

# 4.5V to 18V, 3A 1ch Synchronous Buck Converter BD95835EFJ



## ●Description

BD95835EFJ is a 1ch synchronous buck converter that can generate a wide range of output voltage at the input voltage range (4.5V to 18V). Space-saving and high efficient switching regulator can be achieved due to built-in N-MOSFET power transistors. The IC also incorporates constant ON TIME control mode which facilitates ultra-high transient response against changes in load. Variable soft start function, short circuit protection and over voltage protection are incorporated. The BD95835EFJ is designed for power supplies for Digital AV Equipment.

## ●Applications

- LCD TVs
- Set Top Boxes (STB)
- DVD/Blu-ray players/recorders
- Broadband Network and Communication Interface
- Amusement, other.

## ●Features

- Input Voltage Range: 4.5V to 18.0V
- Output Current: 3.0A (Max.)
- Reference Voltage:  $0.750V \pm 1.2\%$
- Output Voltage Range①: 0.9V to  $V_{IN} \times 0.7$   
Using switching frequency  $200kHz \leq Freq \leq 600kHz$
- Output Voltage Range②: 0.9V to  $V_{IN} \times 0.6$   
Using switching frequency  $600kHz < Freq \leq 800kHz$
- Built-in Power MOS FET  
High-side Nch FET ON resistance:  $100m\Omega$  (typ.)  
Low-side Nch FET ON resistance:  $100m\Omega$  (typ.)
- Fast Transient Responses due to ON TIME control
- Over Current Protection (OCP)
- Thermal Shut Down (TSD)
- Under-Voltage Lock-Out (UVLO)
- Short Circuit Protection (SCP)
- Over Voltage Protection (OVP)
- Variable Soft Start

## ●Package

HTSOP-J8

W(Typ.) x D(Typ.) x H(Max.)  
4.90mm x 6.00mm x 1.00mm

## ●Typical Application

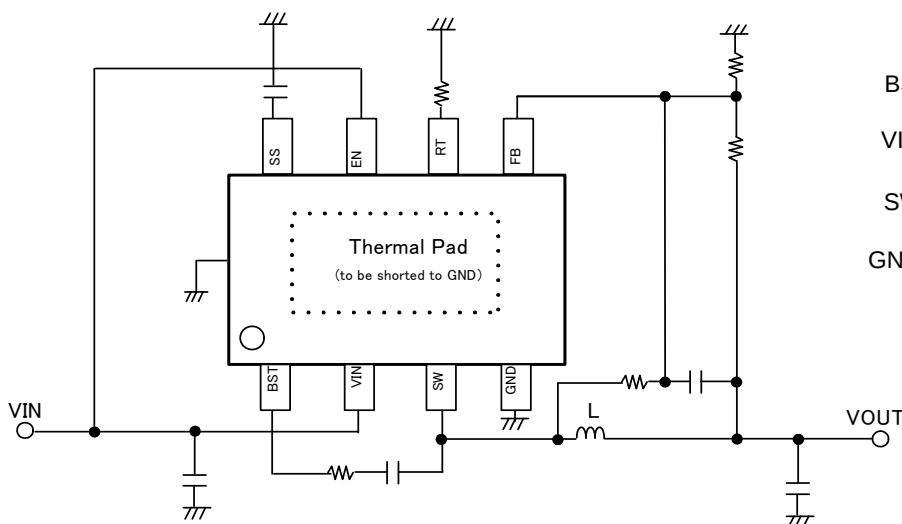


Figure 1. Typical Application Circuit

## ●Pin Configuration (TOP VIEW)

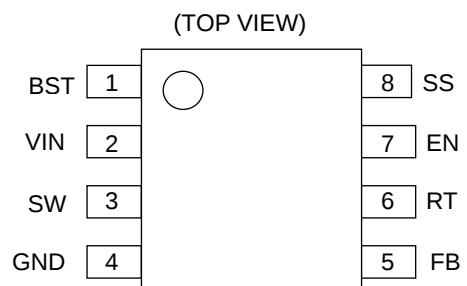


Figure 2. Pin Configuration

## ●Block Diagram

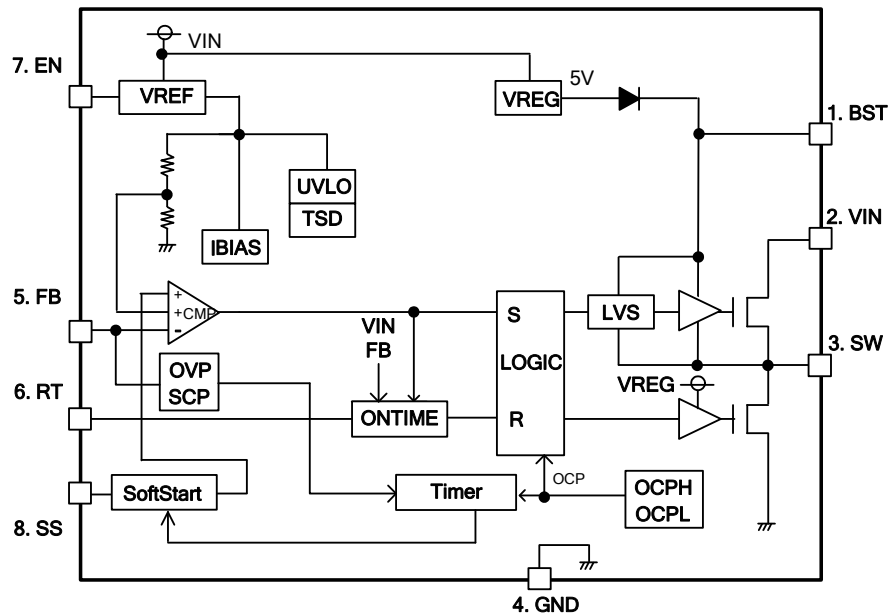


Figure 3. Block Diagram

## ●Pin Description

| No. | Symbol | Description                                                                                                                                                                                     |
|-----|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | BST    | High side FET Gate Driver Power Supply pin.<br>Connect 0.1μF capacitor and 82Ω resistor between BST and SW.<br>BOOT voltage swings from VREG to (VIN + VREG) during normal switching operation. |
| 2   | VIN    | Input Voltage Supply pin.<br>Connect over 10μF ceramic capacitors for decoupling to PGND as near as these pins.                                                                                 |
| 3   | SW     | Switch node connection between High side FET source and Low side FET drain.<br>Connected to inductor (L).                                                                                       |
| 4   | GND    | GND pin for the IC.                                                                                                                                                                             |
| 5   | FB     | Output Voltage Feedback pin.<br>FB is compared with REF in the IC.                                                                                                                              |
| 6   | RT     | Connect a resistor to determine ONTIME.                                                                                                                                                         |
| 7   | EN     | Enable Input pin.<br>When the input voltage of the EN pin reaches at least 1.2V, the switching regulator becomes active. At the voltage less than 0.2 V, the IC becomes standby mode.           |
| 8   | SS     | Connect a capacitor to determine soft start time.                                                                                                                                               |

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

| Parameter                   | Symbol               | Limit              | Unit |
|-----------------------------|----------------------|--------------------|------|
| Input Voltage               | V <sub>IN</sub>      | 20                 | V    |
| SW voltage                  | V <sub>SW</sub>      | 20                 | V    |
| SW voltage (10ns transient) | V <sub>SW</sub> (AC) | 22                 | V    |
| EN voltage                  | V <sub>EN</sub>      | 20                 | V    |
| BST voltage                 | V <sub>BST</sub>     | V <sub>SW</sub> +7 | V    |
| SS, FB, RT voltage          | V <sub>OTH</sub>     | 7                  | V    |
| Power dissipation           | P <sub>d</sub>       | 3760 <sup>*1</sup> | mW   |
| θ <sub>ja</sub> *2          | θ <sub>ja</sub>      | 29.27              | °C/W |
| θ <sub>jc</sub> *2          | θ <sub>jc</sub>      | 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   |

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

\*2 Mount on 4-layer 50mm × 30mm × 1.6mm

### ●Operating Ratings (Ta= -40 to 85°C)

| Parameter              | Symbol              | Limit |     |                       | Unit |
|------------------------|---------------------|-------|-----|-----------------------|------|
|                        |                     | Min   | Typ | Max                   |      |
| Input Voltage          | V <sub>IN</sub>     | 4.5   | 12  | 18                    | V    |
| SW Voltage             | V <sub>SW</sub>     | -0.5  | -   | 18                    | V    |
| Output Current         | I <sub>SW3</sub>    | -     | -   | 3                     | A    |
| Output Voltage Range①※ | V <sub>RANGE1</sub> | 0.9   | -   | V <sub>IN</sub> × 0.7 | V    |
| Output Voltage Range②※ | V <sub>RANGE2</sub> | 0.9   | -   | V <sub>IN</sub> × 0.6 | V    |

①※ Please use at the frequency range : 200kHz ≤ Freq ≤ 600kHz.

②※ Please use at the frequency range : 600kHz < Freq ≤ 800kHz.

Frequency range is limited by input / output conditions.

**●Electrical Characteristics (Unless otherwise noted, VIN=12V, Ta=25°C)**

| Parameters                       | Symbol  | Limit |       |       | Unit | Conditions                |
|----------------------------------|---------|-------|-------|-------|------|---------------------------|
|                                  |         | Min   | Typ   | Max   |      |                           |
| [Output Voltage Detection Block] |         |       |       |       |      |                           |
| FB input bias current            | IFB     | -     | -     | 1     | μA   | FB = 1V                   |
| FB threshold voltage             | VFB1    | 0.741 | 0.750 | 0.759 | V    |                           |
| OVP threshold voltage            | VFB1    | 0.85  | 1.00  | 1.15  | V    |                           |
| SCP threshold voltage            | VFB2    | 0.40  | 0.500 | 0.60  | V    |                           |
| [Output Driver Block]            |         |       |       |       |      |                           |
| High side FET ON resistance      | RONH    | -     | 100   | -     | mΩ   | Isw = -0.8A,<br>BST = 16V |
| Low side FET ON resistance       | RONL    | -     | 100   | -     | mΩ   | Isw = 0.8A                |
| High side FET Leak current       | ILEAKH  | -     | 0     | 1     | μA   | VIN = 18V<br>Vsw = 0V     |
| Low side FET Leak current        | ILEAKL  | -     | 0     | 1     | μA   | Vsw = 18V                 |
| High side FET OCP threshold      | ILIMIT1 | -     | 6     | -     | A    |                           |
| Low side FET OCP threshold       | ILIMIT2 | -     | 4     | -     | A    |                           |
| Internal ONTIME                  | TON     | 360   | 440   | 520   | ns   | RT = 51kΩ,<br>FB = 0.6V   |
| MIN OFFTIME                      | TMOFF   | -     | 380   | -     | ns   | VIN=12V                   |
| [Other Blocks]                   |         |       |       |       |      |                           |
| EN input bias current            | IEN     | 30    | 50    | 70    | μA   | VEN = 12V                 |
| EN threshold voltage             | VEN     | 0.4   | 1.2   | 2.0   | V    |                           |
| EN hystersisys voltage           | VENHYS  | -     | 0.2   | -     | V    |                           |
| UVLO disable voltage             | VUVLO   | 3.8   | 4.0   | 4.2   | V    |                           |
| UVLO hystersisys voltage         | VHYS    | -     | 0.2   | -     | V    |                           |
| SS charge current                | ISS     | 8     | 10    | 12    | μA   |                           |
| SS reset voltage                 | VSSL    | -     | 0.3   | -     | V    |                           |
| Protection Latch Timer           | TLATCH  | -     | 27    | -     | μs   |                           |
| SS discharge resistance          | RSS     | -     | 5     | -     | kΩ   |                           |
| Output discharge resistance      | RVOUT   | -     | 1     | -     | kΩ   |                           |
| Circuit Current                  | ICC     | -     | 1.0   | 2     | mA   | VEN= 12V                  |
| Stand by current                 | IQUI    | -     | 15    | 27    | μA   | VEN= 0V                   |

● Typical Performance Curves (Unless otherwise noted  $T_a=25^{\circ}\text{C}$ ,  $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $\text{freq}=400\text{kHz}$ )

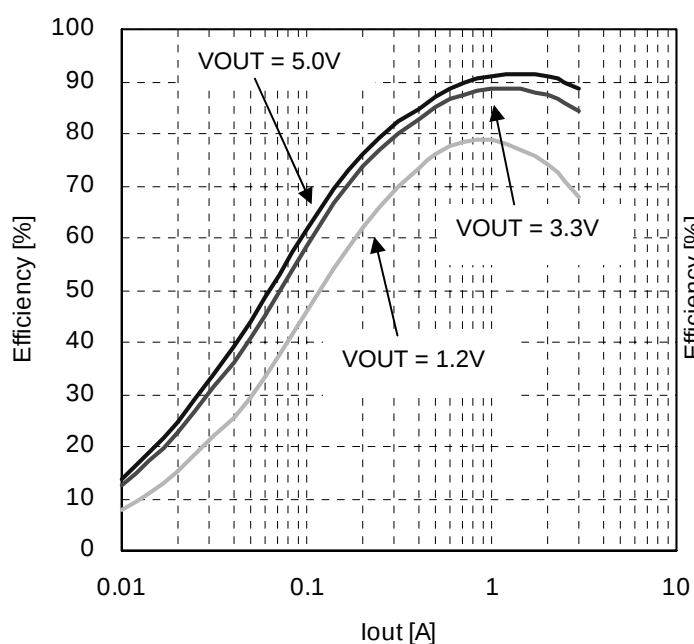


Figure 4. Efficiency 1  
( $V_{\text{IN}}=12\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $400\text{kHz}$ )

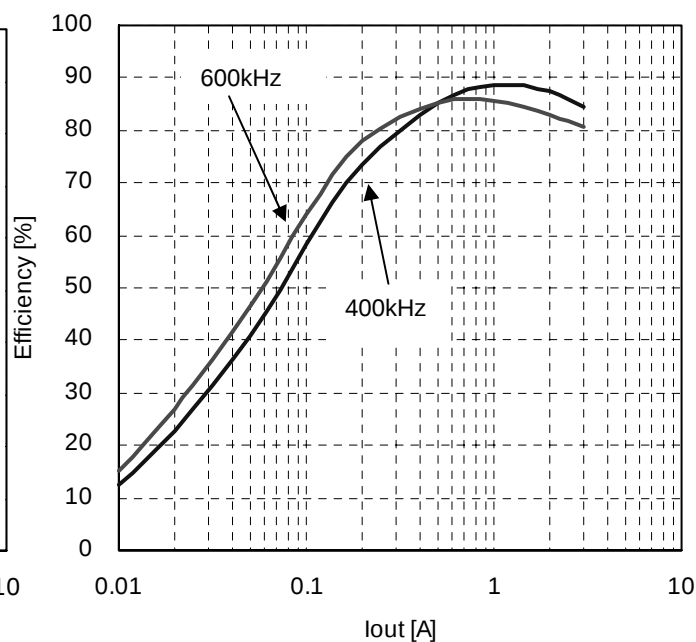


Figure 5. Efficiency 2  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ )

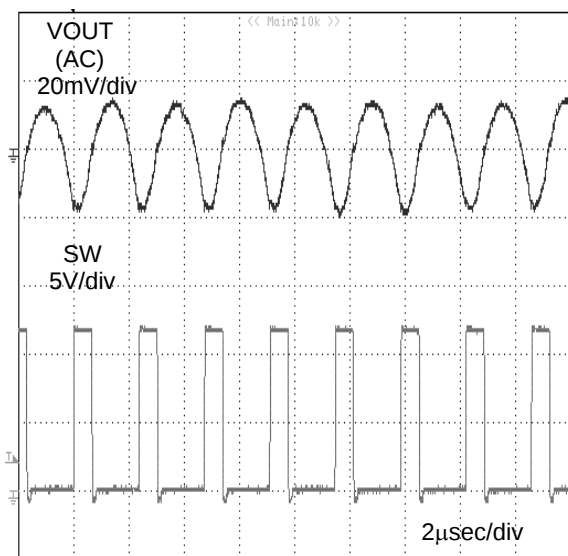


Figure 6. VOUT Ripple voltage  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ ,  $I_{\text{out}}=0\text{A}$ )

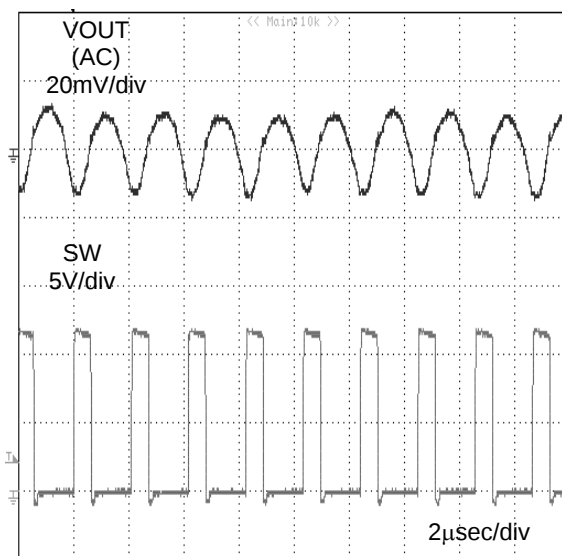


Figure 7. VOUT Ripple voltage  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ ,  $I_{\text{out}}=3\text{A}$ )

● Typical Performance Curves (Unless otherwise noted  $T_a=25^{\circ}\text{C}$ ,  $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $\text{freq}=400\text{kHz}$ ) (Continued)

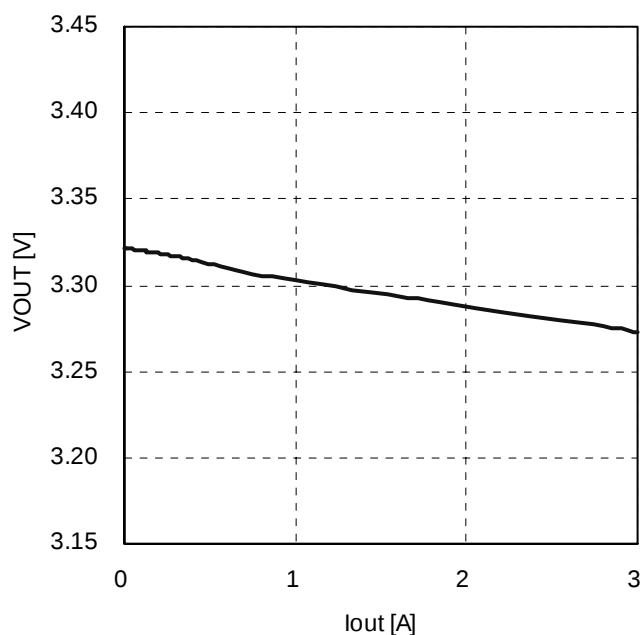


Figure 8. VOUT VOUT Load Regulation  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ )

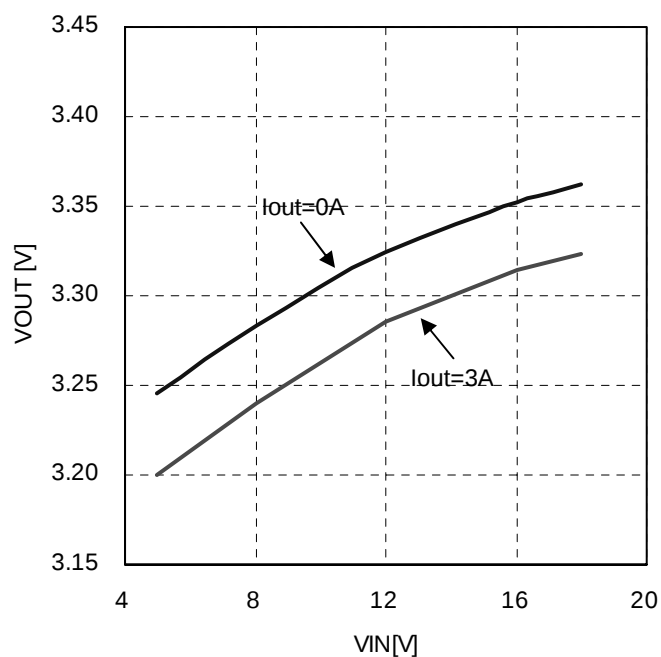


Figure 9. VOUT VOUT Line Regulation  
( $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $I_{\text{out}}=0\text{A} / 3\text{A}$ )

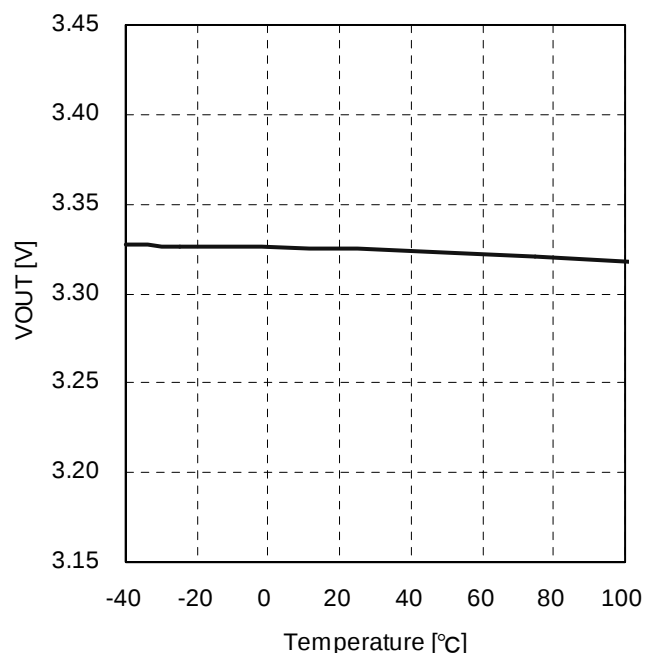


Figure 10. VOUT - Temperature  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $I_{\text{out}}=0\text{A}$ )

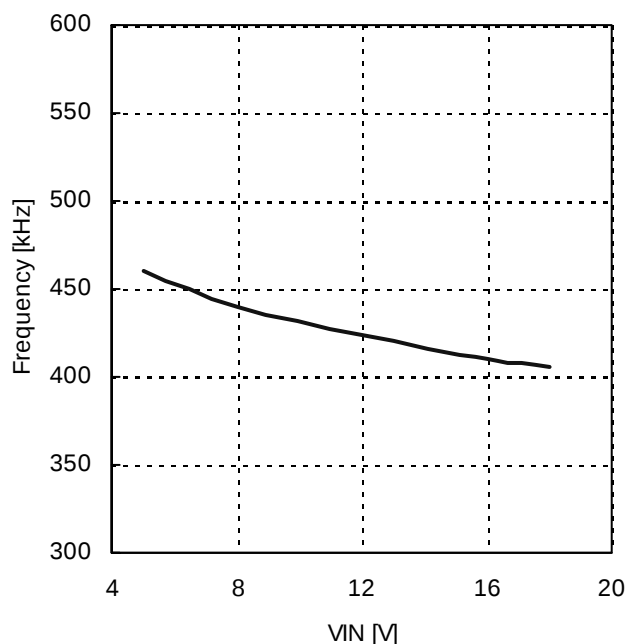


Figure 11. Frequency - VIN  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $I_{\text{out}}=0\text{A}$ )

● Typical Performance Curves (Unless otherwise noted  $T_a=25^{\circ}\text{C}$ ,  $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $\text{freq}=400\text{kHz}$ ) (Continued)

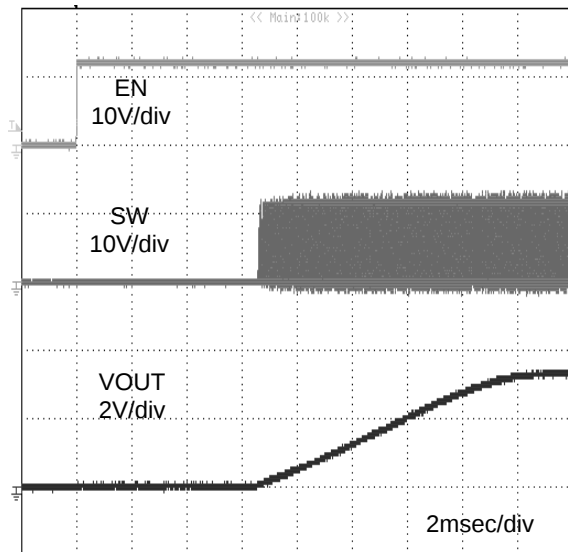


Figure 12. Start up wave form  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ ,  $I_{\text{out}}=0\text{A}$ )

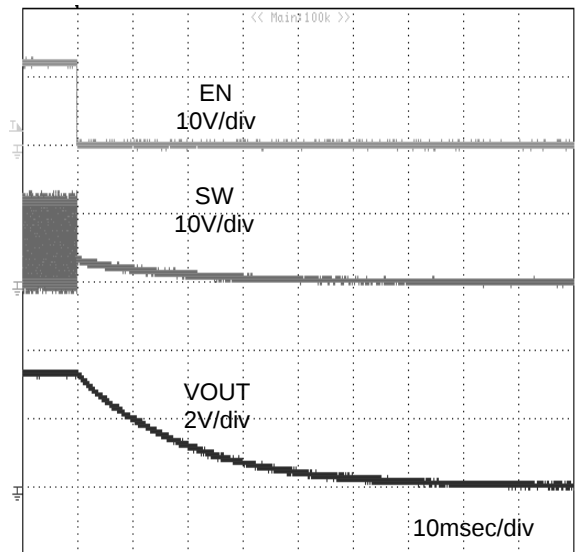


Figure 13. Off wave form  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=3.3\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ ,  $I_{\text{out}}=0\text{A}$ )

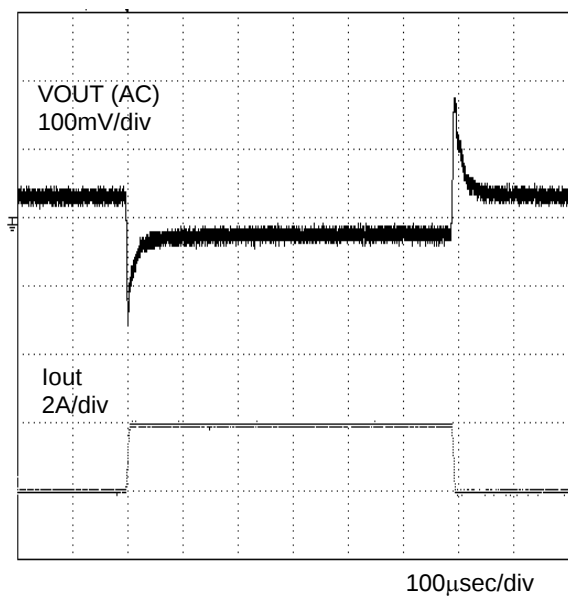


Figure 14. VOUT Transient Response  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ )  
 $I_{\text{out}}=0\Rightarrow 2\text{A}$

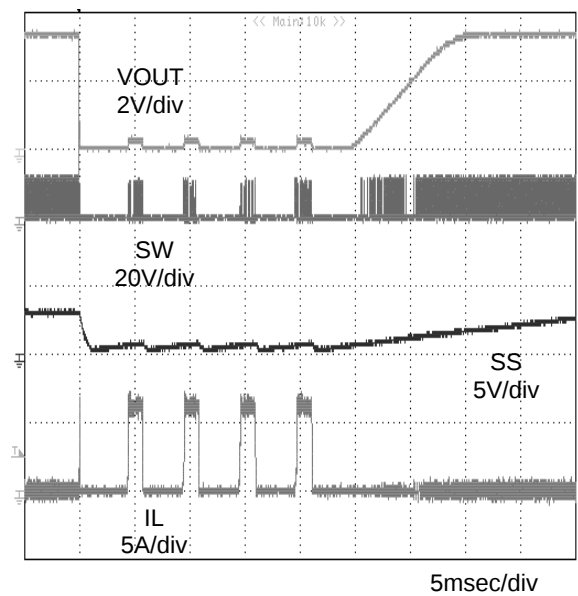


Figure 15. OCP function  
( $V_{\text{IN}}=12\text{V}$ ,  $V_{\text{OUT}}=3.3\text{V}$ ,  $L=4.7\mu\text{H}$ ,  $C_{\text{OUT}}=20\mu\text{F}$ )  
( $V_{\text{OUT}}$  is shorted to GND)

## ●Selection of Components Externally Connected

### 1. Constant ONTIME and operating frequency

ONTIME (Ton) can be determined by VIN input voltage and RT resistor.

$$T_{on} = F_B \times 154\text{pF} \times (1 / V_{IN}) \times (R_T + 5\text{k}\Omega) + 10\text{nsec}$$

$$\text{Freq} = V_{OUT} / V_{IN} \times 1 / T_{on}$$

- FB : FB threshold voltage (0.765V, typ.).
- 154pF, 5kΩ, 10nsec are constant values in the IC.

ONTIME and Frequency are calculated as below when VIN=12V, VOUT=3.3V, RT=62kΩ.

$$T_{on} = 0.750 [\text{V}] \times 154\text{p} [\text{F}] \times (1 / 12 [\text{V}]) \times (62\text{k} [\Omega] + 5\text{k} [\Omega]) + 10\text{n} [\text{sec}]$$

$$= 655\text{n} [\text{sec}]$$

$$\text{Freq} = 3.3 [\text{V}] / 12 [\text{V}] \times 1 / 655\text{n} [\text{sec}]$$

$$= 420\text{k} [\text{Hz}]$$

ONTIME and frequency also depends on other conditions such as output current load.

### 2. Inductor (L) Selection

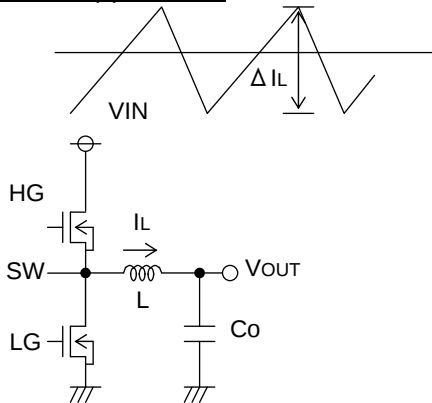


Figure 16. Inductor Ripple Current

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

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

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

$$\Delta I_L = 0.3 \times I_{OUT\text{max}} \quad [\text{A}]$$

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

( $\Delta I_L$ : Inductor 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).

### 3. Output Capacitor (C<sub>OUT</sub>) Selection

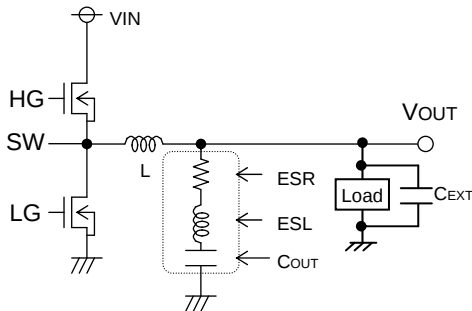


Figure 17. Output Capacitor

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 below.

$$\Delta V_{OUT} = \Delta I_L / (8 \times C_{OUT} \times f) + ESR \times \Delta I_L + ESL \times \Delta I_L / T_{ON}$$

(ESR: Equivalent series resistance, ESL: Equivalent series inductance)

Also, give consideration to the conditions in formula 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 23). Please set the over current detection value with regards to these capacitance.

$$C_O + C_{EXT} \leq \frac{T_{SS} \times (\text{Limit} - I_{OUT})}{V_{OUT}}$$

Limit: OCP current limit

I<sub>OUT</sub>: Output current

T<sub>SS</sub>: soft start time

Note: an improper output capacitor may cause startup malfunctions.

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

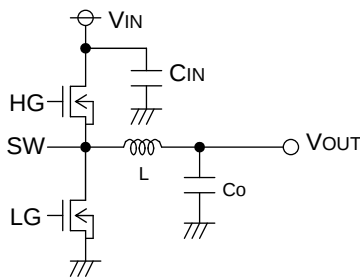


Figure 18. Input Capacitor

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 as below.

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

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

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

### 5. Output Voltage Setting

In the case of ceramic capacitors with small ESR, the FB ripple is very small. So it needs external ripples to stabilize the system. The FB voltage ramp is expected around 50mV. The external ramp is generated through the circuit as follows.

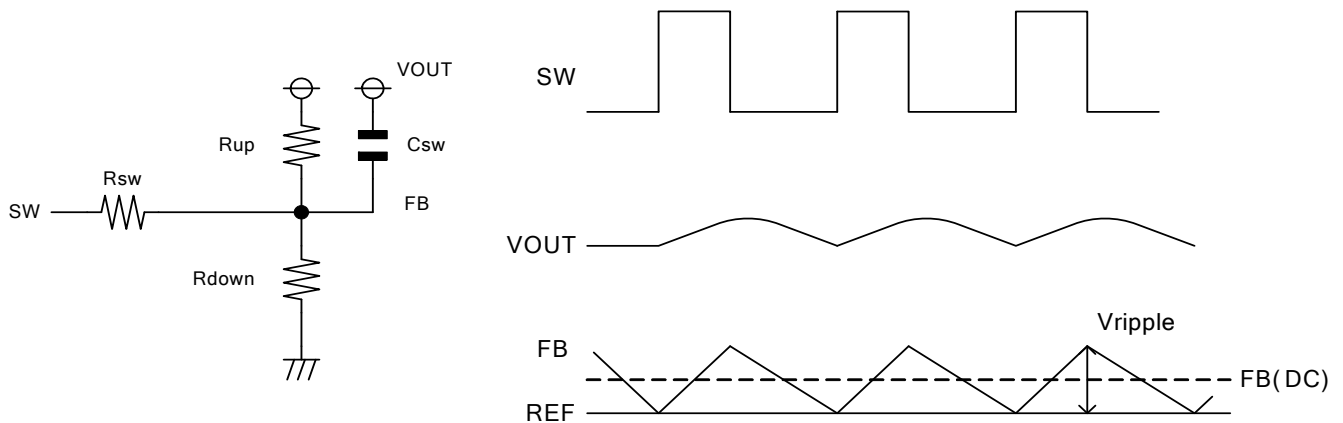


Figure 19. Ripple Injection Circuit

The FB ramp follows:

$$V_{\text{ripple}} = (V_{\text{IN}} - V_{\text{OUT}}) \times T_{\text{on}} / (C_{\text{sw}} R_{\text{sw}}) \quad (T < C_{\text{sw}} R_{\text{up}} // R_{\text{down}} \ll C_{\text{sw}} R_{\text{sw}})$$

So, average FB voltage follows:

$$FB(\text{DC}) = 0.75V + V_{\text{ripple}}/2$$

Periodically averaged, SW voltage is equal to VOUT. So output voltage VOUT follows:

$$V_{\text{OUT}} = FB(\text{DC}) \times \{1 + R_{\text{up}} // R_{\text{sw}} / R_{\text{down}}\}.$$

In case of output capacitor with large ESR, no external ramp circuit is needed. VOUT follows:

$$V_{\text{OUT}} = FB(\text{DC}) \times \{1 + R_{\text{up}} / R_{\text{down}}\}$$

### 6. Soft start time

Soft start delay  $T_d$ , Soft start time  $T_{ss}$  determines as follows:

$$T_d = C_{ss} \times V_{th} / I_{ss} \text{ [sec]}$$

$$T_{ss} = C_{ss} \times V_{REF} / I_{ss} \text{ [sec]}$$

$C_{ss}$  : SS pin external capacitor

$V_{th}$  : Internal MOS  $V_{th}$  typ 0.7V

$V_{REF}$  : reference voltage typ. 0.75V

$I_{ss}$  : SS charge current typ. 10uA

Rush current is determined as follows:

$$I_{IN} = C_{OUT} \times V_{OUT} / T_{ss} \text{ [A]}$$

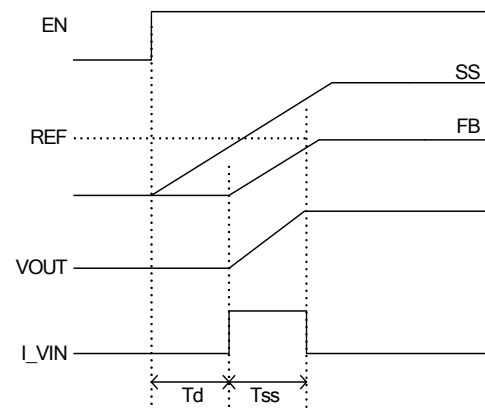


Figure 20. Soft start Timing Chart

When  $EN=L$ , UVLO, TSD operates, SS is discharged.

In case of Self-resume type, SS is also discharged after 30us latch off delay detecting OVP or SCP.

(SS discharge resistance :  $R_{ss} = 5k\Omega$  typ)

## ●Operation Description

### 1. Load transient operation

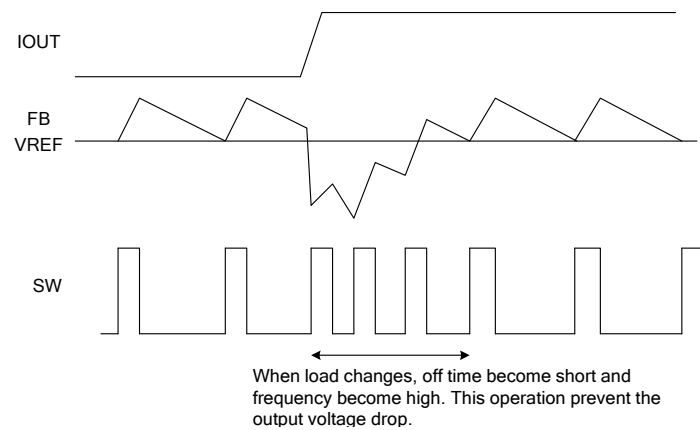


Figure 22. Load transient operation

When FB bellows REF voltage, SW goes high for constant ONTIME.

When load changes fast, short SW=L time cause high frequency and small VOUT drop.

SW=L time is normally limited by MIN\_OFFTIME depending on VIN voltage.

External ramp circuit influence Load response characteristics.

### 2. High-side FET OCP function

When high-side FET current exceeds OCP limit, high-side FET is off. SW=L time is normally limited by MIN OFFTIME, but is limited by 10 times MIN OFFTIME after OCP detected. This operation decrease coil current,

### 3. Low-side FET OCP function

When low-side FET current from SW to GND exceeds OCP limit, low-side FET is off.

### 4. SCP function

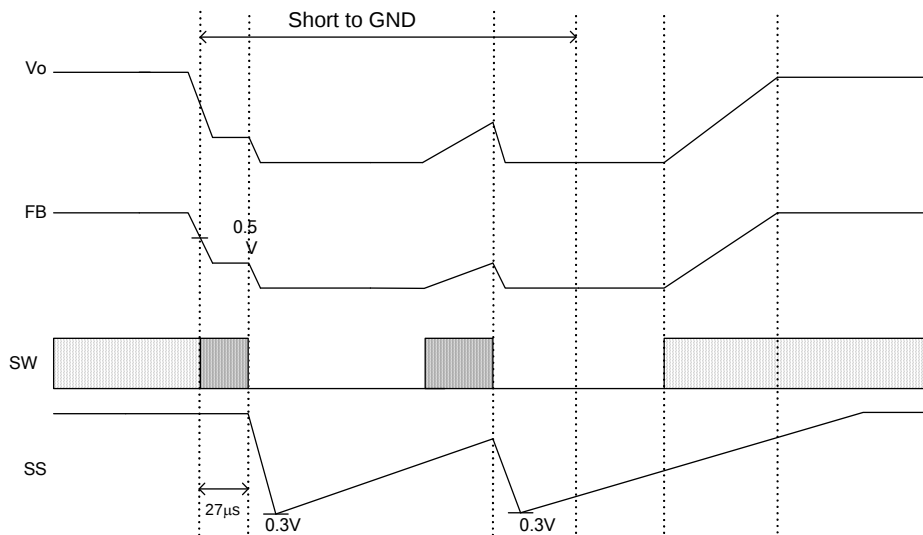


Figure 22. SCP Timing Chart

SCP monitors FB voltage. When FB falls below 0.5V, 27µs later, SW=HiZ and SS is discharged  
When SS<0.3V, the IC is reset and restart.

### 5. OVP function

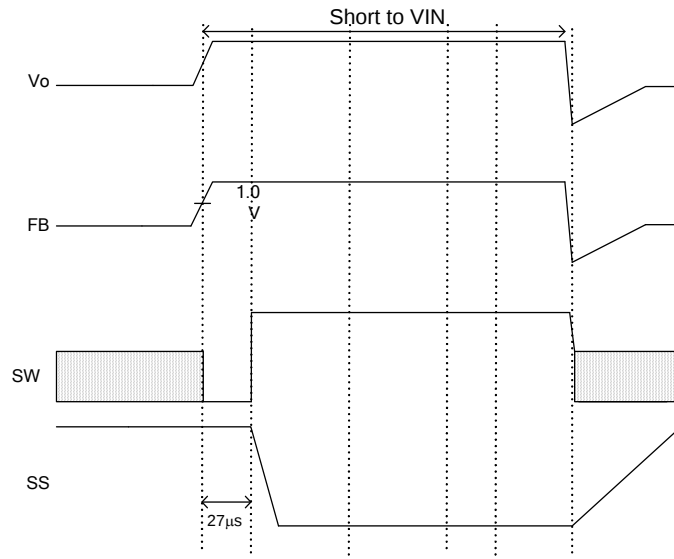


Figure 23. OVP Timing Chart

SCP monitors FB voltage. When FB exceeds 1.0V, 27µs later, SW=HiZ and SS is discharged. When SS<0.3V, the IC is reset and restart.

### 6. TSD Operation (Self Recovery)

If the junction temperature exceeds  $T_j = 175^{\circ}\text{C}$ , SW=HiZ and SS is discharged. When  $T_j$  falls below  $160^{\circ}\text{C}$ , it returns to standard operation.

### 7. UVLO Operation

When VCC falls below 3.8V, UVLO operates. SW=HiZ and SS is discharged. UVLO is released when VCC goes up to 4.0V, and starts normal operation.

### ●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 (PGND) plain.

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

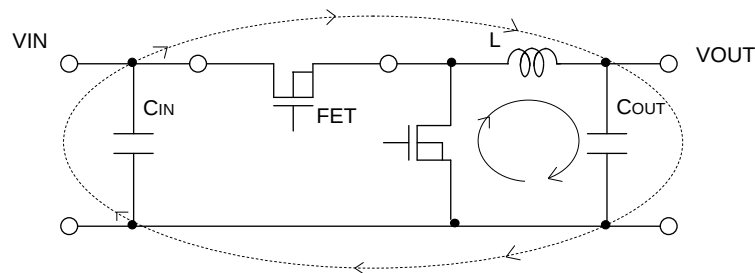


Figure 24. Current loop Buck regulator system

- 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 should be connected to PGND as close as possible to the VIN terminal.
- The inductor and the output capacitors should be placed close to SW pin as much as possible.

## ●Evaluation Board Circuit

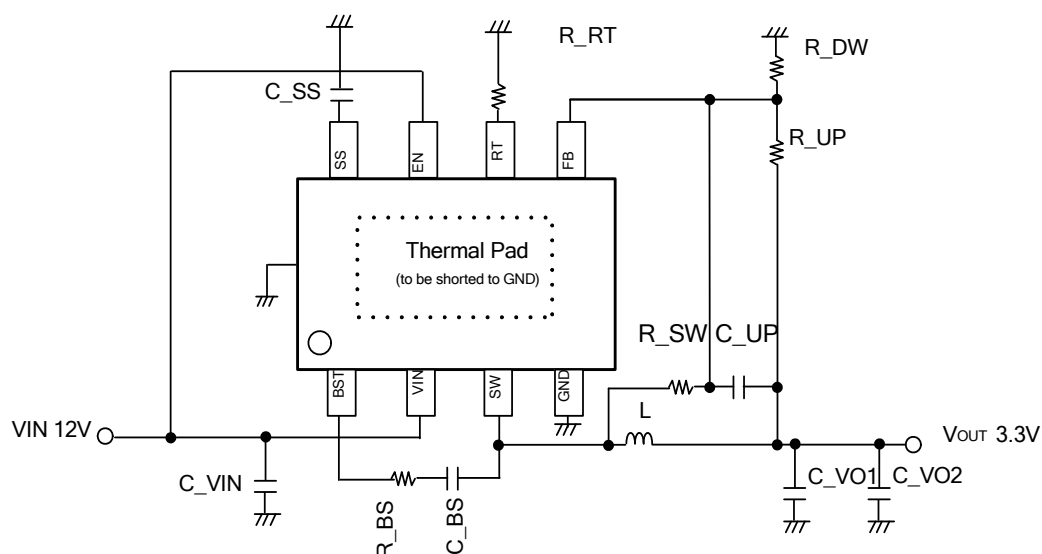


Figure 25. Typical Application Circuit

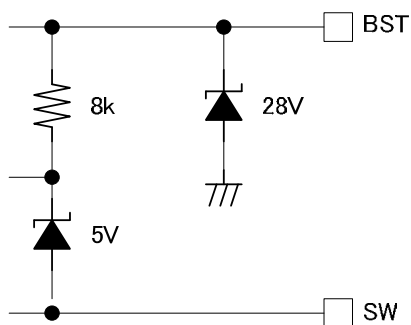
## • Recommended Components List (VIN=12V, VOUT=3.3V, Freq=420kHz)

| Symbol | Part              | Value       | Manufacture | Series           |
|--------|-------------------|-------------|-------------|------------------|
| L      | Coil              | 4.7μH       | TOKO        | FDVC0630-4R7M    |
|        |                   |             | TDK         | SPM6530-4R7M     |
| C_VIN  | Ceramic capacitor | 10μF / 25V  | Murata      | GRM31CR71E16KA12 |
| C_VO1  | Ceramic capacitor | 10μF / 25V  | Murata      | GRM31CR71E16KA12 |
| C_VO2  | Ceramic capacitor | 10μF / 25V  | Murata      | GRM31CR71E16KA12 |
| C_BS   | Ceramic capacitor | 0.1μF / 50V | Murata      | GRM18 Series     |
| R_BS   | Resistance        | 82 Ω        | Rohm        | MCR03 Series     |
| C_SS   | Ceramic capacitor | 0.1μF / 50V | Murata      | GRM18 Series     |
| R_RT   | Resistance        | 62k Ω       | Rohm        | GRM18 Series     |
| R_UP   | Resistance        | 36k Ω       | Rohm        | GRM18 Series     |
| R_DW   | Resistance        | 10k Ω       | Rohm        | MCR03 Series     |
| R_SW   | Resistance        | 360k Ω      | Rohm        | MCR03 Series     |
| C_UP   | Ceramic capacitor | 390pF / 50V | Rohm        | GRM18 Series     |

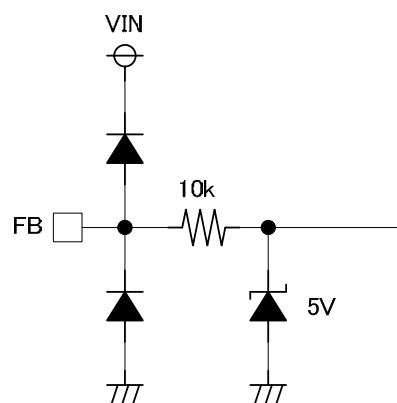
※The above components list is an example. Please check actual circuit characteristics on the application carefully before use.

## ● I/O Equivalence circuit

1. BST

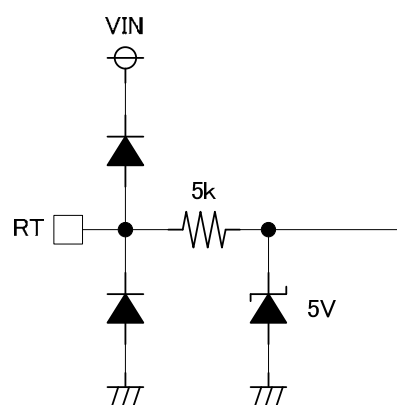


5. FB

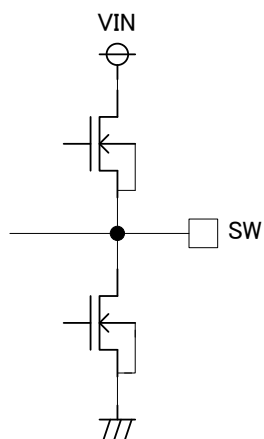


2. VIN

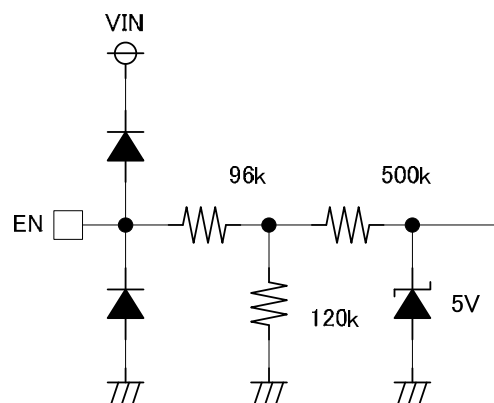
6. RT



3. SW

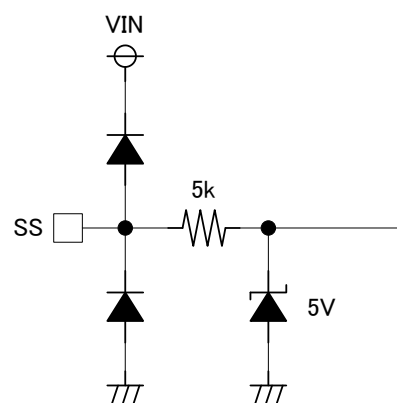


7. EN



4. GND

8. SS



## ●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, PGND 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.

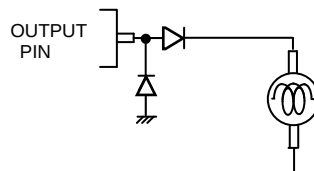


Figure 26. Back Electromotive Force

- (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.

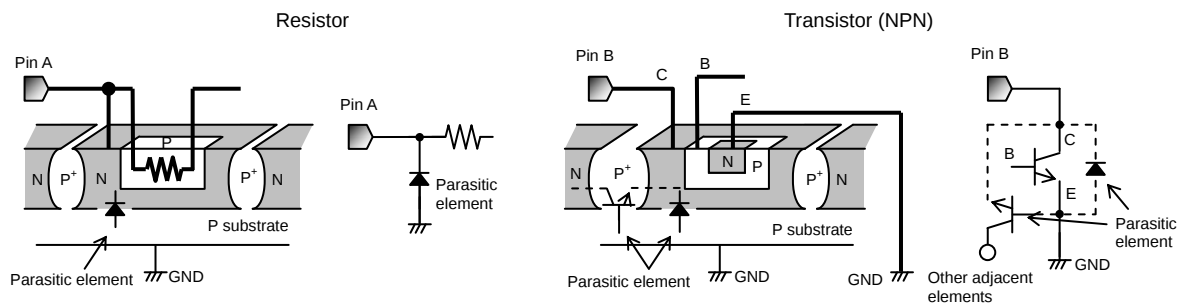


Figure 27. Example of IC structure

## (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

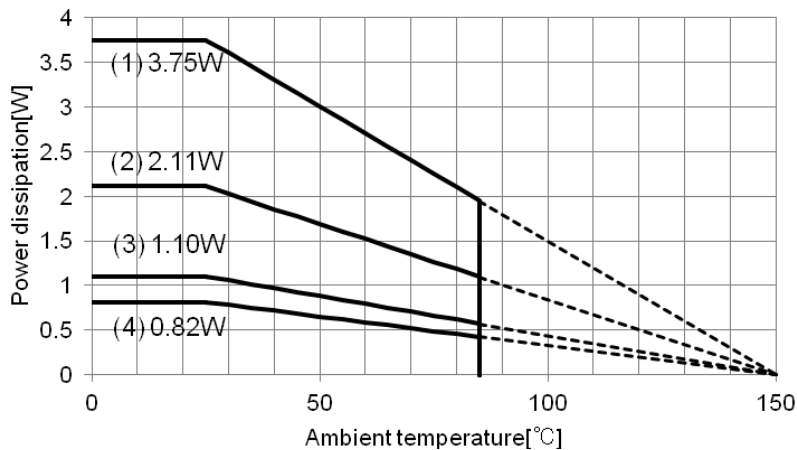
The IC incorporates a built-in thermal shutdown circuit, which is designed to turn the IC off completely in the event of thermal overload. It is not designed to protect the IC from damage or guarantee its operation. ICs should not be used after this function has activated, or in applications where the 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                     | 15                         |

## (15) Heat Sink (FIN)

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

## ● Thermal Derating Curves



## HTSOP-J8 Package

On 70 × 70 × 1.6 mm glass epoxy PCB

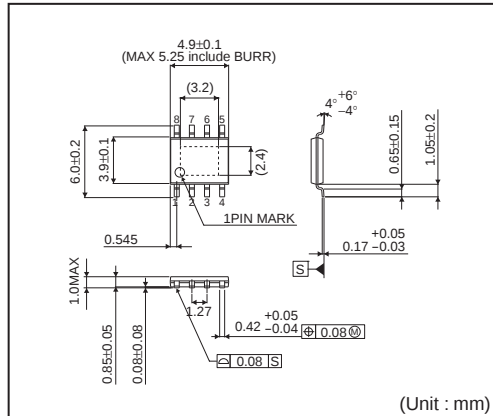
- (1) 4-layer board (Backside copper foil area 70 mm × 70 mm)
- (2) 2-layer board (Backside copper foil area 70 mm × 70 mm)
- (3) 2-layer board (Backside copper foil area 15 mm × 15 mm)
- (4) 1-layer board (Backside copper foil area 0 mm × 0 mm)

## ●Ordering Information

Diagram illustrating the breakdown of the part number **EFJ8359DBE2** into its components:

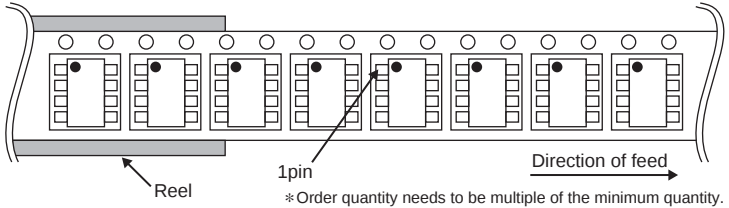
- Part Number:** B D 9 5 8 3 5 E F J
- Package:** EFJ: HTSOP-J8
- Packaging and forming specification:** E2: Embossed tape and reel

## ●Physical Dimension Tape and Reel Information

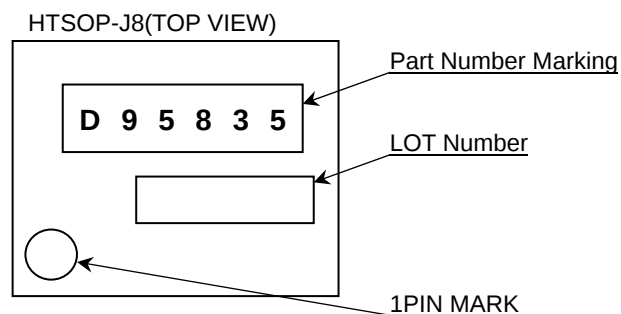
**HTSOP-J8**

<Tape and Reel information>

|                   |                                                                                                                                                     |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Tape              | Embossed carrier tape                                                                                                                               |
| Quantity          | 2500pcs                                                                                                                                             |
| Direction of feed | E2<br>( The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand ) |



### ● Marking Diagram



## ●Revision History

| Date        | Revision | Changes                                                                                                                                                                                                                                                            |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 31.Aug.2012 | 001      | New Release                                                                                                                                                                                                                                                        |
| 14.Feb.2013 | 002      | 2/19 page Block Diagram (7.SS→8.SS、 4.GND added)<br>2/19 page Pin Description (BOOT→BST)<br>3/19 page Operating Ratings (VIN min. 4.2V→4.5V same as 1/19 page)<br>4/19 page Electrical Characteristics (BOOT→BST)<br>15/19 page I/O Equivalence circuit (BOOT→BST) |
| 08.Apr.2013 | 003      | 8/20 page Constant ON time and operating frequency<br>(Revised the description and calculation formula)                                                                                                                                                            |
| 29.May.2013 | 004      | 1/20 page Output Voltage Range (Revised the description)<br>3/20 page Output Voltage Range (Revised the description)                                                                                                                                               |

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(Note1) Medical Equipment Classification of the Specific Applications

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|-----------|-----------|------------|-----------|
| 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.
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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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- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

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- In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

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  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
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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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