The LT1082 is a monolithic high voltage switching regulator. It can be operated in all standard switching configurations including buck, boost, flyback, forward, and inverting. A 1A high efficiency switch is included on the die along with all oscillator, control, and protection circuitry.

The LT1082 operates with supply voltages from 3V to 75V, switch voltage up to 100V and draws only 4.5mA quiescent current. It can deliver load power up to 20W with no external power devices. By utilizing current-mode switching techniques, it provides excellent AC and DC load and line regulation.

An externally activated shutdown mode reduces total supply current to 120µA typical for standby operation. Totally isolated and regulated outputs can be generated by using the optional “isolated flyback regulation mode” built into the LT1082, without the need for optocouplers or extra transformer windings.

The LT1082 has a unique feature to provide high voltage short-circuit protection. When the FB pin is pulled down to 0.6V and the current out of the pin reaches approximately 350µA, the switching frequency will shift down from 60kHz to 12kHz.

The LT1082 is nearly identical to the lower voltage LT1072. For the major differences in specifications, see the table on the left.
**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage ....................................................... 75V
Switch Output Voltage .......................................... 100V
Feedback Pin Voltage (Transient, 1ms) ................ ±15V
Storage Temperature Range ................ – 65°C to 150°C
Lead Temperature (Soldering, 10 sec) ................. 300°C

Operating Junction Temperature Range
LT1082M ......................................... – 55°C to 150°C
LT1082I ........................................... – 40°C to 125°C
LT1082C ............................................... 0°C to 100°C

**ELECTRICAL CHARACTERISTICS** $V_{IN} = 15V$, $V_C = 0.5V$, $V_{FB} = V_{REF}$, output pin open, unless otherwise specified.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{REF}$</td>
<td>Reference Voltage</td>
<td>Measured at Feedback Pin $V_C = 0.8V$</td>
<td>1.224</td>
<td>1.244</td>
<td>1.264</td>
<td>V</td>
</tr>
<tr>
<td>$I_B$</td>
<td>Feedback Input Current</td>
<td>$V_{FB} = V_{REF}$</td>
<td>1.214</td>
<td>1.244</td>
<td>1.274</td>
<td>V</td>
</tr>
<tr>
<td>$g_m$</td>
<td>Error Amplifier Transconductance</td>
<td>$\Delta I_C = \pm 25\mu A$</td>
<td>3000</td>
<td>4400</td>
<td>6000</td>
<td>μmho</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_C = 1.5V$</td>
<td>2000</td>
<td>4000</td>
<td>7000</td>
<td>μmho</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{C} = 1.5V$</td>
<td>150</td>
<td>200</td>
<td>400</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{FB} = 1V$</td>
<td>120</td>
<td>120</td>
<td>400</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{FB} = 1.5V$</td>
<td>1.8</td>
<td>2.3</td>
<td>2.3</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lo Clamp, $V_{FB} = 1V$</td>
<td>0.12</td>
<td>0.22</td>
<td>0.36</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reference Voltage Line Regulation</td>
<td>$3V \leq V_{IN} \leq V_{MAX}$, $V_C = 0.8V$</td>
<td>0.03</td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td>$A_V$</td>
<td>Error Amplifier Voltage Gain</td>
<td>$0.9V \leq V_C \leq 1.4V$</td>
<td>350</td>
<td>650</td>
<td>350</td>
<td>V/V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum Input Voltage</td>
<td>2.6</td>
<td>3.0</td>
<td>3.0</td>
<td>V</td>
</tr>
</tbody>
</table>
**ELECTRICAL CHARACTERISTICS**  \( V_{\text{IN}} = 15\text{V}, \ V_C = 0.5\text{V}, \ V_{\text{FB}} = V_{\text{REF}}, \) output pin open, unless otherwise specified.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_Q )</td>
<td>Supply Current</td>
<td>( 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}}, \ V_C = 0.6\text{V} )</td>
<td>4.5</td>
<td>7.0</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Control Pin Threshold</td>
<td>Duty Cycle = 0</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
<td>V</td>
</tr>
<tr>
<td>( )</td>
<td>Normal/Flyback Threshold on Feedback Pin</td>
<td>Duty Cycle = 0</td>
<td>0.58</td>
<td>0.67</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>( f )</td>
<td>Switching Frequency</td>
<td>Duty Cycle = 0</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>kHz</td>
</tr>
<tr>
<td>( BV )</td>
<td>Output Switch Breakdown Voltage</td>
<td>( 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}}, \ ISW = 1.5\text{mA} )</td>
<td>800 ( \mu \text{A} \geq I_{FB} \geq 450 \mu \text{A} )</td>
<td>12</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Control Voltage to Switch</td>
<td>( 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}}, \ ISW = 1.5\text{mA} )</td>
<td>100</td>
<td>115</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{FB}} )</td>
<td>Flyback Reference Voltage</td>
<td>( I_{FB} = 60 \mu \text{A} )</td>
<td>17</td>
<td>18.6</td>
<td>20.5</td>
<td>V</td>
</tr>
<tr>
<td>( )</td>
<td>Change in Flyback Reference Voltage</td>
<td>( 60\mu \text{A} \leq I_{FB} \leq 200\mu \text{A} )</td>
<td>3.5</td>
<td>4.6</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>( )</td>
<td>Flyback Reference Voltage Line Regulation</td>
<td>( I_{FB} = 60 \mu \text{A}, \ 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}} )</td>
<td>0.01</td>
<td>0.03</td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Flyback Amplifier Transconductance ((g_m))</td>
<td>( \Delta I_C = \pm 10\mu \text{A} )</td>
<td>150</td>
<td>300</td>
<td>500</td>
<td>( \mu \text{mho} )</td>
</tr>
<tr>
<td>( V_{\text{SAT}} )</td>
<td>Output Switch “On” Resistance (Note 1)</td>
<td>( I_{SW} = 0.7\text{A} \ (LT1082C), \ ISW = 0.5\text{A} \ (LT1082M) )</td>
<td>0.8</td>
<td>1.2</td>
<td>( \Omega )</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{LIM}} )</td>
<td>Switch Current Limit (LT1082C)</td>
<td>Duty Cycle = 20%</td>
<td>1.07</td>
<td>2.6</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 50%</td>
<td>1.0</td>
<td>2.6</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 80% (Note 2)</td>
<td>0.8</td>
<td>2.4</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Switch Current Limit (LT1082I)</td>
<td>Duty Cycle = 20%</td>
<td>0.85</td>
<td>2.8</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 50%</td>
<td>0.8</td>
<td>2.8</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 80% (Note 2)</td>
<td>0.65</td>
<td>2.6</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Switch Current Limit (LT1082M)</td>
<td>Duty Cycle = 20%</td>
<td>0.75</td>
<td>3.0</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 50%</td>
<td>0.7</td>
<td>3.0</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td></td>
<td>Duty Cycle = 80% (Note 2)</td>
<td>0.6</td>
<td>2.8</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( \Delta I_{\text{IN}} )</td>
<td>Supply Current Increase During Switch-On Time</td>
<td></td>
<td>35</td>
<td>45</td>
<td>mA/A</td>
<td></td>
</tr>
<tr>
<td>( \Delta I_{\text{SW}} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_{\text{CMA}} )</td>
<td>Maximum Switch Duty Cycle</td>
<td></td>
<td>85</td>
<td>92</td>
<td>97</td>
<td>%</td>
</tr>
<tr>
<td>( )</td>
<td>Flyback Sense Delay Time</td>
<td></td>
<td>1.5</td>
<td></td>
<td>( \mu \text{s} )</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Shutdown Mode Supply Current</td>
<td>( 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}}, \ V_C = 0.05\text{V} )</td>
<td>120</td>
<td>350</td>
<td>( \mu \text{A} )</td>
<td></td>
</tr>
<tr>
<td>( )</td>
<td>Shutdown Mode Threshold Voltage</td>
<td>( 3\text{V} \leq V_{\text{IN}} \leq V_{\text{MAX}} )</td>
<td>70</td>
<td>150</td>
<td>250</td>
<td>mV</td>
</tr>
</tbody>
</table>

The ● denotes the specifications which apply over the operating temperature range.

**Note 1:** Measured with \( V_C \) in hi clamp, \( V_{\text{FB}} = 0.8\text{V} \).

**Note 2:** For duty cycles (DC) between 50% and 80%, minimum guaranteed switch current decreases linearly.
TYPICAL PERFORMANCE CHARACTERISTICS

Suggested Core Size and Inductance for Telecom 5V Supply

<table>
<thead>
<tr>
<th>LOAD CURRENT</th>
<th>TYPE 52 POWDERED IRON</th>
<th>Kool Mj or Moly-Permalloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>100mA</td>
<td>T38 250µH</td>
<td>T38 200µH</td>
</tr>
<tr>
<td>200mA</td>
<td>T50 250µH</td>
<td>T38 150µH</td>
</tr>
<tr>
<td>400mA</td>
<td>T60 250µH</td>
<td>T50 150µH</td>
</tr>
<tr>
<td>600mA</td>
<td>T60 250µH</td>
<td>T50 200µH</td>
</tr>
<tr>
<td>800mA</td>
<td>T80 350µH</td>
<td>T80 350µH</td>
</tr>
</tbody>
</table>

Telecom 5V Supply Efficiency

Telecom 5V Supply Short-Circuit Frequency Shift-Down

NOTE: This graph is based on low core loss Peralloy inductor. If powdered iron core inductor is used, the core loss is typically 100mW higher.

Short-Circuit Frequency Shift-Down vs Feedback Current

Switch Current Limit

Maximum Duty Cycle

Flyback Blanking Time

Minimum Input Voltage

Switch Saturation Voltage
TYPICAL PERFORMANCE CHARACTERISTICS

Isolated Mode Flyback Reference Voltage

Reference Voltage and Switching Frequency vs Temperature

Line Regulation

Feedback Bias Current vs Temperature

Normal/Feedback Mode Threshold on Feedback Pin

Shutdown Mode Supply Current

Supply Current vs Supply Voltage (Shutdown Mode)

Driver Current* vs Switch Current

Supply Current vs Input Voltage**

---

* AVERAGE SUPPLY CURRENT = IQ + DC(2.9 + 10^{-2} ISW + 10^{-5} ISW^2)
IQ = QUIESCENT CURRENT, DC = DUTY CYCLE, ISW = SWITCH CURRENT

** UNDER VERY LOW OUTPUT CURRENT CONDITIONS, DUTY CYCLE FOR MOST CIRCUITS WILL APPROACH 10% OR LESS.
**Error Amplifier Transconductance**

\[ g_m = \frac{\Delta I}{\Delta V} (V_C \text{ PIN}) \]

**Shutdown Thresholds**

VOUT = 1.5V (OUT OF V_C PIN)

**Idle Supply Current vs Temperature**

V_IN = 3V

**Feedback Pin Clamp Voltage**

A. VIN = 3V
B. VIN = 15V
C. VIN = 40V
D. VIN = 55V
E. VIN = 75V

**Switch “Off” Characteristics**

**V_C Pin Characteristics**

T_J = 25°C

V_FB = 1.5V (CURRENT INTO V_C PIN)
V_FB = 0.8V (CURRENT OUT OF V_C PIN)

**Transconductance of Error Amplifier**

Frequency (Hz) vs Phase (deg)
**OPERATION**

The LT1082 is a current mode switcher. This means that switch duty cycle is directly controlled by switch current rather than by output voltage. Referring to the block diagram, the switch is turned “on” at the start of each oscillator cycle. It is turned “off” when switch current reaches a predetermined level. Control of output voltage is obtained by using the output of a voltage sensing error amplifier to set current trip level. This technique has several advantages. First, it has immediate response to input voltage variations, unlike ordinary switchers which have notoriously poor line transient response. Second, it reduces the 90° phase shift at mid-frequencies in the energy storage inductor. This greatly simplifies closed-loop frequency compensation under widely varying input voltage or output load conditions. Finally, it allows simple pulse-by-pulse current limiting to provide maximum switch protection under output overload or short conditions. A low dropout internal regulator provides a 2.3V supply for all internal circuitry on the LT1082. This low dropout design allows input voltage to vary from 3V to 75V with virtually no change in device performance. A 60kHz oscillator is the basic clock for all internal timing. It turns “on” the output switch via the logic and driver circuitry. Special adaptive anti-sat circuitry detects onset of saturation in the power switch and adjusts driver current instantaneously to limit switch saturation. This minimizes driver dissipation and provides very rapid turn-off of the switch.

A 1.2V bandgap reference biases the positive input of the error amplifier. The negative input is brought out for output voltage sensing. This feedback pin has a second function: when pulled low with an external resistor and with \( I_{FB} \) of 60\( \mu \)A to 200\( \mu \)A, it programs the LT1082 to
disconnect the main error amplifier output and connects the output of the flyback amplifier to the comparator input. The LT1082 will then regulate the value of the flyback pulse with respect to the supply voltage. This flyback pulse is directly proportional to output voltage in the traditional transformer coupled flyback topology regulator. By regulating the amplitude of the flyback pulse, the output voltage can be regulated with no direct connection between input and output. The output is fully floating up to the breakdown voltage of the transformer windings. Multiple floating outputs are easily obtained with additional windings. A special delay network inside the LT1082 ignores the leakage inductance spike at the leading edge of the flyback pulse to improve output regulation.

When IFB drawn out of the FB pin reaches 350µA, the LT1082 shifts the switching frequency down to 12kHz. This unique feature provides high voltage short-circuit protection in systems like the telecom 5V supplies with input voltages down to ~70V; lower frequency is needed under short-circuit conditions with current mode switchers because minimum “on” time cannot be forced below the internally set blanking time. Referring to the telecom 5V supply circuit on the front page, with output shorted to ground, the V_FB stays at 0.6V when sourcing IFB up to 1mA. If the FB pin is forced to source more than 1mA, the frequency shifting function may be defeated. Therefore, the minimum suggested value for R_FB is 1k and the maximum suggested value is 1.2k. Also, no capacitance more than 1nF should be used on the FB pin, because it may cause unstable switching frequency in this low frequency mode.

The error signal developed at the comparator input is brought out externally. This pin (V_C) has four different functions. It is used for frequency compensation, current limit adjustment, soft starting, and total regulator shutdown. During normal regulator operation this pin sits at a voltage between 0.9V (low output current) and 2V (high output current). The error amplifiers are current output (g_m) types, so this voltage can be externally clamped for adjusting current limit. Likewise, a capacitor-coupled external clamp will provide soft start. Switch duty cycle goes to zero if the V_C pin is pulled to ground through a diode, placing the LT1082 in an idle mode. Pulling the V_C pin below 0.15V causes total regulator shutdown, with only 120µA supply current for shutdown circuitry biasing. See AN19 for full application details.

Extra Pins on the MiniDIP Packages

The miniDIP LT1082 has the emitters of the power transistor brought out separately from the ground pin. This eliminates errors due to ground pin voltage drops and allows the user to reduce switch current limit by a factor of 2:1 by leaving the second emitter (E2) disconnected. The first emitter (E1) should always be connected to the ground pin. Note that switch “on” resistance doubles when E2 is left open, so efficiency will suffer somewhat when switch currents exceed 100mA. Also, note that chip dissipation will actually increase with E2 open during normal load operation, even though dissipation in current limit mode will decrease. See “Thermal Considerations.”

Thermal Considerations When Using the MiniDIP Packages

The low supply current and high switch efficiency of the LT1082 allow it to be used without a heat sink in most applications when the TO-220 package is selected. This package is rated at 50°C/W. The miniDIPs, however, are rated at 100°C/W in ceramic (J) and 90°C/W in plastic (N).

Care should be taken for miniDIP applications to ensure that the worst case input voltage and load current conditions do not cause excessive die temperatures. The following formulas can be used as a rough guide to calculate LT1082 power dissipation. For more details, the reader is referred to Application Note 19 (AN19), “Efficiency Calculations” section.

Average supply current (including driver current) is:

\[ I_{IN} = 4.5mA + I_{SW} (0.004 + DC/28) \]

where \( I_{SW} \) = switch current
DC = switch duty cycle

Switch power dissipation is given by:

\[ P_{SW} = (I_{SW})^2 \cdot R_{SW} \cdot DC \]

\( R_{SW} = \) LT1082 switch “on” resistance (1.2Ω maximum)
**OPERATION**

Total power dissipation is the sum of supply current times input voltage plus switch power:

\[ P_{TOT} = (I_{IN})(V_{IN}) + P_{SW} \]

In a typical example, using negative-to-positive converter to generate 5V at 0.5A from a −45V input, duty cycle is approximately 12%, and switch current is about 0.5A, yielding:

\[ I_{IN} = 4.5mA + 0.5(0.004 + DC/28) = 8.7mA \]
\[ P_{SW} = (0.5)^2 \cdot 1.2\Omega \cdot (0.12) = 0.036W \]
\[ P_{TOT} = (45V)(8.7mA) + 0.036 = 0.43W \]

Temperature rise in a plastic miniDIP would be 90°C/W times 0.43W, or approximately 39°C. The maximum ambient temperature would be limited to 100°C (commercial temperature limit) minus 39°C, or 61°C.

In most applications, full load current is used to calculate die temperature. However, if overload conditions must also be accounted for, four approaches are possible. First, if loss of regulated output is acceptable under overload conditions, the internal thermal limit of the LT1082 will protect the die in most applications by shutting off switch current. **Thermal limit** is not a tested parameter, however, and should be considered only for noncritical applications with temporary overloads. A second approach is to use the larger TO-220 (T) package which, even without a heat sink, may limit die temperatures to safe levels under overload conditions. In critical situations, heat sinking of these packages is required; especially if overload conditions must be tolerated for extended periods of time.

The third approach for lower current applications is to leave the second switch emitter (miniDIP only) open. This increases switch “on” resistance by 2:1, but reduces switch current limit by 2:1 also, resulting in a net 2:1 reduction in I^2R switch dissipation under current limit conditions.

The fourth approach is to clamp the VC pin to a voltage less than its internal clamp level of 2V. The LT1082 switch current limit is zero at approximately 1V on the VC pin and 1.6A at 2V on the VC pin. Peak switch current can be externally clamped between these two levels with a diode. See AN19 for details.

**LT1082 Synchronizing**

The LT1082 can be externally synchronized in the frequency range of 75kHz to 90kHz. This is accomplished as shown in the accompanying figures. Synchronizing occurs when the VC pin is pulled to ground with an external transistor. To avoid disturbing the DC characteristics of the internal error amplifier, the width of the synchronizing pulse should be under 1µs. C2 sets the pulse width at ≈ 0.6µs. The effect of a synchronizing pulse on the LT1082 amplifier offset can be calculated from:

\[ \Delta V_{OS} = \frac{\frac{KT}{q}(t_S)(f_S)(I_C + V_C/R_3)}{I_C} \]

\[ KT/q = 26mV \text{ at } 25°C \]
\[ t_S = \text{pulse width} \]
\[ f_S = \text{pulse frequency} \]
\[ I_C = \text{LT1082 VC source current (≈ 200µA)} \]
\[ V_C = \text{LT1082 operating VC voltage (1V to 2V)} \]
\[ R_3 = \text{resistor used to set mid-frequency “zero” in LT1082 frequency compensation network.} \]

With \( t_S = 0.6\mu s, f_S = 80kHz, V_C = 1.5V, \text{ and } R_3 = 2k, \) offset voltage shift is ≈ 5mV. This is not particularly bothersome, but note that high offset could result if \( R_3 \) were reduced to a much lower value. Also, the synchronizing transistor must sink higher currents with low values of \( R_3 \), so larger drives may have to be used. The transistor must be capable of pulling the VC pin to within 100mV of ground to ensure synchronizing.

**Synchronizing the LT1082**

\[ \text{SILICONIX OR EQUIVALENT} \]

*FROM 5V LOGIC*
Totally Isolated Converter

Minimum load of 0.15A is required for each output. (See AN19)

Boost Converter

Minimum load of 0.15A is required for each output. (See AN19)
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

T Package
5-Lead TO-220

Dimensions in inches (millimeters) unless otherwise noted.