FEATURES

- High CMRR: typically 90dB at 60Hz
- Wide bandwidth and high slew rate
- Low distortion and low noise
- Available in 0 dB, -3 dB, and -6 dB versions
- Pin compatible with SSM2143 and INA137

APPLICATIONS

- Balanced Audio Line Receivers
- Summing Amplifiers
- Differential Amplifiers
- Current Shunt Monitors
- Ground Loop Eliminator

Description

The THAT 124x series of precision differential amplifiers are designed primarily for use as audio balanced line receivers. Gains of 0 db, -3 dB, and -6 dB are available to suit various applications requirements.

The THAT 1246 is drop-in compatible with the Burr-Brown INA137 and Analog Devices SSM2143, while the THAT 1240 is drop-in compatible with the SSM2140.

All devices exhibit 90 dB of typical common-mode rejection, slew rates of 12 V/µs, a 20MHz bandwidth, and 0.0006% THD. Both surface-mount and DIP packages are available.

The THAT 124x family are laser-trimmed to obtain the precision resistor matching needed for high CMR performance. Fashioned in THAT Corporation's proprietary dielectric isolation (DI) process, the THAT 124x series provides the sonic benefit of discrete designs, with the compact size, reliability, matching, and thermal tracking of a fully integrated solution.

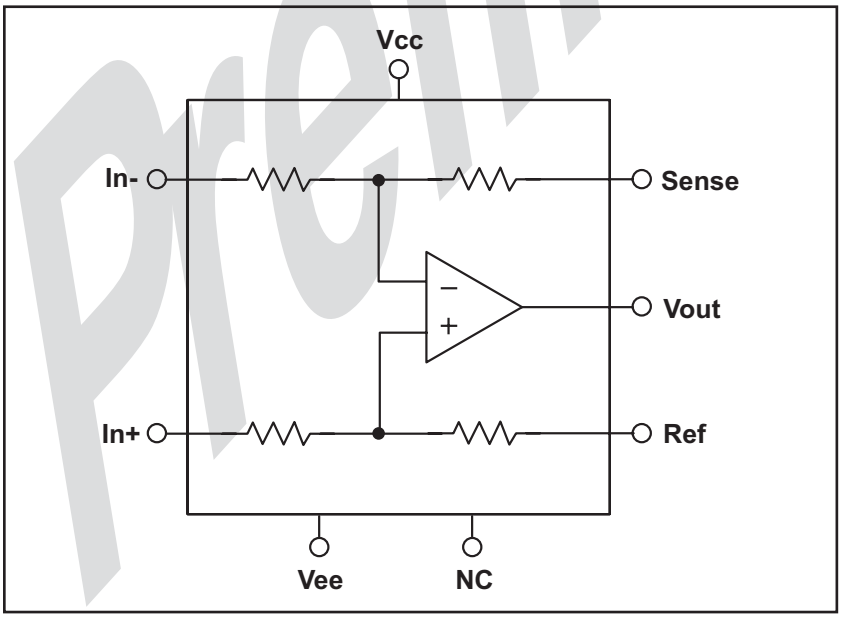

Figure 1. THAT1240-series equivalent circuit diagram

Pin Name	DIP Pin	SO Pin
Ref	1	1
In-	2	2
In+	3	3
Vee	4	4
Sense	5	5
Vout	6	6
Vcc	7	7
NC	8	8

Table 1. 1240 Series pin assignments

Gain	Plastic DIP	Plastic SO
0 dB	1240P	1240S
-3 dB	1243P	1243S
-6 dB	1246P	1246S

Table 2. Ordering information

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SPECIFICATIONS[1]

Absolute Maximum Ratings (T_A = 25°C)

Positive Supply Voltage (V_{CC})	+18 V	Power Dissipation (P_D) (T_A = 75°C)	TBD mW
Negative Supply Voltage (V_{EE})	-18 V	Operating Temperature Range (T_{OP})	0 to +70°C
Storage Temperature Range (T_{ST})	-40 to +125°C	Junction Temperature (T_J)	150°C
Output Short-Circuit Duration (t_{SH})	Continuous	Lead Temperature (Soldering 60 seconds)	TBD °C
Positive Input Voltage (Ref, Sense)	+18 V	Negative Input Voltage (Ref, Sense)	-18 V

	THAT1240	THAT1243	THAT1246
Positive Input Voltage (In+,In-)	Vcc x 2	Vcc x 2.4	Vcc x 3
Negative Input Voltage (In+, In-)	Vee x 2	Vee x 2.4	Vee x 3

Recommended Operating Conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Positive Supply Voltage	V_{CC}		+2.2		+18	V
Negative Supply Voltage	V_{EE}		-2.2		-18	V

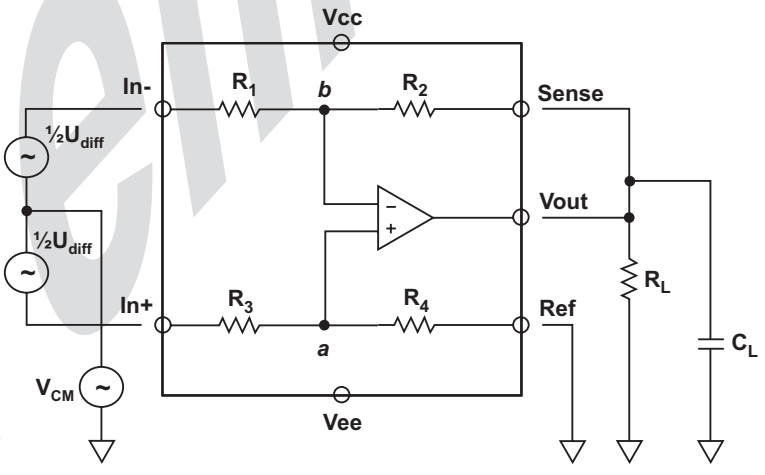
Electrical Characteristics[2]

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Current	I_{CC}	No signal	—	2.1	3.4	mA
Input Voltage Range	$V_{IN-DIFF}$	Differential (equal and opposite swing)				
		THAT1240 (0 dB gain)	—	21.5	—	dBu[3]
		THAT1243 (-3 dB gain)	—	24.5	—	dBu
		THAT1246 (-6 dB gain)	—	27.5	—	dBu
	V_{IN-CM}	Common mode				
		THAT1240 (0 dB gain)	—	27.5	—	dBu
		THAT1243 (-3 dB gain)	—	29.1	—	dBu
		THAT1246 (-6 dB gain)	—	31.0	—	dBu
Input Impedance[4]	Z_{IN-CM}	Common mode (all versions)	—	9	—	kΩ
	$Z_{IN-DIFF}$	Differential				
		THAT1240	—	18	—	kΩ
		THAT1243	—	21	—	kΩ
		THAT1246	—	24	—	kΩ
Common Mode Rejection	CMR	Matched source impedances; V_{CM} = ±10V				
		DC	70	90	—	dB
		60 Hz	70	90	—	dB
		20 kHz	—	85	—	dB
		44 kHz	—	60	—	dB
Power Supply Rejection[5]	PSR	At 60 Hz, with V_{CC} = -V_{EE}				
		THAT1240	—	82	—	dB
		THAT1243	—	80	—	dB

1. All specifications are subject to change without notice.
2. Unless otherwise noted, T_A=25°C, V_{CC} = +15V, V_{EE} = -15V, Gain=-6dB
3. 0 dBu = 0.775Vrms.
4. See test circuit in Figure 2.
5. Defined with respect to differential gain.

Electrical Characteristics (Cont'd)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Total Harmonic Distortion	THD	$V_{IN-DIFF}$ = 10 dBV; BW = 20 kHz; f = 1 kHz				
		R_L = 2 kΩ	—	0.0006	—	%
Output Noise	$e_{n(OUT)}$	BW = 20 kHz				
		THAT1240	—	-106	—	dBu
		THAT1243	—	-107	—	dBu
		THAT1246	—	-109	—	dBu
Slew Rate	SR	R_L = 2 kΩ; C_L = 300 pF	7	12	—	V/µs
Small Signal Bandwidth	BW_{-3dB}	R_L = 2 kΩ; C_L = 10 pF				
		THAT1240	12	24	—	MHz
		THAT1243	17	33	—	MHz
		THAT1246	23	44	—	MHz
		R_L = 2 kΩ; C_L = 300 pF				
		THAT1240	11	17	—	MHz
		THAT1243	13	18	—	MHz
		THAT1246	14	20	—	MHz
Output Gain Error	$G_{ER(OUT)}$	f = 1 kHz	—	±0.03	±0.5	%
Output Voltage Swing	V_O	R_L = 2 kΩ	±12.5	±13	—	V
Output Offset Voltage	V_{OFF}	No signal	-7	0	+7	mV
Output Short Circuit Current	I_{SC}	R_L = 0 Ω	—	±25	—	mA
Resistive Load	R_{Lmin}		—	—	2	kΩ
Capacitive Load	C_{Lmax}		300	—	—	pF



Part no.	Gain	$R_1 = R_3$	$R_2 = R_4$
THAT1240	0 dB	9 kΩ	9 kΩ
THAT1243	-3 dB	10.5 kΩ	7.5 kΩ
THAT1246	-6 dB	12 kΩ	6 kΩ

Figure 2. THAT1240 series test circuit

Application Notes

The THAT 1240, 1243, and 1246 are precision differential amplifiers with gains of zero, -3 and -6 dB respectively, and are primarily intended as balanced line receivers for pro audio. However, their topology lends itself to other applications as well.

Figures 3 and 4 show the THAT 1240 and THAT 1246 configured as zero and -6 dB line receivers respectively. These devices can be used to retrofit circuits currently using the SSM 2141, INA134, SSM2143, or INA137. While the THAT 1240 and THAT 1246 are form, fit and functionally compatible with their competitors' equivalent versions, their slew rate and bandwidth are superior.

Like other amplifiers of this type, all of THAT Corporation's line receivers can accept common mode voltages that exceed the power supply rails. Consider Figure 2. Assume that the circuit is configured as shown, but with no differential excitation. In+ and In- are shorted together, as are Vout and Sense. Ref is tied to ground. *a* and *b* will be held at the same voltage by feedback.

The maximum voltage allowed at the internal node *a* is V_{CC} minus 2V, while the minimum voltage is V_{EE} plus 2V. The voltage at *a* can be calculated

$$a = V_{PK-CM}\left[\frac{R4}{R3+R4}\right]$$

Isolating V_{PK-CM}, we see that

$$V_{PK-CM} = a\left[\frac{R4+R3}{R4}\right]$$

Thus, the maximum input in dBu would be

$$V_{IN\,\max-dbu} = 20\log\left[\frac{\frac{(Vcc-2V)}{\sqrt{2}}\times\left[\frac{R4+R3}{R4}\right]}{0.775}\right]$$

With ±18V supplies, the THAT 1240 can tolerate a maximum common mode input of 29.3 dBu. Under the same conditions, the THAT1243 can tolerate 30.0 dBu and the THAT 1246 can tolerate 32.9 dBu. These numbers are slightly higher than the datasheet specifications, since they're calculated with a slightly higher supply voltage. Also note that high levels of common mode input compromise the maximum differential mode signal that can be handled by these ICs.

Figure 5 shows a THAT 1240 configured as a precision summing amplifier. This circuit uses both the In+ and Ref pins as inputs. Refering to Figure 2, it can be shown by superposition that the voltage at *a* will be

$$a = (In+)\left[\frac{R4}{R4+R3}\right] + Ref\left[\frac{R3}{R4+R3}\right]$$

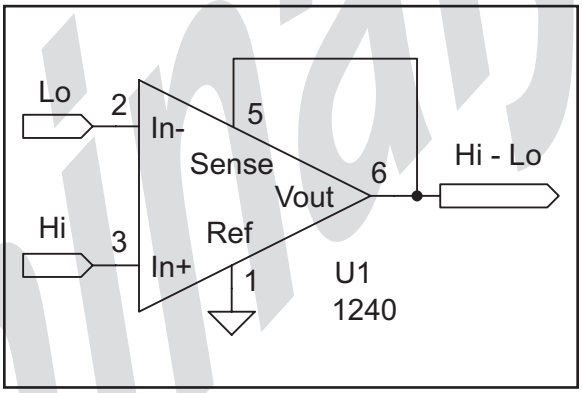


Figure 3. Zero dB line receiver

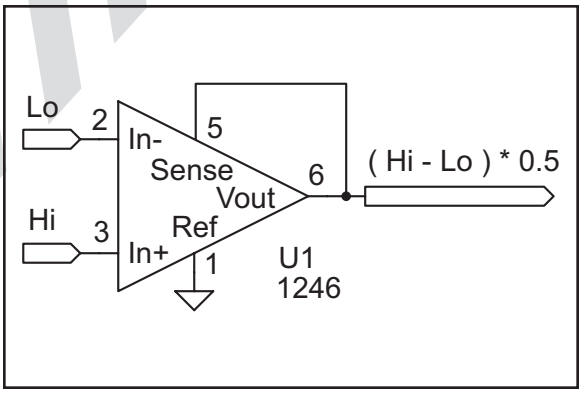


Figure 4. -6 dB line receiver

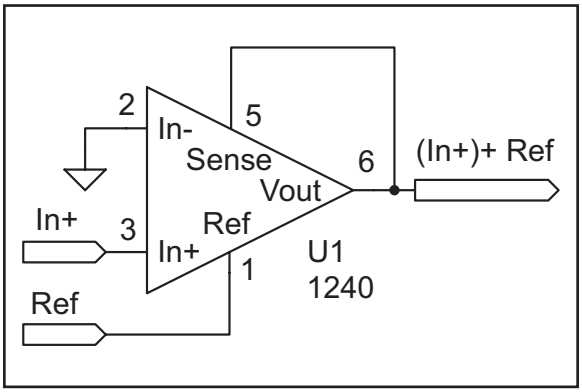


Figure 5. Precision summing circuit

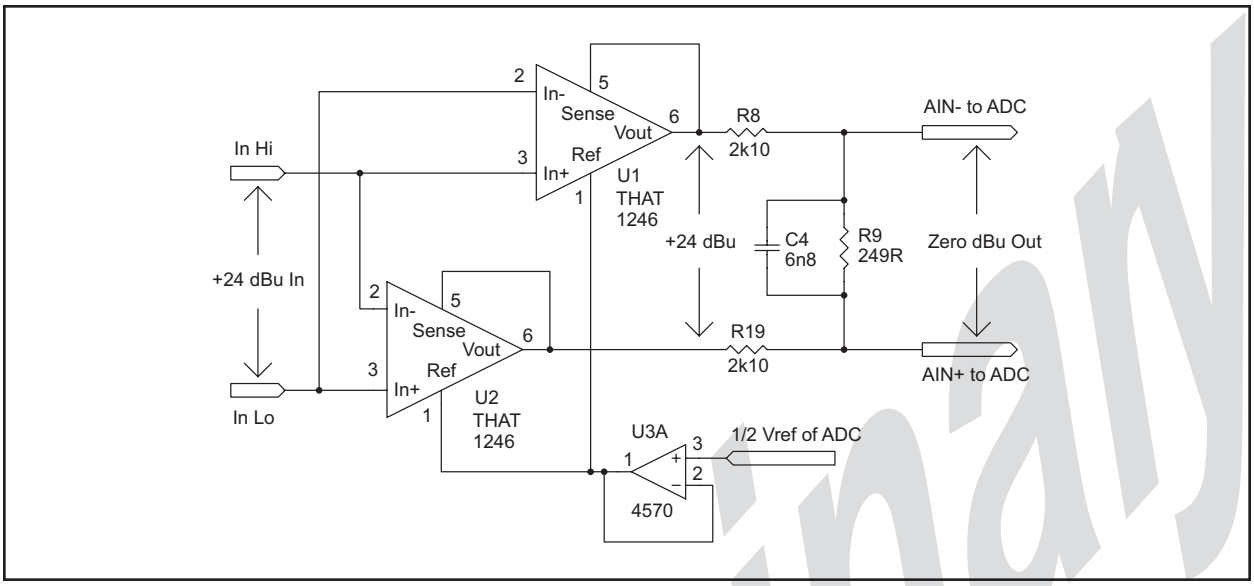


Figure 6. Circuit for audio ADCs with balanced inputs

Since R3=R4 in the THAT 1240, this equation can be simplified to

$$a = \frac{(In+)+Ref}{2}$$

The output voltage would then be

$$Vout = a \times (1 + \frac{R2}{R1})$$

Since R2=R1, combining equations results in

$$Vout = (In+) + Ref$$

Figure 6 shows a convenient method of driving a typical audio ADC with balanced inputs. This circuit accepts +24 dBu in, and using a pair of THAT 1246s, the signal level between their respective outputs is +24 dBu. An attenuator network brings the signal down another 24 dB while attenuating the noise of the line receivers as well.

The output noise of a THAT 1246 is -109 dBu, and since there are two of them, the total noise level going into the resistive pad will be -106 dBu. The pad reduces the noise level to -130 dBu at the input to the ADC. The noise density resulting from the line receivers will therefore be

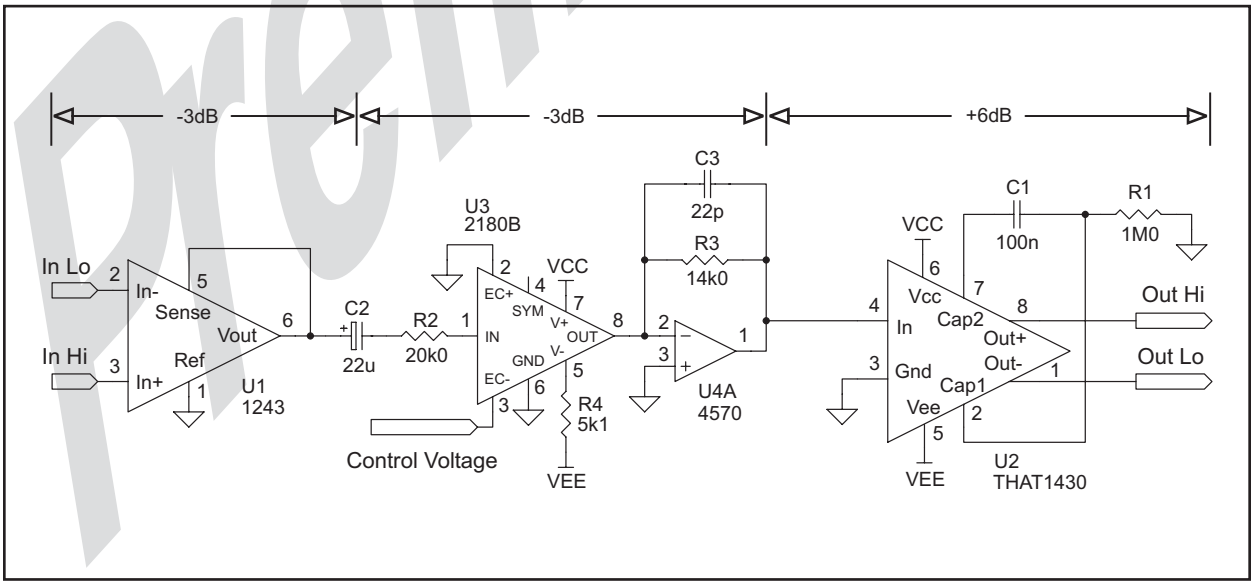


Figure 7. Automated gain control of a balanced signal

$$e_{n\ line\ receiver} = \frac{10\,(\frac{-130dBu}{20}) \times 0.775}{\sqrt{20kHz}} = 1.73\,\frac{nV}{\sqrt{Hz}}$$

The noise of the 249Ω resistor is 2.05 nV/√Hz. We can assume that the noise contribution of R8 and R19 will be negligible, and therefore, the total noise density going into the input of the ADC will be

$$e_{n\ total} = \sqrt{(1.73\,\frac{nV}{\sqrt{Hz}})^2 + (2.06\,\frac{nV}{\sqrt{Hz}})^2} = 2.68\,\frac{nV}{\sqrt{Hz}}$$

The noise floor can then be calculated to be

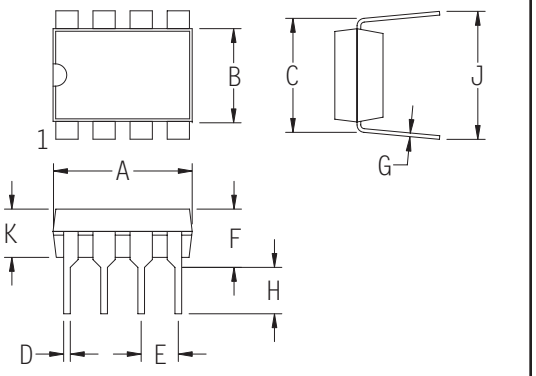
$$Noise_{dBu} = 20\log\left[\frac{2.68\frac{nV}{\sqrt{Hz}} \times \sqrt{20kHz}}{0.775}\right] = -126.2\,dBu$$

Figure 7 shows an excellent method for controlling gain in a balanced system. There is often a temptation in these systems to keep the signal balanced and use two VCAs to independently control the gain on each half of the balanced signal. Unfortunately, this can results in common mode to differential mode conversion (degradation of CMRR) when there are even slight differences in gain between the VCAs. A better approach is to convert the signal to single-ended, alter the gain, and then convert back to balanced.

In Figure 7 we use a THAT 1243 -3 dB line receiver to do the balanced to single-ended conversion. The VCA section also has a static gain of -3 dB due to the ratio of R2 and R3. This circuit can accept 24 dBu, since the THAT 1243 output stage is capable of 21 dBu without distortion. Reducing R3 to 14 kΩ results in a 3 dB reduction in VCA output noise. This arrangement results in 3 dB greater dynamic range compared to the case where a -6 dB line receiver and a VCA with zero dB static gain are used. After the VCA, the signal is restored to 24 dBu by the THAT 1430.

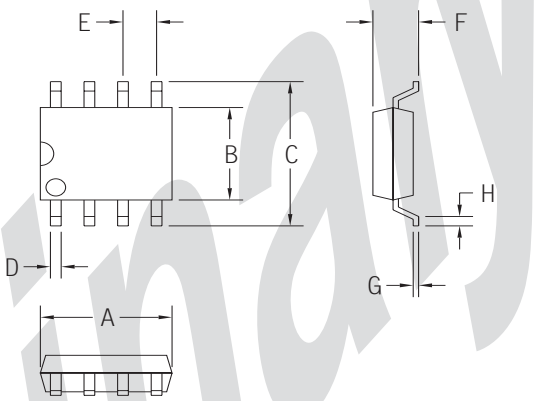
Package Information

The THAT 1240 series is available in both 8-pin mini-DIP and 8-pin SOIC packages. The package dimensions are shown in Figures 8 and 9, while the pinouts are given in Table 1.



ITEM	MILLIMETERS	INCHES
A	9.52±0.10	0.375±0.004
B	6.35±0.10	0.250±0.004
C	7.49/8.13	0.295/0.320
D	0.46	0.018
E	2.54	0.100
F	3.68/4.32	0.145/0.170
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 8. -P (DIP) version package outline drawing



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 9. -S (SO) version package outline drawing

Notes: