ROHM Switching Regulator Solutions

Evaluation Board: Synchronous Boost DC/DC Converter

Introduction
This application note will provide the steps necessary to operate and evaluate ROHM’s synchronous boost DC/DC converter using the BU33UV7NUX-EVK-101 evaluation board. Component selection, operating procedures, and application data are included.

Description
The BU33UV7NUX converter provides a power supply solution for products powered by two-cell alkaline, NiCd, NiMH, one-cell Li-ion, or Li-polymer batteries. It can operate even if the input voltage drops to 0.6V. The BU33UV7NUX has a built-in reset circuit that can be set to detect reset at 1.5V (reset release voltage: 1.9V). When MODE=H, the maximum output current is 500 mA with a current consumption of 13μA. Also, when MODE=L, the maximum output current is 100mA with a current consumption of 7μA. The output voltage is fixed to 3.3V using an internal resistor divider. When the Vin voltage is higher than 3.3V, Vout matches Vin.

Applications
- Single-/Two-Cell Alkaline, NiCd/NiMH or Single-Cell Li Battery-Powered Products
- IC Recorders
- Wireless Mice
- Portable Audio Players, PDAs
- Cellular Phones
- Personal Medical Products
- Remote Control

Features
- Synchronous Boost DC/DC Converter
- Input Voltage Range: 0.6 ~ 4.5V
- Fixed Output Voltage: 3.3V
- Efficiency: 94%(max.)
- Current Consumption: 7μA(MODE=L), 13μA(MODE=H)
- Startup Voltage: 0.9V
- Iomax 500mA @Vout=3.3V, Vin=1.8V (Ta=25°C)
- Disconnect Function during EN-OFF and UVLO
- Auto-PFM/PWM [MODE=H]
- FIXED PFM [MODE=L]
- Reset Function (Detect Voltage = 1.5V)
- Pass-Through Function (Vin > Vout)
- 10-pin “VSON010X3020” package

Evaluation Board Operating Limits and Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>VCC</td>
<td>MIN</td>
<td>0.6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BU33UV7NUX</td>
<td>TYP</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAX</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Minimum Start-up Voltage</td>
<td>Vmin</td>
<td>MIN</td>
<td>0.875</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BU33UV7NUX</td>
<td>TYP</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MINAFT</td>
<td>0.925</td>
<td></td>
</tr>
<tr>
<td>Minimum Input Voltage After Start-up</td>
<td>VinAFT</td>
<td>—</td>
<td>0.26</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage / Current</td>
<td>Vout</td>
<td>—</td>
<td>3.3</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>BU33UV7NUX</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ionut</td>
<td>—</td>
<td>—</td>
<td>A</td>
</tr>
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</table>

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Evaluation Board

![BU33UV7NUX Evaluation Board](image1)

Fig1: BU33UV7NUX Evaluation Board

Evaluation Board Schematic

![BU33UV7NUX Evaluation Board Schematic](image2)

Fig2: BU33UV7NUX Evaluation Board Schematic
Evaluation Board I/O

Below is a reference application circuit

![Reference Application Circuit](image)

**Evaluation Board Operating Procedure**

1. Set the operating mode of the IC by the position of SW0. When the switch is moved to the upper position (MODE→GND) the IC will be in PFM Only Mode and the output will be able to supply a maximum 50mA. When the switch is moved to the bottom position (MODE→VCC) the IC will be in Auto PFM/PWM Mode and the output will supply a maximum of 500mA.

2. Disable the IC by setting SW1 to the upper position. When the switch is moved to the bottom position (EN→VCC) the IC is enabled, while moving the switch to the upper position (EN→GND) disables the IC.

3. Connect the power supply’s GND terminal to the AGND test point on the evaluation board.

4. Connect the power supply’s Vcc terminal to the Vin test point on the evaluation board. This will provide Vin to the IC. Please note that Vcc should be in range of 0.9V to 4.5V. Operation continues even if Vcc drops to 0.6V.

5. Connect the electronic load or voltmeter to PGND and Vout. Do not connect when the load turned on.

6. Turn on the power supply and enable the IC by setting the position of SW1 to the lower position. The output voltage Vout (+3.3V) can be measured at the test point VOUT. Now turn on the load. The load can be increased up to 0.05A/0.5A (max.) depending on the MODE setting used.

**Reset Circuit**

Use the RSTB and EN pins to operate the reset circuit. Reset is initiated and operation stopped when the input voltage drops to 1.5V. Operation resumes when the input voltage reaches 1.9V.

Set the RSTB pin to open when not using the reset circuit.
Typical Performance Data

The following are graphs of the efficiency, load response, line regulation, quiescent current, output voltage ripple response and more. Unless otherwise indicated, $V_{IN}=2.4\,\text{V}$, $V_{OUT}=3.3\,\text{V}$, $L_0=4.7\,\mu\text{H}$, $C_1=22\mu\text{F} \times 2$ and $T_a=25\,^\circ\text{C}$.

![Efficiency vs Output Current](image1)

![Efficiency vs Output Current](image2)

![Output Voltage vs Output Current](image3)

![Output Voltage vs Output Current](image4)
Typical Performance Data - continued

![Graph: Output Voltage vs Input Voltage](image1)

Fig 8: Output Voltage vs Input Voltage
("Line Regulation", MODE=H: Auto-PFM/PWM, 3.3KΩ resistive load)

![Graph: Maximum Output Current vs Input Voltage](image2)

Fig 9: Maximum Output Current vs Input Voltage
("Maximum I_{OUT} vs V_{IN}", EN=H)

![Graph: Circuit Current vs Input Voltage](image3)

Fig 10: Circuit Current vs Input Voltage
("I_{CC1}", EN=MODE=L, No load)

![Graph: Circuit Current vs Input Voltage](image4)

Fig 11: Circuit Current vs Input Voltage
("I_{CC2}", MODE=L:Fixed PFM, No load)
Typical Performance Data - continued

Fig 12: Circuit Current vs Input Voltage
("Iccs", MODE=H:Auto-PFM/PWM, No load)

Fig 13: Frequency vs Input Voltage
("Frequency", MODE=H:Auto-PFM/PWM)

Fig 14: PMOS ON Resistance vs Input Voltage
("PMOS ON Resistance", MODE=H:Auto-PFM/PWM)

Fig 15: Ripple Voltage vs Output Current
("Ripple", Vin=2.4V)
Typical Performance Data - continued

Fig 16: Transient Response
(V_{IN}=2.4V, MODE=L:Fixed PFM, Output current 1mA ↦ 100mA)

Fig 17: Transient Response
(V_{IN}=2.4V, MODE=L:Fixed PFM, Output current 1mA ↦ 100mA)

Fig 18: Transient Response
(V_{IN}=2.4V, MODE=H:Auto-PFM/PWM, Output current 1mA ↦ 100mA)

Fig 19: Transient Response
(V_{IN}=2.4V, MODE=H:Auto-PFM/PWM, Output current 1mA ↦ 100mA)
Typical Performance Data - continued

Fig 20: Start-up Waveform  
(VIN=0.9V, 3.3KΩ resistive load, MODE=L:Fixed PFM)

Fig 22: Start-up Waveform  
(VIN=0.9V, 3.3KΩ resistive load, MODE=H:Auto-PFM/PWM)

Fig 21. Start-up Waveform  
(VIN=2.4V, 3.3KΩ resistive load, MODE=L:Fixed PFM)

Figure 23. Start-up Waveform  
(VIN=2.4V, 3.3KΩ resistive load, MODE=H:Auto-PFM/PWM)
Figure 24: Shutdown Waveform (Vin=2.4V, Output current=0mA, MODE=L:Fixed PFM)

Figure 25: Shutdown Waveform (Vin=2.4V, Output current=0mA, MODE=H:Auto-PFM/PWM)

Figure 30: Output Voltage Ripple Response Characteristics
Yellow=Vout, Blue=SW Node
(Vin=1.8V, Vout=3.3V, Iout=0, MODE=L)

Figure 31: Output Voltage Ripple Response Characteristics
Yellow=Vout, Blue=SW Node
(Vin=1.8V, Vout=3.3V, Iout=100mA, MODE=L)
Typical Performance Data - continued

Fig 36: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=0, MODE=H)

Fig 37: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=500mA, MODE=H)
Application Notes

Inductor Selection

An inductor value of 4.7µH exhibits good performance over the entire input and output voltage ranges.

The maximum inductor current ($I_{PEAK}$) can be calculated using the following equations.

\[
I_{PEAK} = I_{OUT} \times \left( \frac{V_{OUT}}{V_{IN} \times \eta} \right) \times \left( \frac{\Delta I}{2} \right)
\]

\[
\Delta I = \left( \frac{V_{IN}}{L} \right) \times \left( \frac{V_{OUT}-V_{IN}}{V_{OUT}} \right) \times \left( \frac{1}{f} \right)
\]

( $\eta$: Efficiency, $\Delta I$: Output Ripple Voltage, $f$: Switching Frequency)

The inductor should be selected so as to satisfy the above $I_{PEAK}$ value.

Evaluation Board BOM

Below is a table showing the Bill of Materials. Part numbers and suppliers are included.

<table>
<thead>
<tr>
<th>No.</th>
<th>Qty.</th>
<th>Reference</th>
<th>Description</th>
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<td>U1</td>
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<td>L0</td>
<td>4.7µH, 2.43A, 5mm<em>4mm</em>1.5mm</td>
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<td>Open</td>
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<td>NKK</td>
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<td>TP</td>
<td>N/A</td>
<td>TP</td>
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