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 V_{IN} voltage is higher than 3.3V, V_{OUT} matches V_{IN}.

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 @V_{OUT}=3.3V, V_{IN}=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 (V_{IN} > V_{OUT})
- 10-pin "VSON010X3020" package

Evaluation Board Operating Limits and Absolute Maximum Ratings

Parameter	Symbol	Limit			Unit	Conditions
		MIN	TYP	MAX		
Supply Voltage						
BU33UV7NUX	V_{CC}	0.6	–	4.5	V	
Minimum Start-up Voltage						
BU33UV7NUX	V_{MIN}	0.875	0.9	0.925	V	
Minimum Input Voltage After Start-up						
BU33UV7NUX	V_{MINAFT}	–	0.26	0.6	V	
Output Voltage / Current						
BU33UV7NUX	V_{OUT}	–	3.3	–	V	
	I_{OUT}	–	–	0.05/0.5	A	MODE=L, MODE=H

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Evaluation Board

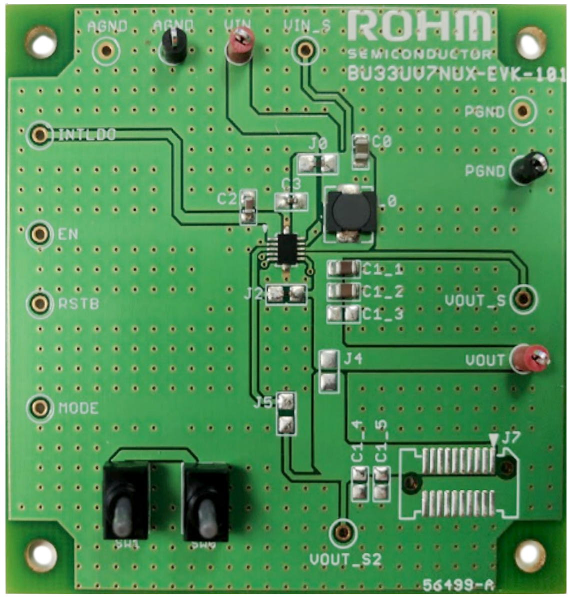

Fig1: BU33UV7NUX Evaluation Board

Evaluation Board Schematic

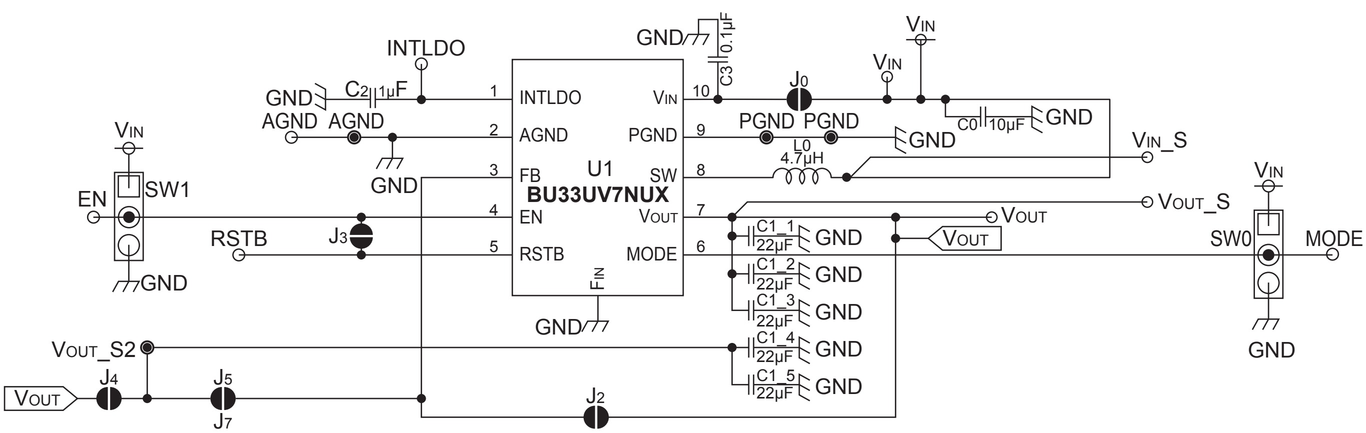

Fig2: BU33UV7NUX Evaluation Board Schematic

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Evaluation Board I/O

Below is a reference applicaiton circuit

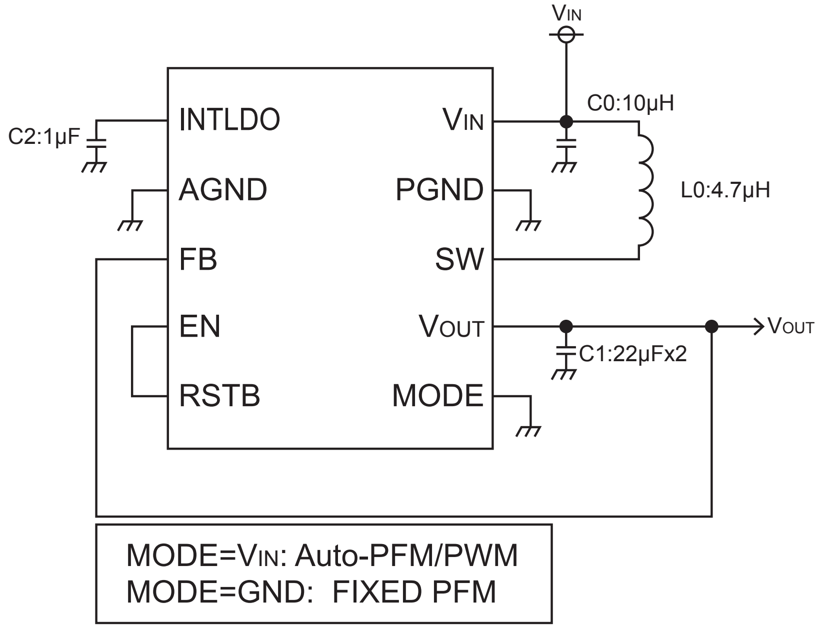

Fig3: BU33UV7NUX Reference Application Circuit

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→V_{CC}) 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 V_{CC} terminal to the V_{IN} test point on the evaluation board. This will provide V_{IN} to the IC. Please note that V_{CC} should be in range of 0.9V to 4.5V. Operation continues even if V_{CC} drops to 0.6V.

5. Connect the electronic load or voltmeter to PGND and V_{OUT}. 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 V_{OUT} (+3.3V) can be measured at the test point V_{OUT}. 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.

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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}=2.4V, V_{OUT}=3.3V, L0=4.7μH, C1=22μF×2 and Ta=25°C.

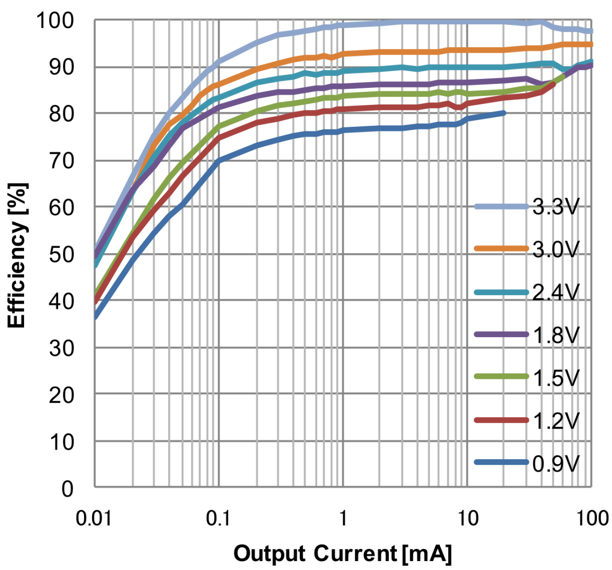

Fig 4: Efficiency vs Output Current
(“Efficiency”, MODE=L:Fixed PFM)

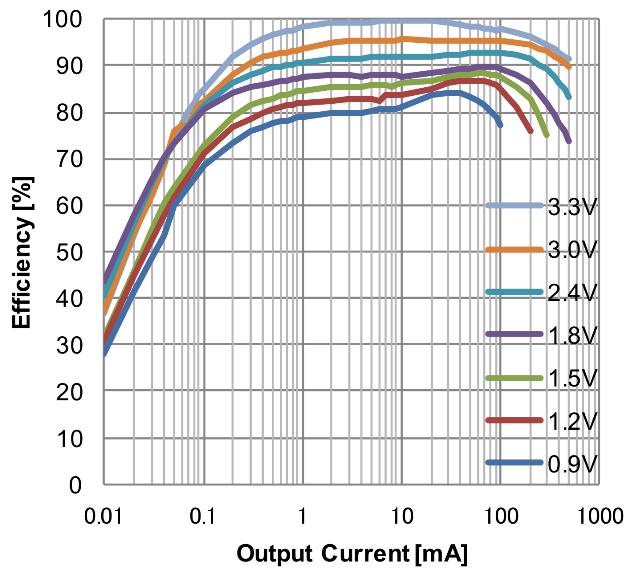

Fig 5: Efficiency vs Output Current
(“Efficiency”, MODE=H:Auto-PFM/PWM)

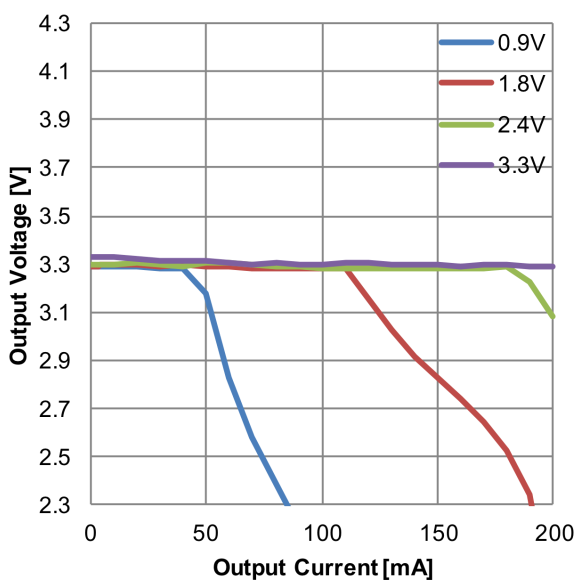

Fig 6: Output Voltage vs Output Current
(“Load Regulation”, MODE=L:Fixed PFM)

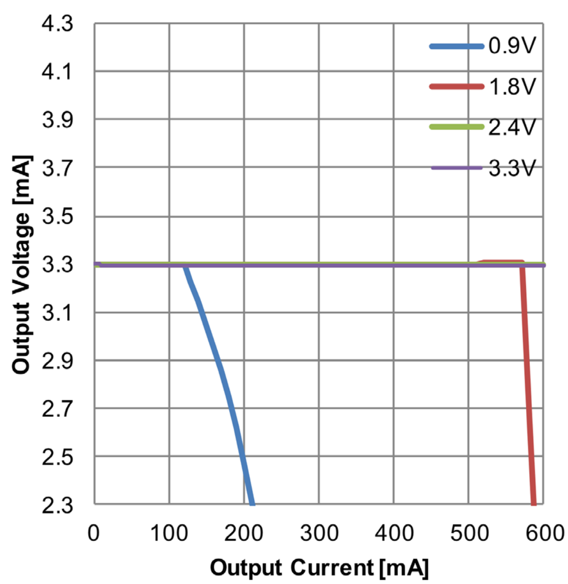

Fig 7: Output Voltage vs Output Current
(“Load Regulation”, MODE=H:Auto-PFM/PWM)

Typical Performance Data - continued

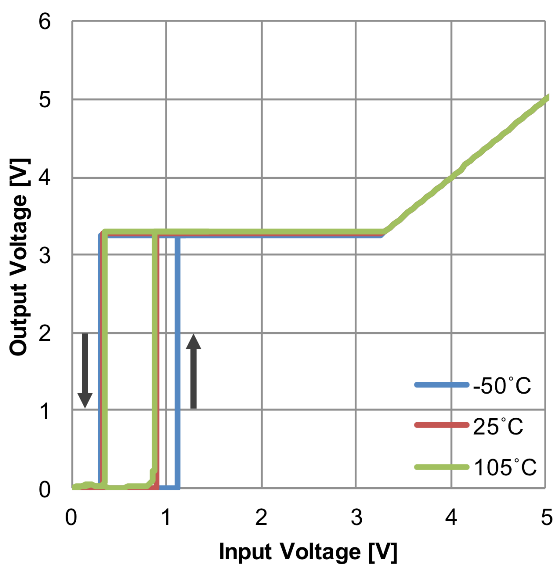

Fig 8: Output Voltage vs Input Voltage
("Line Regulation", MODE=H: Auto-PFM/PWM,
3.3KΩ resistive load)

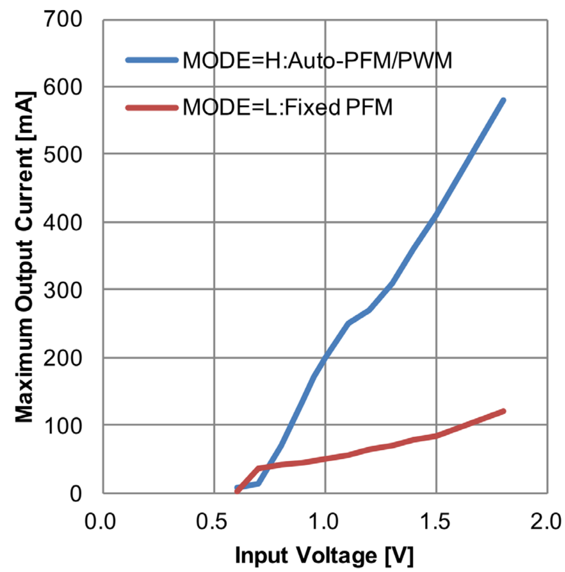

Fig 9: Maximum Output Current vs Input Voltage
("Maximum I_{OUT} vs V_{IN}", EN=H)

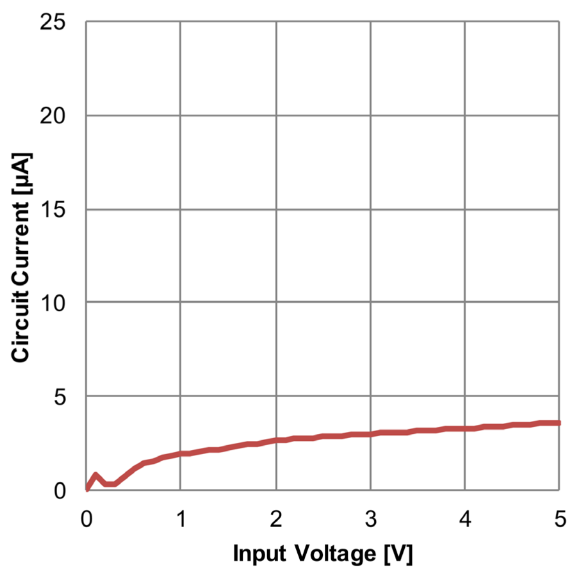

Fig 10: Circuit Current vs Input Voltage
("I_{CC1}", EN=MODE=L, No load)

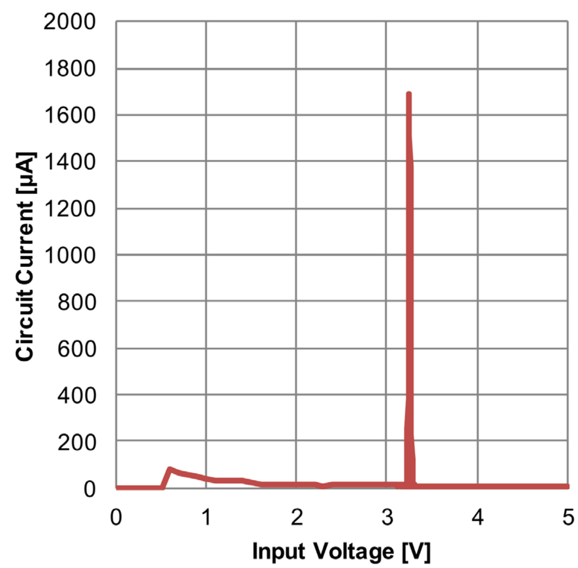

Fig 11: Circuit Current vs Input Voltage
("I_{CC2}", MODE=L:Fixed PFM, No load)

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Typical Performance Data - continued

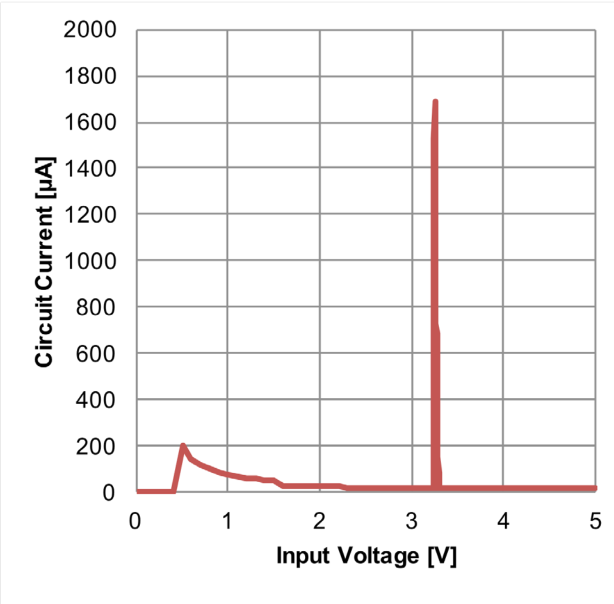

Fig 12: Circuit Current vs Input Voltage
("ICC3", MODE=H:Auto-PFM/PWM, No load)

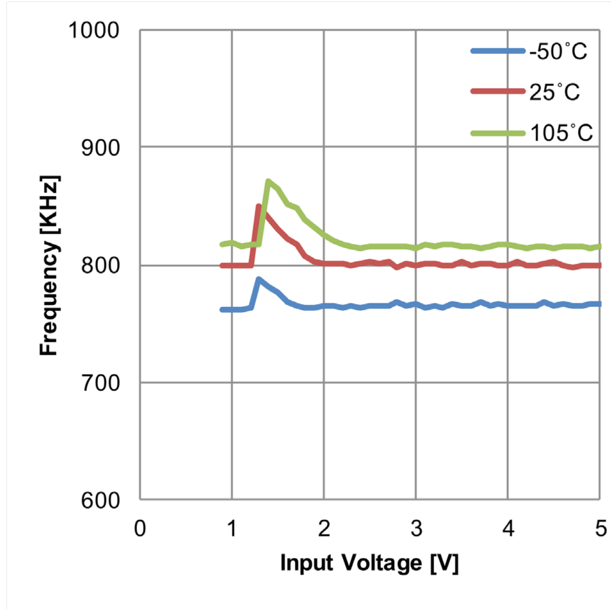

Fig 13: Frequency vs Input Voltage
("Frequency", MODE=H:Auto-PFM/PWM)

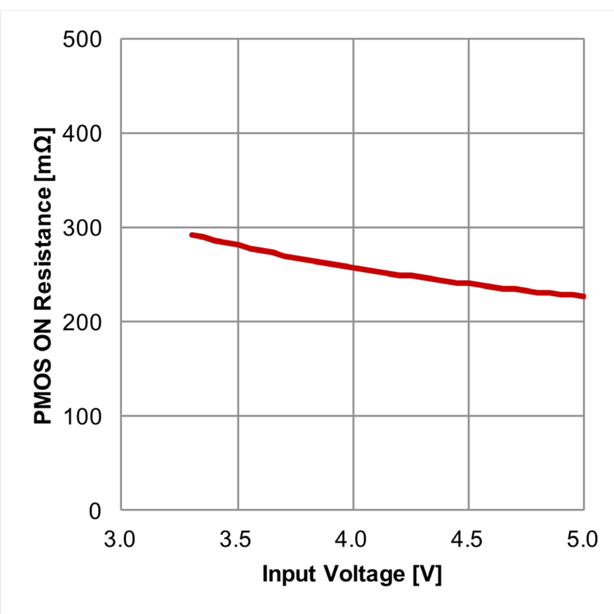

Fig 14: PMOS ON Resistance vs Input Voltage
("PMOS ON Resistance", MODE=H:Auto-PFM/PWM)

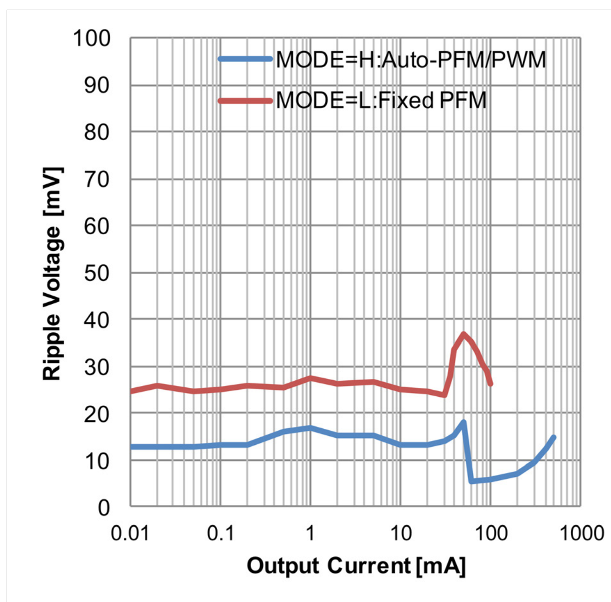

Fig 15: Ripple Voltage vs Output Current
("Ripple", V_{IN}=2.4V)

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Typical Performance Data - continued

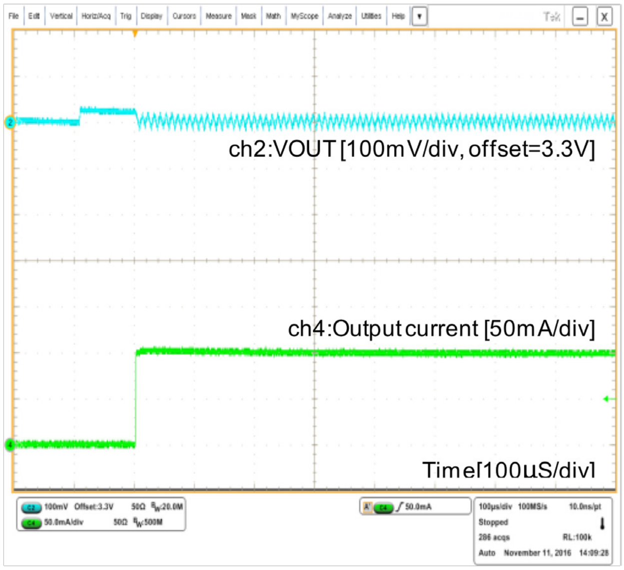

Fig 16: Transient Resonse
(VIN=2.4V, MODE=L:Fixed PFM, Output current 1mA↔100mA)

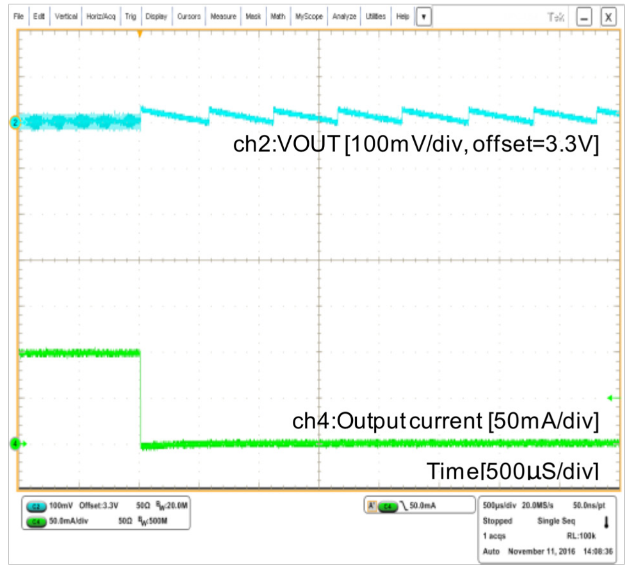

Fig 17: Transient Resonse
(VIN=2.4V, MODE=L:Fixed PFM, Output current 1mA↔100mA)

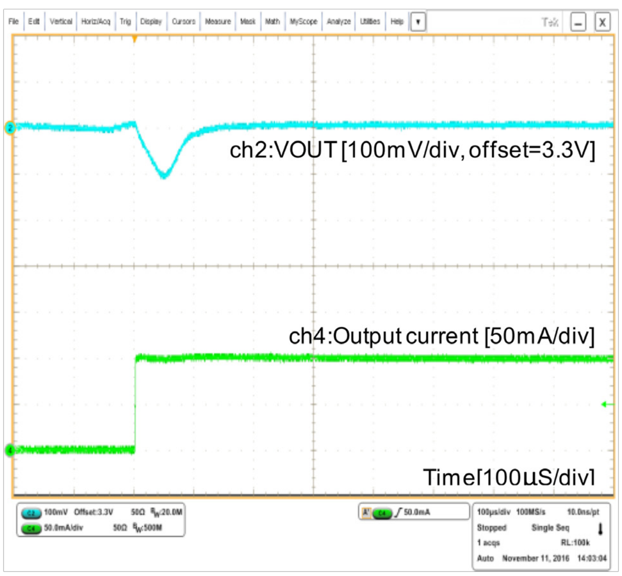

Fig 18: Transient Resonse
(VIN=2.4V, MODE=H:Auto-PFM/PWM, Output current 1mA↔100mA)

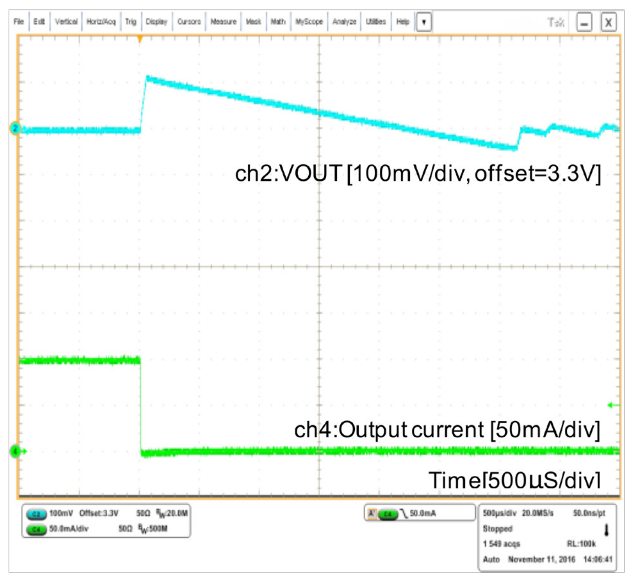

Fig 19: Transient Resonse
(VIN=2.4V, MODE=H:Auto-PFM/PWM, Output current 1mA↔100mA)

Typical Performance Data - continued

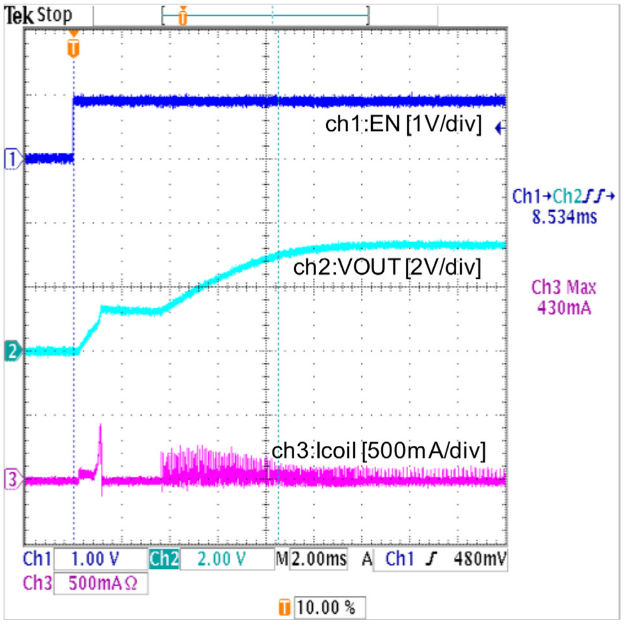

Fig 20: Start-up Waveform
(V_{IN}=0.9V, 3.3KΩ resistive load, MODE=L:Fixed PFM)

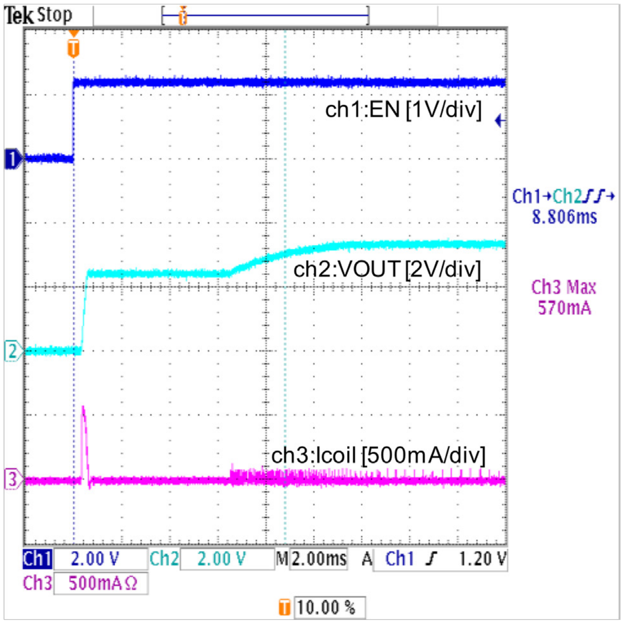

Figure 21. Start-up Waveform
(V_{IN}=2.4V, 3.3KΩ resistive load, MODE=L:Fixed PFM)

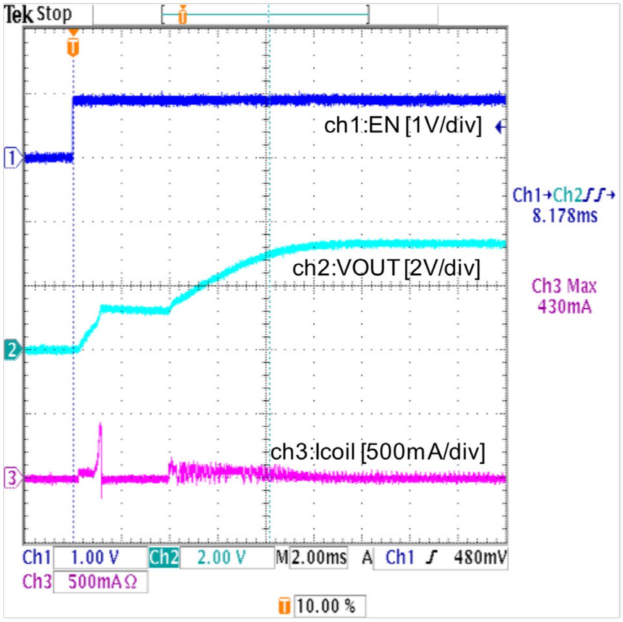

Fig 22: Start-up Waveform
(V_{IN}=0.9V, 3.3KΩ resistive load,
MODE=H:Auto-PFM/PWM)

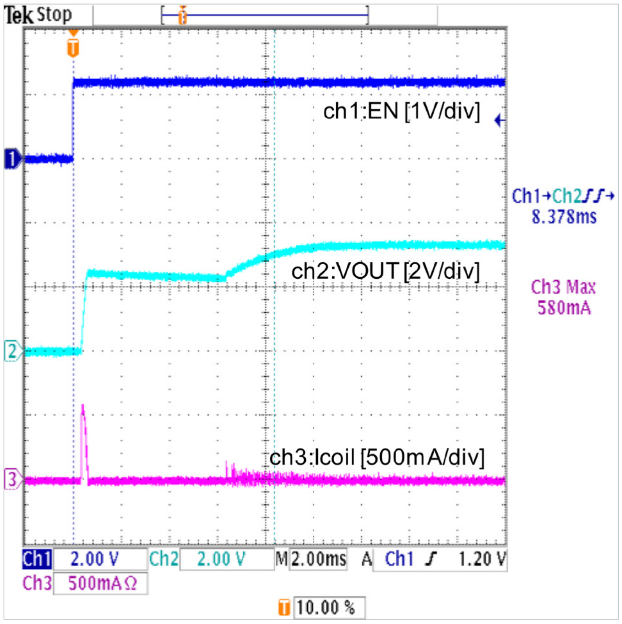

Figure 23. Start-up Waveform
(V_{IN}=2.4V, 3.3KΩ resistive load,
MODE=H:Auto-PFM/PWM)

Typical Performance Data - continued

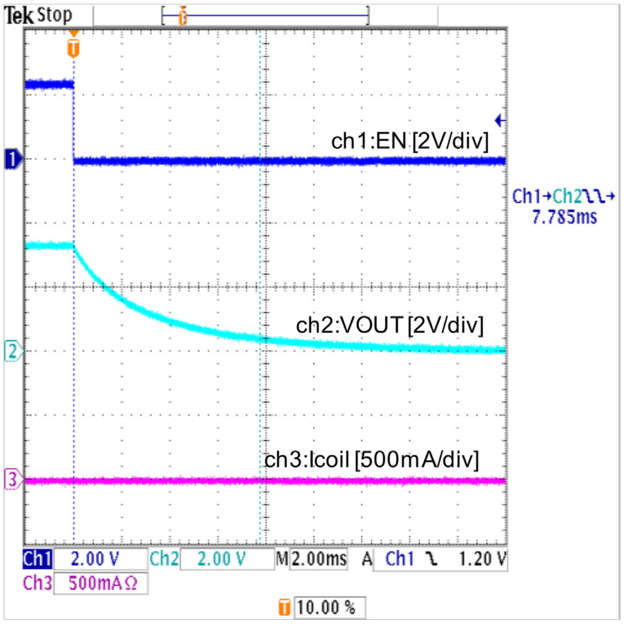

Fig 24: Shutdown Waveform
(V_{IN}=2.4V, Output current=0mA, MODE=L:Fixed PFM)

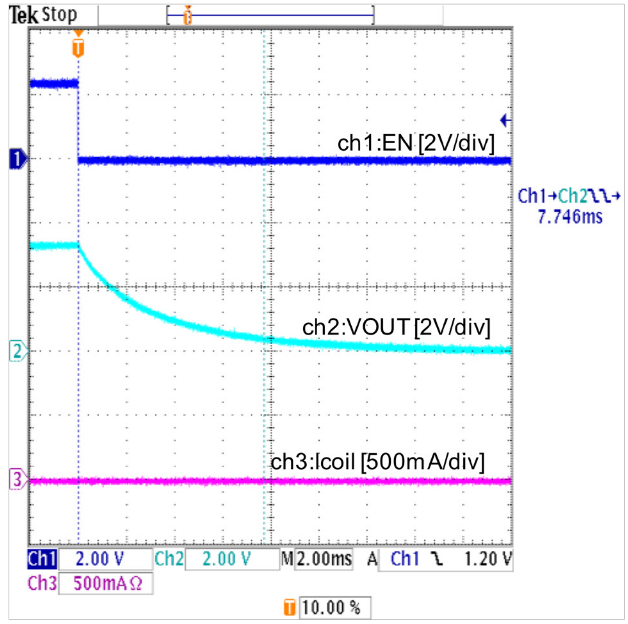

Figure 25. Shutdown Waveform
(V_{IN}=2.4V, Output current=0mA,
MODE=H:Auto-PFM/PWM)

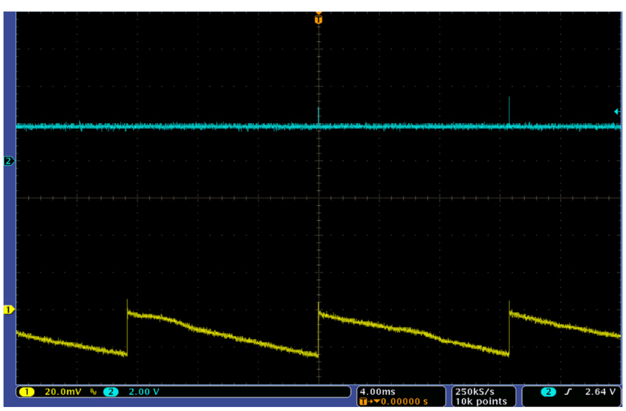

Fig 30: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=0, MODE=L)

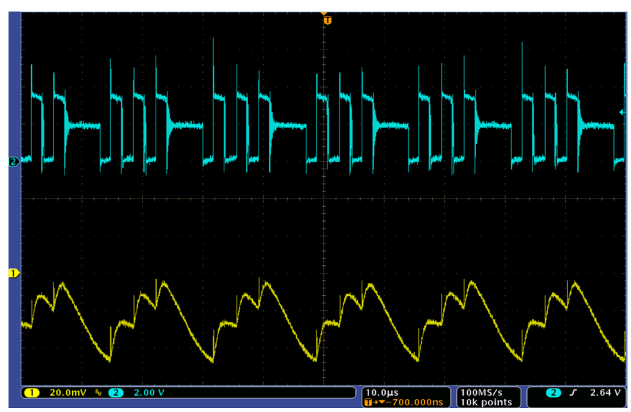

Fig 31: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=100mA, MODE=L)

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Typical Performance Data - continued

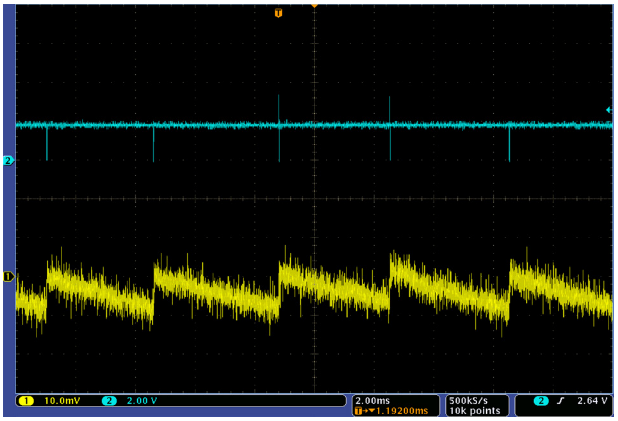

Fig 36: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=0, MODE=H)

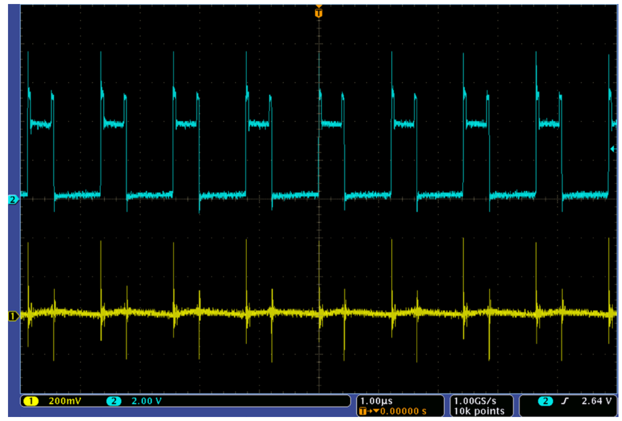

Fig 37: Output Voltage Ripple Response Characteristics
Yellow=V_{OUT}, Blue=SW Node
(V_{IN}=1.8V, V_{OUT}=3.3V, I_{OUT}=500mA, MODE=H)

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Application Notes

Inductor Selection

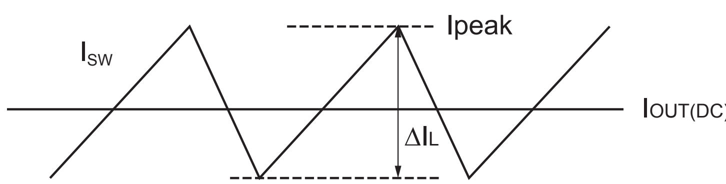
An inductor value of 4.7μH exhibits good performance over the entire input and output voltage ranges.

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

$$I_{PEAK} = I_{OUT} \times \left(V_{OUT} \frac{V_{OUT}}{V_{IN} \times \eta} \right) \times \left(\frac{\Delta I_L}{2} \right)$$

$$\Delta I_L = \left(\frac{V_{IN}}{L} \right) \times \left(\frac{V_{OUT} - V_{IN}}{V_{OUT}} \right) \times \left(\frac{1}{f} \right)$$

(η: Efficiency, ΔIL: 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.

No.	Qty.	Reference	Description	Manufacturer	Part No.
1	1	U1	Boost Converter	ROHM	BU33UV7NUX
2	1	C2	1μF, 16V, X5R, 0603	TDK	C1608X5R1C105K
3	1	C3	0.1μF, 16V, X5R, 0402	TAIYO YUDEN	EMK105BJ104KV-F
4	1	C0	10μF, 16V, X5R, 0805	TAIYO YUDEN	EMK212ABJ106KD-T
5	2	C1_1, C1_2	22μF, 25V, X5R, 0805	Murata	GRM21BR61E226ME44L
6	3	C1_3, C1_4, C1_5	N/A	N/A	Open
7	1	L0	4.7μH, 2.43A, 5mm*4mm*1.5mm	TDK	VLF504015MT-4R7M
8	2	J0, J2	N/A	N/A	Short
9	3	J3, J4, J5	N/A	N/A	Open
10	1	J7	N/A	N/A	Open
11	2	SW0, SW1	Switch	NKK	G13AP
12	13	INTLDO, AGND, EN, RSTB, MODE, V_{OUT}, V_{OUT}_S, V_{OUT}_S2, PGND, V_{IN}, V_{IN}_S	TP	N/A	TP

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