LIA130
Optically Isolated Error Amplifier

Features
- Optocoupler, Precision Reference, and Error Amplifier in a Single Package
- 1.240V ± 1% Reference (@ 25°C)
- Linear Optical Coupler Technology with an Industry Standard 431-type
- CTR 300% to 600% Linearity
- 3750Vrms Isolation

Applications
- Power System for Workstations
- Telecom Central Office Supply
- Telecom Bricks

Description
The LIA130 is an optically isolated amplifier with a 431-type precision programmable shunt reference combined in the same package. The optocoupler portion of the LIA130 comprises a Gallium Arsenide (GaAs) light-emitting diode (LED) optically coupled to a silicon phototransistor. The current transfer ratio of the device is between 300% and 600%.

The combination of features in the LIA130 is optimal for use in isolated AC-to-DC power supplies and DC-to-DC converters. It replaces several discrete components, saves valuable circuit board space, and reduces complexity.

The device is available in DIP and surface-mount packages.

Approvals
- UL Recognized Component: File # E76270
- CSA Certified Component: Certificate # 1305490

Ordering Information

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIA130</td>
<td>8 Pin DIP (50/Tube)</td>
</tr>
<tr>
<td>LIA130S</td>
<td>8-Pin Surface Mount (50/Tube)</td>
</tr>
<tr>
<td>LIA130STR</td>
<td>8-Pin Surface Mount (1000/Reel)</td>
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</tbody>
</table>
Absolute Maximum Ratings ( @ 25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Ratings</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-Emitter Voltage</td>
<td>V_CED</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Emitter-Collector Voltage</td>
<td>V_ECO</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>V_LED</td>
<td>10</td>
<td>V</td>
</tr>
<tr>
<td>Input DC Current</td>
<td>I_Led</td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Collector Current</td>
<td>I_C</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>Input Power Dissipation</td>
<td>P_D</td>
<td>145</td>
<td>mW</td>
</tr>
<tr>
<td>Transistor Power Dissipation</td>
<td>P_D</td>
<td>85</td>
<td>mW</td>
</tr>
<tr>
<td>Total Power Dissipation</td>
<td>P_D</td>
<td>145</td>
<td>mW</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>T_STG</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>T_OPR</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
</tbody>
</table>

Absolute Maximum Ratings are stress ratings. Stresses in excess of these ratings can cause permanent damage to the device. Functional operation of the device at conditions beyond those indicated in the operational sections of this data sheet is not implied.

Parameters Conditions Symbol Min Typ Max Units
LED forward voltage @ 25°C L_LED = 5 mA, V_CREF = V_FB (Fig.1) V_F 0.9 - 1.4 V
Reference voltage @ 25°C V_COMP = V_FB, L_LED = 10 mA, -40 to +85°C (Fig.1) V_REF 1.224 1.24 1.259 V
Deviation of V_REF over temperature 1 | T_a = -40 to +85°C | V_REF (DEV) - 0.28 TBD mV
Ratio of V_REF variation to the output of the error amplifier I_Led = 10 mA, V_COMP = V_FB to 10 V (Fig.2) ΔV_REF/ΔV_COMP - 0.002 TBD mV/V
Feedback input current I_REF = 10 mA, R1 = 10 kΩ (Fig.3) I_REF 0.09 TBD μA
Deviation of I_REF over temperature 1 | T_a = -40 to +85°C | I_REF (DEV) - 0.028 TBD μA
Minimum drive current V_COMP = V_FB (Fig.1) I_MIN = - 45 80 μA
Off-state error amplifier current V_LED = 6 V, V_FB = 0 (Fig.4) I_OFF 0.001 0.1 μA
Error amplifier output impedance 2 V_COMP = V_FB, L_LED = 0.1 mA to 15 mA, f<1 kHz | Z_OUT 0.22 - Ω
Collector dark current V_CE = 10V (Fig.5) I_CE 0.3 50 nA
Collector-emitter voltage breakdown I_C = 1.0mA BV_CE 70 - - V
Emitter-collector voltage breakdown I_E = 100 μA BV_CE 7 - - V

1. The deviation parameters V_REF(DEV) and I_REF(DEV) are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage, ΔV_REF, is defined as:

   |ΔV_REF| (ppm/°C) = (V_REF(DEV)/V_REF(Ta 25°C)) X 10^6 / ΔT_a

   where ΔT_a is the rated operating free-air temperature range of the device.

2. The dynamic impedance is defined as |Z_OUT| = ΔV_COMP/ΔLED. When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

   |Z_OUT, Tot| = |ΔV/ΔI| X [1 + R1/R2]
**Transfer Characteristics @ 25°C**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current transfer ratio</td>
<td>$I_{LED} = 5$ mA, $V_{COMP} = V_{FB}$, $V_{CE} = 5$ V (Fig. 6)</td>
<td>CTR</td>
<td>300</td>
<td>500</td>
<td>600</td>
<td>%</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$I_{LED} = 10$ mA, $V_{COMP} = V_{FB}$, $I_C = 2.5$ mA (Fig. 6)</td>
<td>$V_{CE(SAT)}$</td>
<td>-</td>
<td>0.099</td>
<td>0.5</td>
<td>V</td>
</tr>
</tbody>
</table>

**Isolation Characteristics @ 25°C**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
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<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input-output insulation leakage current</td>
<td>RH = 45%, $T_A = 25°C$, $t = 5s$, $V_{IO} = 3000$ V</td>
<td>$I_{IO}$</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>μA</td>
</tr>
</tbody>
</table>

**Collector-emitter saturation voltage**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RH &lt;= 50%, $T_A = 25°C$, $t = 1$ min</td>
<td>$V_{ISO}$</td>
<td>2500</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
</tbody>
</table>

**Resistance (input to output)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{IO} = 500$ VDC</td>
<td>$R_{IO}$</td>
<td>-</td>
<td>$10^{12}$</td>
<td>-</td>
<td>Ω</td>
</tr>
</tbody>
</table>

**Switching Characteristics @ 25°C**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>(Fig. 7)</td>
<td>$B_W$</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>kHz</td>
</tr>
<tr>
<td>Common mode transient immunity at output high</td>
<td>$I_{LED} = 0$ mA, $V_{cm} = 10$ VPP, $R_L = 2.2$ kΩ (Fig. 8)</td>
<td>$</td>
<td>CMH</td>
<td>$</td>
<td>-</td>
<td>TBD</td>
</tr>
<tr>
<td>Common mode transient immunity at output low</td>
<td>$I_{LED} = 10$ mA, $V_{cm} = 10$ VPP, $R_L = 2.2$ kΩ (Fig. 8)</td>
<td>$</td>
<td>CML</td>
<td>$</td>
<td>-</td>
<td>TBD</td>
</tr>
</tbody>
</table>

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1. Device is considered as a two terminal device: Pins 1, 2, 3 and 4 are shorted together and Pins 5, 6, 7 and 8 are shorted together.

2. Common mode transient immunity at output high is the maximum tolerable (positive) $dV_{cm}/dt$ on the leading edge of the common mode pulse signal, $V_{cm}$, to assure that the output will remain high. Common mode transient immunity at output low is the maximum tolerable (negative) $dV_{cm}/dt$ on the trailing edge of the common mode pulse signal, $V_{cm}$, to assure that the output will remain low.

**Electrical Characteristics**

**Example Application for the LIA130**
Test Circuits

- $I_{\text{LED}}$ Test Circuit
- $I_{\text{OFF}}$ Test Circuit
- $I_{\text{CEO}}$ Test Circuit
- CTR, $V_{\text{CE-sat}}$ Test Circuit
- $V_{\text{REF}}, V_{F}, I_{\text{LED-min}}$ Test Circuit
- $\Delta V_{\text{REF}} / \Delta V_{\text{COMP}}$ Test Circuit
Test Circuits (cont.)

Frequency Response

CMH and CML
The Performance data shown in the graphs above is typical of device performance. For guaranteed parameters not indicated in the written specifications, please contact our application department.
*The Performance data shown in the graphs above is typical of device performance. For guaranteed parameters not indicated in the written specifications, please contact our application department.
The LIA130
The LIA130 is essentially an optically isolated error amplifier. It comprises three of the necessary components to form an isolated power supply: an optocoupler, an error amplifier, and a reference voltage device. The LIA130 is the functional equivalent of a 431 series shunt voltage regulator plus an optocoupler in the same package.

LED Pin
The LED within the LIA130 is powered by a sample of the output voltage that is being regulated. Typically, a resistor divider is provided to keep this voltage sample within the operating range of the LED and its series resistor. As the output voltage changes, the LED light output changes, which provides a changing error voltage from the phototransistor output of the LIA130. The sampled voltage must be at least 1.24V (the reference voltage) plus 1.5V (the LED voltage drop) or a minimum of 2.74 volts. The sampled voltage can also be provided from a slaved secondary winding of the transformer rather than a resistor divider.

NC Pins
The NC (not connected) pins have no internal connection and must not have any connection to the secondary side, as this might compromise the primary-to-secondary isolation.

COMP Pin
The frequency response of the converter can be optimized for the particular application by placing a compensation network between the COMP pin and the FB pin of the LIA130. In a system with a typical low-bandwidth requirement, only a 0.1µF capacitor might be needed.

If the system has more critical bandwidth requirements, then measurements must be made of the system's loop. See "Practical Design of Power Supplies" by Ron Lenk, IEEE Press, 1998, for an excellent description.

C & E Pins
The output phototransistor of the LIA130 provides the isolated and amplified error signal that represents the DC output level of the converter. Typically, the collector of the phototransistor will be pulled up to voltage and the emitter will be grounded.

The value of the collector's pull-up resistor and the value of the LED current-limiting resistor must be determined together with respect to the input voltage range of the PWM circuitry. The variation in CTR of the LIA130 must also be taken into account.

As an example, consider first that the minimum CTR of the LIA130 is 300%. If the current-limiting resistor of the LED is set to allow a maximum current through the LED of 1mA when the converter output is at a nominal 15 volts:

\[ R_{\text{LED}} = \frac{15\text{V} - 2.74\text{V}}{0.001\text{A}} = 12.260k\Omega \]

then a minimum of 3mA will flow through the collector pull-up resistor. If the collector is pulled up to 12V and the PWM has an internal reference voltage of 5V, then the minimum resistor value is:

\[ R_{\text{PULLUP}} > \frac{(12\text{V} - 5\text{V})}{0.003\text{A}} > 2.333k\Omega \]

[Standard values can be selected for \( R_{\text{LED}} \) and \( R_{\text{PULLUP}} \) and the small differences then re-calculated.]
Manufacturing Information

Moisture Sensitivity

All plastic encapsulated semiconductor packages are susceptible to moisture ingestion. IXYS Integrated Circuits Division classified all of its plastic encapsulated devices for moisture sensitivity according to the latest version of the joint industry standard, IPC/JEDEC J-STD-020, in force at the time of product evaluation. We test all of our products to the maximum conditions set forth in the standard, and guarantee proper operation of our devices when handled according to the limitations and information in that standard as well as to any limitations set forth in the information or standards referenced below.

Failure to adhere to the warnings or limitations as established by the listed specifications could result in reduced product performance, reduction of operable life, and/or reduction of overall reliability.

This product carries a Moisture Sensitivity Level (MSL) rating as shown below, and should be handled according to the requirements of the latest version of the joint industry standard IPC/JEDEC J-STD-033.

<table>
<thead>
<tr>
<th>Device</th>
<th>Moisture Sensitivity Level (MSL) Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIA130 / LIA130S</td>
<td>MSL 1</td>
</tr>
</tbody>
</table>

ESD Sensitivity

This product is ESD Sensitive, and should be handled according to the industry standard JESD-625.

Reflow Profile

This product has a maximum body temperature and time rating as shown below. All other guidelines of J-STD-020 must be observed.

<table>
<thead>
<tr>
<th>Device</th>
<th>Maximum Temperature x Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIA130 / LIA130S</td>
<td>250°C for 30 seconds</td>
</tr>
</tbody>
</table>

Board Wash

IXYS Integrated Circuits Division recommends the use of no-clean flux formulations. However, board washing to remove flux residue is acceptable, and the use of a short drying bake may be necessary. Chlorine-based or Fluorine-based solvents or fluxes should not be used. Cleaning methods that employ ultrasonic energy should not be used.

\[\text{Pb}\]

\[\text{RoHS}\]

\[\text{E3}\]
MECHANICAL DIMENSIONS

LIA130

LIA130S

PCB Hole Pattern

Dimensions

mm
(inches)

PCB Land Pattern

Dimensions

mm
(inches)
NOTES:
1. Dimensions carry tolerances of EIA Standard 481-2
2. Tape complies with all "Notes" for constant dimensions listed on page 5 of EIA-481-2