**FEATURES**

- Guaranteed 0.4% Initial Voltage Tolerance
- 0.1Ω Typical Dynamic Output Impedance
- Fast Turn-On
- Sink Current Capability, 1mA to 100mA
- Low Reference Pin Current
- Available in J8, N8, S8 or 3-Lead TO-92 Z Packages

**APPLICATIONS**

- Linear Regulators
- Adjustable Power Supplies
- Switching Power Supplies

**DESCRIPTION**

The LT®1431 is an adjustable shunt voltage regulator with 100mA sink capability, 0.4% initial reference voltage tolerance and 0.3% typical temperature stability. On-chip divider resistors allow the LT1431 to be configured as a 5V shunt regulator, with 1% initial voltage tolerance and requiring no additional external components. By adding two external resistors, the output voltage may be set to any value between 2.5V and 36V. The nominal internal current limit of 100mA may be decreased by including one external resistor.

A simplified 3-pin version, the LT1431CZ/LT1431IZ, is available for applications as an adjustable reference and is pin compatible with the TL431.
LT1431

**ABSOLUTE MAXIMUM RATINGS** (Note 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>V+, V_COLLECTOR</td>
<td>36V</td>
</tr>
<tr>
<td>V_COMP, R_TOP, R_MID, V_REF</td>
<td>6V</td>
</tr>
<tr>
<td>GND-F to GND-S</td>
<td>0.7V</td>
</tr>
</tbody>
</table>

### Ambient Temperature Range
- LT1431M, LT1431MP: –55°C to 125°C
- LT1431I: –40°C to 85°C
- LT1431C: 0°C to 70°C

### Junction Temperature Range
- LT1431M, LT1431MP: –55°C to 150°C
- LT1431I: –40°C to 100°C
- LT1431C: 0°C to 100°C

### Storage Temperature Range
- –65°C to 150°C

### Lead Temperature (Soldering, 10 sec)
- 300°C

### Pin Configuration

#### TOP VIEW

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>COLLECTOR</td>
</tr>
<tr>
<td>2</td>
<td>COMP</td>
</tr>
<tr>
<td>3</td>
<td>V+</td>
</tr>
<tr>
<td>4</td>
<td>R_TOP</td>
</tr>
<tr>
<td>5</td>
<td>GND-S</td>
</tr>
<tr>
<td>6</td>
<td>GND-F</td>
</tr>
<tr>
<td>7</td>
<td>R_MID</td>
</tr>
<tr>
<td>8</td>
<td>REF</td>
</tr>
</tbody>
</table>

#### BOTTOM VIEW

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REF ANODE</td>
</tr>
<tr>
<td>2</td>
<td>CATHODE</td>
</tr>
</tbody>
</table>

### Order Information

#### Lead Free Finish

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Tape and Reel</th>
<th>Part Marking</th>
<th>Package Description</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1431CN8#PBF</td>
<td>LT1431CN8#TRPBF</td>
<td>LT1431 CN8</td>
<td>8-Lead Plastic DIP</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LT1431IN8#PBF</td>
<td>LT1431IN8#TRPBF</td>
<td>LT1431 IN8</td>
<td>8-Lead Plastic DIP</td>
<td>–40°C to 85°C</td>
</tr>
<tr>
<td>LT1431CS8#PBF</td>
<td>LT1431CS8#TRPBF</td>
<td>LT1431</td>
<td>8-Lead Plastic SO</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LT1431IS8#PBF</td>
<td>LT1431IS8#TRPBF</td>
<td>LT1431I</td>
<td>8-Lead Plastic SO</td>
<td>–40°C to 85°C</td>
</tr>
<tr>
<td>LT1431MPS8#PBF</td>
<td>LT1431MPS8#TRPBF</td>
<td>LT1431</td>
<td>8-Lead Plastic SO</td>
<td>–55°C to 125°C</td>
</tr>
<tr>
<td>LT1431MJ8#PBF</td>
<td>LT1431MJ8#TRPBF</td>
<td>LT1431 MJ8</td>
<td>8-Lead CERDIP</td>
<td>–55°C to 125°C</td>
</tr>
<tr>
<td>LT1431CZ#PBF</td>
<td>LT1431CZ#TRPBF</td>
<td>LT1431 CZ</td>
<td>3-Lead TO-92 Plastic</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LT1431IZ#PBF</td>
<td>LT1431IZ#TRPBF</td>
<td>LT1431 IZ</td>
<td>3-Lead TO-92 Plastic</td>
<td>–40°C to 85°C</td>
</tr>
</tbody>
</table>

Consult LTC Marketing for parts specified with wider operating temperature ranges.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: [http://www.linear.com/leadfree/](http://www.linear.com/leadfree/)
For more information on tape and reel specifications, go to: [http://www.linear.com/tapeandreel/](http://www.linear.com/tapeandreel/)
# ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$. $I_K = 10mA$ unless otherwise specified (Note 2).

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1431I, LT1431M</th>
<th>LT1431C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{REF}}$</td>
<td>Reference Voltage</td>
<td>$V_{KA} = 5V$, $I_K = 2mA$, (Note 3)</td>
<td>●</td>
<td>2.490</td>
<td>2.500</td>
</tr>
<tr>
<td>$\Delta V_{\text{REF}}/\Delta T$</td>
<td>Reference Drift</td>
<td>$V_{KA} = 5V$, $I_K = 2mA$</td>
<td>●</td>
<td>2.465</td>
<td>2.510</td>
</tr>
<tr>
<td>$\Delta V_{\text{REF}}/V_{KA}$</td>
<td>Voltage Ratio, Reference to Cathode (Open-Loop Gain)</td>
<td>$I_K = 2mA$, $V_{KA} = 3V$ to 36V</td>
<td>●</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>$</td>
<td>I_{\text{REF}}</td>
<td>$</td>
<td>Reference Input Current</td>
<td>$V_{KA} = 5V$, $T_A = 25^\circ C$</td>
<td>●</td>
</tr>
<tr>
<td>$</td>
<td>I_{\text{MIN}}</td>
<td>$</td>
<td>Minimum Operating Current</td>
<td>$V_{KA} = V_{\text{REF}}$ to 36V</td>
<td>●</td>
</tr>
<tr>
<td>$</td>
<td>I_{\text{OFF}}</td>
<td>$</td>
<td>Off-State Cathode Current</td>
<td>$V_{KA} = 36V$, $V_{\text{REF}} = 0V$</td>
<td>●</td>
</tr>
<tr>
<td>$</td>
<td>I_{\text{LEAK}}</td>
<td>$</td>
<td>Off-State Collector Leakage Current</td>
<td>$V_{\text{COLL}} = 36V$, $V^+ = 5V$, $V_{\text{REF}} = 2.4V$</td>
<td>●</td>
</tr>
<tr>
<td>$</td>
<td>Z_{\text{KA}}</td>
<td>$</td>
<td>Dynamic Impedance</td>
<td>$V_{KA} = V_{\text{REF}}$, $I_K = 1mA$ to 100mA, $f \leq 1kHz$</td>
<td>●</td>
</tr>
<tr>
<td>$I_{\text{LIM}}$</td>
<td>Collector Current Limit</td>
<td>$V_{KA} = V_{\text{REF}} + 50mV$</td>
<td>●</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>5V Reference Output</td>
<td>Internal Divider Used, $I_K = 2mA$</td>
<td></td>
<td>4.950</td>
<td>5.000</td>
<td>5.050</td>
</tr>
</tbody>
</table>

**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:** $V_{KA}$ is the cathode voltage of the LT1431CZ/I and corresponds to $V^*$ of the LT1431CN8/IN8/CS8/IS8. $I_K$ is the cathode current of the LT1431C/I and corresponds to $I(V^*) + I_{\text{COLLECTOR}}$ of the LT1431CN8/IN8/CS8/IS8.

**Note 3:** The LT1431 has bias current cancellation which is effective only for $V_{KA} \geq 3V$. A slight (~2mV) shift in reference voltage occurs when $V_{KA}$ drops below 3V. For this reason, these tests are not performed at $V_{KA} = V_{\text{REF}}$. 

1431se

LT1431

LINEAR TECHNOLOGY
**TYPICAL PERFORMANCE CHARACTERISTICS**

Transconductance and Phase vs Frequency (Ref to Comp)

Dynamic Impedance vs Frequency

VCOMP vs Temperature vs ICOLL

ICOMP vs VCOMP vs VREF

Noise vs Frequency

0.1Hz to 10Hz Noise
**PIN FUNCTIONS**

**COLL (Pin 1):** Open collector of the output transistor. The maximum pin voltage is 36V. The saturation voltage at 100mA is approximately 1V.

**COMP (Pin 2):** Base of the driver for the output transistor. This pin allows additional compensation for complex feedback systems and shutdown of the regulator. It must be left open if unused.

**V+ (Pin 3):** Bias voltage for the entire shunt regulator. The maximum input voltage is 36V and the minimum to operate is equal to VREF (2.5V). The quiescent current is typically 0.6mA.

**RTOP (Pin 4):** Top of the on-chip 5k-5k resistive divider that guarantees 1% accuracy of operation as a 5V shunt regulator with no external trim. The pin is tied to COLL for self-contained 5V operation. It may be left open if unused. See note on parasitic diodes below.

**GND-S (Pin 5):** Ground reference for the on-chip resistive divider and shunt regulator circuitry except for the output transistor. This pin allows external current limit of the output transistor with one resistor between GND-F (force) and GND-S (sense).

**GND-F (Pin 6):** Emitter of the output transistor and substrate connection for the die.

**RMID (Pin 7):** Middle of the on-chip resistive divider string between RTOP and GND-S. The pin is tied to REF for self-contained 5V operation. It may be left open if unused.

**REF (Pin 8):** Control pin of the shunt regulator with a 2.5V threshold. If V+ > 3V, input bias current cancellation reduces IB to 0.2µA typical.

COMP, RTOP, RMID, and REF have static discharge protection circuits that must not be activated on a continuous basis. Therefore, the absolute maximum DC voltage on these pins is 6V, well beyond the normal operating conditions.

As with all bipolar ICs, the LT1431 contains parasitic diodes which must not be forward biased or else anomalous behavior will result. Pin conditions to be avoided are RTOP below RMID in voltage and any pin below GND-F in voltage (except for GND-S).

The following pin definitions apply to the Z package.

**CATHODE:** Corresponds to COLL and V+ tied together.

**ANODE:** Corresponds to GND-S and GND-F tied together.

**REF:** Corresponds to REF.

---

**BLock Diagram**
**APPLICATIONS INFORMATION**

**Frequency Compensation**

As a shunt regulator, the LT1431 is stable for all capacitive loads on the COLL pin. Capacitive loading between 0.01 µF and 18 µF causes reduced phase margin with some ringing under transient conditions. Output capacitors should not be used arbitrarily because output noise is not necessarily reduced.

Excess capacitance on the REF pin can introduce enough phase shift to induce oscillation when configured as a reference >2.5 V. This can be compensated with capacitance between COLL and REF (phase lead). More complicated feedback loops may require shaping of the frequency response of the LT1431 with dominant pole or pole-zero compensation. This can be accomplished with a capacitor or series resistor and capacitor between COLL and COMP.

The compensation schemes mentioned above use voltage feedback to stabilize the circuits. There must be voltage gain at the COLL pin for them to be effective, so the COLL pin must see a reasonable AC impedance. Capacitive loading of the COLL pin reduces the AC impedance, voltage gain, and frequency response, thereby decreasing the effectiveness of the compensation schemes, but also decreasing their necessity.

**TYPICAL APPLICATIONS**

![2.5V Reference 3-Pin Package](image)

**2.5V Reference 3-Pin Package**

**2.5V Reference 8-Pin Package**

**5V Reference**

**Increasing 5V Reference**

**Programmable Reference with Adjustable Current Limit**
PNP Low Dropout 5V Regulator*

```
V_{IN} - 0.1\mu F
1k
0.015\mu F
150\Omega
2N2219
20\Omega**
47\Omega
MJE2955
LT1431
COMP
COLL
REF
LT1431
GND-F
GND-S
V+
RMIDRTOP
2 1
5 6
8
7
1k
5V
330\mu F
```

Measured Dropout Voltage
420mV at 4A
190mV at 2A
95mV at 1A
60mV at 0.5A

*NO SHORT-CIRCUIT PROTECTION
**MAY BE INCREASED AT LOWER WATTAGE FOR LOWER OUTPUT CURRENTS

FET Low Dropout 5V Regulator with Current Limit

```
V_{IN} ≥ 5.2V
47\mu F
1.5k
LT1006
1N4148
0.002\Omega*
MTP50N05EL
MTM25N05L
12V
5V, 2.5A
```

**Measured Dropout Voltages**

<table>
<thead>
<tr>
<th>I_{LOAD}</th>
<th>MTP50N05EL</th>
<th>MTM25N05L</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>47mV</td>
<td>145mV</td>
</tr>
<tr>
<td>1A</td>
<td>22mV</td>
<td>73mV</td>
</tr>
<tr>
<td>0.5A</td>
<td>11.5mV</td>
<td>37mV</td>
</tr>
</tbody>
</table>

*1.5" #23 SOLID COPPER WIRE
→ 0.002Ω → 3A LIMIT
TYPICAL APPLICATIONS

12V to 5V Buck Converter with Foldback Current Limit*

Isolated 5V to ±15V Flyback Converter

Fully Loaded Output Ripple vs Filtering

*CONTACT LTC FOR HIGH EFFICIENCY SWITCHING REGULATORS

**L. BELL INDUSTRIES J.W. MILLER DIVISION 9310-36 10µH, 450mA
TYPICAL APPLICATIONS

5V Power Supply Monitor with ±500mV Window and 50mV Hysteresis

High Efficiency Buck Converter $E = 85\% \text{ to } 89\%$

Transfer Function

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTANCES ARE IN $\Omega$, 0.25W, 5%
2. ALL CAPACITANCES ARE IN $\mu$F, 50V, 10%
3. SHUTDOWN LOGIC STATE MUST BE DEFINED BY A LOGIC GATE OR BY TYING TO GND
SCHEMATIC DIAGRAM

PACKAGE DESCRIPTION

J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)

NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP/PLATE OR TIN PLATE LEADS
PACKAGE DESCRIPTION

N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)

S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610)

NOTE:
1. DIMENSIONS ARE IN INCHES
   MILLIMETERS
   *THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

2. DRAWING NOT TO SCALE

3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.15 mm (0.006")

NOTE:
1. DIMENSIONS IN INCHES
   MILLIMETERS

2. DRAWING NOT TO SCALE

3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.15 mm (0.006")
### REVISION HISTORY

(Revision history begins at Rev D)

<table>
<thead>
<tr>
<th>REV</th>
<th>DATE</th>
<th>DESCRIPTION</th>
<th>PAGE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>4/10</td>
<td>M-grade parts re-released. Obsolete package shading removed.</td>
<td>2, 11</td>
</tr>
<tr>
<td>E</td>
<td>7/11</td>
<td>Added LT1431MPS8 to data sheet. Changes reflected throughout.</td>
<td>1 to 14</td>
</tr>
</tbody>
</table>
## PACKAGE DESCRIPTION

**Z Package**

3-Lead Plastic TO-92 (Similar to TO-226)

(Reference LTC DWG # 05-08-1410 Rev C)

### Package Dimensions

- **DIA**: 0.060 ± 0.005
  (1.524 ± 0.127)
- **MAX**: 0.180 ± 0.005
  (4.572 ± 0.127)
- **MIN**: 0.100 ± 0.005
  (2.540 ± 0.127)
- **UNCONTROLLED LEAD DIMENSION**: 0.050
  (1.270)
- **BSC**: 0.016 ± 0.003
  (0.406 ± 0.076)
- **MAX**: 0.150 ± 0.002
  (3.811 ± 0.051)

### Bulk Pack Dimensions

- **BULK PACK**: 0.015 ± 0.002
  (0.381 ± 0.051)
- **MIN**: 0.060 ± 0.010
  (1.524 ± 0.254)
- **MAX**: 0.100 ± 0.010
  (2.540 ± 0.254)

### TO-92 Tape and Reel

- **TO-92 TAPE AND REEL**: 0.098 +0.016/–0.04
  (2.50 +0.41/–0.10)
- **2 PLCS**

### Notes

- **REFER TO TAPE AND REEL SECTION OF LTC DATA BOOK FOR ADDITIONAL INFORMATION**

---

## RELATED PARTS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT4430</td>
<td>Secondary-Side Optocoupler Driver with Reference Voltage</td>
<td>Overshoot Control Prevents Output Overshoot during Start-Up and Short-Circuit Recovery</td>
</tr>
<tr>
<td>LT3757/LT3758</td>
<td>Boost, Flyback, SEPIC and Inverting Controller</td>
<td>2.9V/5.5V ≤ Vin ≤ 40V/100V, 100kHz to 1MHz Fixed Frequency, 3mm × 3mm DFN-10 and MSOP-10E Packages</td>
</tr>
<tr>
<td>LTC3803/LTC3803-3/LTC3803-5</td>
<td>Flyback DC/DC Controller with Fixed 200kHz or 300kHz Operating Frequency</td>
<td>Vin and Vout Limited by External Components, 6-Pin ThinSOT™ Package</td>
</tr>
<tr>
<td>LTC3873/LTC3873-5</td>
<td>No RSENSE Constant Frequency Flyback, Boost, SEPIC Controller</td>
<td>Vin and Vout Limited Only by External Components, 8-Pin ThinSOT™ and 2mm × 3mm DFN-8 Packages</td>
</tr>
<tr>
<td>LTC3805/LTC3805-5</td>
<td>Adjustable Constant Frequency (70kHz to 700kHz) Frequency Flyback DC/DC Controller</td>
<td>Vin and Vout Limited by External Components, MSOP-10E and 3mm × 3mm DFN-10 Packages</td>
</tr>
<tr>
<td>LT1952/LT1952-1</td>
<td>Isolated Synchronous Forward Controllers</td>
<td>Ideal for Medium Power 24V and 48V Input Applications</td>
</tr>
<tr>
<td>LTC3723-1/LTC3723-2</td>
<td>Synchronous Push-Pull and Full-Bridge Controllers</td>
<td>High Efficiency with On-Chip MOSFET Drivers</td>
</tr>
<tr>
<td>LTC3721-1/LTC3721-2</td>
<td>Non-Synchronous Push-Pull and Full-Bridge Controllers</td>
<td>Minimizes External Components, On-Chip MOSFET Drivers</td>
</tr>
<tr>
<td>LTC3722/LTC3722-2</td>
<td>Synchronous Isolated Full Bridge Controllers</td>
<td>Ideal for High Power 24V and 48V Input Applications</td>
</tr>
</tbody>
</table>