THAT Corporation

Low Noise, High Performance Audio Preamplifier IC

THAT 1510, 1512

FEATURES

- Low Noise:
  1 nV/√Hz input noise (60dB gain)
  34 nV/√Hz input noise (0dB gain) (1512)
- Low THD+N (full audio bandwidth):
  0.001% ≤ 40dB gain
  0.005% @ 60dB gain
- Low Current: 6mA typ.
- Wide Bandwidth: 7MHz @ G=100
- High Slew Rate: 19 V/µs
- Wide Output Swing: ±13.3V on ±15V supplies
- Gain adjustable from 0 to >60dB with one external resistor
- Industry Standard Pinouts

APPLICATIONS

- Differential Low Noise Preamplifiers
- Differential Summing Amplifiers
- Differential Variable Gain Amplifiers
- Microphone Preamplifiers
- Moving-Coil Transducer Amplifiers
- Line Input Stages
- Audio
- Sonar
- Instrumentation

Description

The THAT 1510 and 1512 are high performance audio preamplifiers suitable for microphone preamp and bus summing applications. The ICs are available in a variety of packages and pin configurations, making them pin compatible with the Analog Devices SSM2019 and SSM2017 (discontinued), and the Texas Instruments INA217 and INA163.

Gain for both parts is adjustable via one external resistor, making it possible to control gain over a wide range with a single-gang potentiometer. The 1510 gain equation is identical to that of the SSM 2019, reaching 6dB gain with a 10kΩ resistor. The 1512 reaches 0dB gain with a 10kΩ resistor. Because the 1512 exhibits significantly lower noise at lower gain settings, it is recommended over the 1510 for new designs.

Designed from the ground up in THAT's complementary dielectric isolation process and including laser-trimmed Si-Chrome thin film resistors, the THAT 1510 and 1512 improve on existing integrated microphone preamps by offering lower noise at low gains, wider bandwidth, higher slew rate, lower distortion, and lower supply current. The parts feature internal ESD overload protection on all critical pins.

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

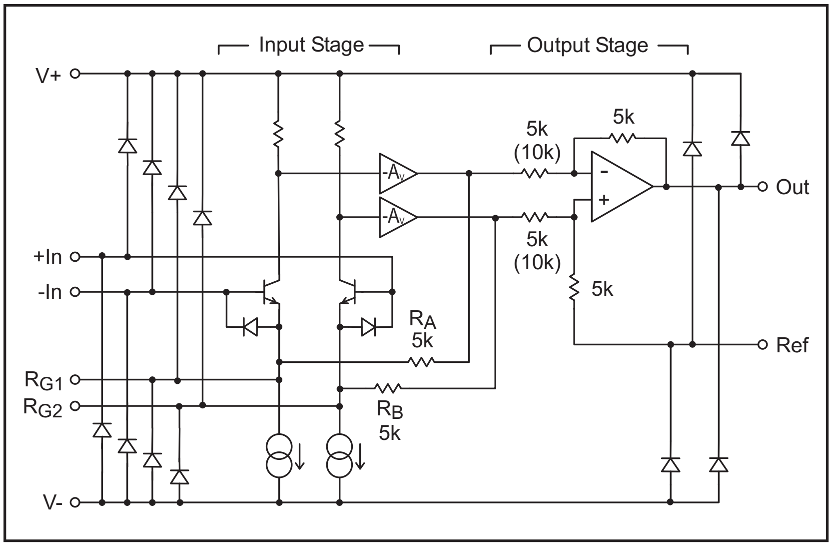

Figure 1. THAT 1510 / 1512 Equivalent Circuit Diagram
(THAT 1512 values shown in parentheses)

Pin Name	DIP8 PKG	SO8 Pkg	SO16 Pkg	SO14 Pkg
RG1	1	1	2	3
-In	2	2	4	4
+In	3	3	5	5
V-	4	4	7	6
Ref	5	5	10	10
Out	6	6	11	9
V+	7	7	13	11
RG2	8	8	15	12

Table 1. 1510 / 1512 pin assignments

Part Type	DIP8 Pkg	SO8 Pkg	SO14 Pkg	SO16 Pkg
1510	1510P08-U	1510S08-U	1510S14-U	1510W16-U
1512	1512P08-U	1512S08-U	1512S14-U	Inquire

Table 2. Ordering Information

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Document 600031 Rev. 04

SPECIFICATIONS[1]

Absolute Maximum Ratings (T_A = 25°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[2]

				1510			1512		
Parameter	Symbol	Conditions	Min	Typ	Max	Min	Typ	Max	Units
Supply Current	I_{CC}, $-I_{EE}$	No signal	—	6.0	7.9	—	6.0	7.9	mA
		V_{CC} = $-V_{EE}$ = 20V	—	—	8.0	—	—	8.0	mA
Input Bias Current	I_B	No signal; Either input connected to GND	—	4.8	14	—	4.8	14	µA
Input Offset Current	$I_{B\text{-}OFF}$	No signal	-1.4	—	+1.4	-1.4	—	+1.4	µA
Offset Voltage									
Output Stage Output Offset	Vos_{OO}	No Signal, V_{CM}=0	-5	—	+5	-5	—	+5	mV
Input Stage Input Offset	Vos_{II}		-250	—	+250	-250	—	+250	µV
Total Output Offset		G=voltage gain	-5-0.25G		5+0.25G	-5-0.25G		5+0.25G	mV
Input Voltage Range									
Common Mode	$V_{IN\text{-}CM}$	Common mode, all gains	—	± 13	—	—	± 13	—	V
Differential Mode	$V_{IN\text{-}UNBAL}$	Unbalanced One input to GND, 0dB gain	-13	—	+13	-13	—	+13	V
Differential Gain	G_{diff}		0	—	70	-6	—	64	dB
Ref Input Voltage Range			—	± 8	—	—	± 8	—	V
Ref Input Impedance			—	10	—	—	15	—	kΩ
Ref Input Gain to Output			—	0	—	—	0	—	dB
Input Impedance	$Z_{IN\text{-}DIFF}$	Differential							
		0dB gain	—	32||1.9	—	—	37||1.9	—	MΩ||pF
		20dB gain	—	32||2.0	—	—	37||2.0	—	MΩ||pF
		40dB gain	—	32||2.5	—	—	36||3.1	—	MΩ||pF
		60dB gain	—	29||8.0	—	—	31||13.9	—	MΩ||pF
	$Z_{IN\text{-}CM}$	Common mode all gains	—	8||7.7	—	—	9||7.7	—	MΩ||pF

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1. All specifications are subject to change without notice.
2. Unless otherwise noted, V_{CC} = +15V, V_{EE} = -15V, T_A=25°C,

Electrical Characteristics (Cont'd)

				1510			1512		
Parameter	Symbol	Conditions	Min	Typ	Max	Min	Typ	Max	Units
Common Mode Rejection	CMR	V_{CM} =± 10V; DC to 60 Hz							
		0 dB gain	45	60	—	45	60	—	dB
		20 dB gain	65	80	—	65	80	—	dB
		40 dB gain	85	100	—	85	100	—	dB
		60 dB gain	105	120	—	105	120	—	dB
Power Supply Rejection	PSR	V_{CC}= -V_{EE}; ±5V to ±20V; DC to 60 Hz							
		0 dB gain	—	85	—	—	60	—	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} = 7Vrms; R_L = 5 kΩ f = 1kHz; BW = 20 kHz							
		0 dB gain	—	0.0005	—	—	0.001	—	%
		20 dB gain	—	0.0012	—	—	0.004	—	%
		40 dB gain	—	0.0016	—	—	0.005	—	%
		60 dB gain	—	0.005	—	—	0.008	—	%
Equivalent Input Noise	$e_{n(OUT)}$	f = 1kHz,							
		0 dB gain	—	57	—	—	34	—	nV/√Hz
		20 dB gain	—	7	—	—	4.6	—	nV/√Hz
		40 dB gain	—	1.7	—	—	1.4	—	nV/√Hz
		60 dB gain	—	1	—	—	1		nV/√Hz
Input Current Noise	i_n	60 dB gain	—	2.0	—	—	2.0	—	pA/√Hz
Noise Figure	NF	60 dB gain							
		R_S = 150 Ω	—	1.6	—	—	1.6	—	dB
		R_S = 200 Ω	—	1.3	—	—	1.3	—	dB
Slew Rate	SR	R_L = 2 kΩ							
		C_L = 50 pF	13	19	—	13	19	—	V/µs
Bandwidth -3dB	BW_{-3dB}	R_L = 2 kΩ; C_L = 10 pF							
		0 dB gain	—	15	—	—	11	—	MHz
		20 dB gain	—	8	—	—	9	—	MHz
		40 dB gain	—	7	—	—	7	—	MHz
		60 dB gain	—	3	—	—	1.6		MHz
Output Gain Error	$G_{ER\ (OUT)}$	f = 1kHz; R_L = 2 kΩ							
		R_G =infinite, G=0 dB	-0.5	—	+0.5	—	—	—	dB
		R_G = 1.1 kΩ, G=20 dB	-0.5	—	+0.5	—	—	—	dB
		R_G = 101 Ω, G=40 dB	-0.5	—	+0.5	—	—	—	dB
		R_G = 10 Ω, G=60 dB	-0.5	—	+0.5	—	—	—	dB
		R_G = 10 kΩ, G=0 dB	—	—	—	-0.5	—	+0.5	dB
		R_G = 526.3 Ω, G=20 dB	—	—	—	-0.5	—	+0.5	dB
		R_G = 50.3 Ω, G=40 dB	—	—	—	-0.5	—	+0.5	dB
		R_G = 5 Ω, G=60 dB	—	—	—	-0.5	—	+0.5	dB
Output Voltage Swing	V_O	R_L = 2 kΩ							
		all gains	±13	±13.3	—	±13	±13.3	—	V
Output Short Circuit Current	I_{SC}	R_L = 0 Ω	—	±17	—	—	± 17	—	mA
Minimum Resistive Load	R_{Lmin}		2	—	—	2	—	—	kΩ
Maximum Capacitive Load	C_{Lmax}		—	—	300	—	—	300	pF
Gain Equation				$A_V = 1 + \frac{10\ k\Omega}{R_G}$			$A_V = 0.5 + \frac{5\ k\Omega}{R_G}$		

Applications

Gain Setting

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

for the 1510: $A_V = 1 + \frac{10k\Omega}{R_G}$ or

for the 1512: $A_V = 0.5 + \frac{5k\Omega}{R_G}$ where

A_V is the voltage gain of the part.

Either part may reach unity gain, but the value of R_G required varies drastically between the two parts. For the 1510, gain is 0dB when R_G is infinite (open); This is the minimum gain for the 1510. At infinite R_G, the 1512 reaches -6dB gain; This is the minimum gain for the 1512. With R_G=10kΩ, the 1512 reaches 0dB gain.

Overall gain accuracy depends on the tolerance of R_G and the accuracy of the internal thin-film resistors connected to pins R_{G1} and R_{G2} in the 1510/1512 (R_A & R_B in Figure 1). These internal resistors have a typical initial accuracy (at room temperature) of ±0.5%, and are typically stable with temperature to within ±200 ppm/°C. Gain will drift with temperature based on the mismatch between the temperature coefficient of the external R_G and that of the internal resistors R_A & R_B.

For variable-gain applications where gain accuracy is important, THAT recommends using discrete, switched resistors for R_G. Where continuous control is required, or where gain accuracy is less critical, a potentiometer may be used. In such applications, designers should take care in specifying the element construction to avoid excess noise. The potentiometer taper will set the circuit's characteristic of gain vs. pot rotation. Typically, reverse log (audio) taper elements offer the desired behavior in which gain increases with clockwise rotation (and lower values for R_G). See THAT Design Note 138 for a discussion of potentiometer taper and gain for the 1510 and 1512 compared to similar parts from other manufacturers.

Noise Performance

Both parts exhibit excellent voltage noise performance of ~1 nV/√Hz at high gains. With ~2 pA/√Hz current noise, they are optimized for relatively low source impedance applications, such as dynamic microphones with typically a few hundred ohm output impedances. But, because they have different internal gain structures, the 1510 has higher equivalent input noise at 0dB gain (~57 nV/√Hz) than the 1512, which runs 4.5 dB lower at ~34 nV/√Hz. The unusual and superior topology of the THAT 1512 makes it's noise performance comparable to some of the better discrete designs currently available.

Inputs

Simple Configurations

As shown in Figure 1, the 1510/1512 includes protection diodes at all pins except V+ and V-. These diodes reduce the likelihood that accidental electro-

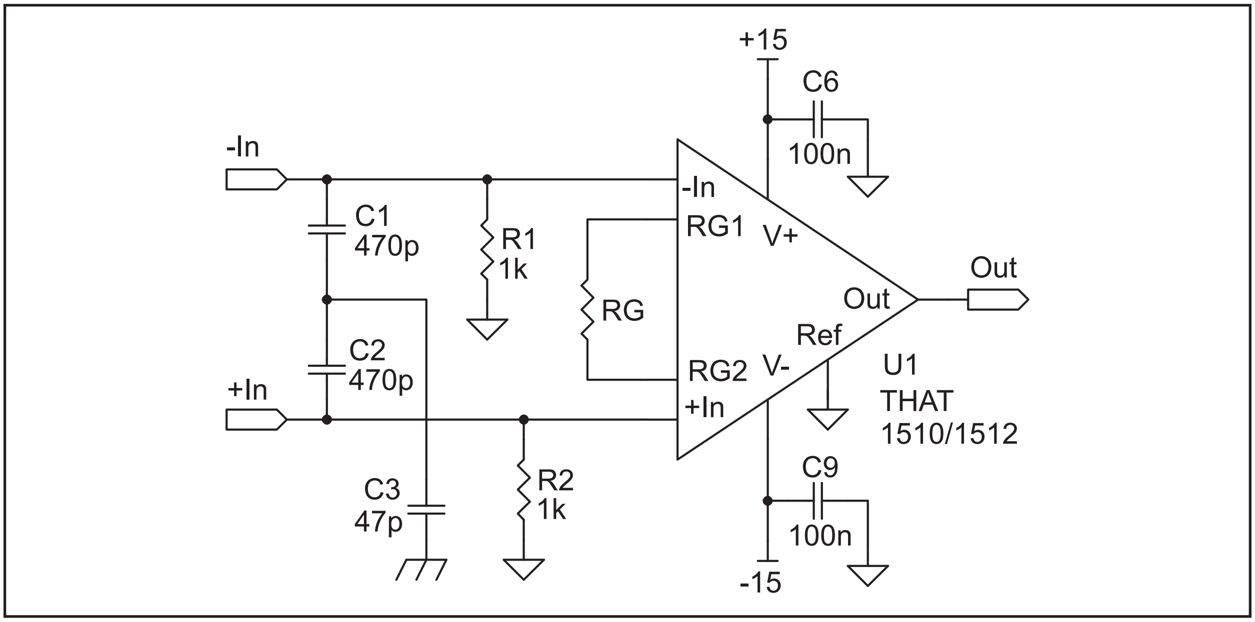

Figure 2. Basic 1510 / 1512 Circuit

static discharge (ESD) or electrical over stress (EOS) will damage the ICs. Other diodes across the base-emitter junctions of the input transistors prevent excessive reverse biasing of these junctions (which would degrade the noise performance of the input devices).

Other than the connection to the protection diodes, the 1510/1512 input pins are connected only to the bases of their respective input devices. For proper operation, the bases must be provided a source of dc bias that will maintain the inputs within the IC's input common-mode range. Two different schemes for this are shown in Figures 2 and 3. Figure 2 is simple, but its output will need to be ac-coupled to the next stage, particularly if R_G is variable to allow gain adjustment. Figure 3 shows the addition of an integrator to servo the output offset. In this circuit, the output offset will depend on that of the external opamp U2, which may be small enough to avoid ac-coupling the output.

Note that the values of R1 and R2 in these figures are small to minimize pickup of unwanted noise and interference. 1kΩ is often used, which yields a differential input impedance of 2kΩ, often considered to be ideal for many microphones.

Phantom Power

Phantom power is required for many condensor microphones. THAT recommends the circuit of Figure 4 when phantom power is included[3]. R3 and R4 are used to limit the current that flows through the bridge circuit of D1 through D4 when C4 and C5 are discharged after being charged to 48V from the phantom voltage supply. R3 and R4 should be kept very small as shown in order to introduce minimal additional noise. C4 and C5 should be kept large to minimize high-pass filtering of the signal, and to avoid amplification of low-frequency current noise in the 1510/1512 input stage.

Other manufacturers have recommended, and many pro audio products include, a zener diode arrangement connected to the bridge rectifier instead of the connection to V+ and V- as shown in Figure 4. While this arrangement does not keep the inputs inside the common mode range, it has the advantage of working even when the power is off. For further insights into this subject, see the Audio Engineering Society preprint "The 48 Volt Phantom Menace," by Gary K. Hebert and Frank W. Thomas, presented at the 110th AES Convention.

When using the more conventional zener diode approach, R3 and R4 must be made larger (e.g., 51Ω)

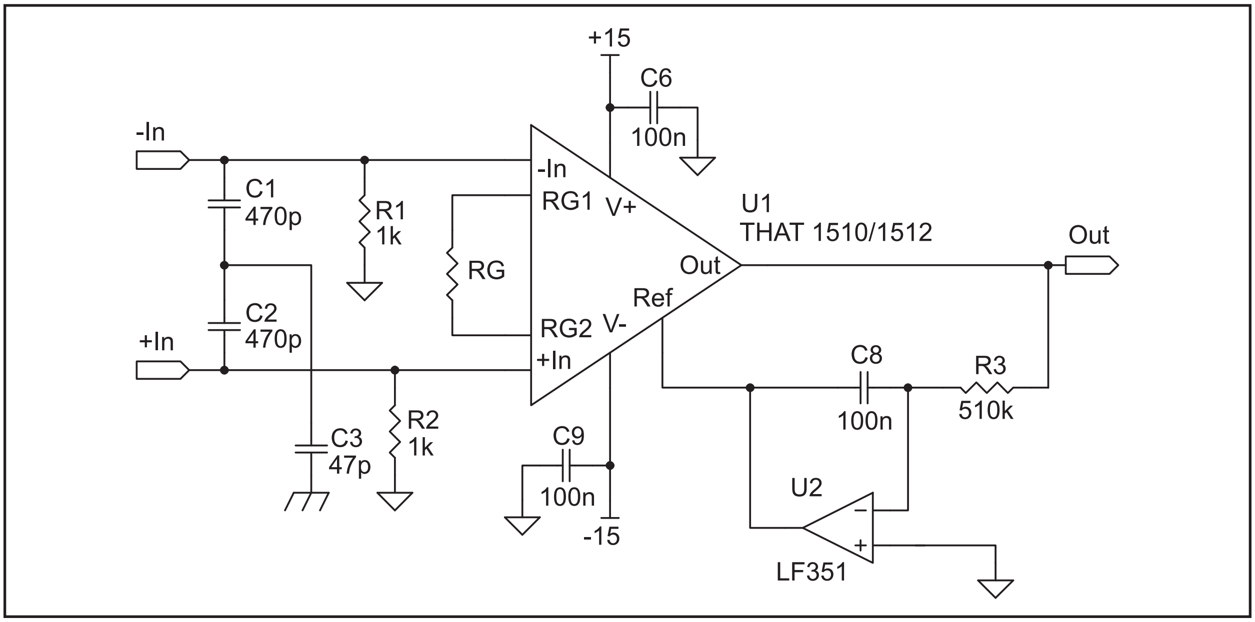

Figure 3. 1510 / 1512 Circuit with Output Offset Servo

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[3] In revisions 0 and 1 of this data sheet, we recommended using Schottky diodes (1N5819 types) to protect the 1510/1512 inputs against overloads. Subsequently, we discovered that the leakage of these diodes could cause problems with DC at the 1510/1512 output. Upon further investigation, we believe that conventional rectifier diodes like 1N4004 provide adequate protection and do not introduce unacceptable leakage. Additionally, 1N4004 diodes are much cheaper and more readily available than the Schottky types.

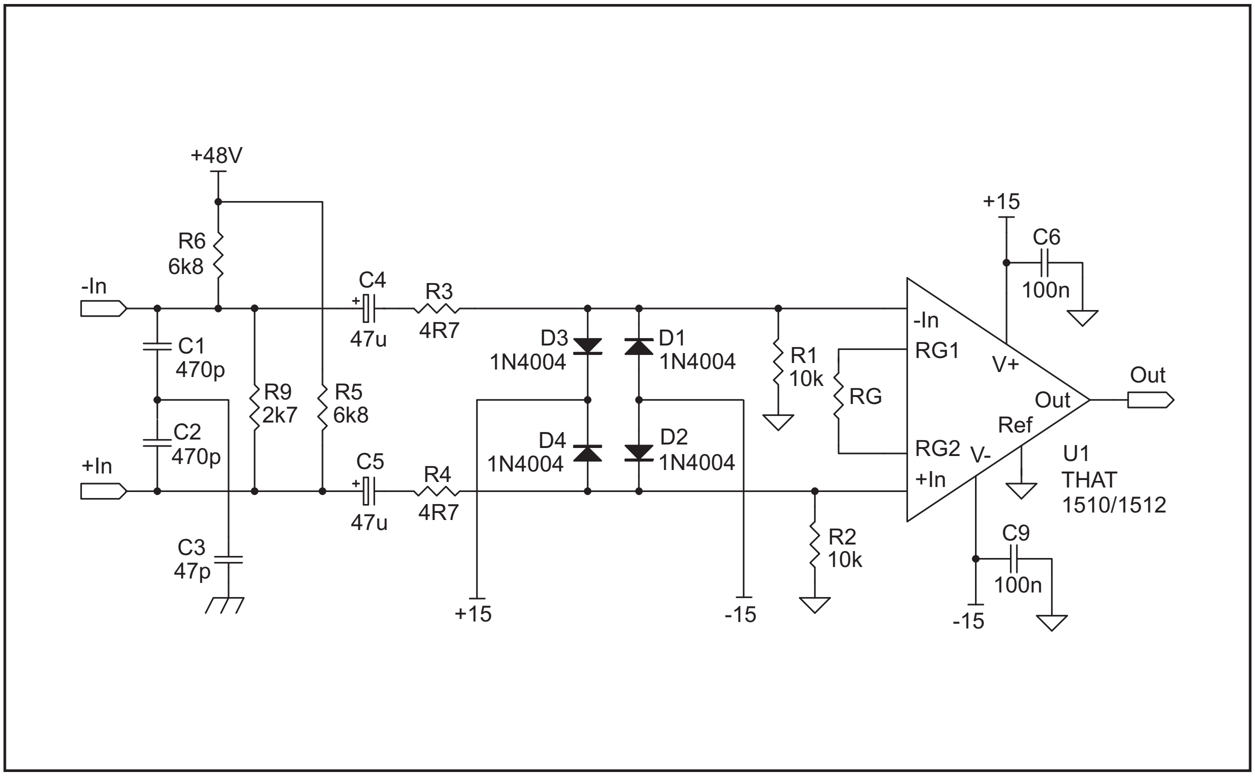


Figure 4. Recommended 1510 / 1512 Circuit with Phantom Power

in order to limit peak currents enough to protect the zener diodes. In such cases, these resistors will limit the noise performance of the preamp. The ultimate floor is set by the impedance of the microphone, but any additional series resistance further degrades performance.

Input Impedance and Line Input Configurations

A higher common-mode input impedance may be desirable (compared with that of Figures 2 and 3), especially when a mic pre-amp input is configured to double as a line receiver. The circuit of Figure 4 also accommodates this objective. In this circuit, R1 and R2 are increased to 10kΩ, boosting the low-frequency common-mode input impedance from 500 Ω to about 2 kΩ. A value of 2.7 kΩ for R9 keeps the differential input impedance at 2 kΩ without reducing the common-mode input impedance.

A line input can then be added by connecting 5.1 kΩ resistors from the line input's + and - input terminals to the positive and negative inputs, respectively, of the 1510/1512 of Figure 4. This increases the differential line input impedance to ~12.2 kΩ, and results in a net attenuation (pad) of approximately 15.7 dB between the line input and the output shown in Figure 4. Since, in many pro audio applications, the minimum pre-amp gain is 10 dB, the pad effectively cancels out this minimum gain while adding an additional 6dB of attenuation, which allows the resulting line input to accommodate high line level signals.

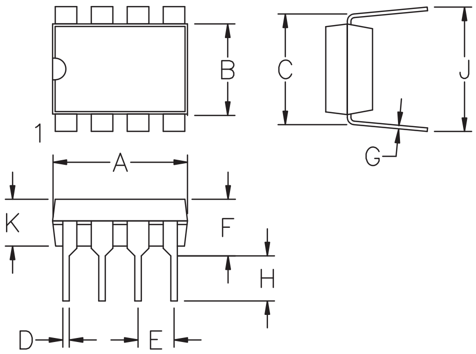
Reference Terminal

The "Ref" pin provides a 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 kΩ/R_{REF}.

Package Information

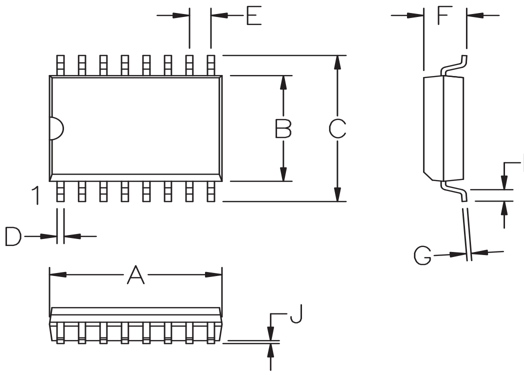
Both the THAT 1510 and 1512 are available in 8-pin SOIC, 8-pin DIP, and 14-pin SOIC packages. The 1510 is also available in a 16-pin (widebody) SOIC package. Other version/package combinations will be considered based on customer demand. The package dimensions are shown in Figures 5, 6, 7, & 8, while pinouts are given in Table 1.

All versions of the 1510 and 1512 are lead free and RoHS compliant. Material Declaration Data Sheets on the parts are available at our web site, www.thatcorp.com or upon request.



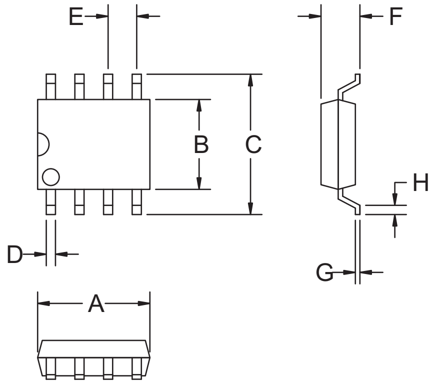
ITEM	MILLIMETERS	INCHES
A	9.53	0.375
B	6.35±0.10	0.250±0.004
C	7.47/8.13	0.294/0.320
D	0.46	0.018
E	2.54	0.100
F	3.66/4.32	0.144/0.170
G	0.25	0.010
H	3.18±0.10	0.125±0.004
J	8.13/9.40	0.320/0.370
K	3.30±0.10	0.130±0.004

Figure 5. 8-pin DIP package outline



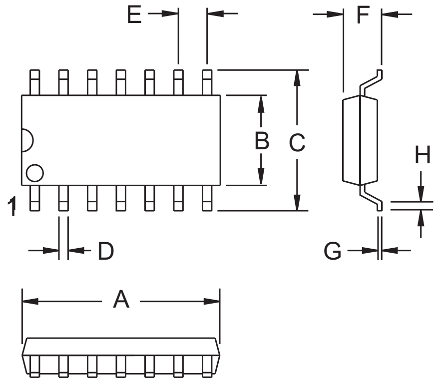
ITEM	MILLIMETERS	INCHES
A	10.10/10.29	0.397/0.405
B	7.39/7.59	0.291/0.299
C	10.11/10.52	0.398/0.414
D	0.30/0.51	0.012/0.020
E	1.27	0.050
F	2.44/2.64	0.096/0.104
G	0.23/0.33	0.009/0.013
H	0.51/1.02	0.020/0.040
J	0.10/0.30	0.004/0.012

Figure 6. 16-pin SO Wide package outline



ITEM	MILLIMETERS	INCHES
A	4.80/4.98	0.189/0.196
B	3.81/3.99	0.150/0.157
C	5.80/6.20	0.228/0.244
D	0.36/0.46	0.014/0.018
E	1.27	0.050
F	1.35/1.73	0.053/0.068
G	0.19/0.25	0.0075/0.0098
H	0.41/1.27	0.016/0.05

Figure 7. 8-pin SOIC package outline



ITEM	MILLIMETERS	INCHES
A	8.56/8.79	0.337/0.346
B	3.81/3.99	0.150/0.157
C	5.80/6.20	0.228/0.244
D	0.36/0.46	0.014/0.018
E	1.27	0.050
F	1.35/1.73	0.053/0.068
G	0.19/0.25	0.0075/0.0098
H	0.41/1.27	0.016/0.05

Figure 8. 14-pin SOIC package outline

Notes