1.5MHz, 1.5A Synchronous Step-Down Converter

FEATURES

- High Efficiency: Up to 96%
- 1.5MHz Constant Frequency Operation
- 1500mA Output Current
- No Schottky Diode Required
- 2.3V to 6.5V Input Voltage Range
- Adjustable Output Voltage Range Options from 0.6V to Vin
- 100% Duty Cycle Low Dropout Operation
- Low Quiescent Current: 35µA
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- Thermal Fault Protection
- Inrush Current Limit and Soft Start
- <1µA Shutdown Current
- Tiny SOT23-5 Package

APPLICATIONS

- Cellular and Smart Phones
- Wireless and DSL Modems
- PDAs
- Digital Still and Video Cameras
- MP3 Players

GENERAL DESCRIPTION

The IA2014 are high-efficiency, high frequency synchronous step-down DC-DC regulator ICs capable of delivering up to 1.5A output currents. The IA2014 can operate over a wide input voltage range from 2.3V to 6V and integrates main switch and synchronous switch with very low RDS(ON) to minimize the conduction loss.

It is ideal for powering portable equipment that runs from a single cell Lithium-Ion (Li+) battery. The output voltage can be regulated as low as 0.6V. The IA2014 can also run at 100% duty cycle for low dropout operation, extending battery life in portable system.

This device offers two operation modes, PWM mode and PFM Mode switching control, which allows a high efficiency over the wider range of the load.

The IA2014 is offered in a low profile (1mm) 5-pin, thin SOT package, and is available in an adjustable version.

TYPICAL APPLICATION

Figure 1. Typical Application Circuit

![Graph showing voltage output at different input voltages: V_IN=2.8V, V_IN=3.6V, V_IN=5V]
ABSOLUTE MAXIMUM RATINGS (Note 1)

- Input Supply Voltage: -0.3V to 6.5V
- RUN,FB Voltages: -0.3V to 6.5V
- SW Voltage: -0.3V to (Vin+0.3V)
- Peak SW Sink and Source Current: 2.5A
- Operating Temperature Range: -40°C to +85°C
- Junction Temperature: 125°C
- Storage Temperature Range: -65°C to 150°C
- Lead Temperature (Soldering, 10s): +300°C

PACKAGE/ORDER INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>SWITCHING FREQUENCY</th>
<th>Temperature Range</th>
<th>OUTPUT VOLTAGE (V)</th>
<th>OUTPUT CURRENT (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA2014-AS25F</td>
<td>1.5MHz</td>
<td>-40°C to +85°C</td>
<td>ADJ</td>
<td>1.5</td>
</tr>
</tbody>
</table>

PIN DESCRIPTION

<table>
<thead>
<tr>
<th>PIN</th>
<th>NAME</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RUN</td>
<td>Chip Enable Pin. Drive RUN above 1.5V to turn on the part. Drive RUN below 0.3V to turn it off. Do not leave RUN floating.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>3</td>
<td>SW</td>
<td>Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.</td>
</tr>
<tr>
<td>4</td>
<td>VIN</td>
<td>Power Supply Input. Must be closely decoupled to GND with a 10μF or greater ceramic capacitor.</td>
</tr>
<tr>
<td>5</td>
<td>FB</td>
<td>Feedback Input. An internal resistive divider divides the output voltage down for comparison to the internal reference voltage.</td>
</tr>
</tbody>
</table>
## ELECTRICAL CHARACTERISTICS

\(V_{\text{IN}}=V_{\text{RUN}}=3.6\, \text{V}, \ V_{\text{OUT}}=1.8\, \text{V}, \ T_{\text{A}} = 25^\circ\text{C}, \) unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range</td>
<td></td>
<td>2.3</td>
<td></td>
<td>8</td>
<td>V</td>
</tr>
<tr>
<td>UVLO Threshold</td>
<td></td>
<td>1.7</td>
<td>1.9</td>
<td>2.1</td>
<td>V</td>
</tr>
<tr>
<td>Input DC Supply Current</td>
<td>(Note 4)</td>
<td></td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>PWM Mode</td>
<td>Vout = 90%, ILoad=0mA</td>
<td>140</td>
<td>300</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>PFM Mode</td>
<td>Vout = 105%, ILoad=0mA</td>
<td>35</td>
<td>70</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Shutdown Mode</td>
<td>V_{\text{RUN}}=0V, V_{\text{IN}}=4.2V</td>
<td>0.1</td>
<td>1.0</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Regulated Feedback Voltage</td>
<td>T_{\text{A}} = 25^\circ\text{C}</td>
<td>0.588</td>
<td>0.600</td>
<td>0.612</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>T_{\text{A}} = 0^\circ\text{C} \leq T_{\text{A}} \leq 85^\circ\text{C}</td>
<td>0.586</td>
<td>0.600</td>
<td>0.613</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>T_{\text{A}} = -40^\circ\text{C} \leq T_{\text{A}} \leq 85^\circ\text{C}</td>
<td>0.585</td>
<td>0.600</td>
<td>0.615</td>
<td>V</td>
</tr>
<tr>
<td>Reference Voltage Line</td>
<td>V_{\text{IN}}=2.5, \text{V} to 6, \text{V}</td>
<td>0.04</td>
<td>0.40</td>
<td></td>
<td>%/V</td>
</tr>
<tr>
<td>Regulation</td>
<td>V_{\text{IN}}=2.5, \text{V} to 6, \text{V}</td>
<td>0.04</td>
<td>0.4</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Output Voltage Load Regulation</td>
<td>V_{\text{IN}}=2.5, \text{V} to 6, \text{V}</td>
<td>0.5</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Oscillation Frequency</td>
<td>Vout=100%</td>
<td></td>
<td>1.5</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td></td>
<td>Vout=0V</td>
<td></td>
<td>300</td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>On Resistance of PMOS</td>
<td>I_{\text{SW}}=100mA</td>
<td>0.13</td>
<td>0.2</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>ON Resistance of NMOS</td>
<td>I_{\text{SW}}=-100mA</td>
<td>0.1</td>
<td>0.2</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Peak Current Limit</td>
<td>V_{\text{IN}}=3, \text{V}, Vout=90%</td>
<td>2.0</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>RUN Threshold</td>
<td></td>
<td>0.30</td>
<td>1.0</td>
<td>1.50</td>
<td>V</td>
</tr>
<tr>
<td>RUN Leakage Current</td>
<td>V_{\text{RUN}}=0V, V_{\text{IN}}=V_{\text{SW}}=5, \text{V}</td>
<td>±0.01</td>
<td>±1.0</td>
<td>±1.0</td>
<td>μA</td>
</tr>
<tr>
<td>SW Leakage Current</td>
<td>V_{\text{RUN}}=0V, V_{\text{IN}}=V_{\text{SW}}=5, \text{V}</td>
<td>±0.01</td>
<td>±1.0</td>
<td>±1.0</td>
<td>μA</td>
</tr>
</tbody>
</table>

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** \(T_{\text{J}}\) is calculated from the ambient temperature \(T_{\text{A}}\) and power dissipation \(P_{\text{D}}\) according to the following formula: \(T_{\text{J}} = T_{\text{A}} + (P_{\text{D}}) \times (250^\circ\text{C}/\text{W})\).

**Note 3:** 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

**Note 4:** Dynamic supply current is higher due to the gate charge being delivered at the switching frequency.
TYPICAL PERFORMANCE CHARACTERISTICS

- Eff1.8V Output
- Eff1.3V Output
- Load Vs Output
- Oscillator Frequency vs Temperature
- Performance Voltage (V) vs Temperature (°C)

PFM MODE
IA2014 is a synchronous buck regulator IC that integrates the PWM/PFM control, high-side and low-side MOSFETs on the same die to minimize the switching transition loss and conduction loss. With ultra low RDS(ON) power switches and proprietary PWM control, this regulator IC can achieve the highest efficiency and the highest switch frequency simultaneously to minimize the external inductor and capacitor size, and thus achieving the minimum solution footprint.

At dropout operation, the converter duty cycle increases to 100% and the output voltage tracks the input voltage minus the Rdson drop of the high-side MOSFET.

The internal error amplifier and compensation provides excellent transient response, load, and line regulation. Soft start function prevents input inrush current and output overshoot during start up.

The IA2014 requires only three external power components (Cin, Cout and L). The adjustable version can be programmed with external feedback to any voltage, ranging from 0.6V to the input voltage.
Setting the Output Voltage

The internal reference VREF is 0.6V (Typical). The output voltage is divided by a resistor, R1 and R2 to the FB pin. The output voltage is given by:

\[ V_{OUT} = V_{REF} \times \left(1 + \frac{R_2}{R_1}\right) \]

Inductor Selection

For most designs, the IA2014 operates with inductors of 1µH to 4.7µH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

\[ L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}} \]

Where \( \Delta I_L \) is inductor Ripple Current. Large value inductors result in lower ripple current and small value inductors result in high ripple current. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range.

Input Capacitor Selection

With the maximum load current at 1.5A, the maximum ripple current through input capacitor is about 0.6Arms. A typical X7R or better grade ceramic capacitor with 6V rating and greater than 10µF capacitance can handle this ripple current well. To minimize the potential noise problem, place this ceramic capacitor really close to the IN and GND pins. Care should be taken to minimize the loop area formed by CIN, and IN/GND pins.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current ratings. The output ripple \( \Delta V_{OUT} \) is determined by:

\[ \Delta V_{OUT} \leq \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times ESR + \frac{1}{8 \times f_{OSC} \times C}} \]

A 10µF ceramic Capacitor can satisfy most applications.

PC Board Layout Checklist

When laying out the printed circuit board, the following checking should be used to ensure proper operation of the IA2014. Check the following in your layout:

1. The power traces, consisting of the GND trace, the SW trace and the VIN trace should be kept short, direct and wide.
2. Does the (+) plates of Cin connect to Vin as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
3. Keep the switching node, SW, away from the sensitive VOUT node.
4. Keep the (-) plates of Cin and Cout as close as possible.