EL5174

550MHz Differential Twisted-Pair Driver

FN7313
Rev.10.00
Aug 3, 2020

The EL5174 is a single high bandwidth amplifier with an output in differential form. It is primarily targeted for applications such as driving twisted-pair lines in component video applications. The inputs can be in either single-ended or differential form but the outputs are always in differential form.

On the EL5174, two feedback inputs provide you with the ability to set the gain of each device (stable at minimum gain of one). For a fixed gain of two, please see the EL5173 data sheet (FN7312).

The output common mode level is set by the associated REF pin, which has a -3dB bandwidth of over 110MHz. Generally, this pin is grounded but can be tied to any voltage reference.

All outputs are short circuit protected to withstand temporary overload condition.

The EL5174 is available in a 8 Ld SOIC package. It is specified for operation across the full -40°C to +85°C temperature range.

Related Literature

For a full list of related documents, visit our website:

- EL5174 product page

Features

- Fully differential inputs, outputs, and feedback
- Differential input range ±2.3V
- 550MHz 3dB bandwidth
- 1100V/µs slew rate
- Low distortion at 5MHz
- Single 5V or dual ±5V supplies
- 60mA maximum output current
- Low power - 12.5mA
- Pb-free (RoHS compliant)

Applications

- Twisted-pair driver
- Differential line driver
- VGA over twisted-pair
- ADSL/HDSL driver
- Single-ended to differential amplification
- Transmission of analog signals in a noisy environment

Ordering Information

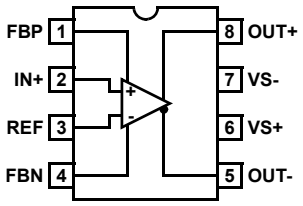
PART NUMBER (Notes 1, 2, 3)	PART MARKING	TEMP. RANGE (°C)	TAPE AND REEL (UNITS)	PACKAGE (RoHS Compliant)	PKG. DWG. #
EL5174ISZ	5174ISZ	-40 to +85	-	8 Ld SOIC	M8.15E
EL5174ISZ-T7	5174ISZ	-40 to +85	2.5k	8 Ld SOIC	M8.15E
EL5174ISZ-T13	5174ISZ	-40 to +85	1k	8 Ld SOIC	M8.15E

NOTE:

1. See TB347 for details about reel specifications.
2. These Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), see the EL5174 device page. For more information about MSL, see TB363.

Pinout

(8 LD SOIC)
TOP VIEW



Pin Descriptions

PIN NUMBER	PIN NAME	PIN FUNCTION
1	FBP	Feedback from non-inverting output
2	IN+	Non-inverting input
3	REF	Inverting inputs, note that on EL5174, this pin is also the REF pin
4	FBN	Feedback from inverting output
5	OUT-	Inverting output
6	VS+	Positive supply
7	VS-	Negative supply
8	OUT+	Non-inverting output

Absolute Maximum Ratings (T_A = +25°C)

Supply Voltage (V_S+ to V_S-) 12V
Supply Voltage Rate-of-rise (dV/dT) 1V/µs
Input Voltage (IN+, IN- to V_S+, V_S-) . . . . . V_S- - 0.3V to V_S+ + 0.3V
Differential Input Voltage (IN+ to IN-) . . . . . ±4.8V
Maximum Output Current . . . . . ±60mA

Thermal Information

Thermal Resistance (Typical, Note 4)	θ_{JA} (°C/W)
8 Ld SOIC Package	120.40

Operating Junction Temperature . . . . . +135°C
Ambient Operating Temperature . . . . . -40°C to +85°C
Storage Temperature Range . . . . . -65°C to +150°C
Power Dissipation . . . . . See Curves
Pb-Free Reflow Profile . . . . . see TB493

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions can adversely impact product reliability and result in failures not covered by warranty.

NOTE:

4. θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air. See TB379 for details.

IMPORTANT NOTE: All parameters having Min/Max specifications are guaranteed. Typ values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: $T_J = T_C = T_A$

Electrical Specifications

V_S+ = +5V, V_S- = -5V, T_A = +25°C, V_{IN} = 0V, R_{LD} = 1kΩ, R_F = 0, R_G = OPEN, C_{LD} = 2.7pF, unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 5)	TYP	MAX (Note 5)	UNIT
AC PERFORMANCE						
BW	-3dB Bandwidth	A_V = 1, C_{LD} = 2.7pF		550		MHz
		A_V = 2, R_F = 500, C_{LD} = 2.7pF		130		MHz
		A_V = 10, R_F = 500, C_{LD} = 2.7pF		20		MHz
BW	±0.1dB Bandwidth	A_V = 1, C_{LD} = 2.7pF		120		MHz
SR	Slew Rate	V_{OUT} = 3V_{P-P}, 20% to 80%	800	1100		V/µs
t_{STL}	Settling Time to 0.1%	V_{OUT} = 2V_{P-P}		10		ns
t_{OVR}	Output Overdrive Recovery Time			20		ns
GBWP	Gain Bandwidth Product			200		MHz
V_{REF}BW (-3dB)	V_{REF} -3dB Bandwidth	A_V = 1, C_{LD} = 2.7pF		110		MHz
V_{REF}SR+	V_{REF} Slew Rate - Rise	V_{OUT} = 2V_{P-P}, 20% to 80%		134		V/µs
V_{REF}SR-	V_{REF} Slew Rate - Fall	V_{OUT} = 2V_{P-P}, 20% to 80%		70		V/µs
V_N	Input Voltage Noise	at 10kHz		21		nV/√Hz
I_N	Input Current Noise	at 10kHz		2.7		pA/√Hz
HD2	Second Harmonic Distortion	V_{OUT} = 2V_{P-P}, 5MHz		-95		dBc
		V_{OUT} = 2V_{P-P}, 20MHz		-94		dBc
HD3	Third Harmonic Distortion	V_{OUT} = 2V_{P-P}, 5MHz		-88		dBc
		V_{OUT} = 2V_{P-P}, 20MHz		-87		dBc
dG	Differential Gain at 3.58MHz	R_{LD} = 300Ω, A_V = 2		0.06		%
dθ	Differential Phase at 3.58MHz	R_{LD} = 300Ω, A_V = 2		0.13		°
INPUT CHARACTERISTICS						
V_{OS}	Input Referred Offset Voltage			±1.4	±25	mV
I_{IN}	Input Bias Current (V_{IN}+, V_{IN}-)		-30	-14	-7	µA
I_{REF}	Input Bias Current (V_{REF})		0.5	2.3	4	µA
R_{IN}	Differential Input Resistance			150		kΩ
C_{IN}	Differential Input Capacitance			1		pF
DMIR	Differential Mode Input Range		±2.1	±2.3	±2.5	V
CMIR+	Common Mode Positive Input Range at V_{IN}+, V_{IN}-			3.4		V
CMIR-	Common Mode Negative Input Range at V_{IN}+, V_{IN}-			-4.3		V

Electrical Specifications $V_S+ = +5V$, $V_S- = -5V$, $T_A = +25°C$, $V_{IN} = 0V$, $R_{LD} = 1k\Omega$, $R_F = 0$, R_G = OPEN, $C_{LD} = 2.7pF$, unless otherwise specified. **(Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 5)	TYP	MAX (Note 5)	UNIT
Gain	Gain Accuracy	V_{IN} = 1V	0.980	0.995	1.010	V
OUTPUT CHARACTERISTICS						
V_{OUT}	Output Voltage Swing	R_L = 500Ω to GND		±3.4		V
I_{OUT}(Max)	Maximum Output Current	R_L = 10Ω, $V_{IN}+$ = ±3.2V	±50	±60	±100	mA
R_{OUT}	Output Impedance			130		mΩ
SUPPLY						
V_{SUPPLY}	Supply Operating Range	V_S+ to V_S-	4.75		11	V
$I_{S(ON)}$	Power Supply Current		10	12.5	14	mA
PSRR	Power Supply Rejection Ratio	V_S from ±4.5V to ±5.5V	60	75		dB

NOTE:

5. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

Connection Diagram

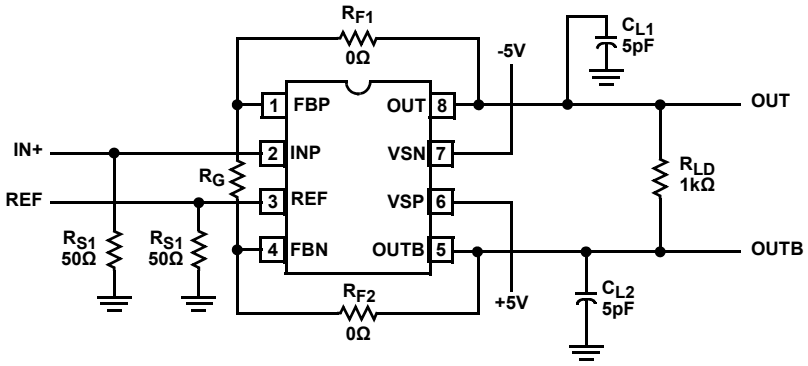


FIGURE 1. EL5174

Typical Performance Curves

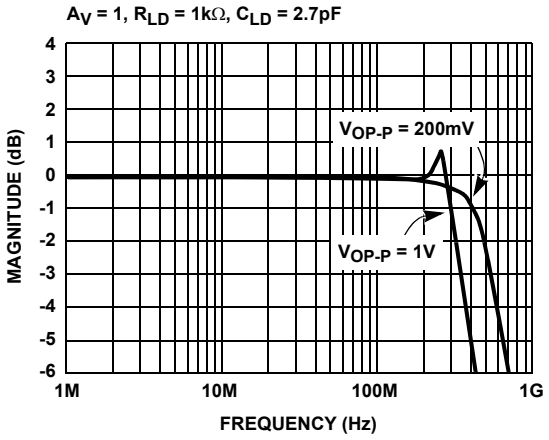


FIGURE 2. FREQUENCY RESPONSE

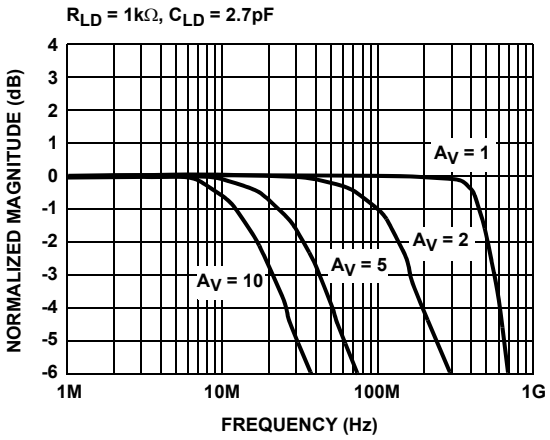


FIGURE 3. FREQUENCY RESPONSE FOR VARIOUS GAIN

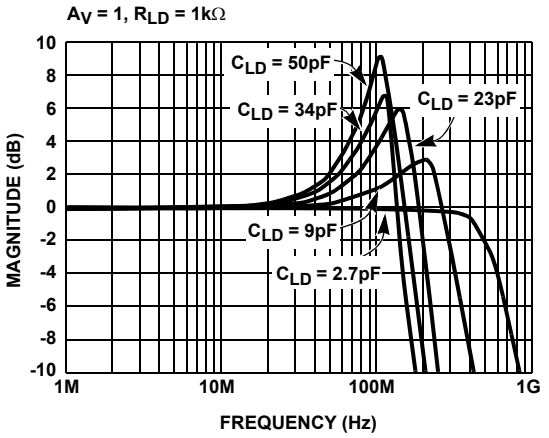


FIGURE 4. FREQUENCY RESPONSE vs C_{LD}

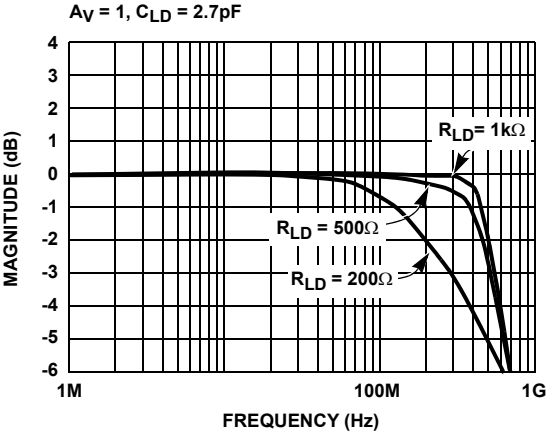


FIGURE 5. FREQUENCY RESPONSE vs R_{LD}

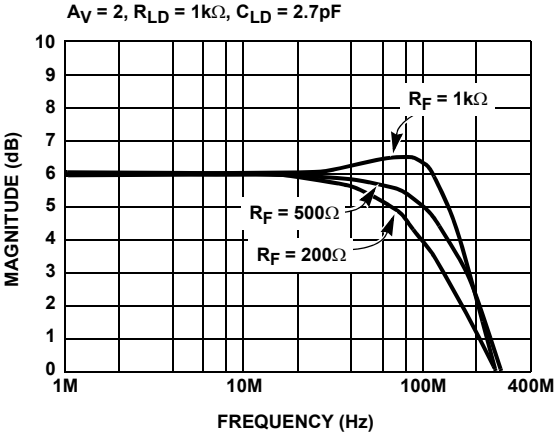


FIGURE 6. FREQUENCY RESPONSE

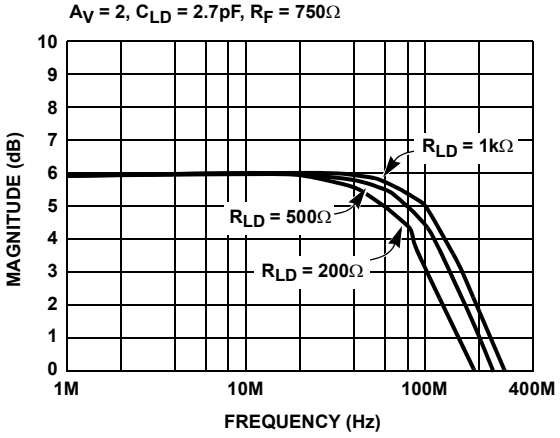


FIGURE 7. FREQUENCY RESPONSE vs R_{LD}

Typical Performance Curves (Continued)

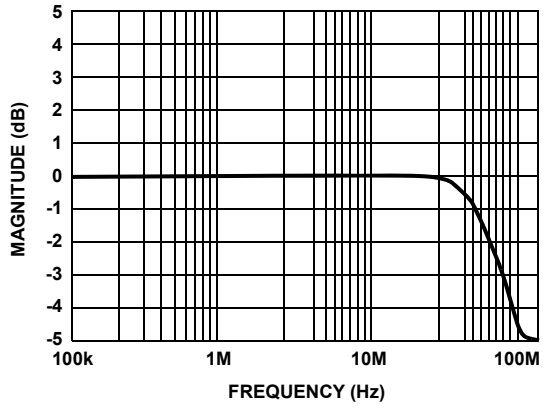


FIGURE 8. FREQUENCY RESPONSE - V_{REF}

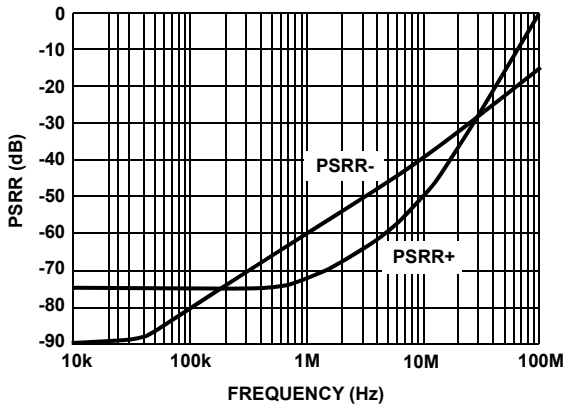


FIGURE 9. PSRR vs FREQUENCY

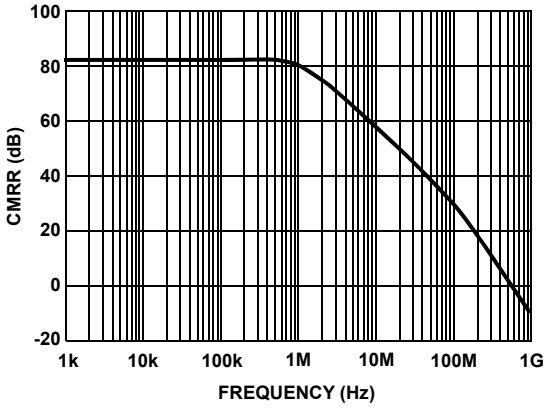


FIGURE 10. CMRR vs FREQUENCY

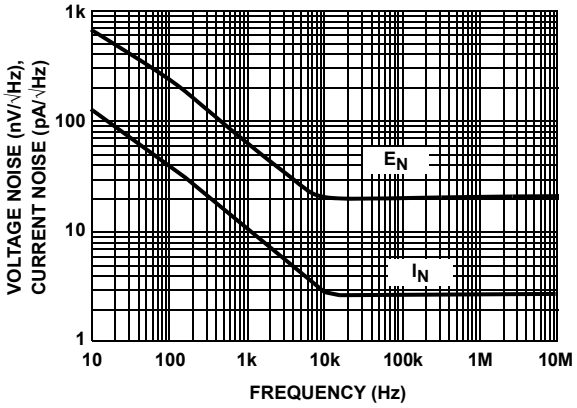


FIGURE 11. VOLTAGE AND CURRENT NOISE vs FREQUENCY

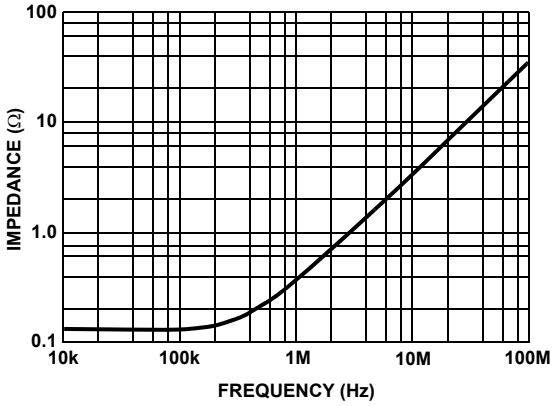


FIGURE 12. OUTPUT IMPEDANCE vs FREQUENCY

Typical Performance Curves (Continued)

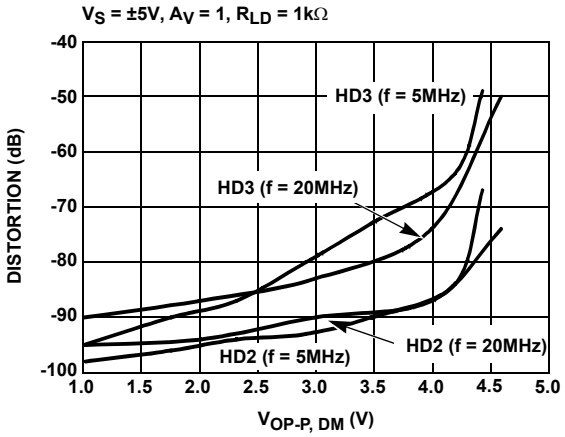


FIGURE 13. HARMONIC DISTORTION vs DIFFERENTIAL OUTPUT VOLTAGE

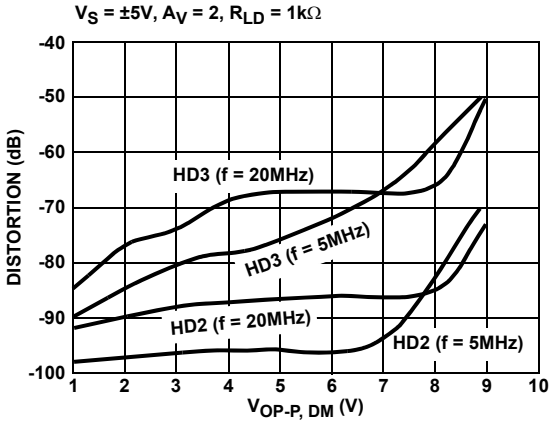


FIGURE 14. HARMONIC DISTORTION vs DIFFERENTIAL OUTPUT VOLTAGE

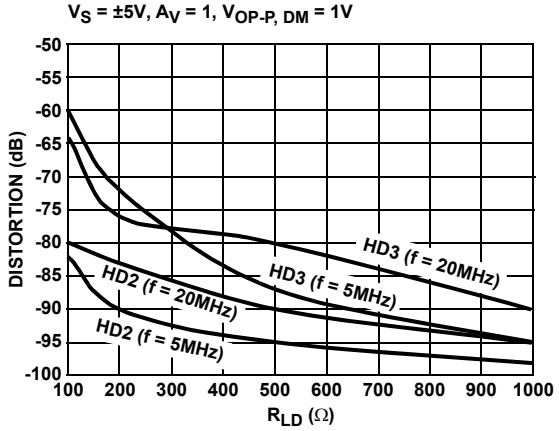


FIGURE 15. HARMONIC DISTORTION vs R_{LD}

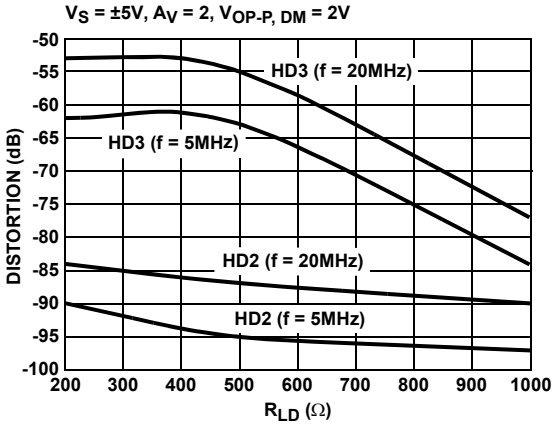


FIGURE 16. HARMONIC DISTORTION vs R_{LD}

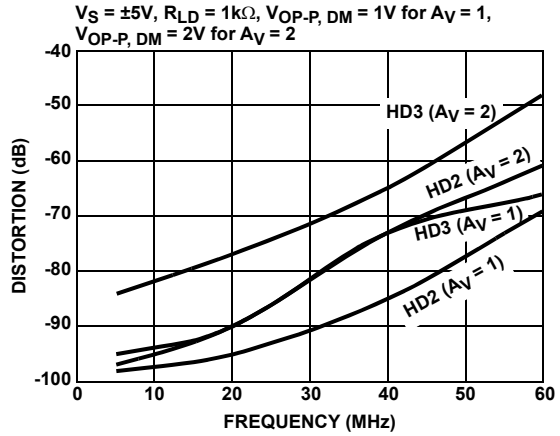


FIGURE 17. HARMONIC DISTORTION vs FREQUENCY

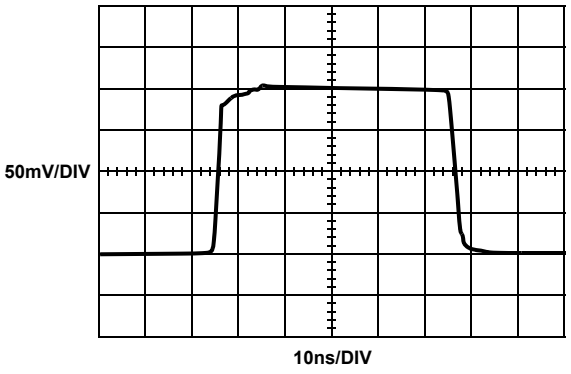


FIGURE 18. SMALL SIGNAL TRANSIENT RESPONSE

Typical Performance Curves (Continued)

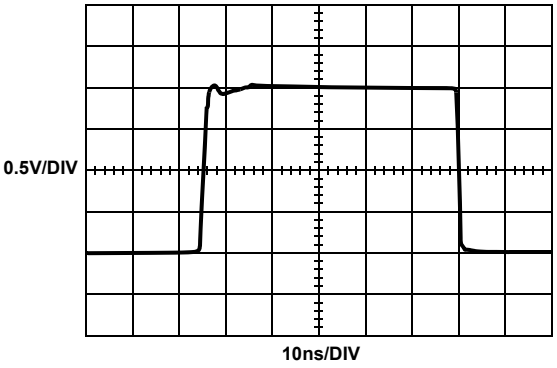


FIGURE 19. LARGE SIGNAL TRANSIENT RESPONSE

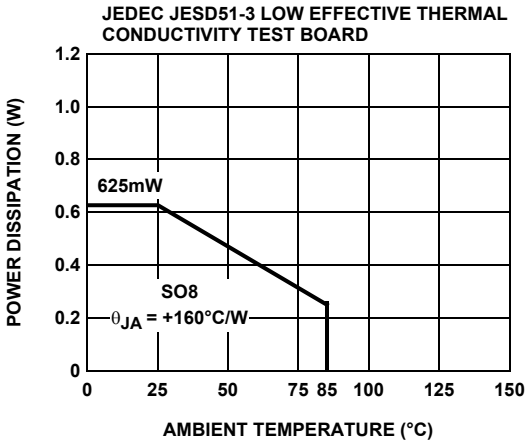


FIGURE 20. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

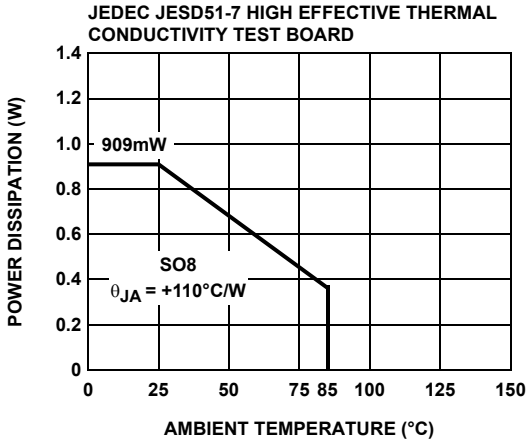
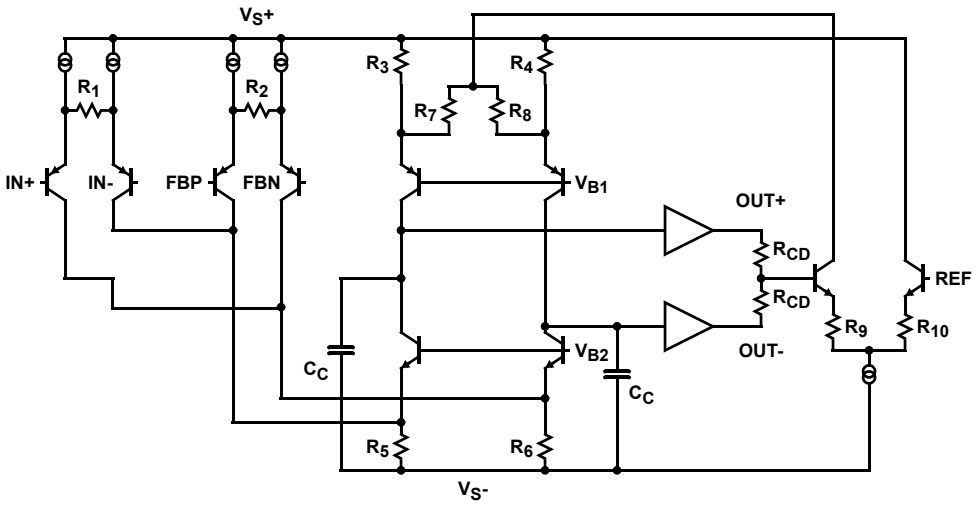


FIGURE 21. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

Simplified Schematic



Description of Operation and Application Information

Product Description

The EL5174 is a low-power, wideband, differential to single-ended amplifier. Because the I_N- pin and REF pin are tied together internally, the EL5174 can be used as a single-ended to differential converter. The EL5174 and is internally compensated for closed loop gain of +1 of greater. Connected in a gain of 1 and driving a 1kΩ differential load, the EL5174 has a -3dB bandwidth of 550MHz. Driving a 200Ω differential load at gain of 2, the bandwidth is about 130MHz.

Input, Output and Supply Voltage Range

The EL5174 is designed to operate with a single supply voltage of 5V to 10V or split supplies with its total voltage from 5V to 10V. The amplifiers have an input common mode voltage range from -4.3V to 3.4V for ±5V supply. The differential mode input range (DMIR) between the two inputs is from -2.3V to +2.3V. The input voltage range at the REF pin is from -3.3V to 3.7V. If the input common mode or differential mode signal is outside the above-specified ranges, it will cause the output signal to become distorted.

The output of the EL5174 can swing from -3.8V to +3.8V at 1kΩ differential load at ±5V supply. As the load resistance becomes lower, the output swing is reduced.

Differential and Common Mode Gain Settings

Because the I_N- pin and REF pin are bound together as the REF pin in an 8 Ld package, the signal at the REF pin is part of the common mode signal and also part of the differential mode signal. For the true balance differential outputs, the REF pin must be tied to the same bias level as the I_N+ pin. For a ±5V supply, just tie the REF pin to GND if the I_N+ pin is biased at 0V with a 50Ω or 75Ω termination resistor. For a single supply application, if the I_N+ is biased to half of the rail, the REF pin should be biased to half of the rail also.

The gain setting for EL5174 is expressed in Equation 1:

$$V_{ODM} = V_{IN}+ \times \left(1 + \frac{R_{F1} + R_{F2}}{R_G}\right)$$

$$V_{ODM} = V_{IN}+ = \left(1 + \frac{2R_F}{R_G}\right) \quad \text{(EQ. 1)}$$

$$V_{OCM} = V_{REF} = 0V$$

where:

V_{REF} = 0V

$R_{F1} = R_{F2} = R_F$

Choice of Feedback Resistor and Gain Bandwidth Product

For applications that require a gain of +1, no feedback resistor is required. Just short the OUT+ pin to FBP pin and OUT- pin to FBN pin. For gains greater than +1, the feedback resistor forms a pole with the parasitic capacitance at the inverting input. As this pole becomes smaller, the amplifier's phase margin is reduced. This causes ringing in the time domain and peaking in the frequency domain. Therefore, R_F has some maximum value that should not be exceeded for optimum performance. If a large value of R_F must be used, a small capacitor in the few Pico farad range in parallel with R_F can help to reduce the ringing and peaking at the expense of reducing the bandwidth.

The bandwidth of the EL5174 depends on the load and the feedback network. R_F and R_G appear in parallel with the load for gains other than +1. As this combination gets smaller, the bandwidth falls off. Consequently, R_F also has a minimum value that should not be exceeded for optimum bandwidth performance. For gain of +1, R_F = 0 is optimum. For the gains other than +1, optimum response is obtained with R_F between 500Ω to 1kΩ.

The EL5174 has a gain bandwidth product of 200MHz for R_{LD} = 1kΩ. For gains ≥5, its bandwidth can be predicted by Equation 2:

$$\text{Gain} \times \text{BW} = 200\text{MHz} \quad \text{(EQ. 2)}$$

Driving Capacitive Loads and Cables

The EL5174 can drive a 23pF differential capacitor in parallel with 1kΩ differential load with less than 5dB of peaking at gain of +1. If less peaking is desired in applications, a small series resistor (usually between 5Ω to 50Ω) can be placed in series with each output to eliminate most peaking. However, this will reduce the gain slightly. If the gain setting is greater than 1, the gain resistor R_G can then be chosen to make up for any gain loss, which may be created by the additional series resistor at the output.

When used as a cable driver, double termination is always recommended for reflection-free performance. For those applications, a back-termination series resistor at the amplifier's output will isolate the amplifier from the cable and allow extensive capacitive drive. However, other applications may have high capacitive loads without a back-termination resistor. Again, a small series resistor at the output can help to reduce peaking.

Output Drive Capability

The EL5174 has an internal short-circuit protection. Its typical short circuit current is ±60mA. If the output is shorted indefinitely, the power dissipation could easily increase such that the part will be destroyed. Maximum reliability is maintained if the output current never exceeds ±60mA. This limit is set by the design of the internal metal interconnections.

Power Dissipation

With the high output drive capability of the EL5174, it is possible to exceed the +135°C absolute maximum junction temperature under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for the application to determine if the load conditions or package types need to be modified for the amplifier to remain in the safe operating area.

The maximum power dissipation allowed in a package is determined according to Equation 3:

$$PD_{MAX} = \frac{T_{JMAX} - T_{AMAX}}{\Theta_{JA}} \quad \text{(EQ. 3)}$$

where:

T_{JMAX} = Maximum junction temperature

T_{AMAX} = Maximum ambient temperature

θ_{JA} = Thermal resistance of the package

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the load, or as expressed in Equation 4:

$$PD = \left(V_{STOT} \times I_{SMAX} + (V_{STOT} - \Delta V_O) \times \frac{\Delta V_O}{R_{LD}}\right) \quad \text{(EQ. 4)}$$

where:

V_{STOT} = Total supply voltage = $V_S+ - V_S-$

I_{SMAX} = Maximum quiescent supply current

ΔV_O = Maximum differential output voltage of the application

R_{LD} = Differential load resistance

I_{LOAD} = Load current

By setting the two PD_{MAX} equations equal to each other, we can solve the output current and R_{LD} to avoid the device overheat.

Power Supply Bypassing and Printed Circuit Board Layout

As with any high frequency device, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as short as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the V_S- pin is connected to the ground plane, a single 4.7µF tantalum capacitor in parallel with a 0.1µF ceramic capacitor from V_S+ to GND will suffice. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used. In this case, the V_S- pin becomes the negative supply rail.

For good AC performance, parasitic capacitance should be kept to a minimum. Use of wire-wound resistors should be avoided because of their additional series inductance. Use of sockets should also be avoided if possible. Sockets add parasitic inductance and capacitance that can result in compromised performance. Minimizing parasitic capacitance at the amplifier's inverting input pin is very important. The feedback resistor should be placed very close to the inverting input pin. Strip line design techniques are recommended for the signal traces.

Typical Applications

As the signal is transmitted through a cable, the high frequency signal will be attenuated. One way to compensate this loss is to boost the high frequency gain at the receiver side.

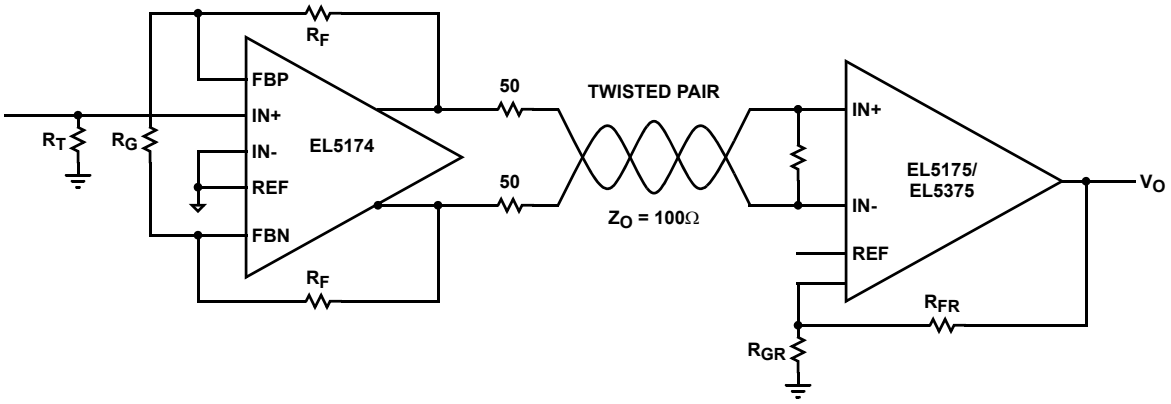
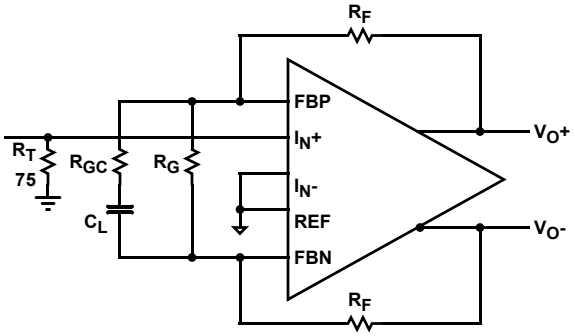
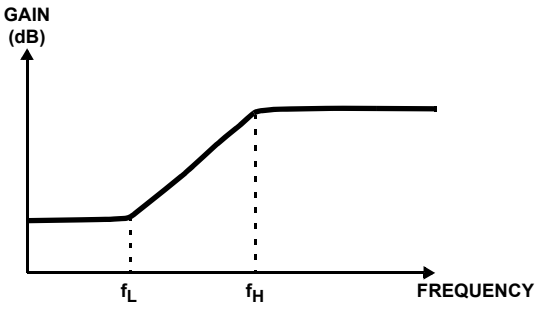


FIGURE 22. TWISTED PAIR CABLE RECEIVER





$$\text{DC Gain} = 1 + \frac{2R_F}{R_G}$$

$$(\text{HF})\text{Gain} = 1 + \frac{2R_F}{R_G \| R_{GC}}$$

$$f_L \cong \frac{1}{2\pi R_G C_C}$$

$$f_H \cong \frac{1}{2\pi R_{GC} C_C}$$

FIGURE 23. TRANSMIT EQUALIZER

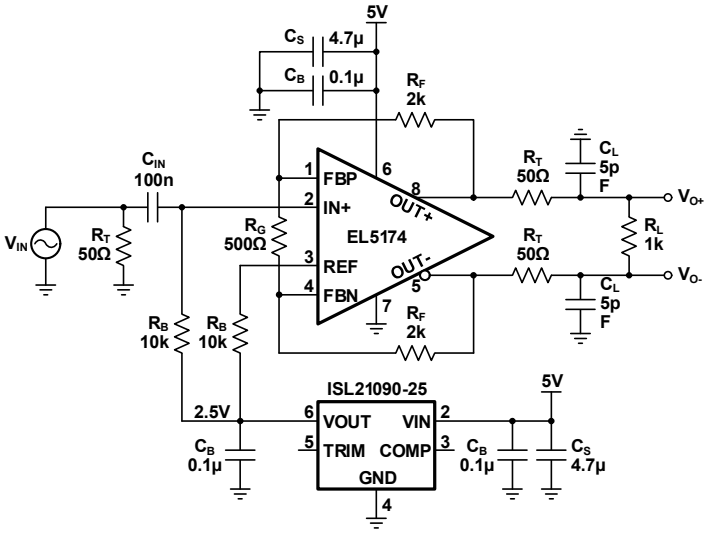


FIGURE 24. Single Supply Operation

Revision History

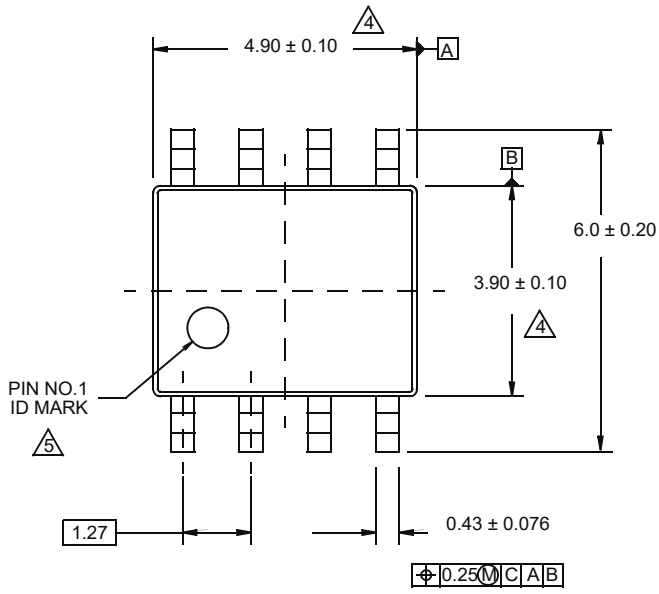
The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to the web to make sure that you have the latest revision.

DATE	REVISION	CHANGE
Aug 3, 2020	10.00	Added Related Literature section Removed EL5374 information from datasheet. Updated Ordering information table by adding tape and reel information and updating notes. Added Figure 24. Removed About Intersil section.
Aug 12, 2015	9.00	Updated Ordering Information table on page 2. Added Revision History and About Intersil sections.

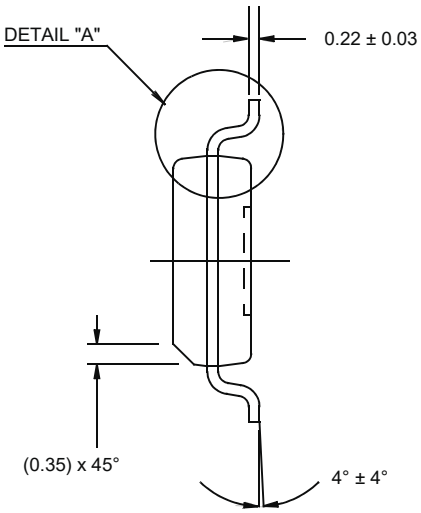
Package Outline Drawing

For the most recent package outline drawing, see M8.15E.

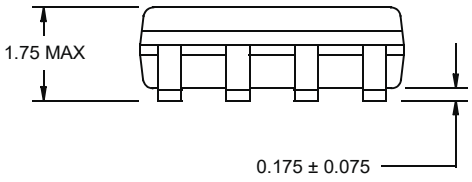
M8.15E
8 Lead Narrow Body Small Outline Plastic Package
Rev 0, 08/09



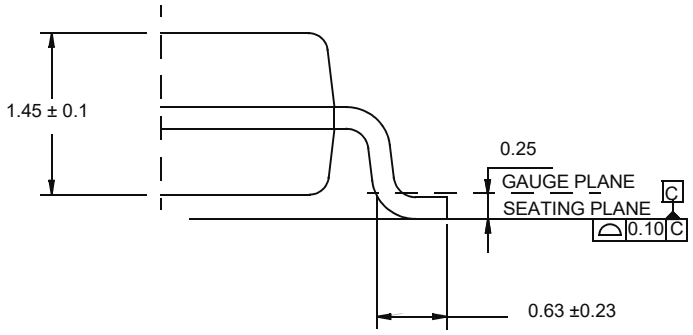
TOP VIEW



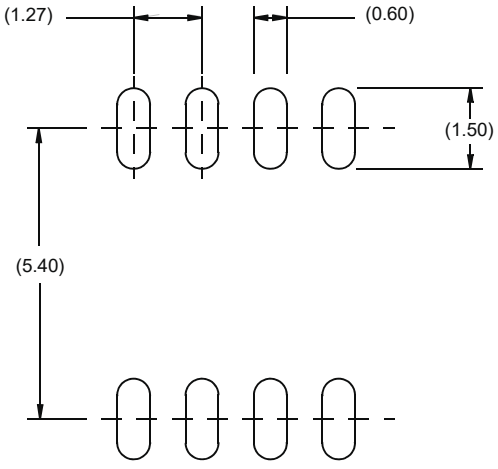
SIDE VIEW "B"



SIDE VIEW "A"



DETAIL "A"



TYPICAL RECOMMENDED LAND PATTERN

NOTES:

1. Dimensions are in millimeters.
   Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSE Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal ± 0.05
4. Dimension does not include interlead flash or protrusions.
   Interlead flash or protrusions shall not exceed 0.25mm per side.
5. The pin #1 identifier may be either a mold or mark feature.
6. Reference to JEDEC MS-012.

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(Rev.1.0 Mar 2020)

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