------------------------------|------------|------------------------------------------|---------------|
| Positive Supply Voltage ( $V_{CC}$ )         | +20 V      | Operating Temperature Range ( $T_{OP}$ ) | -40 to +85°C  |
| Negative Supply Voltage ( $V_{EE}$ )         | -20 V      | Storage Temperature Range ( $T_{ST}$ )   | -40 to +125°C |
| Output Short-Circuit Duration ( $t_{SH}$ )   | Continuous | Junction Temperature ( $T_J$ )           | 150°C         |
| Lead Temp. ( $T_{LEAD}$ ) (Soldering 10 sec) | 260 °C     |                                          |               |

**Recommended Operating Conditions**

| Parameter               | Symbol   | Conditions | Min | Typ | Max | Units |
|-------------------------|----------|------------|-----|-----|-----|-------|
| Positive Supply Voltage | $V_{CC}$ |            | +5  |     | +20 | V     |
| Negative Supply Voltage | $V_{EE}$ |            | -5  |     | -20 | V     |

**Electrical Characteristics<sup>2</sup>**

| Parameter                          | Symbol             | Conditions                                    | Min | 1510<br>Typ | Max       | Min | 1512<br>Typ | Max       | Units           |
|------------------------------------|--------------------|-----------------------------------------------|-----|-------------|-----------|-----|-------------|-----------|-----------------|
| Supply Current                     | $I_{CC},  I_{EE} $ | No signal<br>$V_{CC} =  V_{EE}  = 20\text{V}$ | —   | 6.1         | 8.2       | —   | 6.1         | 8.2       | mA              |
|                                    |                    |                                               | —   | —           | 8.4       | —   | —           | 8.4       | mA              |
| Input Bias Current                 | $I_B$              | No signal; Either input<br>connected to GND   | —   | 8.6         | 25        | —   | 8.6         | 25        | $\mu\text{A}$   |
| Input Offset Current               | $I_{B-OFF}$        | No signal                                     | —   | —           | $\pm 2.5$ | —   | —           | $\pm 2.5$ | $\mu\text{A}$   |
| Output Referred Offset Voltage     | $V_{OSOR}$         | No Signal, $V_{CM}=0$                         | —   | —           | $\pm 50$  | —   | —           | $\pm 25$  | mV              |
| Input Referred Offset Voltage      | $V_{OSIR}$         | 60 dB gain                                    | —   | —           | $\pm 1.2$ | —   | —           | $\pm 1.2$ | mV              |
| Input Voltage Range<br>Common Mode | $V_{IN-CM}$        | Common mode, all gains                        | —   | $\pm 13$    | —         | —   | $\pm 13$    | —         | V               |
| Normal Mode                        | $V_{IN-UNBAL}$     | Unbalanced<br>One input to GND, 0dB gain      | —   | $\pm 13$    | —         | —   | $\pm 13$    | —         | V               |
| Differential Gain                  | $G_{diff}$         |                                               | 0   | —           | 70        | 0   | —           | 60        | dB              |
| Ref Input Voltage Range            |                    |                                               | —   | $\pm 8$     | —         | —   | $\pm 8$     | —         | V               |
| Ref Input Impedance                |                    |                                               | —   | 10          | —         | —   | 15          | —         | k $\Omega$      |
| Ref Input Gain to Output           |                    |                                               | —   | 0           | —         | —   | 0           | —         | dB              |
| Input Impedance                    | $Z_{IN-DIFF}$      | Differential                                  |     |             |           |     |             |           |                 |
|                                    |                    | 0dB gain                                      | —   | 32  1.9     | —         | —   | 37  1.9     | —         | M $\Omega$   pF |
|                                    |                    | 20dB gain                                     | —   | 32  2.0     | —         | —   | 37  2.0     | —         | M $\Omega$   pF |
|                                    |                    | 40dB gain                                     | —   | 32  2.5     | —         | —   | 36  3.1     | —         | M $\Omega$   pF |
|                                    |                    | 60dB gain                                     | —   | 29  8.0     | —         | —   | 31  13.9    | —         | M $\Omega$   pF |
|                                    | $Z_{IN-CM}$        | Common mode                                   |     |             |           |     |             |           |                 |
|                                    |                    | all gains                                     | —   | 8  7.7      | —         | —   | 9  7.7      | —         | M $\Omega$   pF |

1. All specifications are subject to change without notice.

2. Unless otherwise noted,  $V_{CC} = +15\text{V}$ ,  $V_{EE} = -15\text{V}$ ,  $T_A = 25^\circ\text{C}$ ,

| <b>Electrical Characteristics (Cont'd)</b> |               |                                                                      |                                 |             |           |                                  |             |           |                 |
|--------------------------------------------|---------------|----------------------------------------------------------------------|---------------------------------|-------------|-----------|----------------------------------|-------------|-----------|-----------------|
| Parameter                                  | Symbol        | Conditions                                                           | Min                             | 1510<br>Typ | Max       | Min                              | 1512<br>Typ | Max       | Units           |
| Common Mode Rejection                      | CMR           | $V_{CM} = \pm 10V$ ; DC to 60 Hz                                     |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0 dB gain                                                            | 20                              | 55          | —         | 20                               | 55          | —         | dB              |
|                                            |               | 20 dB gain                                                           | 40                              | 75          | —         | 40                               | 75          | —         | dB              |
|                                            |               | 40 dB gain                                                           | 60                              | 95          | —         | 60                               | 95          | —         | dB              |
|                                            |               | 60 dB gain                                                           | 80                              | 115         | —         | 80                               | 115         | —         | dB              |
| Power Supply Rejection                     | PSR           | $V_{CC} =  V_{EE} $ ; $\pm 5V$ to $\pm 20V$ ; DC to 60 Hz            |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0 dB gain                                                            | —                               | 85          | —         | —                                | 85          | —         | dB              |
|                                            |               | 20 dB gain                                                           | —                               | 105         | —         | —                                | 105         | —         | dB              |
|                                            |               | 40 dB gain                                                           | —                               | 120         | —         | —                                | 120         | —         | dB              |
|                                            |               | 60 dB gain                                                           | —                               | 124         | —         | —                                | 124         | —         | dB              |
| Total Harmonic Distortion                  | THD+N         | $V_{OUT} = 7V_{rms}$ ; $R_L = 5 k\Omega$<br>$f = 1kHz$ ; BW = 20 kHz |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0 dB gain                                                            | —                               | 0.0005      | —         | —                                | 0.0005      | —         | %               |
|                                            |               | 20 dB gain                                                           | —                               | 0.0005      | —         | —                                | 0.0005      | —         | %               |
|                                            |               | 40 dB gain                                                           | —                               | 0.0005      | —         | —                                | 0.0005      | —         | %               |
|                                            |               | 60 dB gain                                                           | —                               | 0.005       | —         | —                                | 0.005       | —         | %               |
|                                            |               | $f = 20kHz$ ; BW = 80 kHz                                            |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0 dB gain                                                            | —                               | 0.002       | —         | —                                | 0.002       | —         | %               |
| Equivalent Input Noise                     | $e_{n(OUT)}$  | $f = 1kHz$ ,<br>0dB gain                                             | —                               | 57          | —         | —                                | 34          | —         | nV/ $\sqrt{Hz}$ |
|                                            |               | 20dB gain                                                            | —                               | 7           | —         | —                                | 4.6         | —         | nV/ $\sqrt{Hz}$ |
|                                            |               | 40dB gain                                                            | —                               | 1.7         | —         | —                                | 1.4         | —         | nV/ $\sqrt{Hz}$ |
|                                            |               | 60dB gain                                                            | —                               | 1           | —         | —                                | 1           | —         | nV/ $\sqrt{Hz}$ |
|                                            |               |                                                                      |                                 |             |           |                                  |             |           |                 |
| Input Current Noise                        | $i_n$         | 60dB gain                                                            | —                               | 2.3         | —         | —                                | 2.3         | —         | pA/ $\sqrt{Hz}$ |
| Noise Figure                               | NF            | 60dB gain                                                            | —                               | 1.6         | —         | —                                | 1.6         | —         | dB              |
|                                            |               | $R_S = 150 \Omega$                                                   | —                               | 1.6         | —         | —                                | 1.6         | —         | dB              |
|                                            |               | $R_S = 200 \Omega$                                                   | —                               | 1.3         | —         | —                                | 1.3         | —         | dB              |
| Slew Rate                                  | SR            | $R_L = 2 k\Omega$<br>$C_L = 50 pF$                                   | 16                              | 28          | —         | 16                               | 24          | —         | V/ $\mu s$      |
| Bandwidth -3dB                             | $BW_{-3dB}$   | $R_L = 2 k\Omega$ ; $C_L = 10 pF$                                    |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0dB gain                                                             | —                               | 15          | —         | —                                | 11          | —         | MHz             |
|                                            |               | 20dB gain                                                            | —                               | 8           | —         | —                                | 9           | —         | MHz             |
|                                            |               | 40dB gain                                                            | —                               | 7           | —         | —                                | 7           | —         | MHz             |
|                                            |               | 60dB gain                                                            | —                               | 3           | —         | —                                | 1.6         | —         | MHz             |
| Output Gain Error                          | $G_{ER(OUT)}$ | $f = 1kHz$ ; $R_L = 2 k\Omega$                                       |                                 |             |           |                                  |             |           |                 |
|                                            |               | 0dB gain                                                             | —                               | $\pm 0.25$  | $\pm 1$   | —                                | $\pm 0.25$  | $\pm 1$   | dB              |
|                                            |               | 20dB gain                                                            | —                               | $\pm 0.20$  | $\pm 1$   | —                                | $\pm 0.20$  | $\pm 1$   | dB              |
|                                            |               | 40dB gain                                                            | —                               | $\pm 0.20$  | $\pm 1$   | —                                | $\pm 0.20$  | $\pm 1$   | dB              |
|                                            |               | 60dB gain                                                            | —                               | $\pm 0.05$  | $\pm 0.5$ | —                                | $\pm 0.05$  | $\pm 0.5$ | dB              |
| Output Voltage Swing                       | $V_O$         | $R_L = 2 k\Omega$<br>all gains                                       | $\pm 13$                        | $\pm 13.3$  | —         | $\pm 13$                         | $\pm 13.3$  | —         | V               |
| Output Short Circuit Current               | $I_{SC}$      | $R_L = 0 \Omega$                                                     | —                               | $\pm 17$    | —         | —                                | $\pm 17$    | —         | mA              |
| Minimum Resistive Load                     | $R_{Lmin}$    |                                                                      | —                               | 2           | —         | —                                | 2           | —         | k $\Omega$      |
| Maximum Capacitive Load                    | $C_{Lmax}$    |                                                                      | —                               | —           | 200       | —                                | —           | 200       | pF              |
| Gain Equation                              |               |                                                                      | $G = 1 + \frac{10 k\Omega}{RG}$ |             |           | $G = 0.5 + \frac{5 k\Omega}{RG}$ |             |           |                 |
| Gain Resistor (ideal values)               | RG            | 0dB gain                                                             |                                 | $\infty$    |           |                                  | 10k         |           | $\Omega$        |
|                                            |               | 20dB gain                                                            |                                 | 1,100       |           |                                  | 526.3       |           | $\Omega$        |
|                                            |               | 40dB gain                                                            |                                 | 101         |           |                                  | 50.3        |           | $\Omega$        |
|                                            |               | 60dB gain                                                            |                                 | 10          |           |                                  | 5           |           | $\Omega$        |

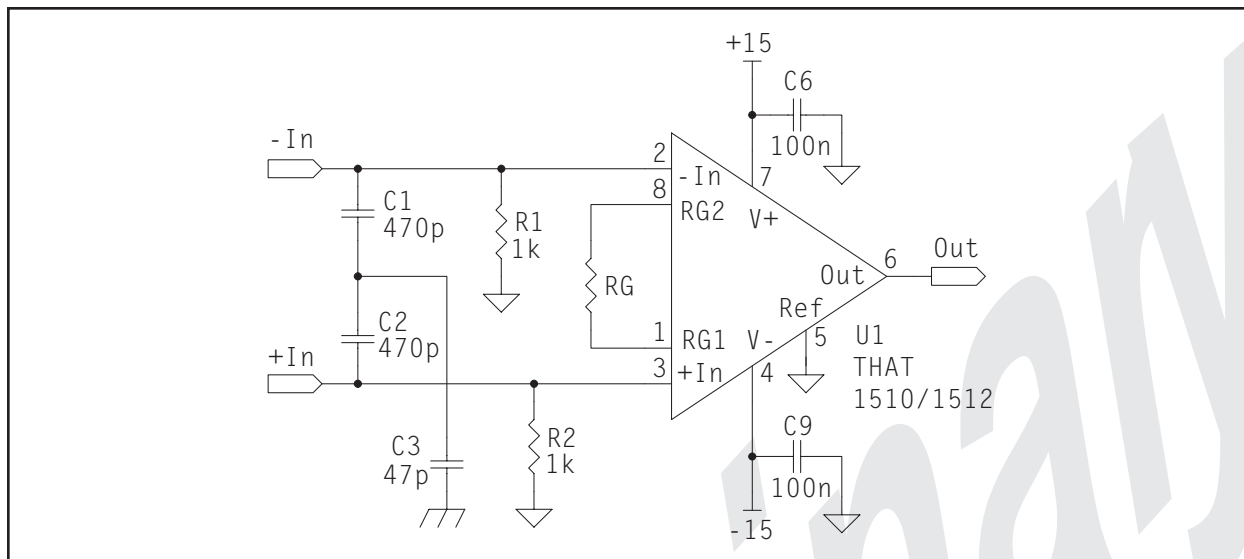


Figure 2. Basic 1510 / 1512 Circuit

## Applications

### Gain Setting

A single external resistor between the RG1 and RG2 pins is all that is needed to set the gain of the THAT 1510 / 1512, according to the formulae

$$\text{for the 1510: } G = 1 + \frac{10\text{k}\Omega}{RG} \quad \text{or} \quad RG = \frac{10\text{k}\Omega}{G-1}$$

$$\text{for the 1512: } G = 0.5 + \frac{5\text{k}\Omega}{RG} \quad \text{or} \quad RG = \frac{5\text{k}\Omega}{G-0.5}$$

For unity gain operation on the 1510, RG1 and RG2 may be left open. RG should be set to 10kΩ in the 1512. To avoid excess noise and ensure temperature stability, non-inductive wirewound or metal-film resistors are recommended for RG.

Total gain accuracy will depend on both the tolerance on RG, and on the gain equation accuracy of the THAT 1510/1512. Total gain drift will result from the mismatch between the tempo of RG and the

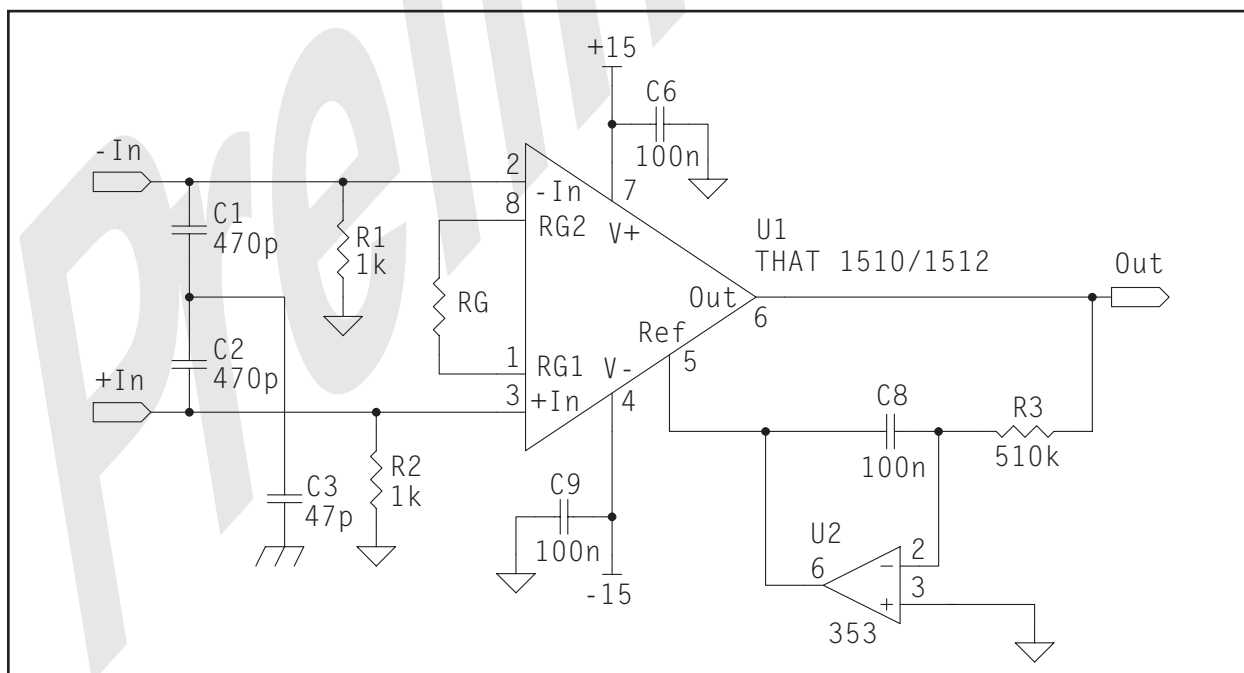


Figure 3. 1510 / 1512 Circuit with Output Offset Correction

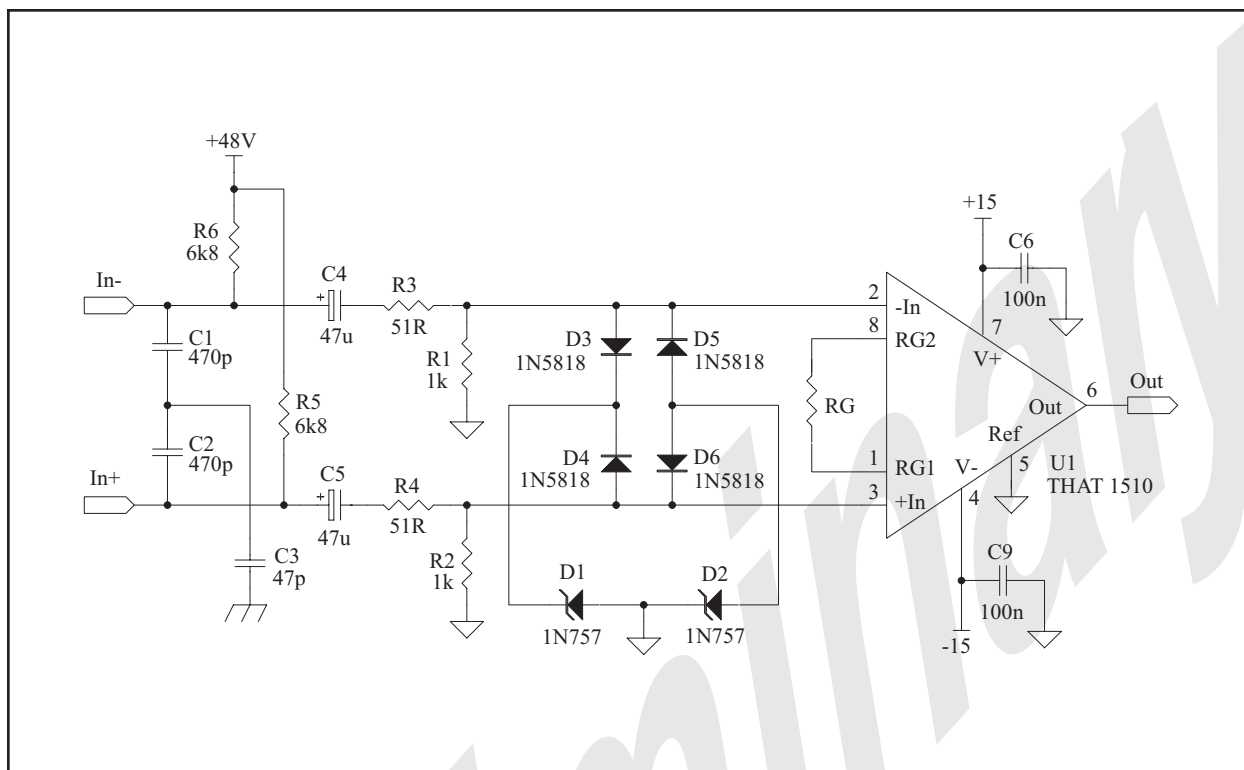


Figure 4. Typical 1510 / 1512 Circuit with Phantom Power

tempco of the internal resistors ( $\pm 20$  ppm/ $^{\circ}\text{C}$  typical).

## Noise Performance

Thoughtful design results in these devices having significantly lower noise at low gains than similar IC microphone preamps. At zero dB gain, equivalent input noise of the THAT 1510 is 55 nV/ $\sqrt{\text{Hz}}$ , nearly 6 dB better than competitive IC designs. The unusual topology of the THAT 1512 results in an equivalent input noise of 34 nV/ $\sqrt{\text{Hz}}$  at zero dB gain, which makes it comparable to some of the better discrete designs currently available. At 1 kHz, the equivalent input noise for both devices is 1 nV/ $\sqrt{\text{Hz}}$  at 60 dB gain.

## Inputs

Protection diodes are employed at all pins except V+ and V- of the THAT 1510/1512. These diodes reduce the likelihood of accidental ESD/EOS damage to the IC. Other diodes across the base-emitter junctions of the input transistors prevent reverse bias of these junctions and consequent degradation of their noise performance.

The inputs of the THAT 1510 and 1512's are floating, so a dc bias connection is required to maintain the inputs within the IC's input common-mode range.

Four different schemes are shown in Figures 2, 3, 4, and 5. Note that the values of R1 and R2 in these figures should be kept small to minimize pickup of unwanted noise and interference. A value of 1 k $\Omega$  is often used, since some microphones require a differential input impedance of this magnitude. Unfortunately, one would usually desire a significantly higher common mode input impedance to minimize the common mode degradation caused by unbalanced source impedances. Figure 5 shows a technique which allows higher common mode input impedance while maintaining a lower differential source impedance.

## Reference Terminal

The "Ref" pin provides the reference for the output signal, and is normally connected to analog ground. If necessary, the "Ref" pin can be used for offset correction or DC level shifting. A non-zero reference source resistance will reduce the IC's common-mode rejection (CMR) by the ratio of 10 k $\Omega$ /R<sub>REF</sub>.

## Phantom Power

Phantom power is required for condenser microphones. A phantom power circuit is shown in Figure 4. Diodes D1 through D6 are necessary to protect the THAT 1510/1512 from transient voltages

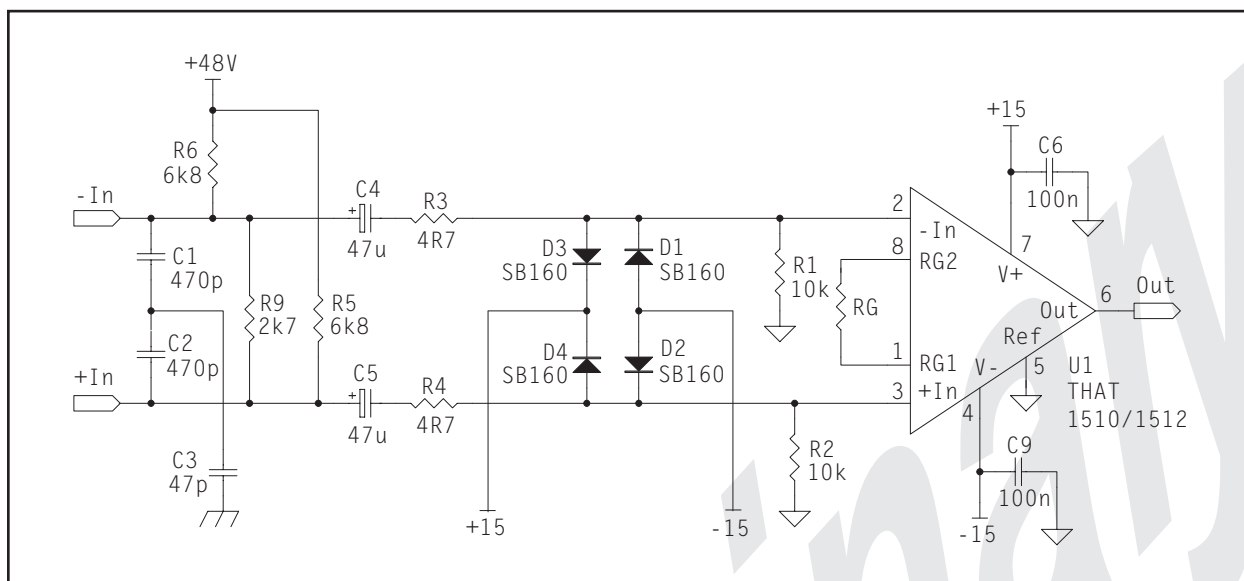


Figure 5. Preferred 1510 / 1512 Circuit with Multiple Phantom Power

that may occur when microphones are connected or disconnected.

While figure 4 shows a protection scheme that reflects the current industry practice, a better solution is shown in figure 5. Like figure 4, this circuit uses a diode bridge (composed of very fast 1N5818s), but in this case, the diodes are connected directly to the

power supply rails. While this arrangement doesn't keep the inputs inside the common mode range, it has the advantage of working even when the power is off. For further insights in to this subject, see *The 48 Volt Phantom Menace*, by Gary K. Hebert and Frank W. Thomas, presented at the 110th AES Convention.

### Package Information

The THAT 1510 and 1512 are available in 8-pin DIP and 16-pin SOIC packages. The package dimen-

sions are shown in Figures 6 and 7 while pinouts are given in Table 1.

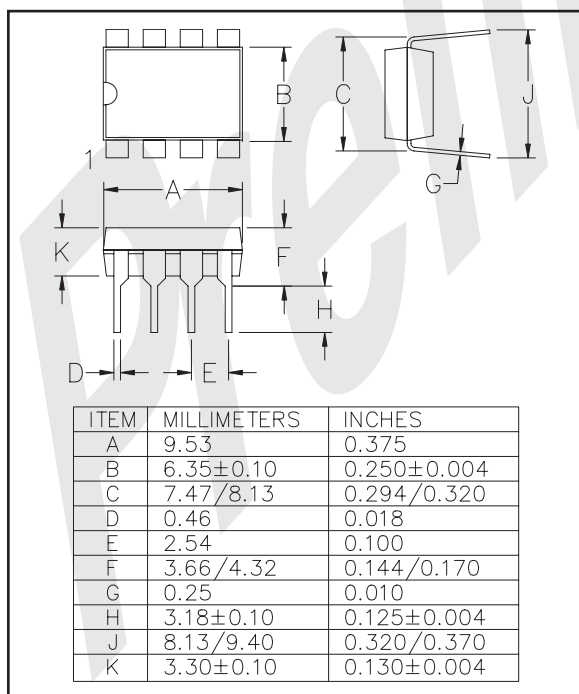


Figure 6. -P (8-pin DIP) version package outline

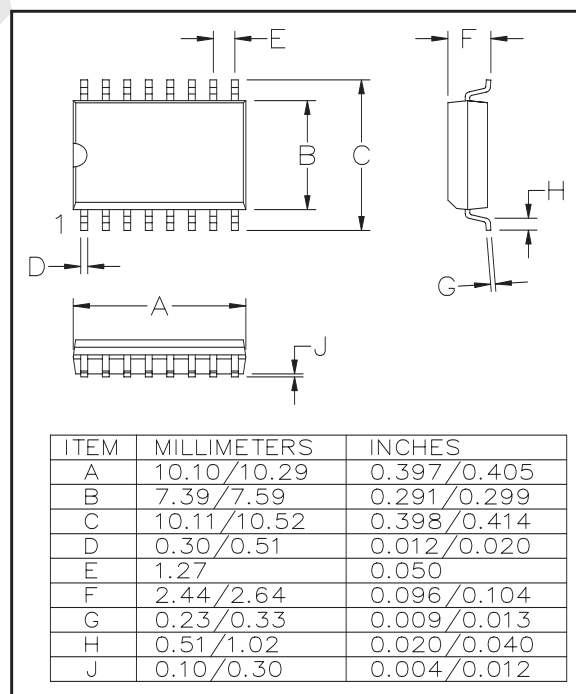


Figure 7. -S16 (16-pin SO) version package outline