

# Dual Synchronous Buck Converter



## BD93291EFJ

### Description

The BD93291EFJ is a dual synchronous buck converter. It integrates wide input voltage range (8.0V to 26V) synchronous buck converter and low input voltage (Vout1 : 5.0V) synchronous buck converter.

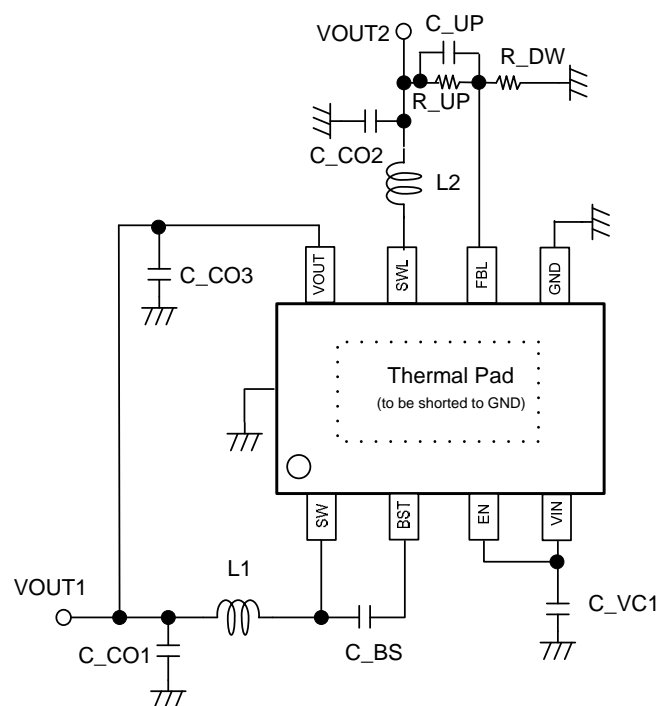
The IC also incorporates a new technology called H<sup>3</sup>Reg™, a Rohm proprietary control method which facilitates ultra-high transient response against changes in load. SLLM (Simple Light Load Mode) technology is also integrated to improve efficiency when powering lighter loads. For protection and ease of use, the IC also incorporates soft start.

Space-saving and high efficient switching regulator can be achieved due to built-in N-MOSFET power transistor in HTSOP-J8 package.

### Applications

- Distributed Power System
- Pre-Regulator for Linear Regulator

### Typical Application Circuit



### Features

- Dual Synchronous Buck Converter in small package.
- standby mode ( Istandby = 0uA )
- High Voltage Synchronous Buck Converter(Vout1)
  - Wide input range(8.0V to 26V) \*absolute voltage 30V
  - H<sup>3</sup>Reg™ DC/DC Converter Controller included
  - Output Current 1.7A \*1
  - FET on resistance High-side 0.175Ω/Low-side 0.175Ω
  - Internal soft-start function
  - Switching Frequency 300 to 600kHz (\*According to input/output conditions)
  - Fixed output voltage (5.0V ± 1.5%; Normal Mode)
- Low Voltage Synchronous Buck Converter(Vout2)
  - Input voltage range 5.0V(VOUT1)
  - H<sup>3</sup>Reg™ DC/DC Converter Controller included
  - Output Current 0.5A \*1
  - FET on resistance High-side 0.25Ω/Low-side 0.25Ω
  - Internal soft-start function
  - Switching Frequency 1.5M to 2.5MHz (\*According to input/output conditions)
  - Feedback voltage (0.8V ± 1.5%; Normal Mode)
- Protection Circuits
  - Under Voltage Lockout Protection
  - Thermal Shutdown
  - Over Current Protection
- HTSOP-J8 Package with Exposed thermal PAD.

\*1 Vout1 maximum output current capability is 2.5A, and Vout2 maximum output current capability is 1.5A with the optimal PCB power consumption design.

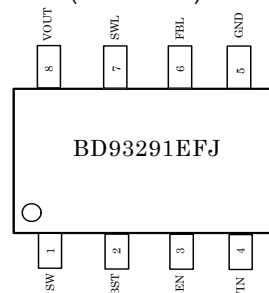
### Structure

- Silicon Monolithic Integrated Circuit

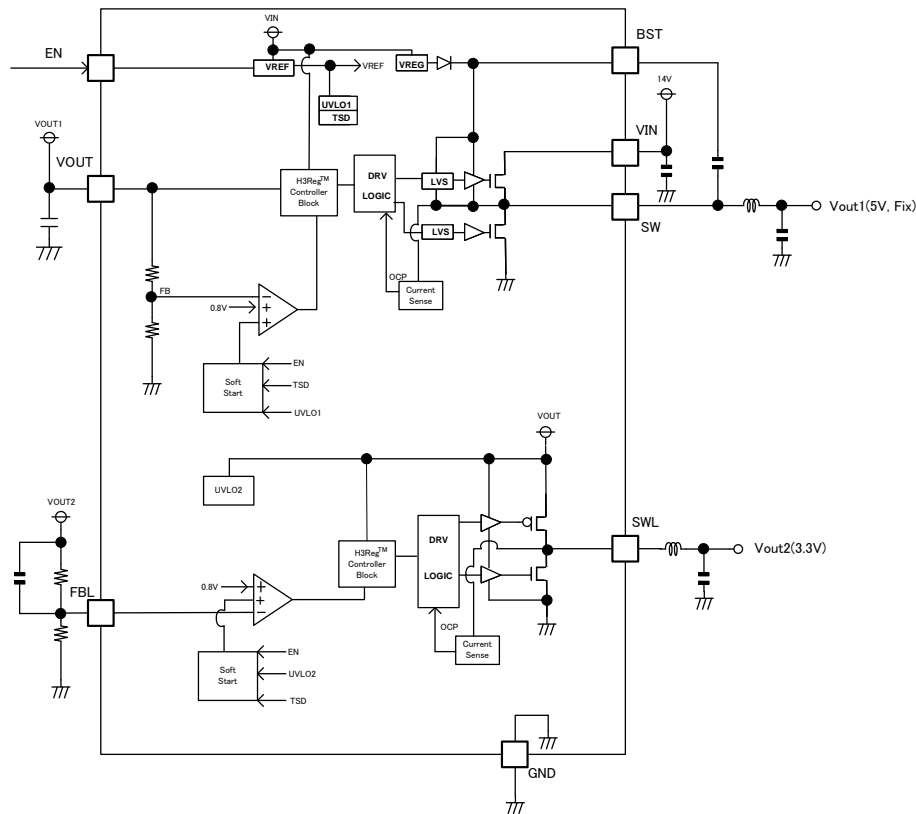
### Package

- HTSOP-J8 6.00mm x 4.90mm x 1.00mm

### PIN Configuration (TOP VIEW)



● Block Diagram



● Pin Assignment and Pin Function

No.	Symbol	Description
1	SW	Connect the inductor switching node of high voltage buck converter. This pin is connected to the source node of High side FET and the drain node of Low side FET.
2	BST	Connect 0.1uF Boot Strap capacitor between BST pin and SW pin. This capacitor is for generating the driving voltage of High-side N-channel MOSFET.
3	EN	This is Enable pin of BD93291EFJ. High input (2.3V typ.) is output active. Low input (1.8V typ.) is IC shutdown. The internal impedance of EN pin is high, therefore add capacitor between EN and GND pin to reduce noise influence when this pin is connected to high-impedance node.
4	VIN	Power supply pin of high voltage buck converter. This pin is connected to power FET supply and internal control blocks of high voltage buck converter. Connect to 10uF(recommended value) ceramic capacitor for bias capacitor.
5	GND	This pin is Low-side N-channel MOSFET power ground of high voltage buck converter, Low-side N-channel MOSFET power ground of low voltage buck converter and analog ground of other blocks.
6	FBL	This pin is output voltage feed-back pin of low voltage buck converter. Refer to ---page regarding the setting of output voltage.
7	SWL	Connect the inductor switching node of low voltage buck converter. This pin is connected to the drain node of High side Pch-FET and the drain node of Low side FET.
8	VOUT	This pin is power supply pin of low voltage buck converter and output voltage feed-back pin of high voltage buck converter. This pin is connected to power FET supply and internal control blocks of low voltage buck converter. Connect to 10uF(recommended value) ceramic capacitor for bias capacitor.

●Absolute maximum ratings (Ta = 25°C)

Parameter	Symbol	Rating	Unit
Supply Voltage 1	V <sub>IN</sub>	30	V
Switch Voltage 1	V <sub>SW</sub>	30	V
Supply Voltage 2	V <sub>OUT</sub>	7.0	V
Switch Voltage 2	V <sub>SWL</sub>	7.0	V
Power Dissipation for HTSOP-J8	P <sub>d</sub>	3760 <sup>*1</sup>	mW
Package thermal resistance $\theta_{ja}$ *2	$\theta_{ja}$	29.27	°C/W
Package thermal resistance $\theta_{jc}$ *2	$\theta_{jc}$	3.75	°C/W
Operating Temperature Range	T <sub>opr</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C
Junction Temperature	T <sub>jmax</sub>	150	°C
BST Voltage	V <sub>BST</sub>	V <sub>SW</sub> +7	V
EN Voltage	V <sub>EN</sub>	30	V

\*1 Derating is done 30.08 mW/°C for operating above Ta $\geq$ 25°C(Mount on 4-layer 70.0mm × 70.0mm × 1.6mm board)

\*2 Mount on 4-layer 50mm x 30mm x 1.6mm application board

●Operation Range(Ta= -40 to 85°C)

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage 1	V <sub>IN</sub>	8.0	14	26	V
Supply Voltage 2	V <sub>OUT</sub>	-	5.0	-	V
SW Voltage 1	V <sub>SW</sub>	-0.5	-	26	V
SW Voltage 2	V <sub>SWL</sub>	-0.5	-	5.5	V
Output voltage range 1 (Fixed)	V <sub>out1</sub>	-	5.0	-	V
Output voltage range 2	V <sub>out2</sub>	0.8	3.3	4.0	V

●Electrical characteristics (unless otherwise specified VIN=14V, VOUT1=5V, VOUT2=3.3V Ta=25°C)

Parameter	Symbol	Limits			Unit	Conditions
		Min	Typ	Max		
【High Voltage Synchronous Buck Converter】						
Output Voltage	VOUT1	4.925	5.0	5.075	V	±1.5%,normal mode
Hi-side FET On-resistance	RONH1	-	0.175	-	Ω	ISW= -0.8A
Lo-side FET On-resistance	RONL1	-	0.175	-	Ω	ISW= 0.8A
Hi/Lo-side FET Leak current	ILEAK1	-	0	10	μA	VIN= 26V, VSW = 0V / 26V
Switch Current Limit	ILIMIT1	3.0	-	-	A	
Soft-start time	VSS1	2.5	5.0	7.5	ms	
ON Time	TON1	635	794	953	ns	Fsw1=450kHz(typ) Iout=0.3A
Minimum Off Time	T OFF1	-	200	-	ns	
【Low Voltage Synchronous Buck Converter】						
Feed-back Voltage	VFBL	0.788	0.8	0.812	V	±1.5%,normal mode
FBL input bias current	IFBL	-1.0	0	1.0	μA	
Hi-side FET On-resistance	RONH2	-	0.25	-	Ω	ISWL= -0.8A
Lo-side FET On-resistance	RONL2	-	0.25	-	Ω	ISWL= 0.8A
Hi/Lo-side FET Leak current	ILEAK2	-	0	10	μA	VOUT1= 5.5V, VSWL = 0V / 5.5V
Switch Current Limit	ILIMIT2	2.0	-	-	A	
Soft-start time	VSS1	1.25	2.5	3.75	ms	
ON Time	TON2	264	330	396	ns	Fsw2=2MHz(typ) Iout=0.2A
Minimum Off Time	T OFF3	-	50	-	ns	
【General】						
Enable Sink current	IEN	33	56	73	μA	VEN= 14V
Enable Threshold voltage 1	VEN_R	2.2	2.3	2.4	V	Rising
Enable Threshold voltage 2	VEN_F	1.7	1.8	1.9	V	Falling
VIN Under Voltage Lockout threshold	VUVLO1	7.1	7.5	7.9	V	VIN rising
VIN Under Voltage Lockout Hysteresis	VHYS1	-	1.0	-	V	
VOUT Under Voltage Lockout threshold	VUVLO2	2.3	2.5	2.7	V	VOUT rising
VOUT Under Voltage Lockout Hysteresis	VHYS2	-	0.2	-	V	
Circuit Current VIN	ICC_VIN	-	0.6	1.5	mA	VOUT= 5.5V, VEN= 14V
Circuit Current VOUT	ICC_VOUT	-	0.6	1.5	mA	VFBL= 1.0V, VEN= 14V
Standby Current	IQUI	-	0	5	μA	VEN= 0V

\* This product is not designed for protection against radioactive rays

●Typical Performance Curves (Unless otherwise noted Ta=25°C, VIN=14V, VOUT1=5V, VOUT2=3.3V)

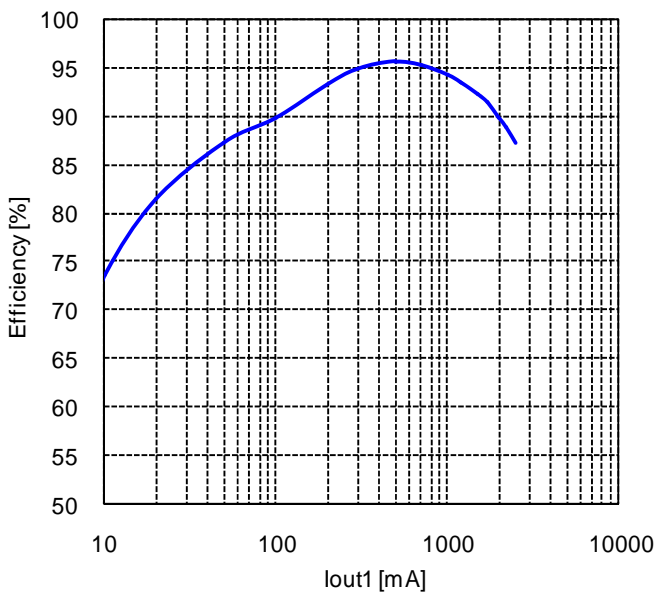


Figure 4. VOUT1 Efficiency  
(VIN=14V, L=22μH)

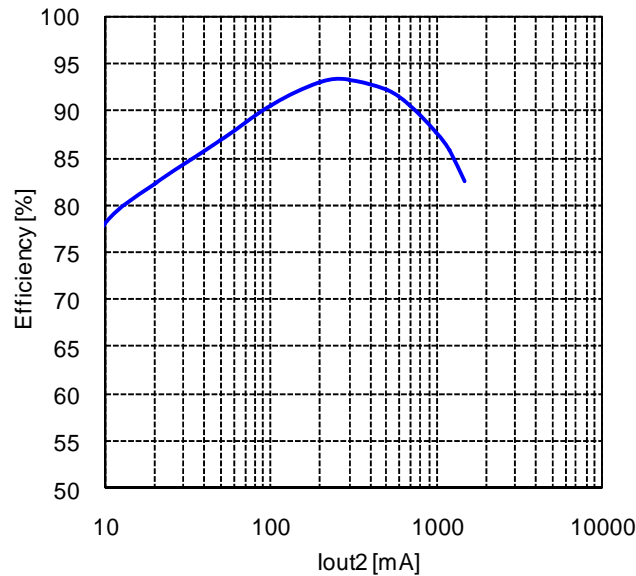


Figure 5. VOUT2 Efficiency  
(VOUT1=5V, VOUT2=3.3V, L=2.2μH)

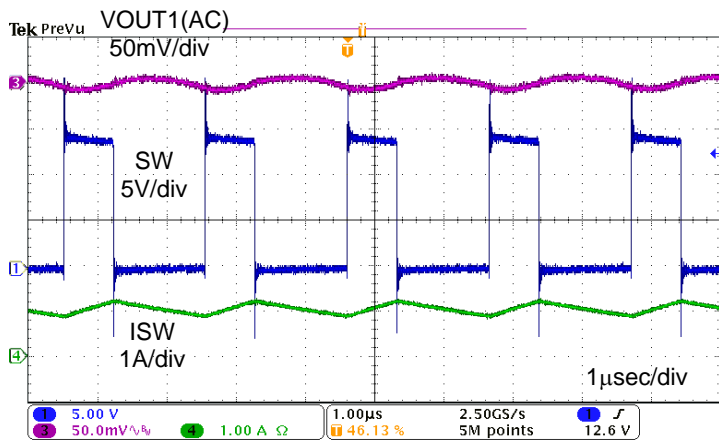


Figure 6. VOUT1 Ripple voltage  
(VIN=14V, L1=22μH, COUT1=22μF, Iout=1A)

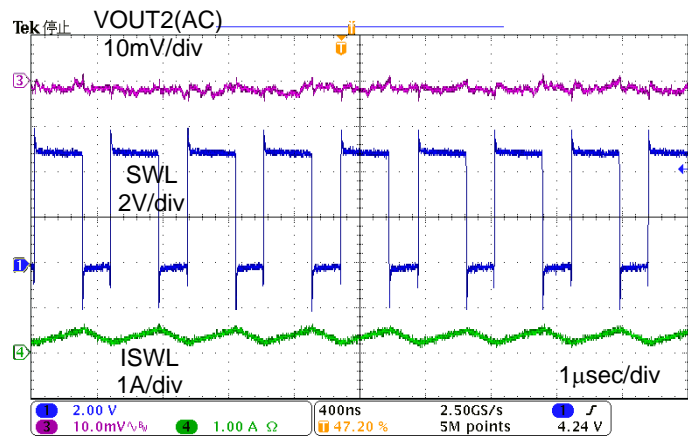


Figure 7. VOUT2 Ripple voltage  
(VOUT1=5V, VOUT2=3.3V, L2=2.2μH, COUT2=22μF, Iout=0.3A)

● Typical Performance Curves (Unless otherwise noted  $T_a=25^\circ\text{C}$ ,  $V_{IN}=14\text{V}$ ,  $V_{OUT1}=5\text{V}$ ,  $V_{OUT2}=3.3\text{V}$ ) (Continued)

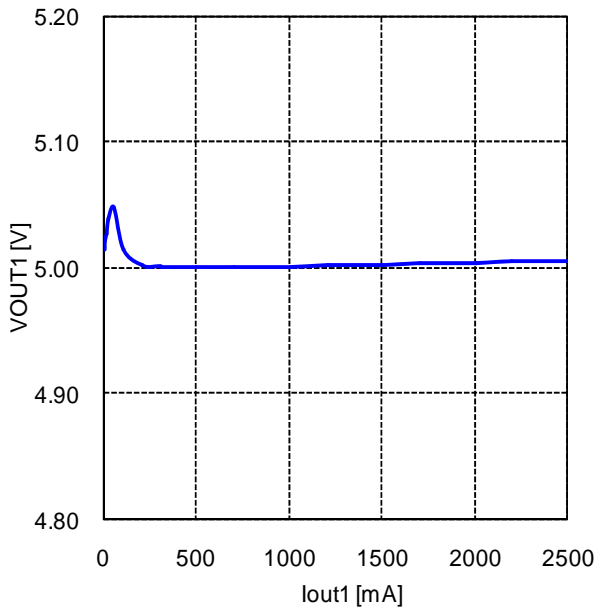


Figure 8. VOUT1 Load Regulation  
( $V_{IN}=14\text{V}$ ,  $L1=22\mu\text{H}$ )

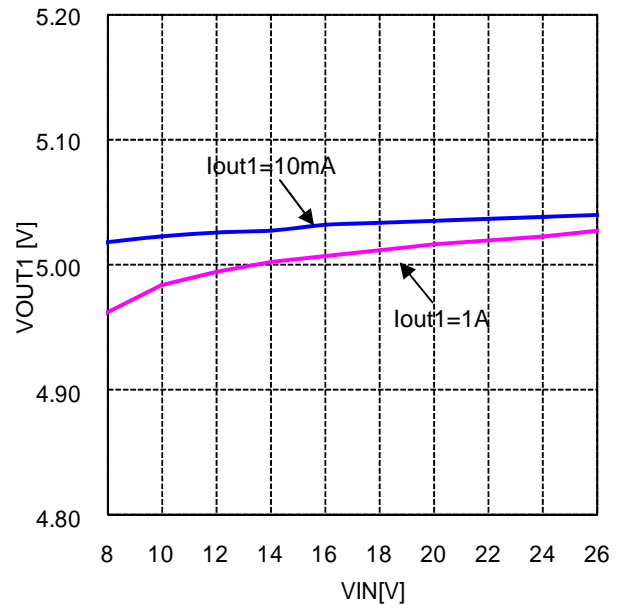


Figure 9. VOUT1 Line Regulation  
( $V_{IN}=14\text{V}$ ,  $L1=22\mu\text{H}$ ,  $I_{out1}=10\text{mA} / 1\text{A}$ )

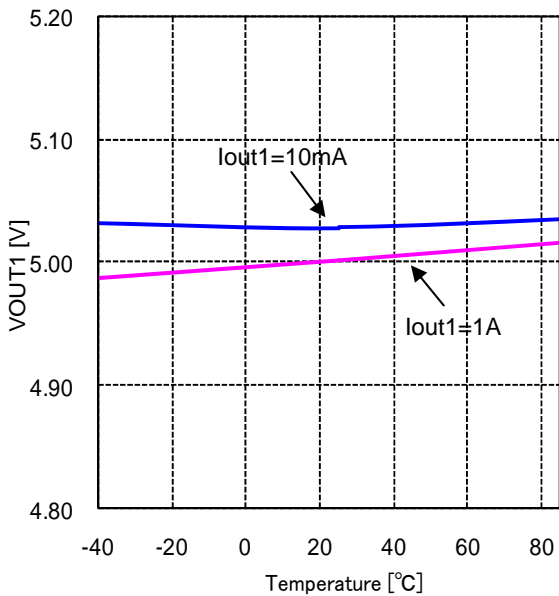


Figure 10. VOUT1 - Temperature  
( $V_{IN}=14\text{V}$ ,  $L1=22\mu\text{H}$ ,  $I_{out1}=10\text{mA}/1\text{A}$ )

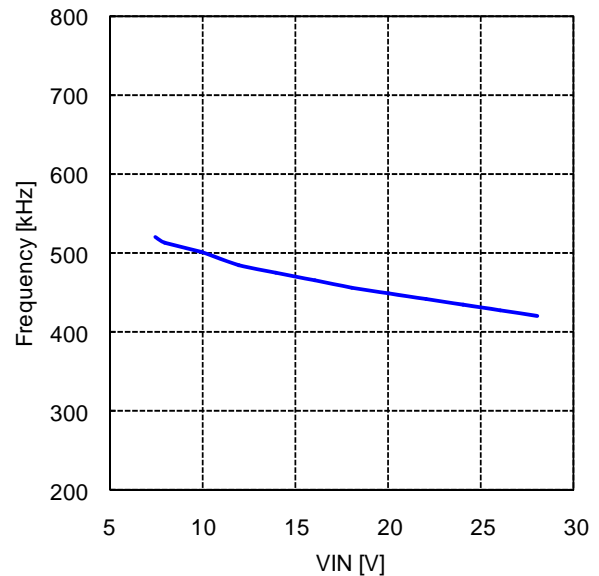


Figure 11. SW\_Frequency - VIN  
( $V_{IN}=14\text{V}$ ,  $L1=22\mu\text{H}$ ,  $I_{out1}=1\text{A}$ )

● Typical Performance Curves (Unless otherwise noted Ta=25°C, VIN=14V, VOUT1=5V, VOUT2=3.3V) (Continued)

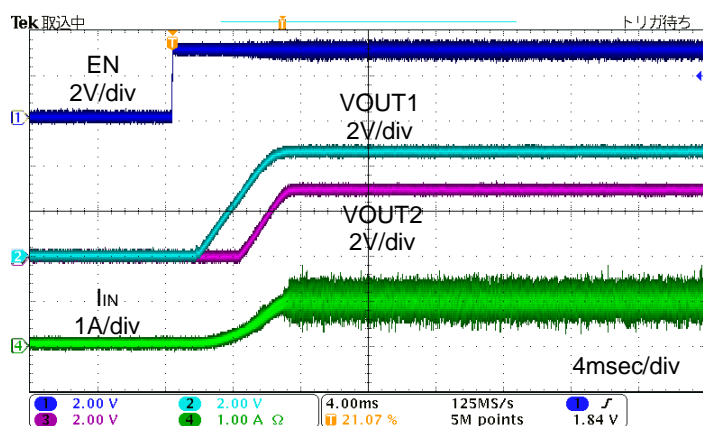


Figure 12. Start up wave form  
(VIN=14V, VOUT1=5V, VOUT2=3.3V, L1=22μH,  
L2=2.2μH, COUT1=22μF, COUT2=2.2μF, Iout1=2A,  
Iout2=1A)

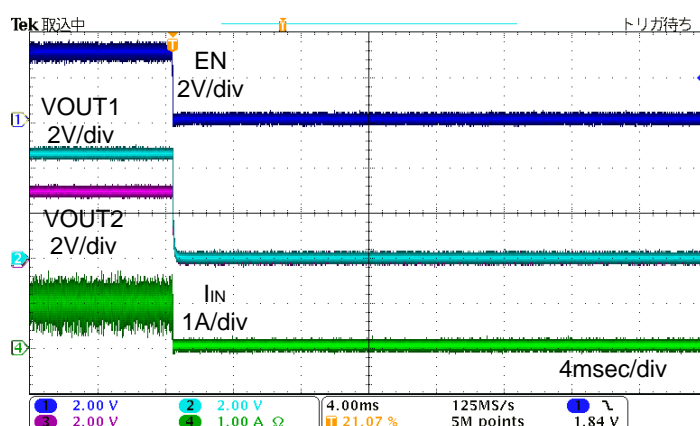


Figure 13. Off wave form  
(VIN=14V, VOUT1=5V, VOUT2=3.3V, L1=22μH,  
L2=2.2μH, COUT1=22μF, COUT2=2.2μF, Iout1=2A,  
Iout2=1A)

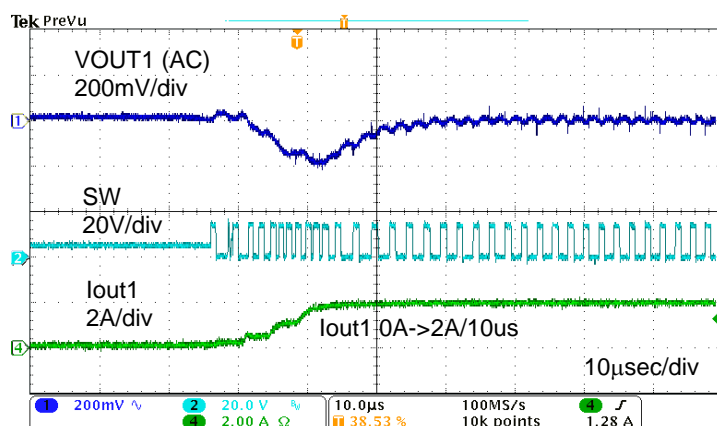


Figure 14. VOUT1 Transient Response  
(VIN=14V, VOUT1=5V, L=22μH, COUT=22μF)  
Iout=0->2A (SR=0.2A/μsec)

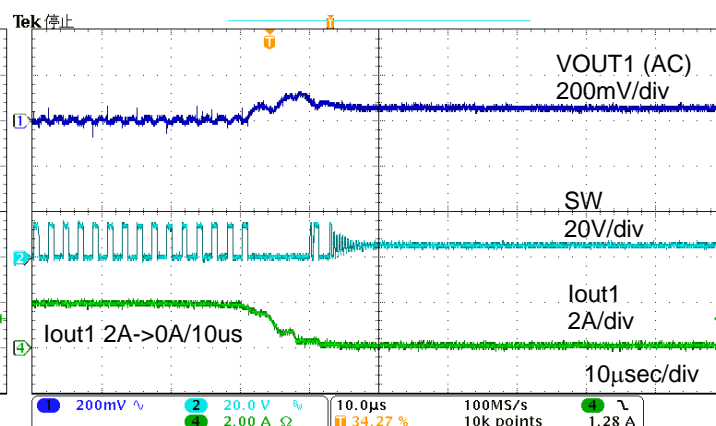


Figure 15. VOUT1 Transient Response  
(VIN=14V, VOUT1=5V, L=22μH, COUT=22μF)  
Iout=2->0A (SR=0.2A/μsec)

●Typical Performance Curves (Unless otherwise noted Ta=25°C, VIN=14V, VOUT1=5V, VOUT2=3.3V) (Continued)

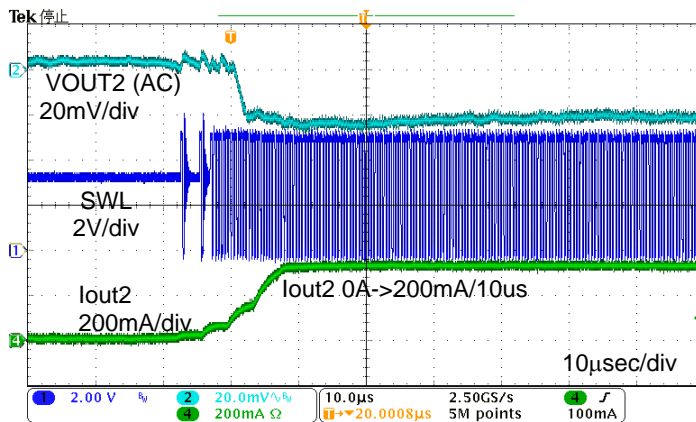


Figure 16. VOUT2 Transient Response  
(VOUT1=5V, VOUT2=3.3V, L2=2.2µH,  
COUT2=22µF),  
Iout2=0→200mA (SR=20mA/µsec)

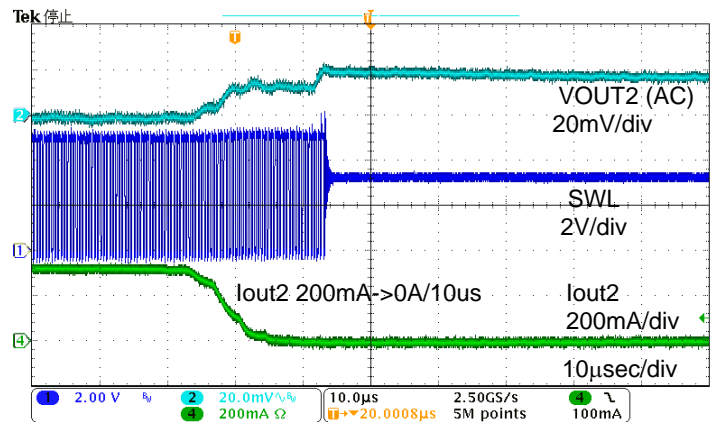


Figure 17. VOUT2 Transient Response  
(VOUT1=5V, VOUT2=3.3V, L2=2.2µH,  
COUT2=22µF),  
Iout2=200mA→0mA (SR=20mA/µsec)

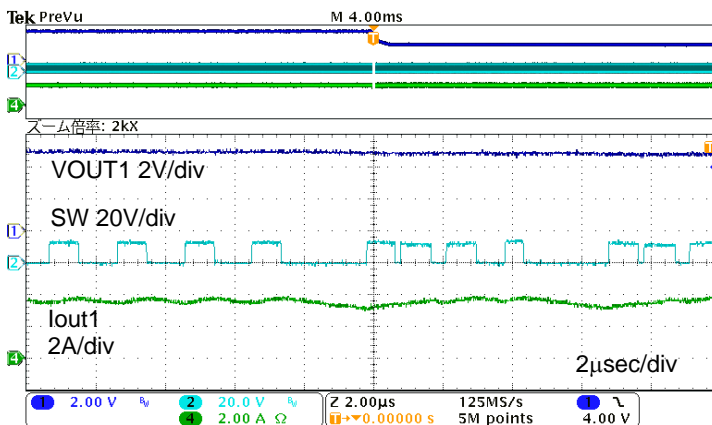


Figure 18. VOUT1 OCP function  
(VIN=14V, VOUT1=5V, VOUT2=3.3V, L1=22µH,  
COUT1=22µF)  
(VOUT1 is shorted to GND)

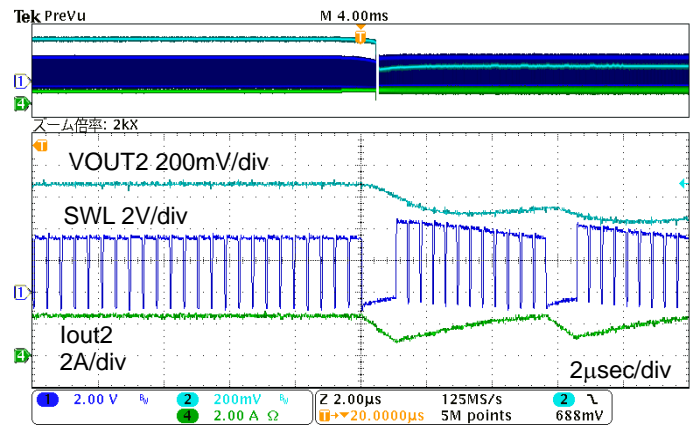


Figure 19. VOUT2 OCP function  
(VIN=14V, VOUT1=5V, VOUT2=3.3V, L2=2.2µH,  
COUT2=22µF)  
(VOUT2 is shorted to GND)

●Typical Performance Curves (Unless otherwise noted Ta=25°C, VIN=14V, VOUT1=5V, VOUT2=3.3V) (Continued)

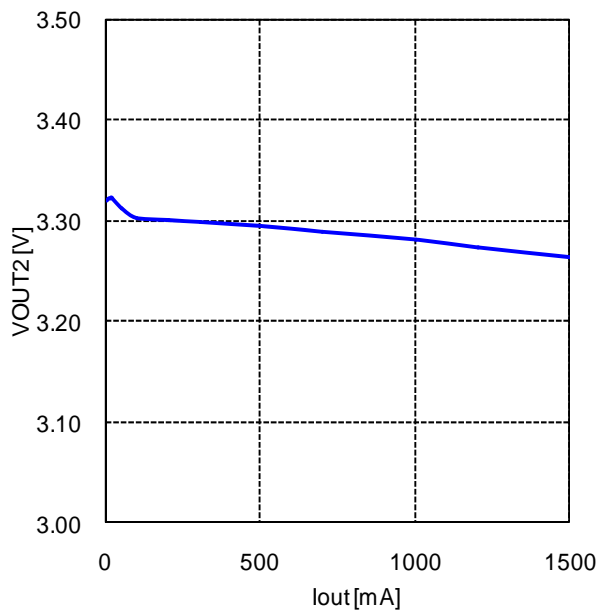


Figure 20. VOUT2 Load Regulation  
(VOUT1=5V, L=2.2μH)

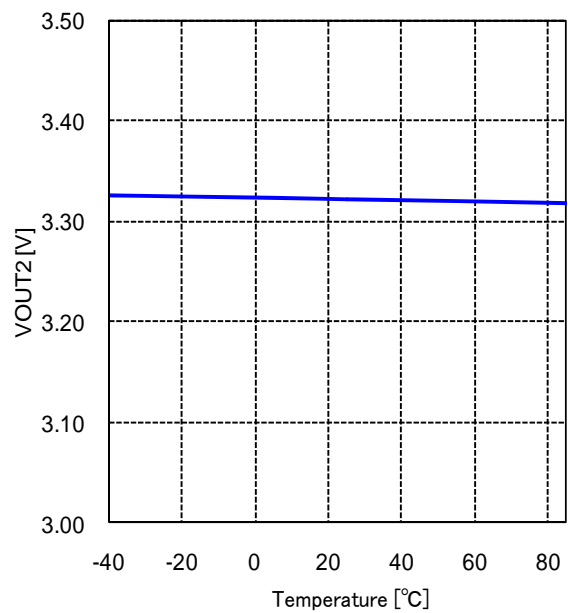


Figure 21. VOUT2 - Temperature  
(VOUT1=5V, L=2.2μH, Iout=1.5A)

## ●Explanation of Operation

The BD93291EFJ is a dual synchronous buck converter incorporating ROHM's proprietary H<sup>3</sup>Reg<sup>TM</sup> CONTROLLA system. When VOUT1 and VOUT2 drop due to a rapid load change, the system quickly restores VOUT1 and VOUT2 by increasing the frequency.

### 1. H<sup>3</sup>Reg<sup>TM</sup> System

#### 1-1. Normal Operation

When FB falls below the threshold voltage (REF), a drop is detected, activating the H<sup>3</sup>Reg<sup>TM</sup> CONTROLLA system.

$$T_{on} = \frac{V_{OUT}}{V_{IN}} \times \frac{1}{f} \quad [\text{sec}] \quad (1)$$

HG (Gate of High side MOSFET) output is determined by the formula (1). LG (Gate of Low side MOSFET) output operates until FB voltage falls below REF voltage after HG becomes OFF. OFF time is restricted by MIN OFF Time ( VOUT1 : 200nsec (typ.), VOUT2 : 50nsec (typ.) ).

Hence, BD93291EFJ runs with a constant on-time by using the input and output voltage to set the internal on-time timer.

#### 1-2. VOUT drops due to a rapid load change

When FB (VOUT) drops due to a rapid load change and the voltage remains below REF, the system quickly restores VOUT by shortening OFF time of HG (increasing the frequency), improving transient response as shown Figure 22 (b).

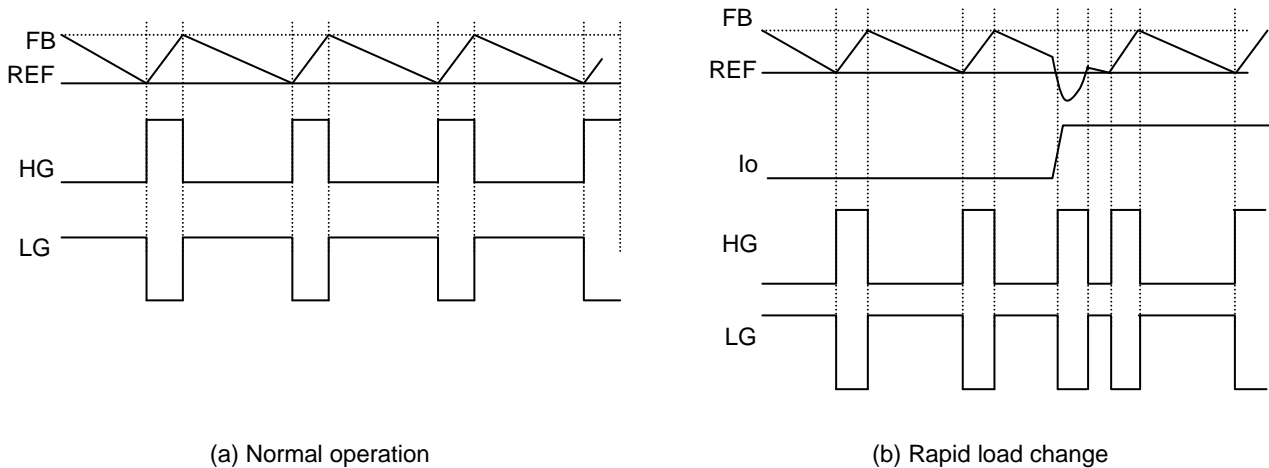


Figure 22. H<sup>3</sup>REG System

## ●Timing Chart

### 1. Soft Start Function

Soft start is utilized when the EN pin is set high. Current control takes effect at startup, enabling a moderate “ramping start” on the output voltage. Soft start time of VOUT1 is 5.0msec (typ) and VOUT2 is 2.5ms (typ).

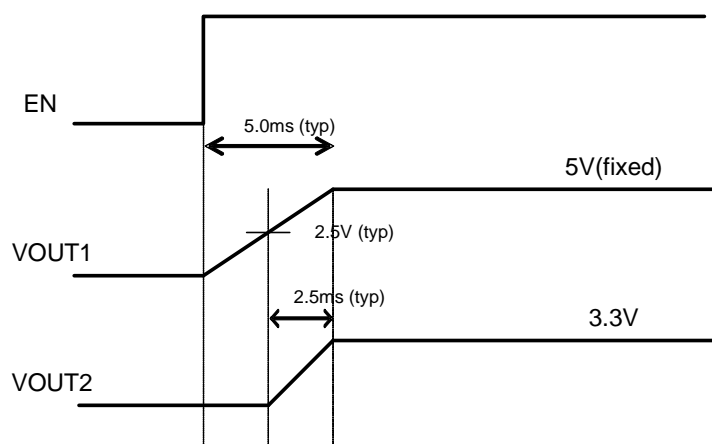


Figure 23. Soft Start Timing Chart

## ●Protection Operation

### 1. OCP Operation

Normally, when FB voltage falls below REF voltage, HG becomes high. However, if the peak current through the inductor ( $I_L$ ) exceeds OCP current value ( $I_{OCP}$ ) during HG=ON, HG become OFF immediately and  $I_L$  is restricted by  $I_{OCP}$ . As the result, the output voltage can decrease as the frequency and duty are changed.

When OCP is released in the state that the output has decreased by OCP operation, the output voltage might rise up due to high-speed load response.

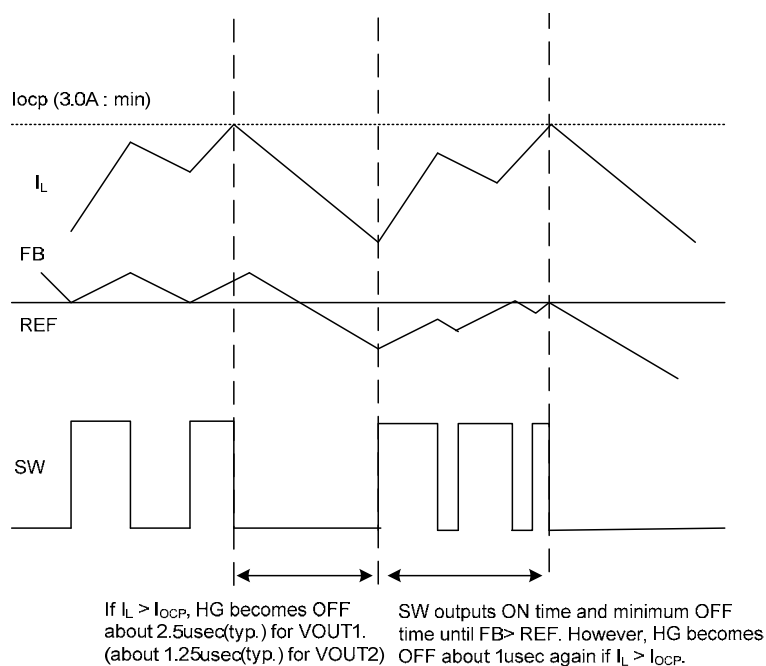


Figure 24. OCP Timing Chart

## 2. TSD Operation (Self Recovery)

TSD is self-activating. If the junction temperature exceeds  $T_j = 175^{\circ}\text{C}$ , and HG, LG, and SS become Low. The IC becomes standby when TSD operating. When  $T_j$  falls below  $150^{\circ}\text{C}$ , it returns to standard operation.

## 3. UVLO Operation

UVLO operates when  $V_{IN}$  voltage falls below 6.5V, and HG and LG become Low. The IC becomes standby when UVLO operating. UVLO is released when  $V_{IN}$  goes up to 7.5V, and starts standard operation

## ● Selection of Components Externally Connected

### 1. Output LC Filter Selection (Buck Converter)

#### 1-1. Inductor (L) Selection

The Output LC filter is required to supply constant current to the output load. A larger value inductance at this filter results in less inductor ripple current ( $\Delta I_L$ ) and less output ripple voltage. However, the larger value inductors tend to have less fast load transient-response, a larger physical size, a lower saturation current and higher series resistance. A smaller value inductance has almost opposite characteristics above.

The value of  $\Delta I_L$  is shown as formula (2). The larger value of the inductance or the faster switching frequency make the lower ripple voltage.

$$\Delta I_L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{L \times f \times V_{IN}} \quad [\text{A}] \quad (2)$$

The proper output ripple current setting is about 30% of maximum output current.

$$\Delta I_L = 0.3 \times I_{OUTMAX} \quad [\text{A}] \quad (3)$$

$$L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{\Delta I_L \times f \times V_{IN}} \quad [\text{H}] \quad (4)$$

( $\Delta I_L$  : output ripple current、 $f$  : switching frequency)

※A larger current than the inductor's rated current will cause magnetic saturation in the inductor, and decrease efficiency.

When selecting an inductor, be sure to allow enough margins to assure that peak current does not exceed the inductor's rated current value.

※To minimize loss of inductor and improve efficiency, choose a inductor with a low resistance (DCR, ACR).

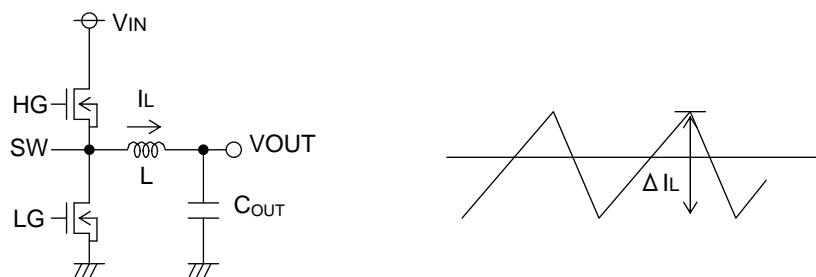


Figure 25. Inductor Ripple Current

### 1-2. Output Capacitor (C<sub>OUT</sub>) Selection

Output Capacitor (C<sub>OUT</sub>) has a considerable influence on output voltage regulation due to a rapid load change and smoothing output ripple voltage. Determine the capacitor by considering the value of capacity, the equivalent series resistance, and equivalent series inductance. Also, make sure the capacitor's voltage rating is high enough for the set output voltage (including ripple).

Output ripple voltage is determined as in formula (5) below.

$$\Delta V_{OUT} = \Delta I_L / (8 \times C_{OUT} \times f) + ESR \times \Delta I_L + ESL \times \Delta I_L / T_{on} \quad [V] \quad (5)$$

( $\Delta I_L$ : Output ripple current, ESR: Equivalent series resistance, ESL: Equivalent series inductance)

Also, give consideration to the conditions in formula (6) below for output capacitance, bearing in mind that output rise time must be established within the fixed soft start time. As output capacitance, bypass capacitor will be also connected to output load side (C<sub>EXT</sub>, Figure 26). Please set the over current detection value with regards to these capacitance.

$$C_{OUT} \leq \frac{SS \times (I_{OCP} - I_{OUT})}{V_{OUT}} \quad [F] \quad (6)$$

(SS : Soft Start time, I<sub>OCP</sub> : OCP Current Limit, I<sub>OUT</sub> : Output Current)

Note: an improper output capacitor may cause startup malfunctions.

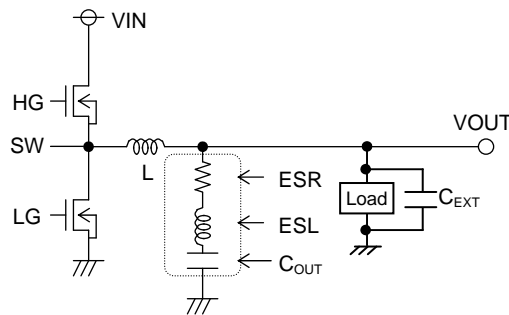


Figure 26. Output Capacitor

### 2. Input Capacitor (C<sub>IN</sub>) Selection

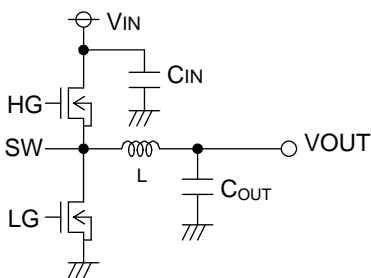


Figure 27. Input Capacitor

In order to prevent transient spikes in voltage, the input capacitor should have a low enough ESR resistance to fully support a large ripple current. The formula for ripple current I<sub>RMS</sub> is given in equation (7) as below.

$$I_{RMS} = I_{OUT} \times \frac{\sqrt{V_{OUT} \times (V_{IN} - V_{OUT})}}{V_{IN}} \quad [A] \quad (7)$$

$$\text{Where } V_{IN} = 2 \times V_{OUT}, I_{RMS} = \frac{I_{OUT}}{2}$$

A low ESR capacitor is recommended to reduce ESR loss and improve efficiency.

Capacitor C<sub>out</sub> between VOUT and GND must be placed near the VOUT pin.

### 3. VOUT2 Output Voltage Setting

The IC controls output voltage as  $REF \doteq V_{FBL}$ .

However, the actual output voltage will also reflect the average ripple voltage value.

The VOUT2 output voltage is set with a resistor divider from the output node to the FBL pin. The formula for output voltage is given in (8) below:

$$VOUT2 = \frac{R_{UP} + R_{DW}}{R_{DW}} \times REF + \Delta VOUT \quad [V] \quad (8)$$

$$REF = V_{FBL}(\text{TYP } 0.8V) + 0.02 - (\text{ON DUTY} \times 0.05) \quad [V] \quad (9)$$

$$\text{ON DUTY} = \frac{VOUT2}{VOUT1} \quad (10)$$

C\_UP is needed to feedback output voltage ripple to FBL pin, the value is calculated to

$$C_{UP} = \frac{11e-6 (+/-30\%)}{R_{UP}} \quad [F] \quad (11)$$

Please refer to eq. (5) regarding  $\Delta VOUT$ .

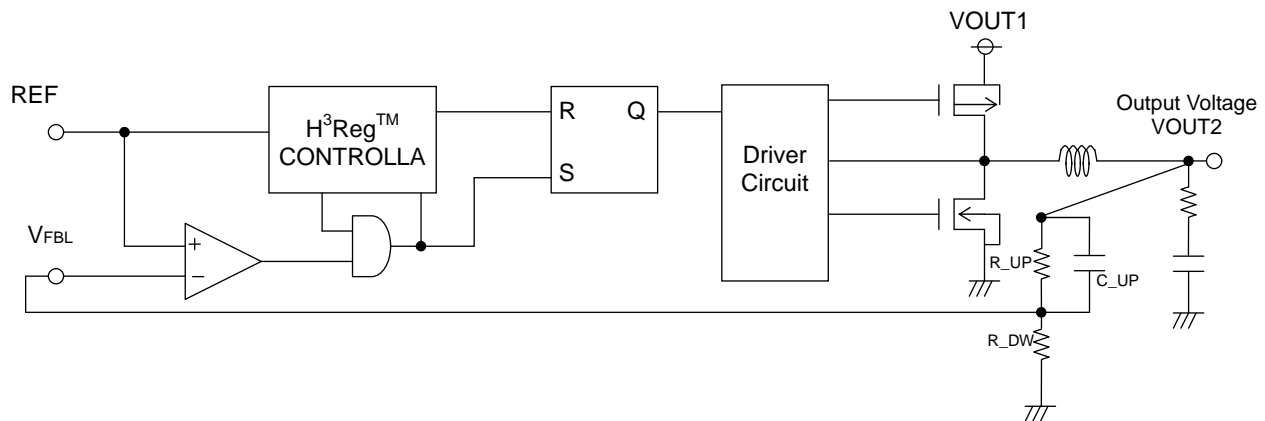


Figure 28. Output Voltage VOUT2 Setting

### 4. Relationship between Output Voltage and ONTIME

BD93291EFJ is a dual synchronous buck converter controlling constant ONTIME. The ONTIME ( $T_{on}$ ) depends on the output voltage settings, as described by the formula (12).

$$T_{on} \doteq \frac{V_{OUT}}{V_{IN}} \times \frac{1}{\text{Frequency}} \quad [\text{sec}] \quad (12)$$

### ●PCB Layout Guide

Two high pulsing current flowing loops exist in the buck regulator system.

The first loop, when FET is ON, starts from the input capacitors, to the VIN terminal, to the SW terminal, to the inductor, to the output capacitors, and then returns to the input capacitor through GND.

The second loop, when FET is OFF, starts from the low FET, to the inductor, to the output capacitor, and then returns to the low FET through GND.

To reduce the noise and improve the efficiency, please minimize these two loop area.

Especially input capacitor and output capacitor should be connected to GND plain.

PCB Layout may affect the thermal performance, noise and efficiency greatly. So please take extra care when designing PCB Layout patterns.

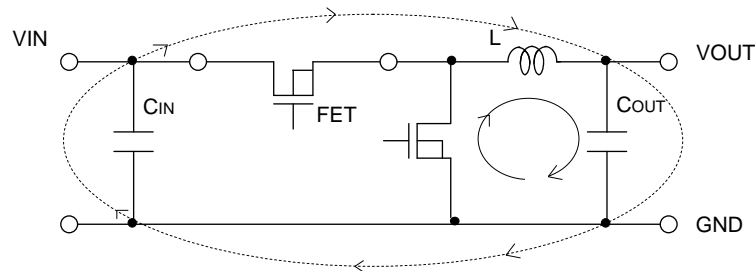


Figure 29. Current loop Buck regulator system

- The thermal pad on the back side of IC has the great thermal conduction to the chip. So using the GND plain as broad and wide as possible can help thermal dissipation. And a lot of thermal via for helping the spread of heat to the different layer is also effective.
- The input capacitors (C\_VC1 and C\_CO3) should be connected as close as possible to the VIN or VOUT terminal. Especially, C\_CO3 between VOUT and GND must be placed near the VOUT pin, and keep the distance "b" less than 2mm.
- When there is unused area on PCB, please arrange the copper foil plain of DC nodes, such as GND, VIN and VOUT for helping heat dissipation of IC or circumference parts.
- To avoid the noise influence from AC combination with the other line, keep the switching line such as SW and SWL not extend as much as possible, and trace shortly and thickly to coil L1 and L2.
- Keep sensitive signal traces such as trace connected FBL away from SW and SWL pins.
- The inductors and the output capacitors should be placed close to SW or SWL pins as much as possible.
- Keep VOUT pattern width "a" more than 3mm to stable the 5V output.

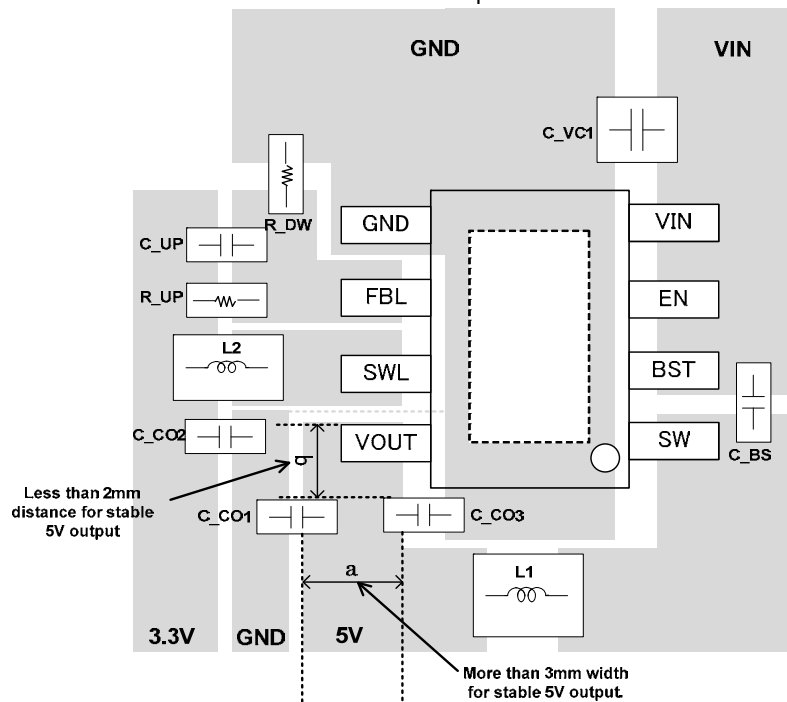


Figure 30. Example of PCB layout pattern

# ●List of Evaluation Board Components

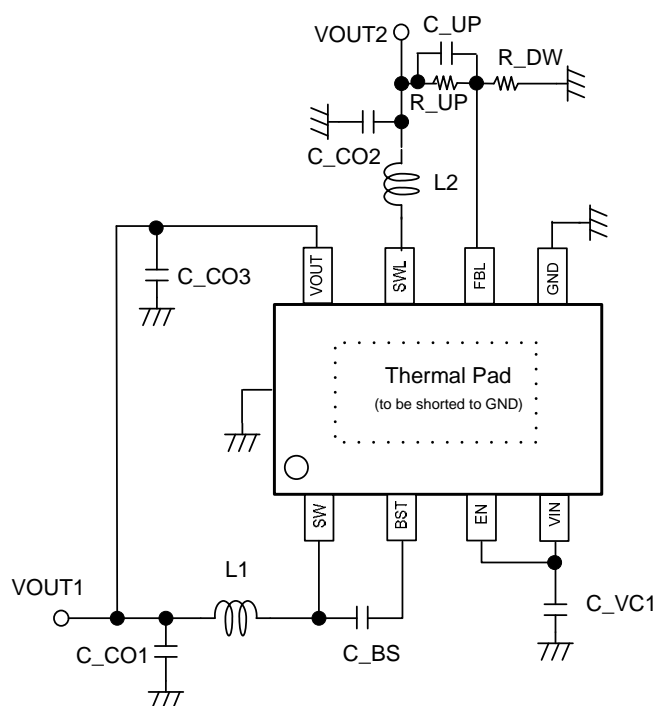


Figure 31. Typical Application Circuit

• Recommended Components List (VIN=14V, VOUT1=5V, VOUT2=3.3V)

Symbol	Part	Value	Manufacture	Series
C_VC1	Ceramic Capacitor	10uF	murata	GRM32DF51H106ZA01L
C_BST	Ceramic Capacitor	0.1uF	murata	GRM188F11H104ZA01
L1	Coil	22uH	TDK	SLF10165 220M 2R4
L2	Coil	2.2uH	TDK	VLF 4012S 2R2M 1R3
C_CO1	Ceramic Capacitor	22uF	murata	GRM21BB31A226ME51L
C_CO2	Ceramic Capacitor	22uF	murata	GRM21BB31A226ME51L
C_CO3	Ceramic Capacitor	10uF	murata	GRM21BB31A106ME18
C_UP	Ceramic Capacitor	680pF	murata	GRM1882C1H681JA01
R_UP	Resistance	16kΩ	ROHM	MCR03 1608size Tolerance F
R_DW	Resistance	5.1kΩ	ROHM	MCR03 1608size Tolerance F

※The above components list is an example. Please check actual circuit characteristics on the application carefully before use.

●I/O Equivalence circuit

<div>SW</div> <div></div>	<div>BST</div> <div></div>	<div>EN</div> <div></div>
<div>FBL</div> <div></div>	<div>SWL</div> <div></div>	<div>VOUT</div> <div></div>

## ●Operational Notes

- (1) Absolute Maximum Ratings  
Use of the IC in excess of absolute maximum ratings may result in damage to the IC. Assumptions should not be made regarding the state of the IC (e.g., short mode or open mode) when such damage is suffered. If operational values are expected to exceed the maximum ratings for the device, consider adding protective circuitry (such as fuses) to eliminate the risk of damaging the IC.
- (2) GND voltage  
The potential of the GND pin must be the minimum potential in the system in all operating conditions.
- (3) Thermal design  
Use a thermal design that allows for a sufficient margin for power dissipation (Pd) under actual operating conditions
- (4) Inter-pin Shorts and Mounting Errors  
Use caution when orienting and positioning the IC for mounting on printed circuit boards. Improper mounting may result in damage to the IC. Shorts between output pins or between output pins and the power supply and GND pins caused by poor soldering or foreign objects may result in damage to the IC.
- (5) Operation in Strong Electromagnetic Fields  
Using this product in strong electromagnetic fields may cause IC malfunction. Caution should be exercised in applications where strong electromagnetic fields may be present.
- (6) ASO (Area of Safe Operation)  
When using the IC, ensure that operating conditions do not exceed absolute maximum ratings or ASO of the output transistors.
- (7) Testing on application boards  
When testing the IC on an application board, connecting a capacitor directly to a low-impedance pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from a jig or fixture during the evaluation process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.
- (8) Electrical Characteristics  
The electrical characteristics indicated in this datasheet may change upon the conditions of temperature, supply voltage, and external components. Please validate/verify your design at the worst case conditions.
- (9) Not of a radiation-resistant design.
- (10) Back Electromotive Force  
If a large inductive load is connected at the output pin that might cause introducing back electromotive force at the start up and at the output disable, please insert protection diodes.

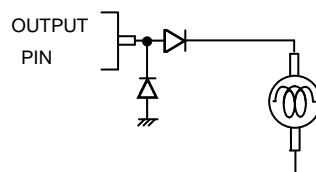


Figure 32. Back Electromotive Force

- (11) Regarding input pins of the IC  
This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. PN junctions are formed at the intersection of these P layers with the N layers of other elements, creating parasitic diodes and/or transistors. For example (refer to the figure below):

- When GND > Pin A and GND > Pin B, the PN junction operates as a parasitic diode
- When GND > Pin B, the PN junction operates as a parasitic transistor

Parasitic diodes occur inevitably in the structure of the IC, and the operation of these parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Accordingly, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

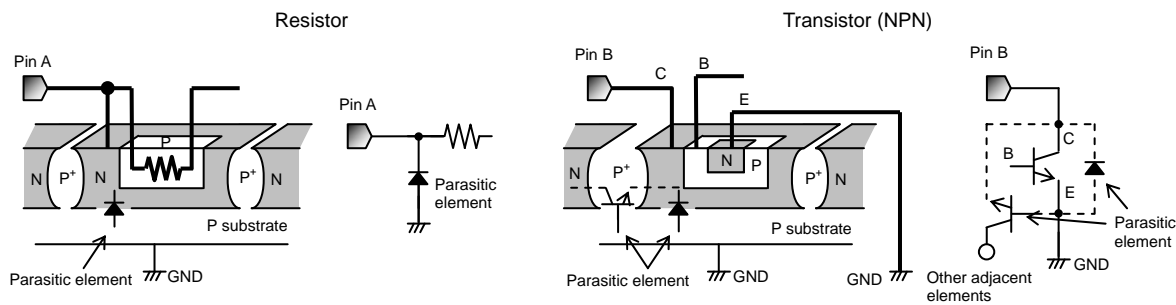


Figure 33. Example of IC structure

- (12) Ground Wiring Pattern  
When using both small-signal and large-current GND traces, the two ground traces should be routed separately but connected to a single ground potential within the application in order to avoid variations in the small-signal ground caused by large currents. Also ensure that the GND traces of external components do not cause variations on GND voltage.
- (13) Operating Condition  
The electrical characteristics indicated in this datasheet are not guaranteed for the whole operational and temperature ranges, however these characteristics do not significantly fluctuate within the operational and temperature ranges.
- (14) Thermal shutdown (TSD) circuit  
The IC incorporates a built-in thermal shutdown circuit, which is designed to turn the IC off completely in the event of thermal overload. It is not designed to protect the IC from damage or guarantee its operation. ICs should not be used after this function has activated, or in applications where the operation of this circuit is assumed. If the thermal shutdown is activated while the load current exists, the output may possibly be latched off at the release of the thermal shutdown.

TSD ON Temp.[°C] (typ.)	Hysteresis Temp[°C] (typ.)
175	25

- (15) Heat Sink (FIN)  
The heat sink (FIN) is connected to the substrate. Please connect it to GND.

Status of this document  
The English 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

●Thermal Derating Curves

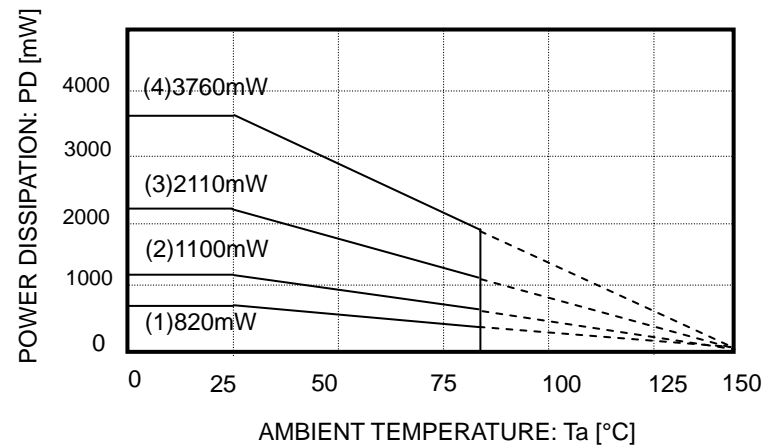


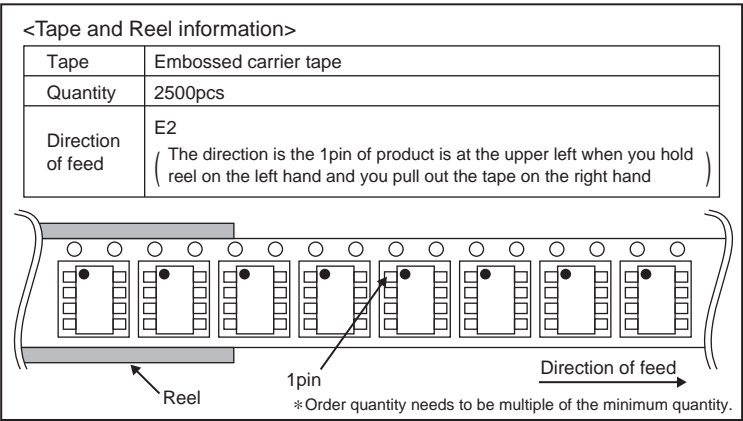
Figure 34. Thermal derating curve (HTSOP-J8)

**HTSOP-J8 Package**  
On 70 × 70 × 1.6 mm glass epoxy PCB  
(1) 1-layer board (Backside copper foil area 0 mm× 0 mm)  
(2) 2-layer board (Backside copper foil area 15 mm × 15 mm)  
(3) 2-layer board (Backside copper foil area 70 mm × 70 mm)  
(4) 4-layer board (Backside copper foil area 70 mm × 70 mm)

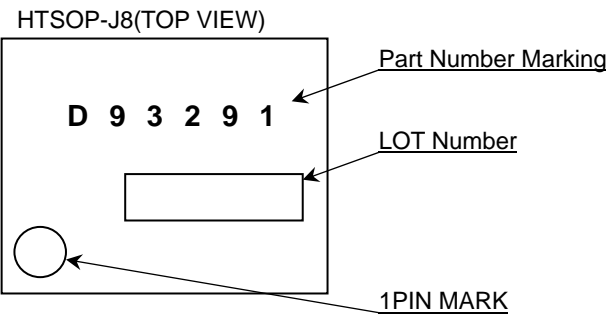
●Ordering Information

B D 9 3 2 9 1 E F J										-	E 2	
Part Number											Package	
											EFJ: HTSOP-J8	
											Packaging and forming specification	
											E2: Embossed tape and reel	

●Physical Dimension Tape and Reel Information



●Marking Diagram



## ●Revision History

Date	Revision	Changes
12.Nov.2012	001	New Release

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JAPAN	USA	EU	CHINA
CLASS III	CLASS III	CLASS II b	CLASS III
CLASS IV		CLASS III	

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  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - 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
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- 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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- Confirm that operation temperature is within the specified range described in the product specification.
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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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