High-Frequency Switchmode Controller

FEATURES

- 15- to 200-V Input Range
- Current-Mode Control
- Internal Start-Up Circuit
- Latched SHUTDOWN
- Soft-Start
- 1.8-MHz Error Amp

DESCRIPTION

The Si9114A is a BiCMOS current-mode pulse width modulation (PWM) controller IC for high-frequency dc/dc converters. Single-ended topologies (forward and flyback) can be implemented at frequencies up to 1 MHz. The oscillator has an internal divide-by-two that limits the duty ratio to 50%. An oscillator sync output allows converters to be synchronized in phase as well as in frequency, in a master/slave configuration.

The high-voltage DMOS transistor allows the IC to interface directly to bus voltages up to 200 V. Other features include a 1.5% accurate voltage reference, 1.8-MHz (min) bandwidth error amplifier, shutdown logic control, soft-start and undervoltage lockout circuits.

The output inverter can typically source 500 mA and sink 700 mA. Shoot-through current is all but eliminated to minimize supply current requirements.

The Si9114A is available in both standard and lead (Pb)-free 14-pin plastic DIP and SOIC packages, and is specified over the industrial, D suffix (−40°C to 85°C) temperature range.

FUNCTIONAL BLOCK DIAGRAM
### ABSOLUTE MAXIMUM RATINGS

- **VCC** ........................................... 18 V
- **V+IN** (Note: **VCC < +VIN + 0.3 V** ) ............... 200 V
- Logic Input (SHUTDOWN, SYNC) ..................... 0.3 V to **VCC + 0.3 V**
- Linear Inputs (FEEDBACK, SENSE, SOFT-START) ... 0.3 V to **VCC + 0.3 V**
- HV Pre-Regulator Input Current (continuous) ........ 5 mA
- Storage Temperature ................................... ~65 to 150 °C
- Operating Temperature ................................. 40 to 85 °C
- Junction Temperature (TJ) .............................. 150 °C

**Power Supply Rejection (PSRR)**
- 9.5 V / **VCC** ........................................ 50 dB
- 16.5 V ............................................... 80 dB

Notes:
- a. Device mounted with all leads soldered or welded to PC board.
- b. Derate 6 mW/°C above 25°C.
- c. Derate 7.2 mW/°C above 25°C.

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### RECOMMENDED OPERATING RANGE

- **VCC** ........................................... 9.5 V to 16.5 V
- **V+IN** ........................................... 15 V to 200 V
- **fOSC** ........................................... 20 kHz to 2 MHz

### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Oscillator Disabled</th>
<th>Over Voltage and Temperature Ranges&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Limits</th>
<th>D Suffix</th>
<th>-40 to 85 °C</th>
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<tr>
<td>Reference</td>
<td></td>
<td></td>
<td><strong>VREF</strong> = -<strong>VIN</strong></td>
<td><strong>VREF</strong> = 0 to -1 mA</td>
<td><strong>Vin</strong> = 0 V, <strong>VCC</strong> = 10 V</td>
<td><strong>Min&lt;sup&gt;a&lt;/sup&gt;</strong></td>
<td><strong>Typ&lt;sup&gt;b&lt;/sup&gt;</strong></td>
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<tr>
<td>Output Voltage</td>
<td><strong>VR</strong></td>
<td><strong>OSC Disabled, TA = 25 °C</strong></td>
<td>3.94</td>
<td>4.0</td>
<td>4.06</td>
<td>V</td>
<td></td>
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<td></td>
<td></td>
<td><strong>OSC Disabled</strong></td>
<td>3.88</td>
<td>4.0</td>
<td>4.12</td>
<td>V</td>
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<td>Short Circuit Current</td>
<td><strong>I&lt;sub&gt;SREF&lt;/sub&gt;</strong></td>
<td></td>
<td>-30</td>
<td>-5</td>
<td>mA</td>
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<tr>
<td>Load Regulation</td>
<td>Δ<strong>V&lt;sub&gt;R&lt;/sub&gt;/Δ</strong></td>
<td><strong>I&lt;sub&gt;SREF&lt;/sub&gt;</strong> = 0 to -1 mA</td>
<td>10</td>
<td>40</td>
<td>mV</td>
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#### Oscillator

- **Initial Accuracy**
  - **f<sub>OSC</sub>**
  - **OSC = 374 kΩ, C<sub>OSC</sub> = 200 pF**
  - **OSC = 70 kΩ, C<sub>OSC</sub> = 200 pF**
  - **Δf = [f(16.5 V) − f(9.5 V)] / f(9.5 V)**
  - **90** | **100** | **110** | kHz |
  - **450** | **500** | **550** |
- **Voltage Stability<sup>c</sup>**
  - **Δf**
  - **OSC TC**
  - **-40 ≤ TA ≤ 85 °C, f<sub>OSC</sub> = 100 kHz**
  - **4** | **7** | % |
- **Temperature Coefficient<sup>c</sup>**
  - **OSC TC**
  - **200** | **500** | ppm/°C |
- **Sync Output Current (Master Mode)**
  - **I<sub>SYNC(IM)</sub>**
  - **V<sub>ROSC</sub> = 5 V**
  - **±1.0** | **±0.0** | mA |
- **Sync Output Current (Slave Mode)**
  - **I<sub>SYNC(IS)</sub>**
  - **V<sub>ROSC</sub> = V<sub>CC</sub>**
  - **±1** | **±500** | nA |

#### Error Amplifier (C<sub>OSC = -VIN OSC Disabled</sub>)

- **Input BIAS Current**
  - **I<sub>IB</sub>**
  - **V<sub>FB</sub> = 5 V, NI = V<sub>REF</sub>**
  - **<1.0** | **±200** | nA |
- **Input OFFSET Voltage**
  - **V<sub>OSZ</sub>**
  - **±5** | **±25** | mV |
- **Open Loop Voltage Gain<sup>c</sup>**
  - **AVOL**
  - **65** | **80** | dB |
- **Unity Gain Bandwidth<sup>c</sup>**
  - **BW**
  - **1.8** | **2.7** | MHz |
- **Output Current**
  - **I<sub>OUT</sub>**
  - **Source (V<sub>FB</sub> = 3.5 V, NI = V<sub>REF</sub>)**
  - **<2.7** | **<1.0** | mA |
  - **Sink (V<sub>FB</sub> = 4.5 V, NI = V<sub>REF</sub>)**
  - **1.0** | **2.4** |
- **Power Supply Rejection**
  - **PSRR**
  - **9.5 V ≤ V<sub>CC</sub> ≤ 16.5 V**
  - **50** | **80** | dB |
## SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Pre-Regulator/Start-Up</td>
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<tr>
<td>Input Leakage Current</td>
<td>+I_IN</td>
<td>+V_IN = 200 V, V_CC ≥ 10 V</td>
<td>&lt;1</td>
<td>10</td>
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<td>µA</td>
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<td>Pre-Regulator Start-Up Current</td>
<td>ISSTART</td>
<td>+V_IN = 48 V, t_PW ≤ 300 µs, V_CC = V_UVLO</td>
<td>8</td>
<td>20</td>
<td></td>
<td>mA</td>
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<tr>
<td>V_CC Pre-Regulator Voltage</td>
<td>V_PR</td>
<td>+V_IN = 48 V</td>
<td>8.8</td>
<td>9.1</td>
<td>9.4</td>
<td>mA</td>
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<td>V_PR - V_UVLO (Turn-On)</td>
<td>V_DELTA</td>
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<td>0.1</td>
<td>0.25</td>
<td>0.7</td>
<td>V</td>
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<td>Undervoltage Lockout Hysteresis</td>
<td>V_HYST</td>
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<td>0.18</td>
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<td>Supply</td>
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<tr>
<td>Supply Current</td>
<td>I_CC</td>
<td>C_LOAD ≤ 50 pF, fOSC = 100 kHz</td>
<td>1.5</td>
<td>2.5</td>
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<td>mA</td>
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<td></td>
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<td>C_LOAD ≤ 500 kHz</td>
<td>2.2</td>
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<td>mA</td>
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<td>Protection</td>
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<td>Current Limit Threshold Voltage</td>
<td>V_SENSE</td>
<td>V_FB = 0 V, NI = V_REF</td>
<td>1.15</td>
<td>1.23</td>
<td>1.30</td>
<td>V</td>
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<td>Current Limit Delay to Output</td>
<td>t_D</td>
<td>V_SENSE = 1.5 V, See Figure 1</td>
<td>77</td>
<td>100</td>
<td></td>
<td>ns</td>
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<td>SHUTDOWN Logic Threshold</td>
<td>V_SD</td>
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<td>2.8</td>
<td>0.5</td>
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<td>µV</td>
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<td>SHUTDOWN Delay to Latched Output</td>
<td>t_SD</td>
<td>See Figure 2</td>
<td>0.20</td>
<td>1.0</td>
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<td>µs</td>
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<td>SHUTDOWN Pull-Up Current</td>
<td>I_SD</td>
<td>V_SD = 0 V</td>
<td>12</td>
<td>23</td>
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<td>Soft-Start Current</td>
<td>I_SS</td>
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<td>12</td>
<td>23</td>
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<td>µA</td>
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<td>Output Inhibit Voltage</td>
<td>V_SS(off)</td>
<td>Soft-Start Voltage to Disable Driver Output</td>
<td>1.6</td>
<td>0.5</td>
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<td>V</td>
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<td>MOSFET Driver</td>
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<tr>
<td>Output High Voltage</td>
<td>V_OH</td>
<td>I_OUT = –10 mA</td>
<td>9.85</td>
<td>9.9</td>
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<td>V</td>
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<tr>
<td>Output Low Voltage</td>
<td>V_OL</td>
<td>I_OUT = 10 mA</td>
<td>0.05</td>
<td>0.15</td>
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<td>mA</td>
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<tr>
<td>Peak Output Current</td>
<td>I_SOURCE</td>
<td>V_OUT = 0 V</td>
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<td>–200</td>
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<td>mA</td>
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<td></td>
<td>I_SINK</td>
<td>V_OUT = V_CC</td>
<td>500</td>
<td>1000</td>
<td></td>
<td>mA</td>
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</table>

### Notes

a. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum.
b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
c. Guaranteed by design, not subject to production test.
d. C_STRAY = 5 pF on C_OSC.
TYPICAL CHARACTERISTICS

- Oscillator Frequency
  - Graph showing frequency vs. supply voltage for different capacitance values.
  - Note: These curves were measured in a board with 3.5 pF of external parasitic capacitance.

- Output Driver Rise and Fall Time
  - Graph showing rise and fall times for different capacitance values (10% to 90% and 90% to 10%).

- Supply Current vs. Output Frequency
  - Graph showing supply current vs. output frequency for different capacitance values.

- Supply Current vs. Supply Voltage
  - Graph showing supply current vs. supply voltage for different capacitance values.

- Switching Frequency vs. Supply Voltage
  - Graph showing switching frequency vs. supply voltage for different capacitance values.
TIMING WAVEFORMS

Current Sense Output

\[ V_{CC} \]

\[ t_d \leq 10 \text{ ns} \]

\[ t_f \leq 10 \text{ ns} \]

\[ V_{CC}^- \]

\[ 90\% \rightarrow 0 \]

\[ 0 \rightarrow 90\% \]

FIGURE 1.

SHUTDOWN

\[ V_{CC} \]

\[ 50\% \rightarrow 0 \]

\[ t_s \]

\[ t_f \leq 10 \text{ ns} \]

\[ V_{CC}^- \]

\[ 90\% \rightarrow 0 \]

FIGURE 2.

PIN CONFIGURATIONS AND ORDERING INFORMATION

Dual-In-Line and SOIC

+VIN 14
SHUTDOWN 13
VREF 12
NI 11
FB 10
COMPENSATION 9
SS 8
VCC 1

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Temperature Range</th>
<th>Package</th>
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<tbody>
<tr>
<td>Si9114ADY</td>
<td>−40 to 85°C</td>
<td>SOIC-14</td>
</tr>
<tr>
<td>Si9114ADY-T1</td>
<td>−40 to 85°C</td>
<td>SOIC-14</td>
</tr>
<tr>
<td>Si9114ADY-T1—E3</td>
<td>−40 to 85°C</td>
<td>PDIP-14</td>
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<tr>
<td>Si9114ADJ</td>
<td>−40 to 85°C</td>
<td>PDIP-14</td>
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<tr>
<td>Si9114ADJ—E3</td>
<td>−40 to 85°C</td>
<td>PDIP-14</td>
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</tbody>
</table>

APPLICATIONS

FIGURE 3. 15-W Forward Converter Schematic

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see http://www.vishay.com/ppg?770025.
**SOIC (NARROW): 14-LEAD (POWER IC ONLY)**

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### Package Information

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<tr>
<th>Dim</th>
<th>Min (MILLIMETERS)</th>
<th>Max (MILLIMETERS)</th>
<th>Min (INCHES)</th>
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<td>A</td>
<td>1.35</td>
<td>1.75</td>
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<td>A₁</td>
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<td>0.38</td>
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<td>C</td>
<td>0.18</td>
<td>0.23</td>
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<td>D</td>
<td>8.55</td>
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<td>E</td>
<td>3.8</td>
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<td>e</td>
<td>1.27 BSC</td>
<td>0.050 BSC</td>
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<td>H</td>
<td>5.80</td>
<td>6.20</td>
<td>0.228</td>
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<td>L</td>
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**ECN: S-40080—Rev. A, 02-Feb-04**

**DWG: 5914**

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**0.101 mm**

**0.004"**
PDIP: 14-LEAD (POWER IC ONLY)

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<td>3.81 - 5.08</td>
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<td>A1</td>
<td>0.38 - 1.27</td>
<td>0.015 - 0.050</td>
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<tr>
<td>B</td>
<td>0.38 - 0.51</td>
<td>0.015 - 0.020</td>
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<td>C</td>
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<td>D</td>
<td>17.27 - 19.30</td>
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<td>E</td>
<td>7.62 - 8.26</td>
<td>0.300 - 0.325</td>
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<td>E1</td>
<td>5.59 - 7.11</td>
<td>0.220 - 0.280</td>
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<td>2.29 - 2.79</td>
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<td>S</td>
<td>1.02 - 2.03</td>
<td>0.040 - 0.080</td>
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ECN: S-40081—Rev. A, 02-Feb-04
DWG: 5919
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