

# Single-chip Type with Built-in FET Switching Regulator Series

## Step-down Switching regulators with Built-in Power MOSFET

### BU9002xNUX Series

#### ● General Description

The BU9002xNUX are a high efficiency 1MHz synchronous step-down switching regulator with low current PFM mode. It provides up to 1.5A load current and an input voltage range from 4.5V to 5.5V, optimized for various applications with input voltage range up to 5V. BU9002xNUX has a mode control pin that allows the user to select Forced PWM (Pulse Width Modulation) mode or PFM (Pulse Frequency Modulation) and PWM auto change mode utilized power save operation at light load current.

#### ● Features

- Fast transient response
- Automatic PFM/PWM operation.
- Forced PWM operation
- Internal Soft Start
- Under voltage lockout
- Over current protection
- Thermal shutdown

#### ● Lineup

Part No.	Output voltage
BU90023NUX	1.230V
BU90028NUX	1.175V

#### ● Applications

- POL, 1Cell Li-ion battery for portable applications , USB accessories

#### ● Package(s)

VSON008X2030

W(Typ.) x D(Typ.) x H(Max.)  
2.00mm x 3.00mm x 0.60mm



VSON008X2030

#### ● Typical Application Circuit(s)

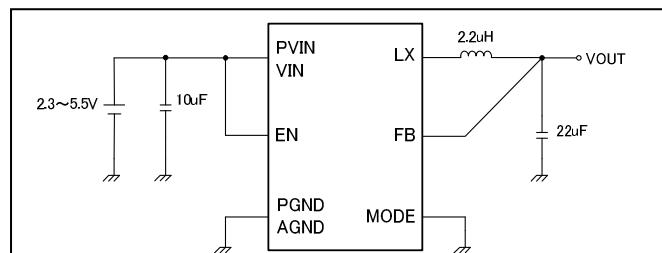


Figure 1. Typical Application Circuit(s)

#### ● Pin Description(s)

#### ● Pin Configuration(s)

(TOP VIEW)

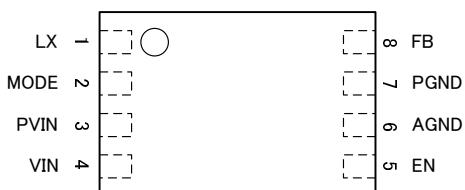


Figure 2. Pin Configuration(s)

Pin No.	Symbol	Function
1	LX	Inductor connection pin
2	MODE	Forced PWM mode pin
3	PVIN	Power supply input pin
4	VIN	Power supply input pin
5	EN	Enable pin
6	AGND	GND pin
7	PGND	GND pin
8	FB	Feedback voltage input pin

## ● Block Diagram(s)

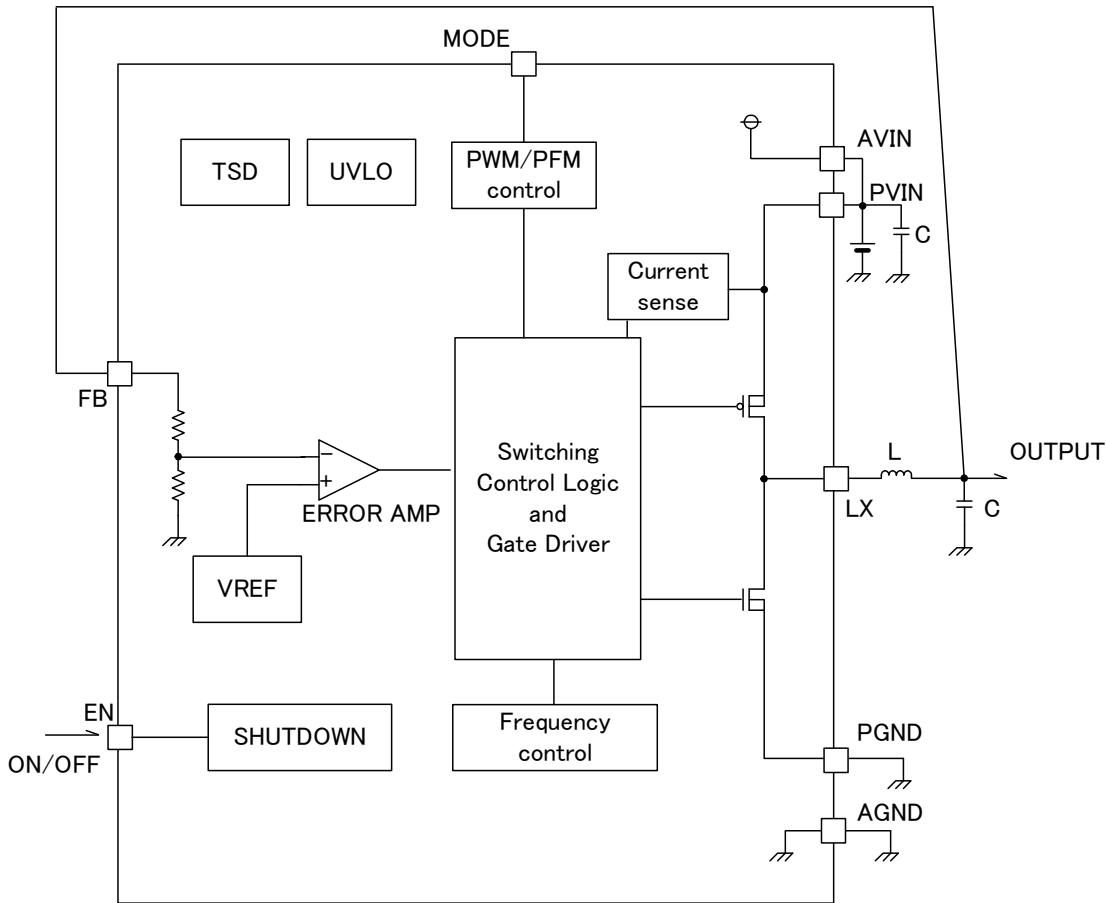


Figure 3. Block Diagram(s)

## ● Description of Block(s)

The BU9002xNUX are a synchronous step-down DC/DC converter that achieves fast transient response from light load to heavy load by hysteretic PWM control system and current constant PFM control system.

## OPWM control

BU9002xNUX operates by hysteretic PWM control. This scheme ensures fast switching, high efficiency, and fast transient response.

When the output voltage is below the VREF voltage, the error comparator output is low to high and turning on P-channel MOSFET until above the VREF voltage and minimum on time.

## OPFM control

At light load the regulator and MODE=low, the regulator operates with reduced switching frequency and improves the efficiency. During PFM operation, the output voltage slightly higher than typical output voltage.

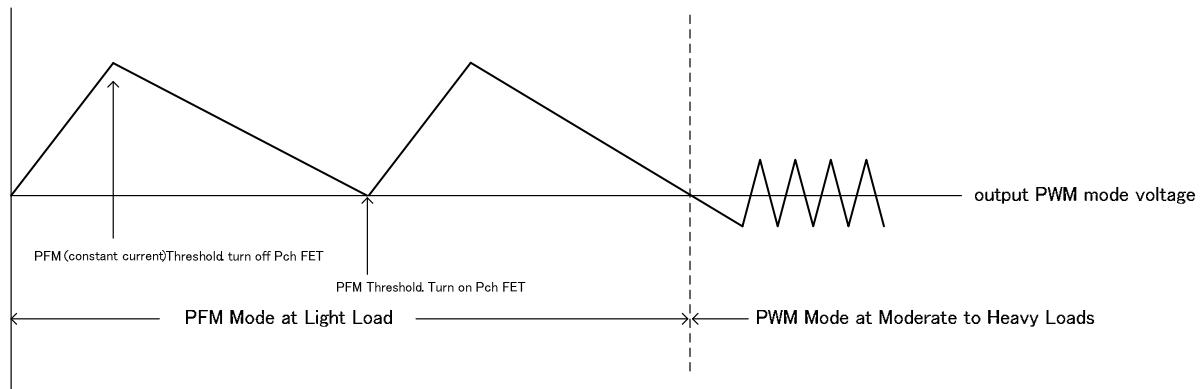


Figure 4. Operation of PFM mode and PWM mode

### ●Description of operations

#### 1) Shutdown

If the EN input pin set to low (<0.4V), all circuit are shut down and the regulator is standby mode.  
Do not leave the EN pin floating.

#### 2) Soft start function

The regulator has a soft start circuit that reduces in-rush current at start-up.  
Typical start up times with a 2.2uF output capacitor is 240usec.

#### 3) Current limit

The BU9002xNUX has a current limit circuit that protects itself and external components during overload condition.

#### 4) UVLO

The BU9002xNUX has a Under Voltage Lock Out circuit that turn off device when  $V_{IN}>2.05V$ (typ.)

#### 5) FORCED PWM MODE

Setting MODE pin high (>1.4V) places the regulator in forced PWM. This control provides noise reduction and output stability.  
Do not leave the MODE pin floating.

#### 6) TSD

The BU9002xNUX has a thermal shutdown feature to protect the device if the junction temperature exceeds 150°C. In thermal shutdown, the DRIVER is disabled.

This circuit is only to cut off the IC from thermal runaway, and has not been design to protect or guarantee the IC. Therefore, the user should not plan to activate this circuit with continued operation in mind.

### ●Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
Maximum input power supply voltage	$V_{IN}$	7	V
Maximum voltage at EN, FB, LX, MODE	$V_{EN}, V_{FB}, V_{LX}, V_{MODE}$	7	V
Power dissipation	$P_d$	0.515	W
Operating temperature range	$T_{opr}$	-40 to +85	°C
Storage temperature range	$T_{stg}$	-55 to +125	°C
Junction temperature	$T_{jmax}$	+125	°C

(\*1) When mounted on the specified PCB (55mm x 63mm), Deducted by 3.9m W/c when used over  $T_a=25^{\circ}C$

### ●Recommended Operating Rating(s)

Parameter	Symbol	Rating			Unit	Series
		Min.	Typ.	Max.		
Input voltage	$V_{IN}$	2.3	-	5.5	V	

## ●Electrical Characteristic(s) (unless otherwise specified VIN=5.0V, Ta=25°C)

Item	Symbol	Rating			Unit	Condition
		Min.	Typ.	Max.		
【Switching regulator】						
Output voltage accuracy	VOUTA	1.206	1.230	1.254	V	BU90023NUX MODE:H(PWM)
		1.152	1.175	1.199		BU90028NUX MODE:H(PWM)
【Soft start】						
Soft start time	Tss	120	240	480	usec	
【Frequency control】						
Switching frequency	fosc	0.8	1.0	2.0	MHz	
【Driver】						
PchFET on resistance	RonP	-	250	400	mOhm	VIN=5.0V
NchFET on resistance	RonN	-	220	350	mOhm	VIN=5.0V
【Control】						
EN pin control voltage	Operation	VENH	1.4	-	VIN	V
	Non Operation	VENL	0	-	0.4	V
MODE pin control voltage	Operation	VMODEH	1.4	-	VIN	Forced PWM
	Non Operation	VMODEL	0	-	0.4	Automatic PFM/PWM
【UVLO】						
Protect threshold voltage	Uvth	1.95	2.05	2.15	V	
Hysteresis	Uvhy	50	100	150	mV	
【Current limit】						
Current limit threshold	ILIMIT	2.2	2.5	2.8	A	PMOS current detect, Open loop
【Output discharge】						
Output discharge resistance	DRES	55	110	220	Ohm	EN=0V
【Circuit current】						
Operating quiescent current	IINS		53	75	uA	EN:H, MODE:L, VOUT=3.6V forced Not switching
Shutdown current	SHD	-	0	1	uA	EN=0V

● Electrical characteristic curves (Reference data)  
**BU90023NUX (1.23V OUTPUT)**

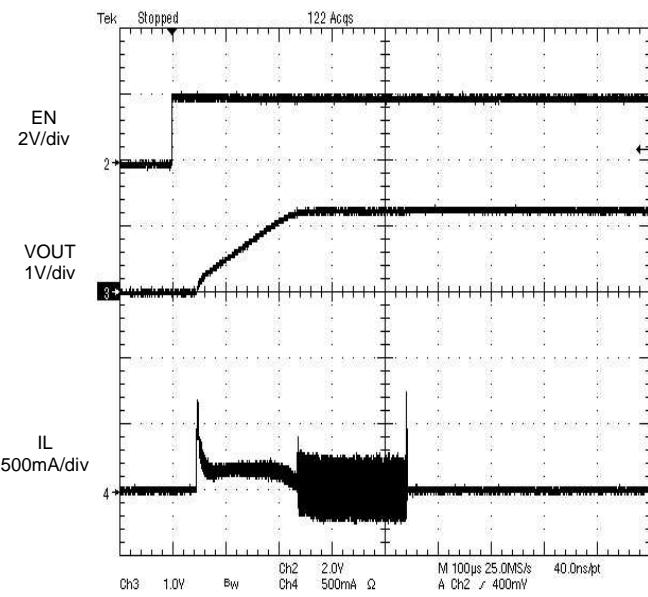


Figure 5. Start up

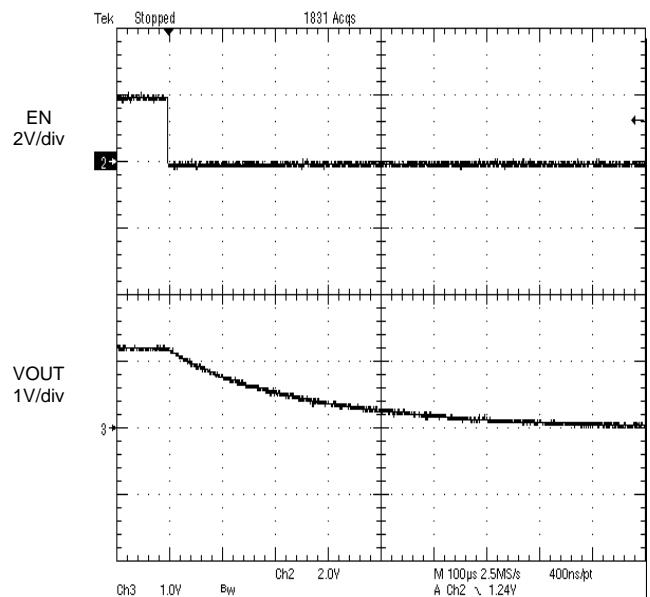
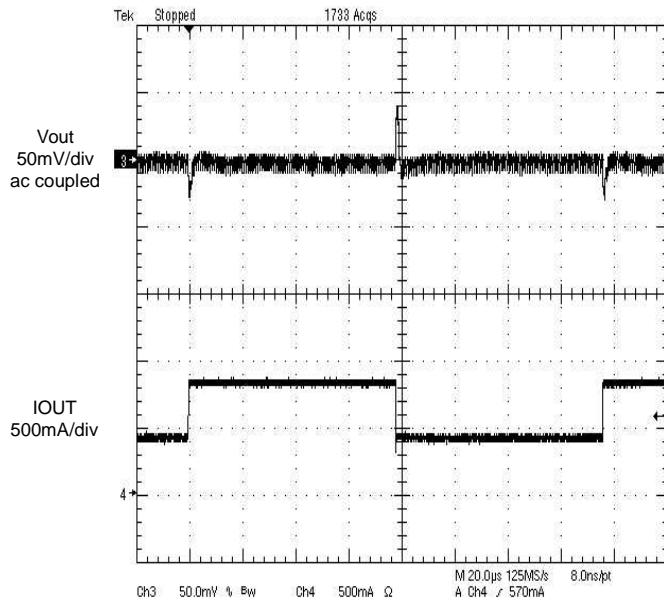
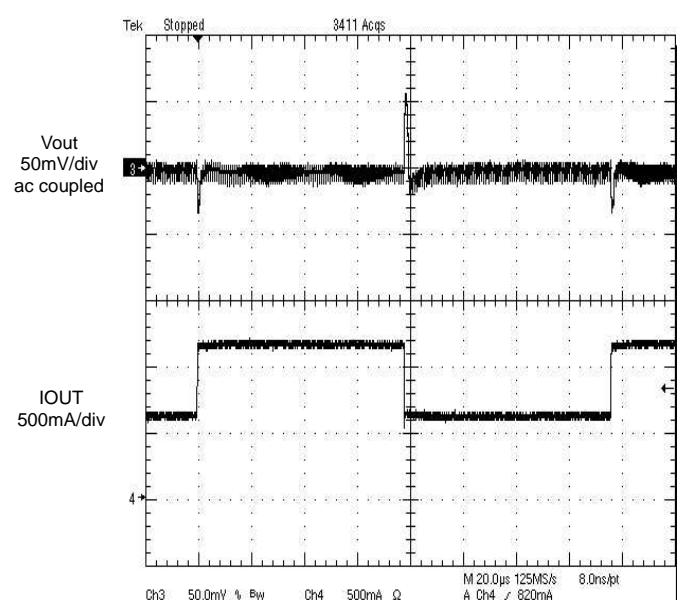


Figure 6. Shut down

Figure 7. Load transient response 400mA to 800mA  
 $tr=tf=100\text{ns}$ , MODE : LowFigure 8. Load transient response 600mA to 1200mA  
 $tr=tf=100\text{ns}$ , MODE : Low

● Electrical characteristic curves (Reference data)  
**BU90023NUX (1.23V OUTPUT) continued**

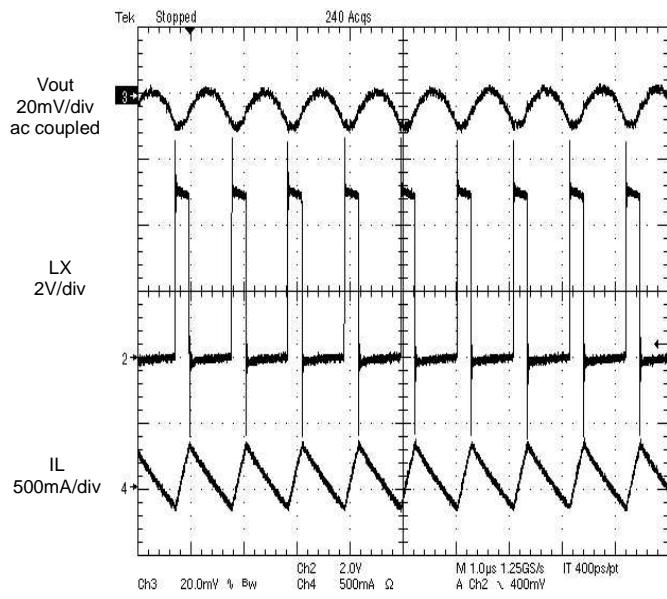


Figure 9. PWM mode  
Operation  $I_{out}=50\text{mA}$

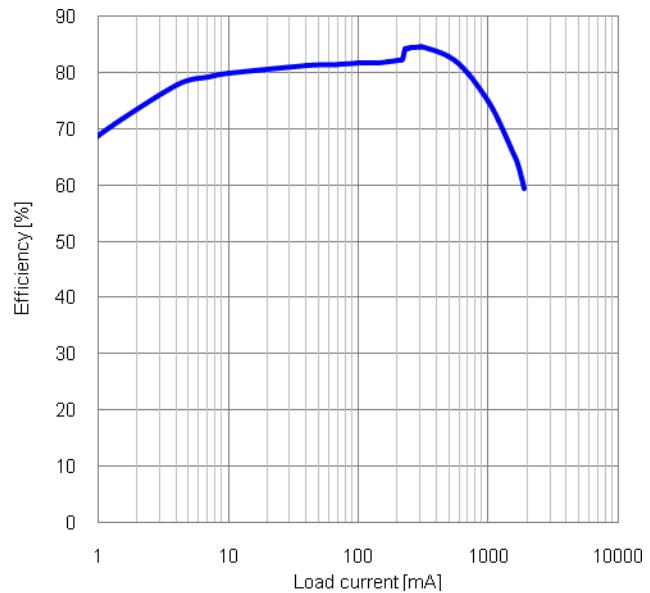


Figure 10. Efficiency vs Load current  
 $V_{IN}=5\text{V}$  PWM/PFM Auto mode

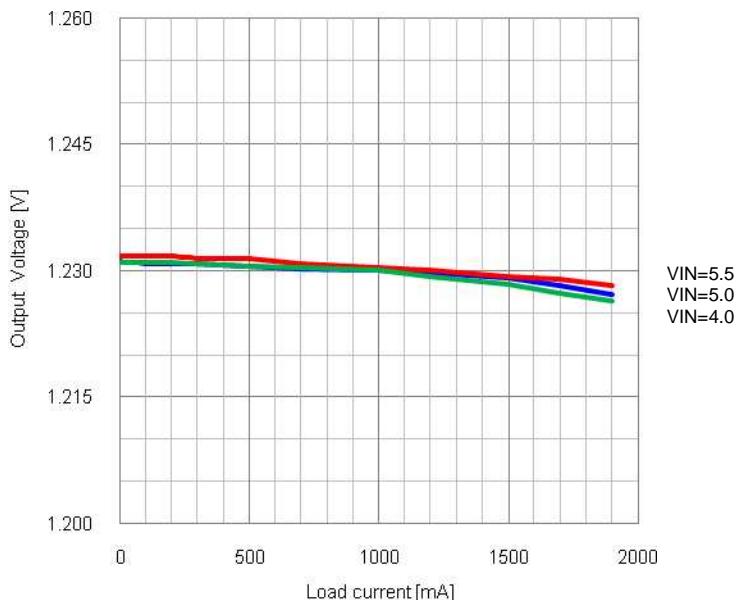


Figure 11. Load regulation  
PWM mode

● Electrical characteristic curves (Reference data)  
**BU90028NUX (1.175V OUTPUT)**

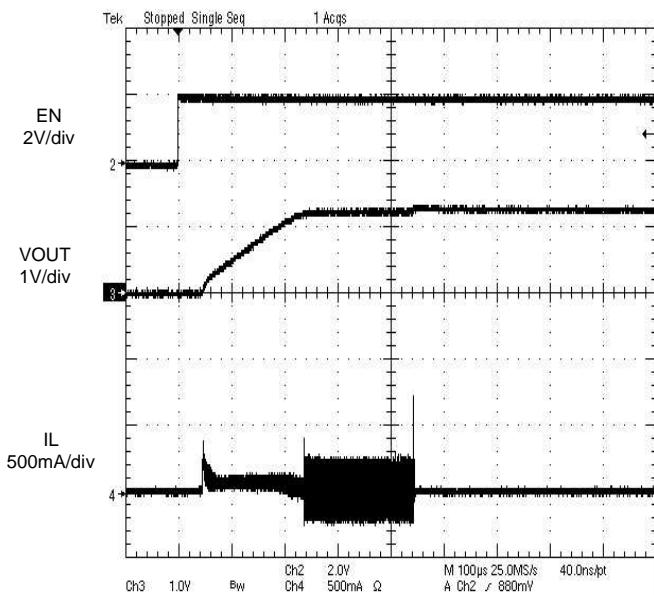


Figure 12. Start up

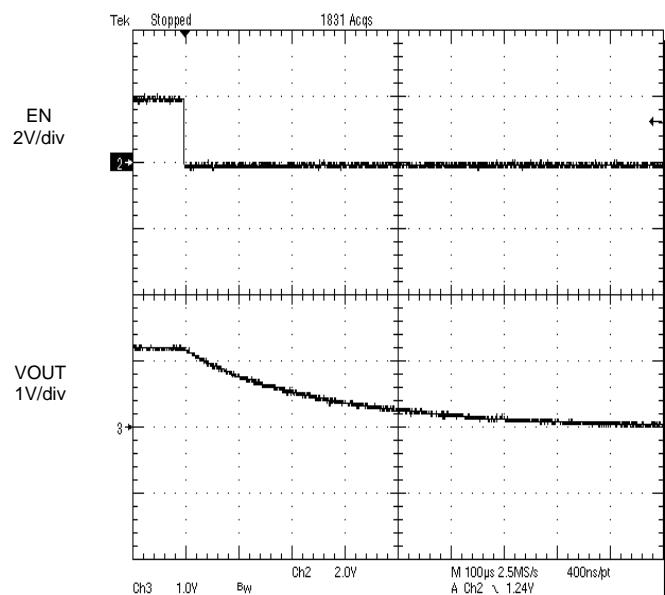
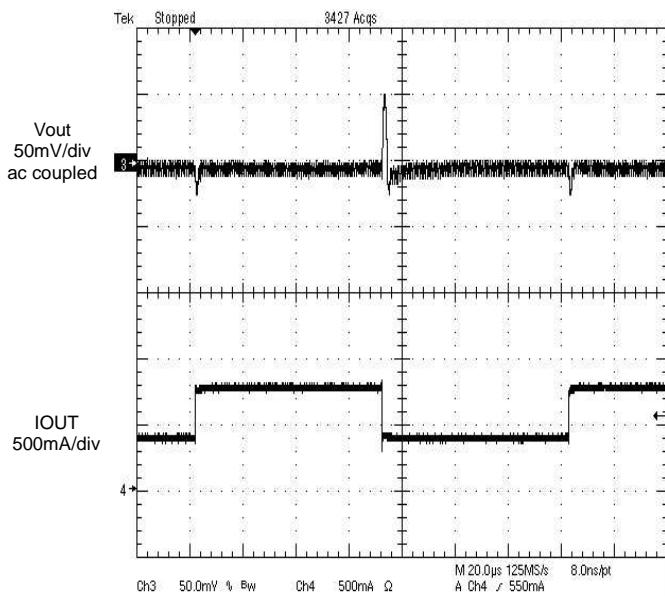
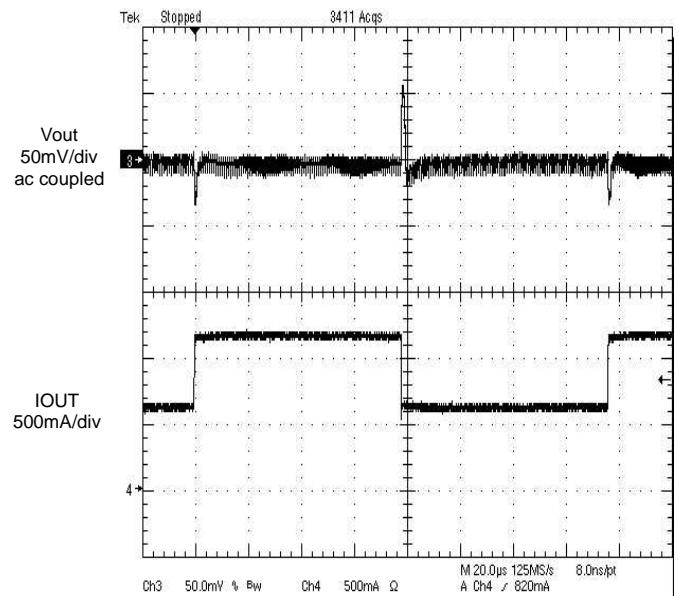


Figure 13. Shut down

Figure 14. Load transient response 400mA to 800mA  
 $tr=tf=100\text{ns}$ , MODE : LowFigure 15. Load transient response 600mA to 1200mA  
 $tr=tf=100\text{ns}$ , MODE : Low

●特性データ(参考データ)  
**BU90028NUX (1.175V 出力) continued**

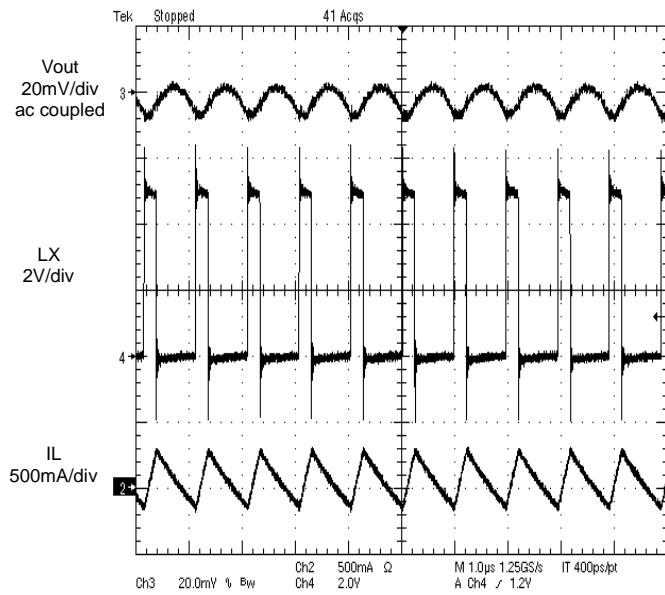


Figure 16. PWM mode  
Operation  $I_{out}=50\text{mA}$

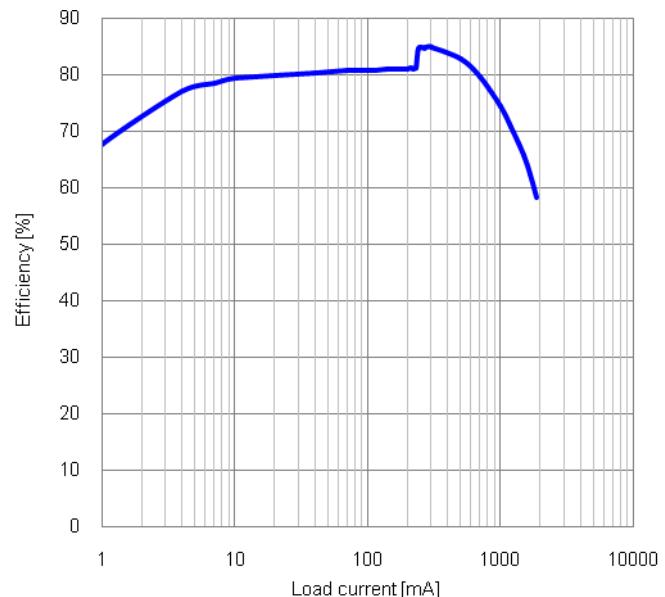


Figure 17. Efficiency vs Load current  
VIN=5V PWM/PFM Auto mode

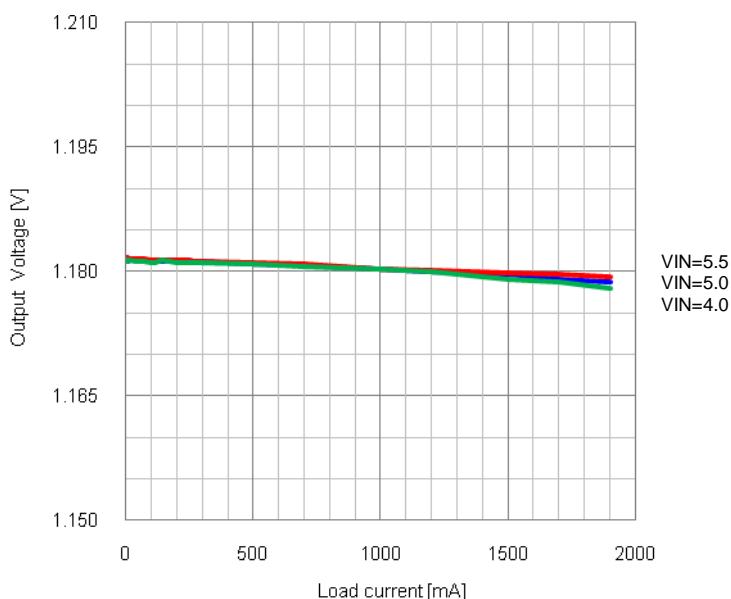


Figure 18. Load regulation  
PWM mode

### ●PC Board layout

The suggested PCB layout for the BU9002xNUX are shown in Figure. The following guidelines should be used to ensure a proper layout.

- 1) The input capacitor CIN should be connect as closely possible to VIN pin and GND pin.
- 2) From the output voltage to the FB pin line should be as separate as possible.
- 3) COUT and L should be connected as closely as possible. The connection of L to the LX pin should be as short as possible.

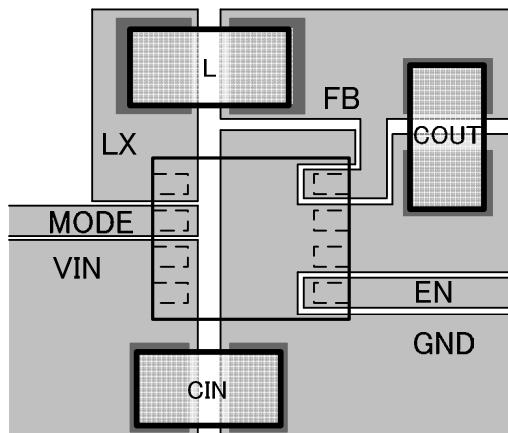


Figure 19. PCB layout

### ●External parts selection

#### Inductor selection

The inductance significantly depends on output ripple current. As shown by following equation, the ripple current decreases as the inductor and/or switching frequency increase.

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

f: switching frequency    L: inductance     $\Delta I_L$ : inductor current ripple

As a minimum requirement, the DC current rating of the inductor should be equal to the maximum load current plus half of the inductor current ripple as shown by the following equation.

$$I_{LPEAK} = I_{OUTMAX} + \frac{\Delta I_L}{2}$$

#### 1) Recommended inductor selection

- $I_{out} \leq 1.5A$

DFE252012C Type 2.2uH (TOKO)

NR4018T2R2M (TAIYO YUDEN)

- $I_{out} \leq 0.6A$

NR3010T2R2M (TAIYO YUDEN)

#### 2) Recommended input capacitor(CIN) selection

C1608 Type 22uF (X5R 6.3V TDK)

#### 3) Recommended output capacitor(COUT) selection

C1608 Type 22uF (X5R 6.3V TDK)

**●Caution of use****1) Absolute maximum ratings**

An excess in the absolute maximum rating, such as supply voltage, temperature range of operating conditions, etc., can break down the devices, thus making impossible to identify breaking mode, such as a short circuit or an open circuit. If any over rated values will expect to exceed the absolute maximum ratings, consider adding circuit protection devices, such as fuses.

**2) GND voltage**

The potential of GND pin must be minimum potential in all condition. As an exception, the circuit design allows voltages up to -0.3 V to be applied to the IC pin.

**3) Thermal design**

Use a thermal design that allows for a sufficient margin in light of the power dissipation ( $P_d$ ) in actual operating conditions.

**4) Inter-pin shorts and mounting errors**

Use caution when positioning the IC for mounting on printed circuit boards. The IC may be damaged if there is any connection error or if pins are shorted together.

**5) Actions in strong electromagnetic field**

Use caution when using the IC in the presence of a strong electromagnetic field as doing so may cause the IC to malfunction.

**6) Mutual impedance**

Power supply and ground wiring should reflect consideration of the need to lower mutual impedance and minimize ripple as much as possible (by making wiring as short and thick as possible or rejecting ripple by incorporating inductance and capacitance).

**7) Thermal shutdown Circuit (TSD Circuit)**

This model IC has a built-in TSD circuit. This circuit is only to cut off the IC from thermal runaway, and has not been design to protect or guarantee the IC. Therefore, the user should not plan to activate this circuit with continued operation in mind.

**8) Regarding input pin of the IC**

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated.

P-N junctions are formed at the intersection of these P layers with the N layers of other elements, creating a parasitic diode or transistor. For example, as shown in the figures below, the relation between each potential is as follows:

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.

When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes can occur inevitable in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Accordingly, methods by which parasitic diodes operate, such as applying a voltage that is lower than the GND (P substrate) voltage to an input pin, should not be used.

**Status of this document**

The Japanese version of this document is formal specification. A customer may use this translation version only for a reference to help reading the formal version.

If there are any differences in translation version of this document formal version takes priority

### ● Ordering Information

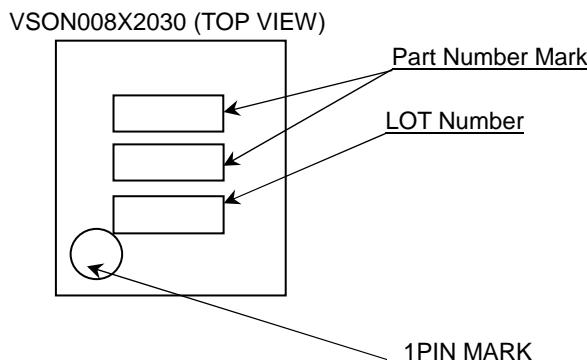
<b>B U 9 0 0 2 x N U X</b>	<b>TR</b>
Part Number	Package NUX: VSON008X2030
	Packaging and forming specification TR: Embossed tape and reel (VSON008X2030)

### ● Physical Dimension Tape and Reel Information

#### VSON008X2030

<p>(Unit : mm)</p>	<p><b>&lt;Tape and Reel information&gt;</b></p> <table border="1"> <tr> <td>Tape</td><td>Embossed carrier tape</td></tr> <tr> <td>Quantity</td><td>4000pcs</td></tr> <tr> <td>Direction of feed</td><td>TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)</td></tr> </table> <p>*Order quantity needs to be multiple of the minimum quantity.</p>	Tape	Embossed carrier tape	Quantity	4000pcs	Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)
Tape	Embossed carrier tape						
Quantity	4000pcs						
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)						

### ● Marking Diagram(s)(TOP VIEW)



Part No.	Part Number Marking
BU90023NUX	U90
	023
BU90028NUX	U90
	028

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CLASS IV		CLASS III	

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  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
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- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
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  - [d] the Products are exposed to high Electrostatic
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3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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