1. FEATURES

- Excellent Matching
  - A-Grade: 0.01% Matching
  - B-Grade: 0.025% Matching
- 0.2ppm/°C Matching Temperature Drift
- ±75V Operating Voltage (±80V Abs Max)
- 8ppm/°C Absolute Resistor Value Temperature Drift
- –40°C to 125°C Operating Temperature
- 8-Lead MSOP Package

2. APPLICATIONS

- Difference Amplifier
- Reference Divider
- Precision Summing /Subtracting

3. GENERAL DESCRIPTION

The LHE5400 is a quad resistor network with excellent matching specifications over the entire temperature range. Matching is also specified when the LHE5400 is configured in a difference amplifier. This enhanced matching specification guarantees CMRR performance to be up to 2× better than independently matched resistors.

All four resistors can be accessed and biased independently, making the LHE5400 a convenient and versatile choice for any application that can benefit from matched resistors.

These resistor networks provide precise ratiometric stability required in highly accurate difference amplifiers, voltage references and bridge circuits.

The LHE5400 is available in a space-saving 8-pin MSOP package, and is specified over the temperature range of –40°C to 125°C.

TYPICAL APPLICATION

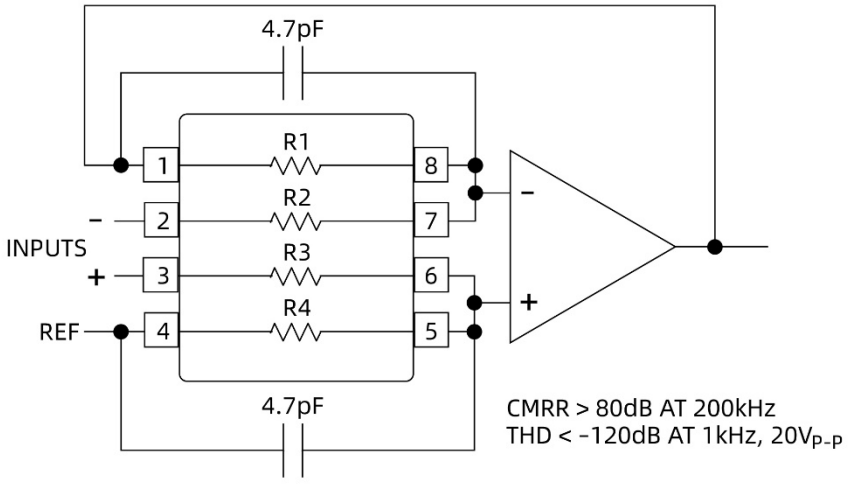

Figure 1. Difference Amplifier

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4. REVISION HISTORY

Version number	Date	Update the content
PreA	May 21, 2024	First edition
PreB	July 12, 2024	Update procurement information
Rev.A	July 19, 2024	Official version
Rev.B	September 6, 2024	Update procurement information
Rev.C	July.14, 2025	Update the list of ordering guide

5. ABSOLUTE MAXIMUM RATINGS

(Note 1)

Total Voltage (Across Any 2 Pins) (Note 2) ..... ±80V
Power Dissipation (Each Resistor) (Note 3) 800mW
Operating Temperature Range
LHE5400..... –40°C to 125°C
Maximum Junction Temperature..... 150°C
Storage Temperature Range..... –65°C to 150°C

6. PIN CONFIGURATION

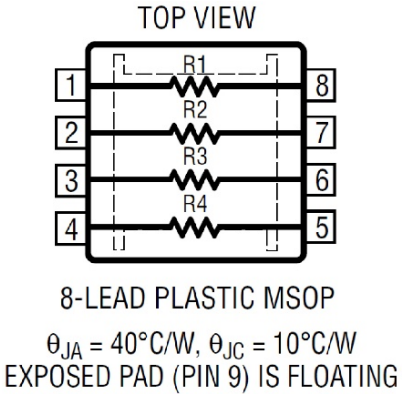


Figure 2. Pin Configuration

7. AVAILABLE OPTIONS

Table 1.

PART NUMBER	R2 = R3 (Ω)	R1 = R4 (Ω)	RESISTOR RATIO
LHE5400-1	10k	10k	1:1
LHE5400-2	100k	100k	1:1
LHE5400-3	10k	100k	1:10
LHE5400-4	1k	1k	1:1
LHE5400-5	1M	1M	1:1
LHE5400-6	1k	5k	1:5
LHE5400-7	1.25k	5k	1:4
LHE5400-8	1k	9k	1:9

8. ELECTRICAL CHARACTERISTICS

The • denotes the specifications which apply over the full specified temperature range, otherwise specifications are at T_A = 25°C.

Table 2.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ΔR/R	Resistor Matching Ratio (Any Resistor to Any Other Resistor)	A-Grade T_A = –40°C to 125°C	•			±0.01	%
		B-Grade T_A = –40°C to 125°C	•			±0.025	%
$(\Delta R/R)_{CMRR}$	Matching for CMRR	A-Grade (Note 4)	•			±0.005	%
		B-Grade (Note 4)	•			±0.015	%
(ΔR/R)/ΔT	Resistor Matching Ratio Temperature Drift		•		±0.2	±1	ppm/°C
	Resistor Voltage Coefficient		•		<0.1		ppm/V
ΔR	Absolute Resistor Tolerance	A-Grade	•			±7.5	%
		B-Grade	•			±15	%
	Distributed Capacitance	Resistor to Exposed Pad			5.5		pF
		Resistor to Resistor			1.4		pF
ΔR/ΔT	Absolute Resistor Value Temperature Drift		•			25	ppm/°C
	Harmonic Distortion	$20V_{P-P}$, 1kHz, Difference Amplifier			–120		dBc

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: The instantaneous difference between the highest voltage applied to any pin and the lowest voltage applied to any other pin should not exceed the Absolute Maximum Rating. This includes the voltage across any resistor, the voltage across any pin with respect to the exposed pad of the package, and the voltage across any two unrelated pins.
Note 3: In order to keep the junction temperature within the Absolute Maximum Rating, maximum power dissipation should be derated at elevated ambient temperatures.
Note 4: (ΔR/R)CMRR (Matching for CMRR) is a metric for the contribution of error from the LHE5400 when used in a difference configuration using the specific resistor pairs of R1/R2 and R4/R3. See Difference Amplifier, Instrumentation Amplifier, and Differential Amplifier circuits in the Typical Applications section for examples.

$$(\Delta R/R)_{CMRR} = \frac{1}{2} \bullet \left(\frac{R2}{R1} - \frac{R3}{R4}\right) \bullet \left(\frac{R1}{R2}\right)$$

The resistor contribution to CMRR can then be calculated in the following way:

$$\frac{1}{CMRR} = (\Delta R/R)_{CMRR} \bullet \left(\frac{4 \bullet \frac{R2}{R1}}{2 + \frac{R2}{R1} + \frac{R3}{R4}}\right)$$

For LHE5400 options with resistor ratio 1:1, the resistor contribution to CMRR can be simplified:

$$CMRR \approx (\Delta R/R)_{CMRR}$$

9. APPLICATIONS INFORMATION

9.1. WHERE TO CONNECT THE EXPOSED PAD

The exposed pad is not DC connected to any resistor terminal. Its main purpose is to reduce the internal temperature rise when the application calls for large amounts of dissipated power in the resistors. The exposed pad can be tied to any voltage (such as ground) as long as the absolute maximum ratings are observed.

There is capacitive coupling between the resistors and the exposed pad, as specified in the Electrical Characteristics table. To avoid interference, do not tie the exposed pad to noisy signals or noisy grounds.

Connecting the exposed pad to a quiet AC ground is recommended as it acts as an AC shield and reduces the amount of resistor-resistor capacitance.

9.2. THERMAL CONSIDERATIONS

Each resistor is rated for relatively high-power dissipation, as listed in the Absolute Maximum Ratings section of

this data sheet. To calculate the internal temperature, rise inside the package, add together the power dissipated in all of the resistors, and multiply by the thermal resistance coefficient of the package (θ_{JA} or θ_{JC} as applicable).

For example, if each resistor dissipates 250mW, for a total of 1W, the total temperature rise inside the package equals 40°C. All 4 resistors will be at the same temperature, regardless of which resistor dissipates more power. The junction temperature must be kept within the Absolute Maximum Rating. At elevated ambient temperatures, this places a limit on the maximum power dissipation.

In addition to limiting the maximum power dissipation, the maximum voltage across any two pins must also be kept less than the absolute maximum rating.

9.3. ESD

The LHE5400 can withstand up to ±1kV of electrostatic discharge (ESD, human body). To achieve the highest precision matching, the LHE5400 is designed without explicit ESD internal protection diodes. ESD beyond this voltage can damage or degrade the device including causing pin-to-pin shorts.

To protect the LHE5400 against large ESD strikes, external protection can be added using diodes to the circuit supply rails or bidirectional Zeners to ground (Figure 3).

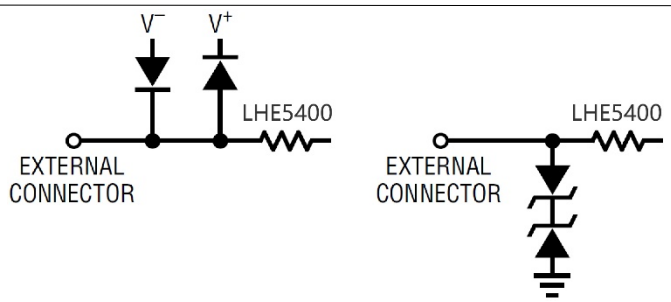


Figure 3. ESD

9.4. MATCHING SPECIFICATION

The LHE5400 specifies matching in the most conservative possible way. In each device, the ratio error of the largest of the four resistors to the smallest of the four resistors meets the specified matching level. Looser definitions would compare each resistor value to the average of the resistor values, which would typically result in specifications that appear twice as good as they are per the LHE5400's more conservative definition. The following two examples illustrate this point.

In an inverting gain-of-1 amplifier, if the largest resistor is allowed to deviate only 0.01% from the smallest resistor, then the worst-case gain can be –1.00005/0.99995 = –1.0001, which is a 0.01% error from the ideal –1.0000. That is the LHE5400 definition. In a looser definition, if each resistor would be allowed to deviate by 0.01% from the average, then the worst-case gain could be –1.0001/0.9999 = –1.0002, which is a 0.02% error from the ideal –1.0000.

In a divide-by-2 resistor divider network, if the largest resistor is allowed to deviate only 0.01% from the smallest resistor, then the worst-case ratio can be 1.00005/(1.00005 + 0.99995) = 0.500025, which is a 0.005% error from the ideal 0.50000. That is the LHE5400 definition. In a looser definition, if each resistor would be allowed to deviate by 0.01% from the average, then the worst-case ratio could be 1.0001/(1.0001 + 0.9999) = 0.50005, which is a 0.01% error from the ideal 0.50000.

10. TYPICAL APPLICATIONS

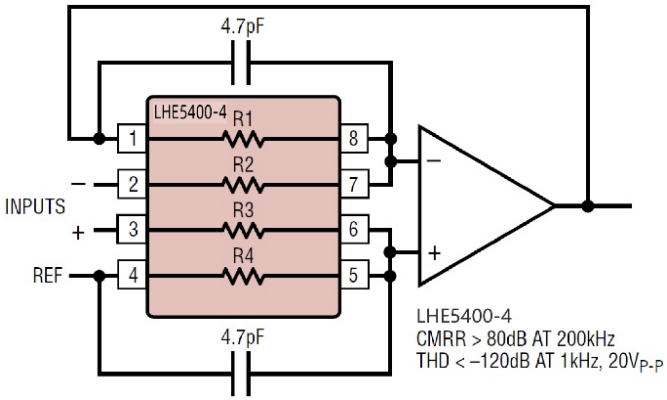


Figure 4. Difference Amplifier

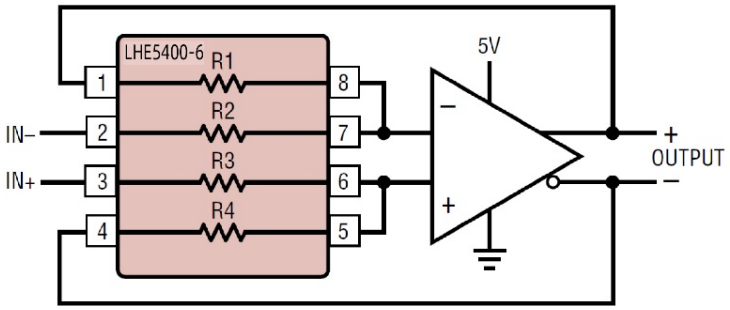
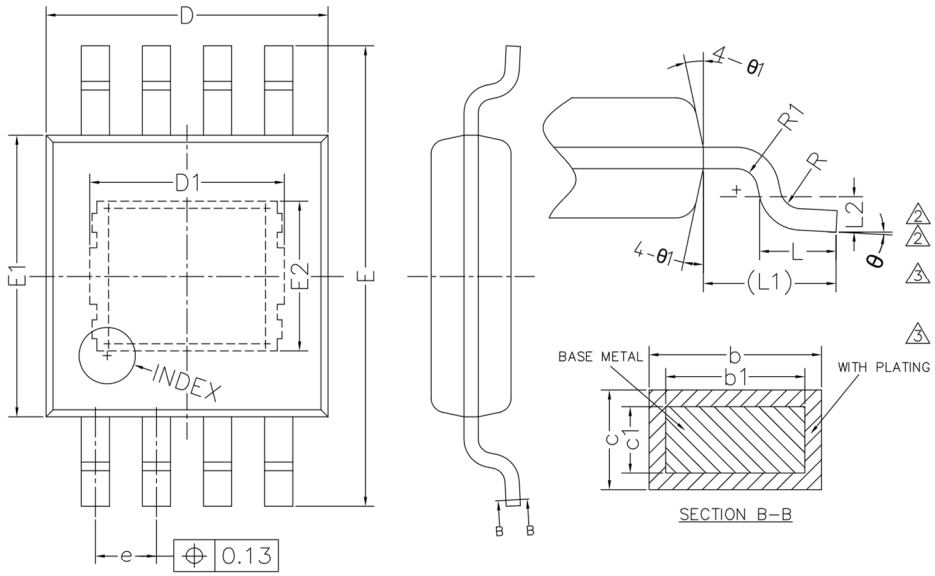


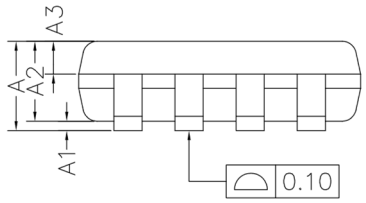
Figure 5. Gain of 5, Fully-Differential Amplifier

11. PACKAGE DESCRIPTION



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.25	–	0.38
b1	0.24	0.30	0.33
c	0.13	–	0.20
c1	0.13	0.15	0.16
D	2.90	3.00	3.10
D1	1.92	2.07	2.22
E	4.75	4.90	5.05
E1	2.90	3.00	3.10
E2	1.45	1.60	1.75
e	0.55	0.65	0.75
L	0.40	0.55	0.70
L1		0.95REF	
L2		0.25BSC	
R	0.07	–	–
R1	0.07	–	–
θ	0°	–	8°
θ1	9°	12°	15°



NOTES: 1. ALL DIMENSIONS IN MILLIMETERS REFER TO JEDEC STANDARD MO-187 AA-T
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2. INDEX ø0.60±0.10 WITH 0.05MAX DEPTH.
3.'D1' AND 'E2' ARE VARIABLES DEPENDING ON DIE PAD SIZES.

Figure 6. Package Description

12. ORDERING GUIDE

Table 3. Ordering Guide

Orderable Device	Package Type	Pin number	Op Temp (°C)	MPQ	Remark
LHE5400A-1MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-2MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-3MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-4MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-5MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-6MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-7MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400A-8MMA	EMSOP	8	-40~125℃	2500EA/REEL	A-Grade
LHE5400B-1MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-2MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-3MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-4MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-5MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-6MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-7MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade
LHE5400B-8MMA	EMSOP	8	-40~125℃	2500EA/REEL	B-Grade