6V to 20V, 1A 1ch
PWM Buck Converter Integrated FET

BD9227F

General Description

The BD9227F is a 20V, 1A non-synchronous PWM duty control buck converter with integrated internal high-side 20V Power MOSFET. Operating frequency is 1.0MHz fixed by inner circuit. Current mode control with internal slope compensation simplifies the external compensation calculation and reduces component count while allowing the use of ceramic output capacitors. Additional protection features are included such as Over Current Protection, Thermal Shutdown and Under Voltage Lockout. The under voltage lockout and hysteresis can be set by external resistor. The BD9227F is available in SOP8.

Features

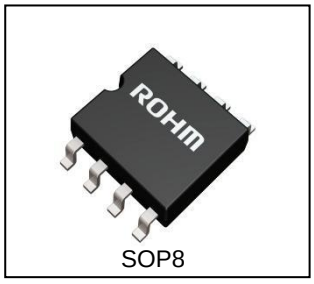
- Wide Operating Input Range 6V to 20V
- 20V/200mΩ Internal Power MOSFET
- 1.0MHz Fixed Operating Frequency
- Current Mode
- Over Current Hiccup Period Protection
- Under Voltage Locked Out(UVLO), Over Voltage Protection(OVP), Thermal Shut Down(TSD)
- Available in SOP8 Package.

Key Specifications

- Input Voltage Range: 6V to 20 V
- Ref. Precision: PWM=H: ±2.0 %(±1.0 %@Ta=25°C)
- Max Output Current: 1A (Max.)
- Switching Frequency: 1.0MHz (Typ.)
- Operating Temperature Range: -40℃ to +85°C

Packages

	W(Typ) x D(Typ) x H(Max)
SOP8	5.00mm x 6.20mm x 1.71mm



SOP8

Applications

- Home Appliance
- VM Motor

Typical Application Circuits

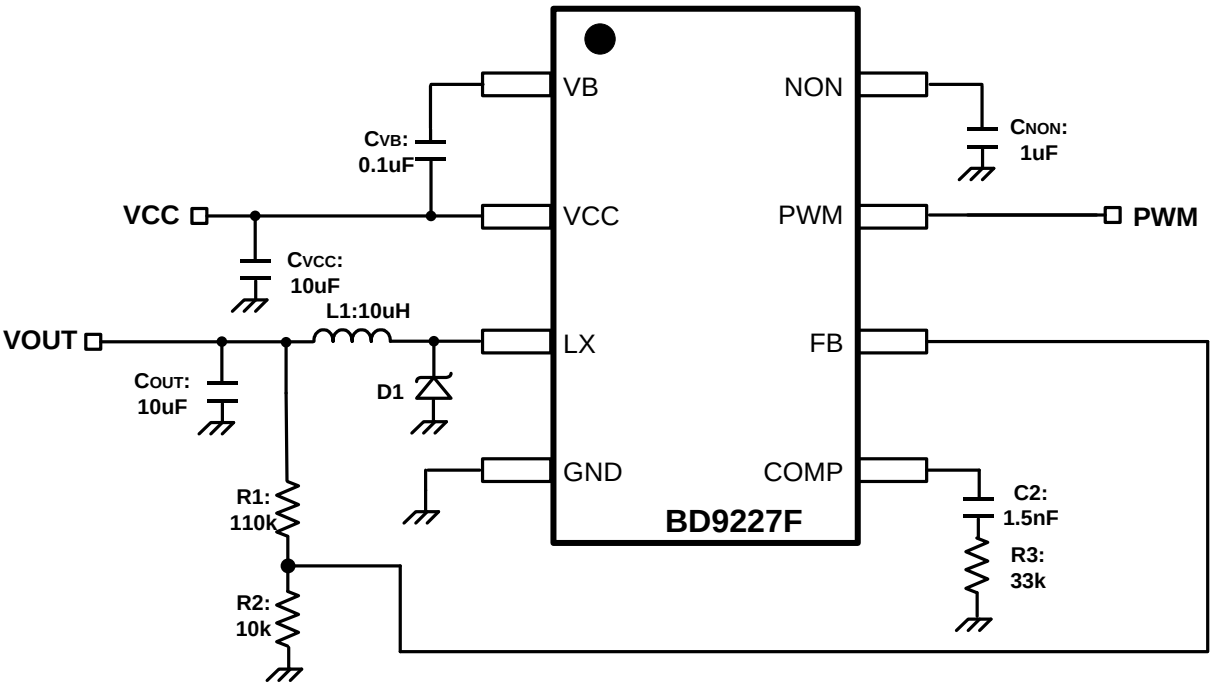


Figure 1. Typical Application Circuit

Pin Configuration

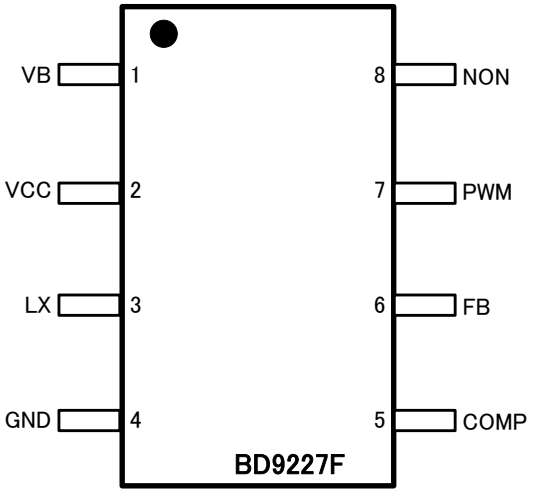


Figure 2. Pin Configuration (TOP VIEW)

Pin Description

Pin No.	Pin Name	Function
1	VB	Inner voltage regulator output power supply
2	VCC	Power supply
3	LX	Switch pin of PWM buck
4	GND	Ground
5	COMP	Compensation node
6	FB	Feedback signal
7	PWM	PWM input signal
8	NON	Inner DC ref voltage

Block Diagram

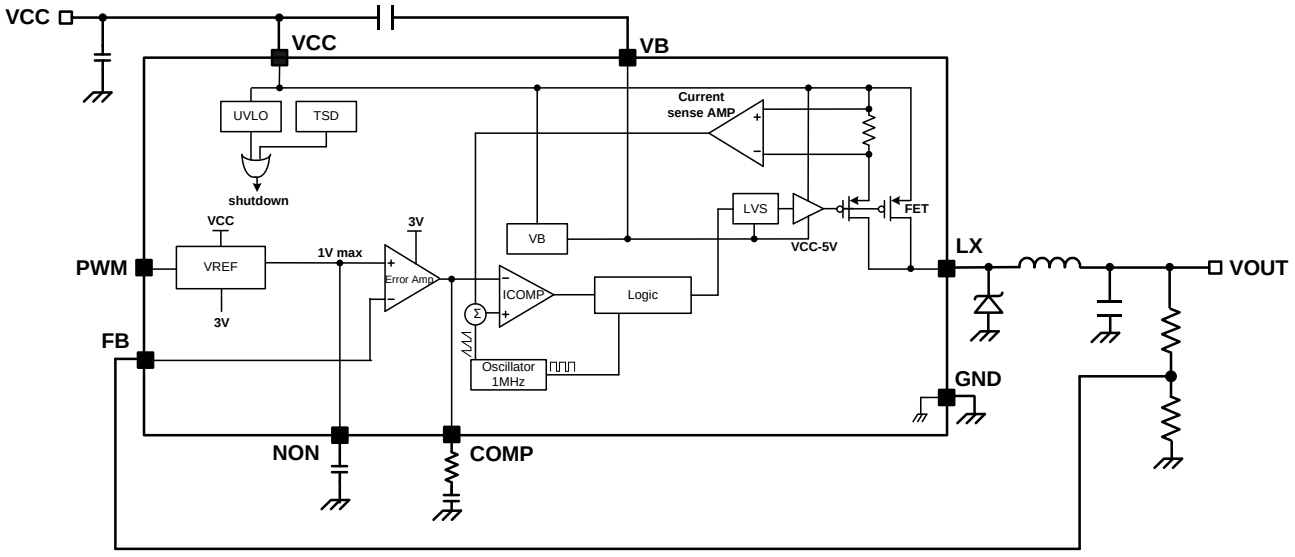


Figure 3. Block Diagram

Description of Blocks

1. VREF
   This block generates reference voltage and current. It starts operation when VCC rise up.
   It provides reference voltage and current to Error AMP, Oscillator, and etc.

2. VB
   This is a gate drive voltage generator and VCC-5.0V regulator for internal circuit voltage.

3. Oscillator
   This is a precise wave oscillation circuit with operation frequency fixed to 1.0MHz.

4. Error AMP
   This is an error amplifier which detects output signal, and outputs PWM control signal.
   Internal reference voltage is set by PWM input signal. Also, the BD9227F have current mode control with internal slope compensation simplifies the external compensation calculation and reduces component count while allowing the use of ceramic output capacitors.

5. ICOMP
   This is a comparator that outputs PWM signal from current feed-back signal and error-amp output for current-mode.

6. Pch FET SW
   This is a 20V/200mΩ Power Pch MOSFET SW that converts inductor current of DC/DC converter.

7. UVLO
   This is a low voltage error prevention circuit.
   This prevents internal circuit error during increase of power supply voltage and during decline of power supply voltage.
   It monitors VCC pin voltage and internal REG voltage, and when VCC voltage becomes 5.3V and below, it turns OFF all output FET and DC/DC converter's output, and Soft Start circuit resets.
   Now this threshold has hysteresis of 200mV(Typ).

8. TSD
   The current of power MOSFET is limited by this function.
   When it detects an abnormal temperature exceeding Tj=175°C, it turns OFF DC/DC Converter Output. The threshold of TSD has Hysteresis (25°C). If temperature falls below 150°C, the IC automatically returns.

9. OVP
   Over Voltage Protection.
   Output voltage is monitored with FB terminal, and output FET is turned off when it becomes VNON+200mV.

10. OCP
    This is a circuit to protect the high-side FET from over-current. Every cycle the switch current and the reference voltage of over-current protection are compared; when the peak inductor current continuously intersects the reference voltage, the high-side switch is turned off. Once 2 times continuous over current is detected, the device will stop and COMP/NON pin voltage will be reset(to GND) and after 8.191ms the device restart. (refer to Page.7 Figure 5)

11. PWM
    The PWM pin is the input pin to control active or inactive of the BD9227F and the PWM input pulse determines the OUTPUT voltage (refer to Page.15 (3) Output Voltage Setting).
    Once the pulse is input on the PWM pin, the internal enable signal turns on then the internal regulator turns on. After the each regulator operates, the BD9227F starts switching. When the low period of the PWM pulse is longer than 2.047msec (typ), the BD9227F stops operation (refer to Page.7 Figure 4).

Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
VCC to GND	V_{CC}	-0.3 to +22	V
VB to GND	V_B	-0.3 to +22	V
LX to GND	V_{LX}	-2.0 to +22	V
VCC to LX	ΔV_{LX}	-0.3 to +22	V
VCC to VB	ΔV_B	-0.3 to +7	V
COMP to GND	V_{COMP}	-0.3 to +7	V
NON to GND	V_{NON}	-0.3 to +7	V
FB to GND	V_{FB}	-0.3 to +7	V
PWM to GND	V_{PWM}	-0.3 to +7	V
High-Side FET Drain Current	I_{DH}	OCP	A
Power Dissipation	Pd	0.633(Note 1)	W
Operating Temperature	Topr	-40 to +85	°C
Storage Temperature	Tstg	-55 to +150	°C
Junction Temperature	Tjmax	150	°C

(Note 1) During mounting of 114.3×76.2×1.57[t] mm 1layer board.Reduce by 5.07mW for every 1℃ increase. (Above 25℃)

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Thermal Resistance*(Note 1)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s*(Note 3)*	2s2p*(Note 4)*	
SOP8				
Junction to Ambient	θ_{JA}	197.4	109.8	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	21	19	°C/W

(Note 1) Based on JESD51-2A(Still-Air)

(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note3) Using a PCB board based on JESD51-3

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3mm x 76.2mm x 1.57mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70µm

(Note 4) Using a PCB board based on JESD51-7

Layer Number of Measurement Board	Material	Board Size	Thermal Via*(Note 5)*	
			Pitch	Diameter
4 Layers	FR-4	114.3mm x 76.2mm x 1.6mmt	1.20mm	Φ0.30mm

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70µm	74.2mm x 74.2mm	35µm	74.2mm x 74.2mm	70µm

(Note 5) This thermal via connects with the copper pattern of all layers

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Input Voltage	V_{CC}	6	-	20	V
Output Voltage	V_{OUT} (Note1)	VCC x 0.252	-	VCC	V
Output Current	I_{OUT}	-	-	1	A
NON Input Voltage	V_{NON}	-	-	1	V
PWM Input Voltage	V_{PWM}	-	-	5.5	V
PWM Input Frequency	F_{PWM}	1	-	50	kHz
Input Capacitor	C_{VCC} (Note2)	4.7	10	-	μF
Inner Regulator Capacitor	C_{VB} (Note3)	0.047	0.1	0.22	μF
Inductor	L (Note4)	4.7	10	-	μH
Output Capacitor	C_{OUT} (Note5)	4.7	10	-	μF
Ref Voltage Capacitor	C_{NON} (Note6)	-	1	-	μF

Please select each capacitor considering the effect of DC bias and temperature coefficient to satisfy the specification.

(Note1) Refer to P.18(10)
(Note2) Refer to P.15 (6)
(Note3) Refer to P.15 (4)
(Note4) Refer to P.14 (1)
(Note5) Refer to P.15 (2)
(Note6) Refer to P.16 (7)

Electrical Characteristics (Unless otherwise specified Ta=25℃, VCC=16.0V, VOUT=12.0V, PWM=H)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Circuit Current						
Operating Non-Switching Supply Current	I_{CC}	-	0.4	1.0	mA	PWM=H, FB=3V (Non-switching)
Standby Quiescent Current	I_{ST}	-	0.05	0.2	mA	PWM=L
Under Voltage Lockout						
Detect Threshold Voltage	V_{UV}	5.0	5.3	5.6	V	VCC falling
Hysteresis Width	V_{UVHY}	-	200	400	mV	
Oscillator						
Oscillating Frequency	F_{SW}	0.80	1.00	1.20	MHz	
Error Amplifier						
FB Pin Reference Voltage	V_{FBN}	0.990	1.000	1.010	V	PWM=H, Ta=25°C
	V_{FBA}	0.980	1.000	1.020	V	PWM=H, Ta=-40 to +85°C
FB Pin Bias Current	I_{FB}	-1.0	0	1.0	μA	VFB = 0 V
NON Inner R	R_{NON}	100	250	400	kΩ	
ICOMP Sink Current	IVC_{SI}	7.5	15	30	μA	COMP=1V, NON=1V, FB=2V
ICOMP Source Current	IVC_{SO}	-30	-15	-7.5	μA	COMP=1V, NON=1V, FB=0V
Error Amplifier Transconductance	G_m	50	115	180	μA/V	ICOMP= ± 3μA, NON=1V, COMP=1V
Switch Current to COMP Transconductance	G_{CS}	-	2.2	5	A/V	VCC=16V
High-Side MOSFET						
On Resistance	R_{ONH}	-	200	-	mΩ	
VB Clamp Voltage	V_B	VCC-5.5	VCC-5	VCC-4.5	V	
Over Current Detect Current	I_{OCP}	1.6	2.6	4.2	A	
PWM						
PWM Logic High Level	V_{PWMH}	1.5	-	5.5	V	
PWM Logic Low Level	V_{PWML}	-	-	0.5	V	
PWM Internal Pull-Down Resistor	R_{PWM}	200	500	800	kΩ	

Timing Chart

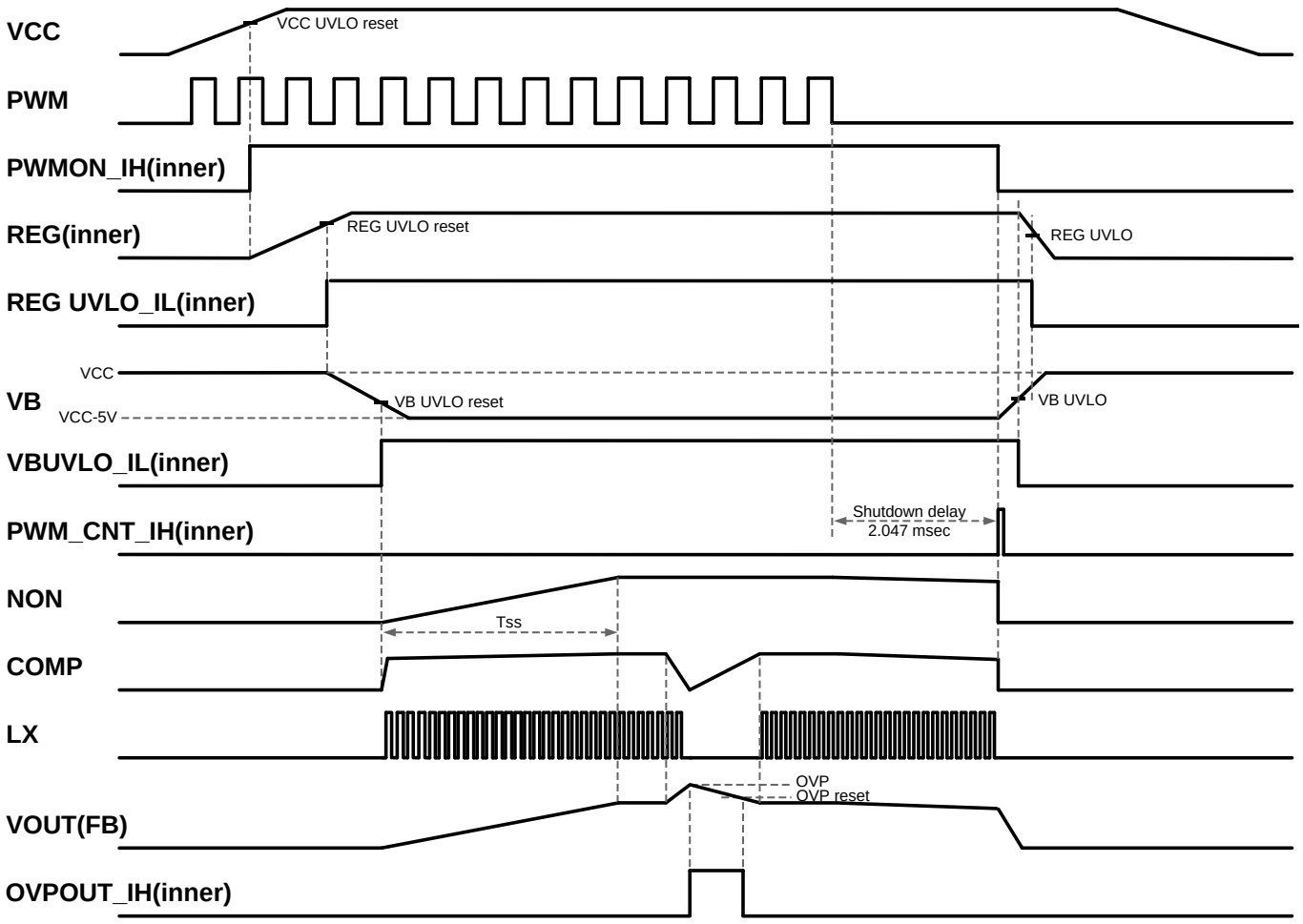


Figure 4. Startup/Shutdown Timing Chart

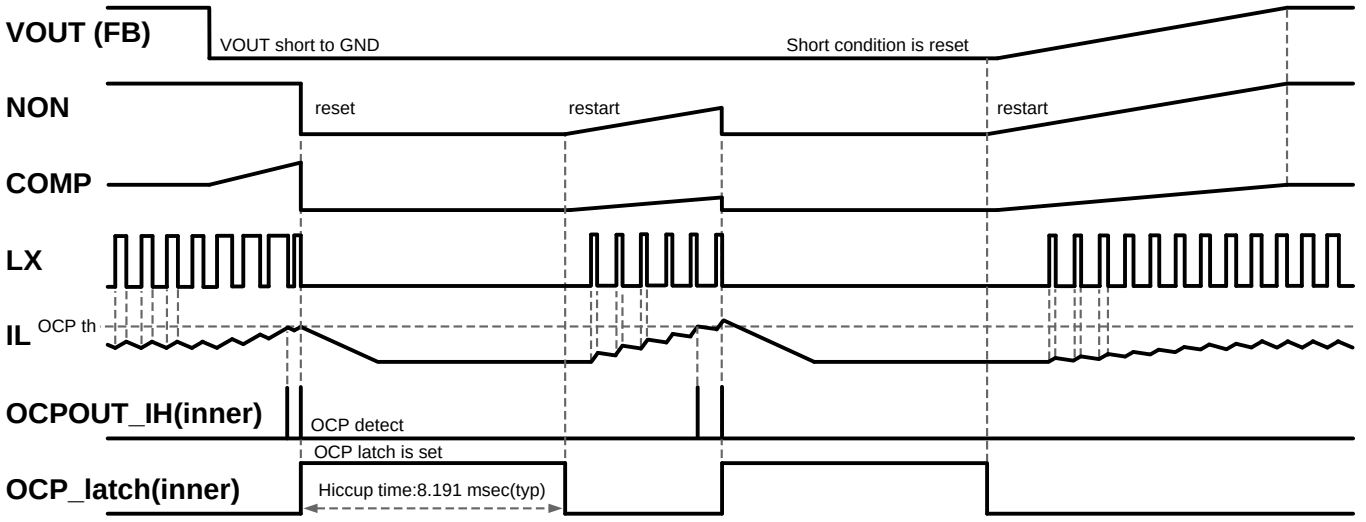


Figure 5. OCP Timing Chart

Typical Performance Characteristics (Unless otherwise specified, Ta=25°C, V_{CC}=16V, V_{OUT}=12V, PWM=3V)

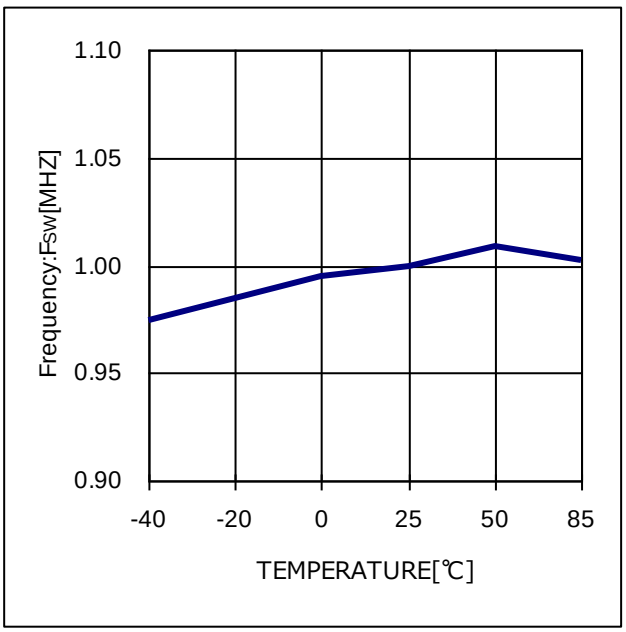


Figure 6. Frequency - Temperature

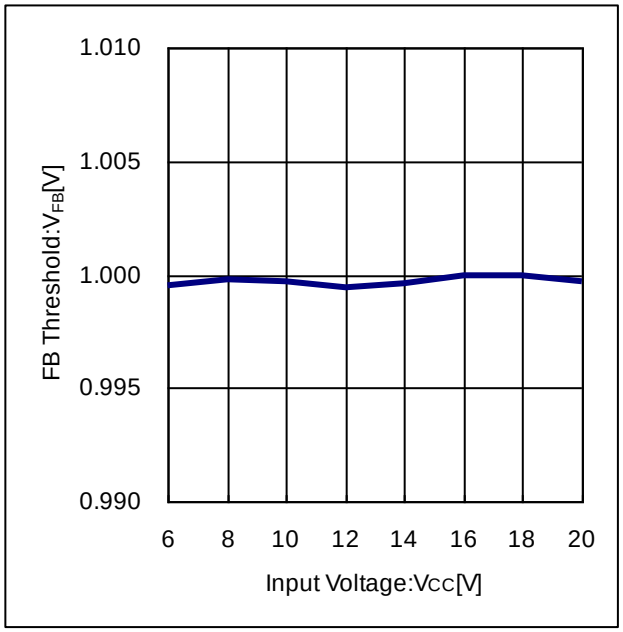


Figure 7. FB Threshold Voltage – Input Voltage

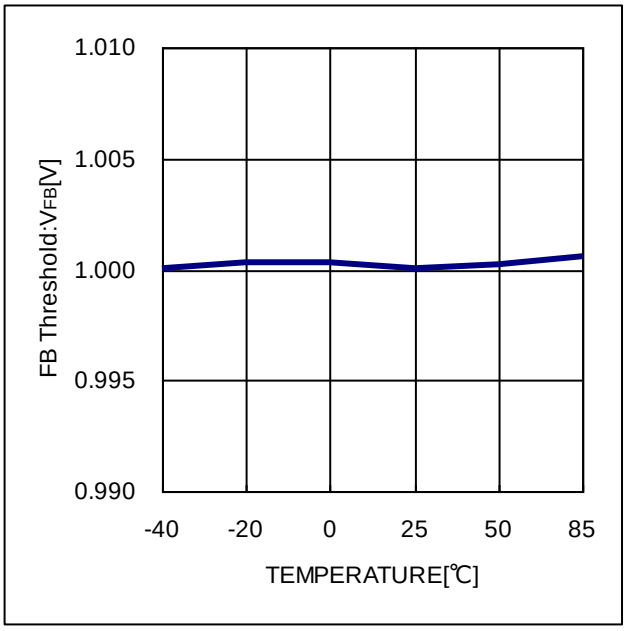


Figure 8. FB Threshold Voltage - Temperature

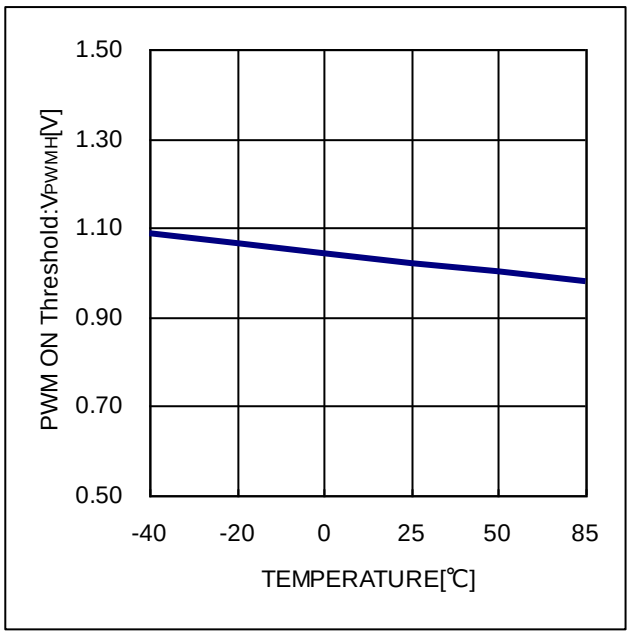


Figure 9. PWM Pin Inner REG ON Threshold - Temperature

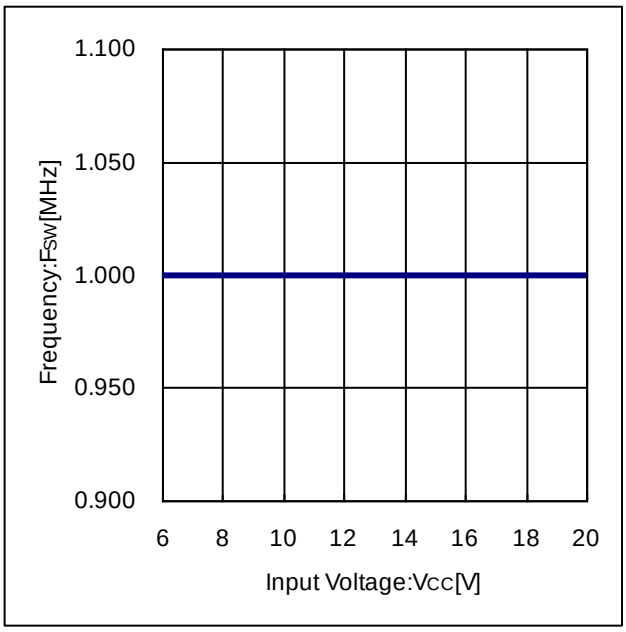


Figure 10. Frequency – Input Voltage

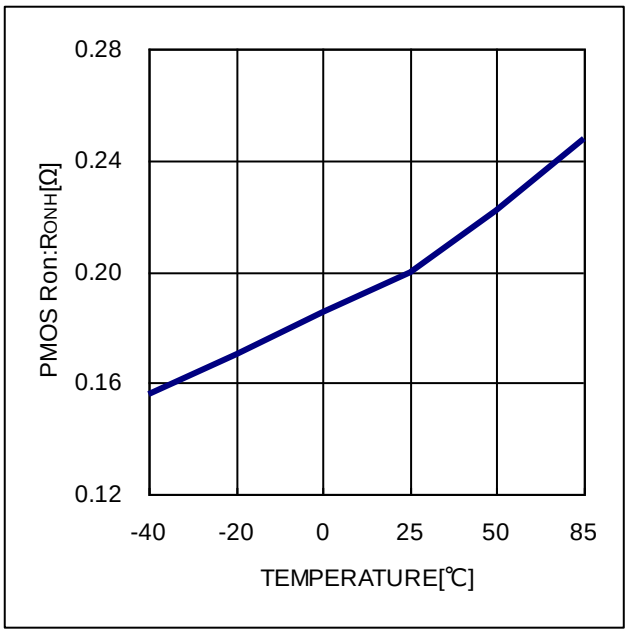


Figure 11. PMOS ON Resistance - Temperature

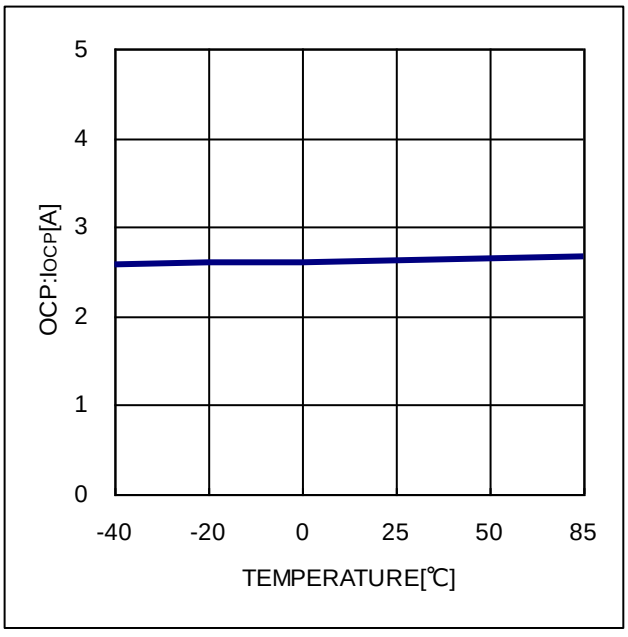


Figure 12. OCP Detect Current - Temperature

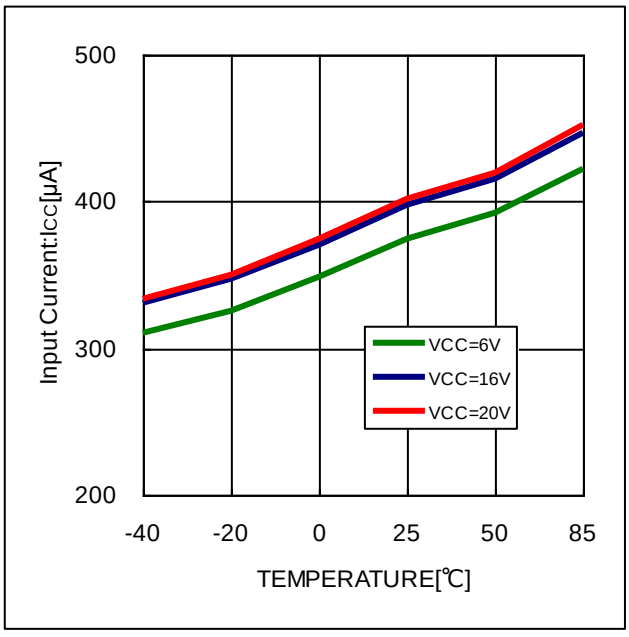


Figure 13. Operating Current – Temperature

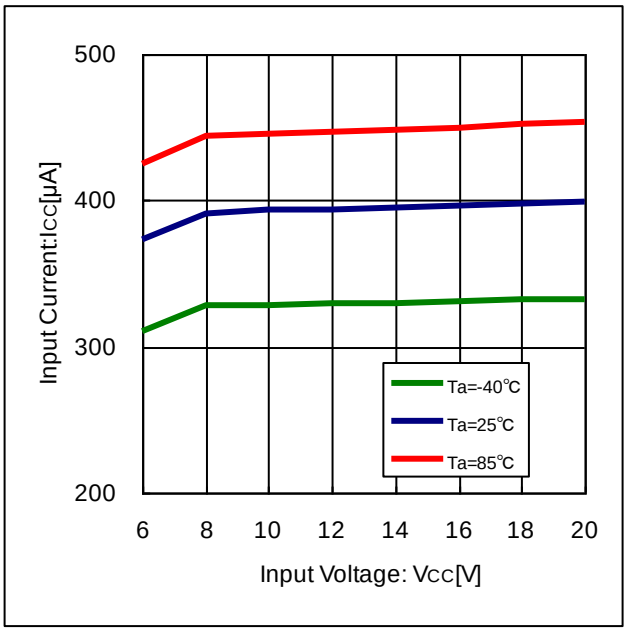


Figure 14. Operating Current – Input Voltage

Reference Characteristics of Typical Application Circuits (VOUT=12V)

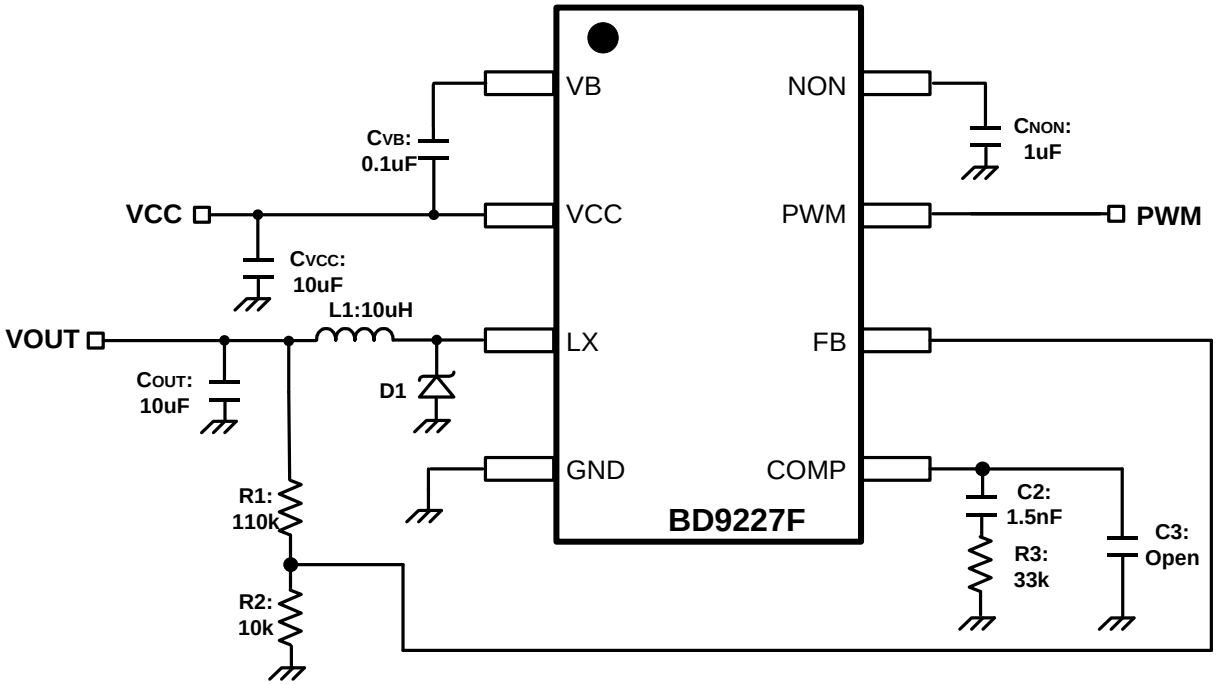


Figure 15. Typical Application Circuit (VOUT=12V)

Parts	L1 :	Coilcraft	LPS5030-103ML	10μH
	CVCC/COUT :	Murata	GRM31CR71E106MA12#	10μF/25V
	CVB :	Murata	GRM155R71E104ME14#	0.1μF/25V
	D1 :	Rohm	RB060MM-30	

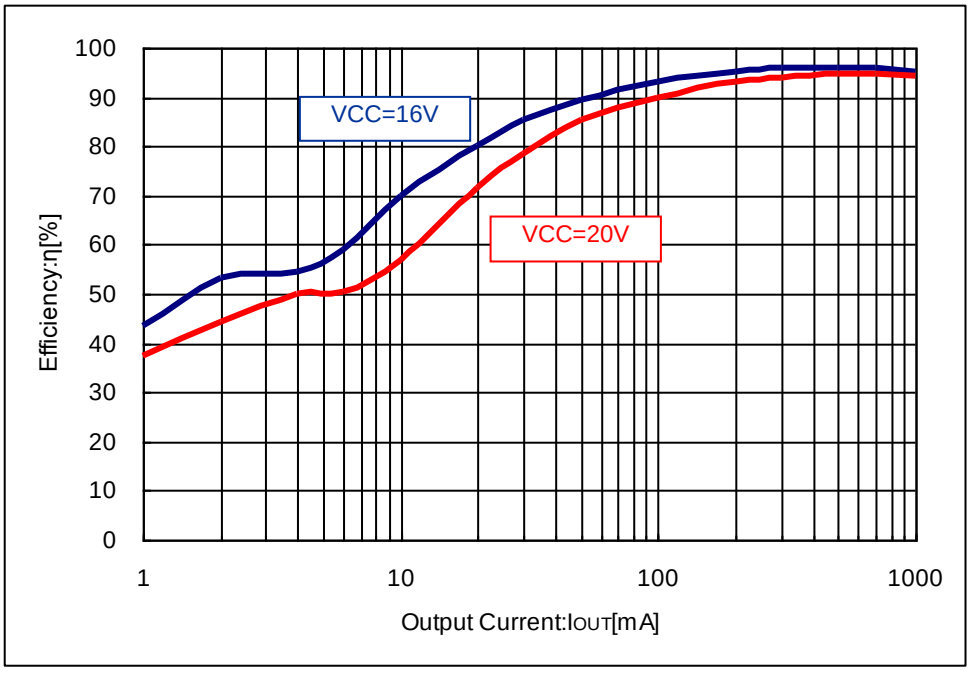


Figure 16. Efficiency-Output Current (VOUT=12V)

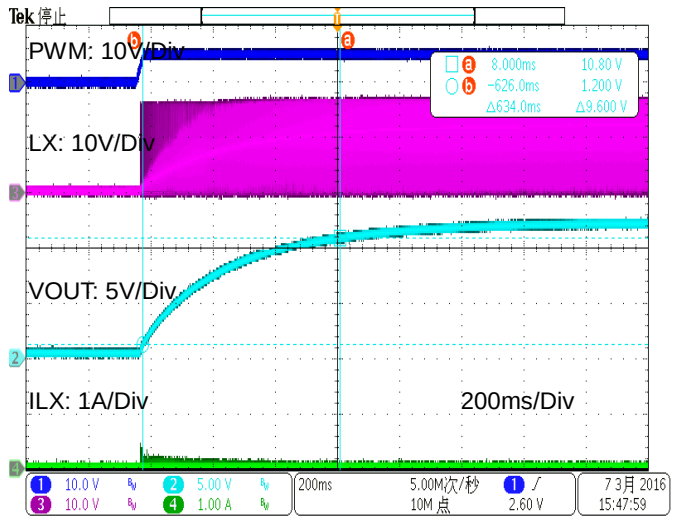


Figure 17. Start-up Characteristics
(VCC=16V, IOUT=0mA, VOUT=12V)

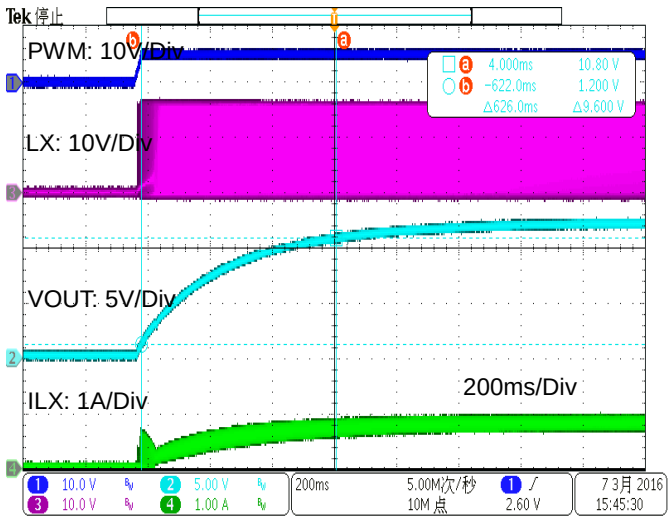


Figure 18. Start-up Characteristics
(VCC=16V, IOUT=1A, VOUT=12V)

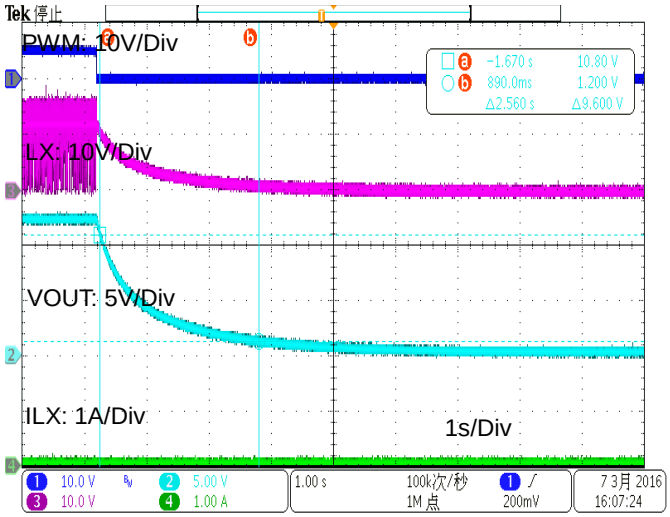


Figure 19. Shut-down Characteristics
(VCC=16V, IOUT=0mA, VOUT=12V)

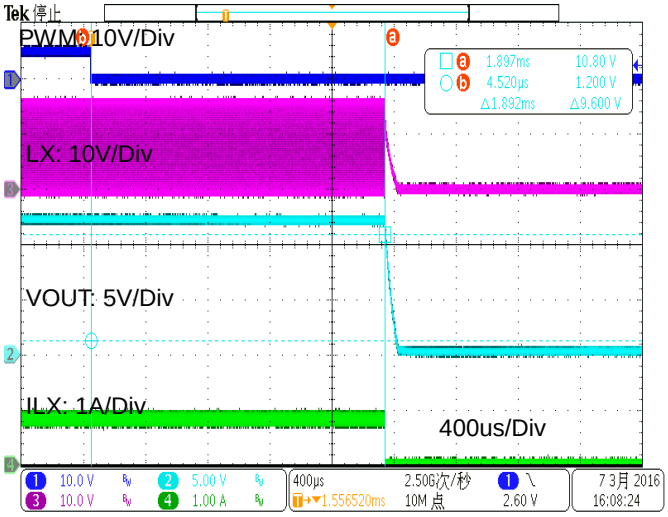


Figure 20. Shut-down Characteristics
(VCC=16V, IOUT=1A, VOUT=12V)

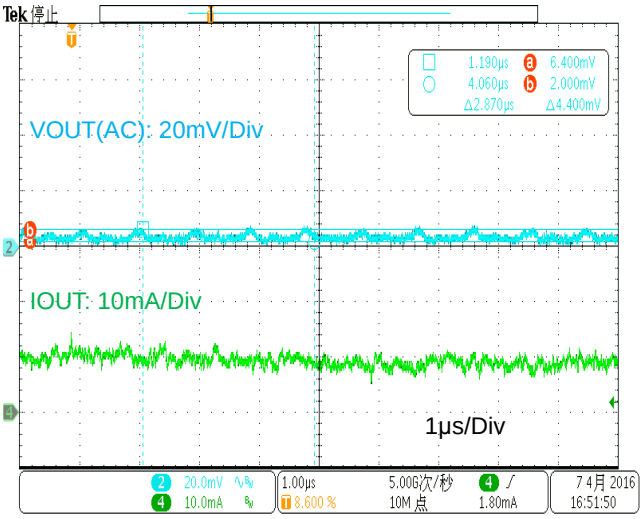


Figure 21. VOUT Ripple
(VCC=16V, IOUT=10mA; VOUT=12V)

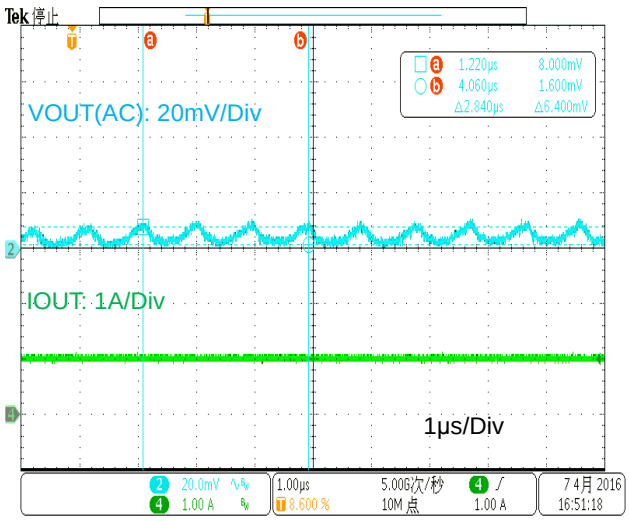


Figure 22. VOUT Ripple
(VCC=16V, IOUT=1A, VOUT=12V)

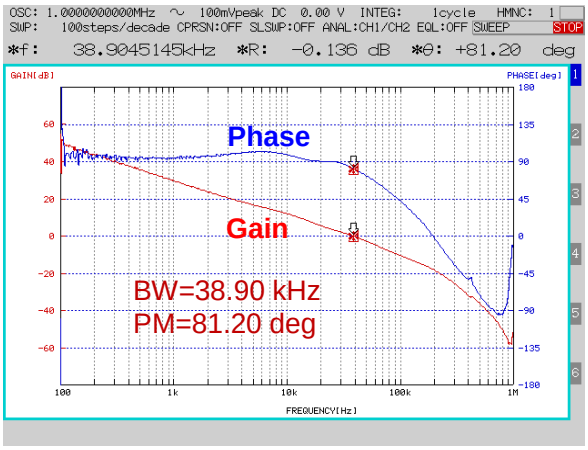


Figure 23. Frequency Response
(VCC=16V, IOUT=100mA, VOUT=12V)

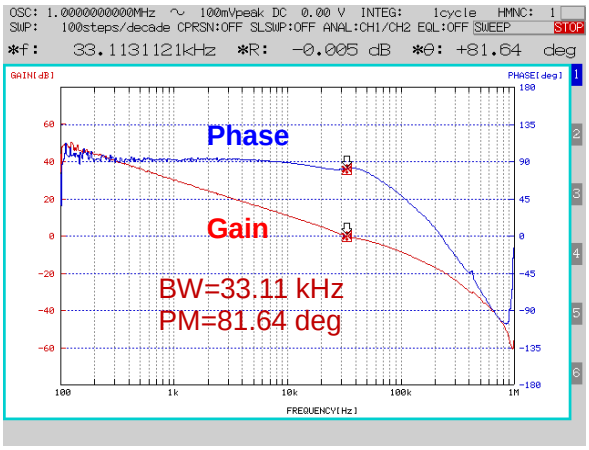


Figure 24. Frequency Response
(VCC=16V, IOUT=1A, VOUT=12V)

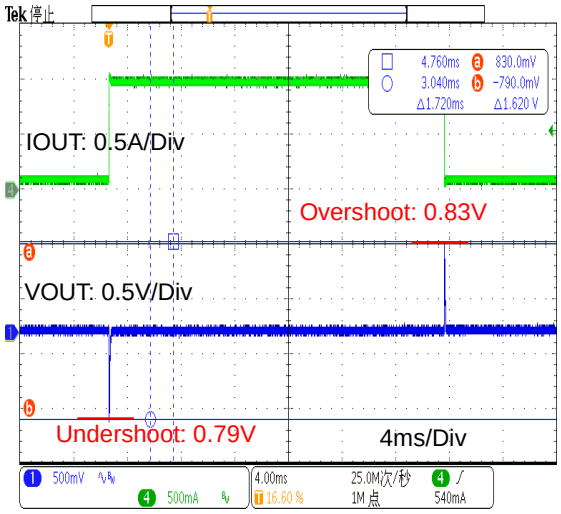


Figure 25. Load Response
(V_{CC}=16V, V_{OUT}=12V, I_{OUT}=100mA⇔1A)

Selection of Components Externally Connected

(1) Inductors

Something of the shield type that fulfills the current rating (Current value Ipeak below), with low DCR is recommended. Value of Inductance influences Inductor Ripple Current and becomes the cause of Output Ripple.
In the same way as the formula below, this Ripple Current can be made small for as big as the L value of Coil or as high as the Switching Frequency.

$$Ipeak = IOUT + \frac{\Delta IL}{2} \quad (1)$$

$$\Delta IL = \frac{VCC - VOUT}{L1} \times \frac{VOUT}{VCC} \times \frac{1}{f} \quad (2)$$

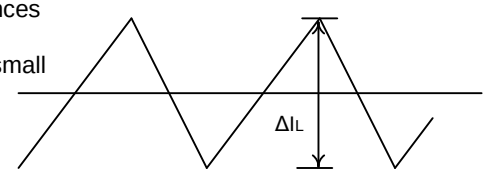


Figure 26. Inductor Current

(ΔIL: Output Ripple Current, VCC: Input Voltage, VOUT: Output Voltage, f: Switching Frequency)

For design value of Inductor Ripple Current, please carry out design tentatively with about 20% ~ 50% of Maximum Input Current. In the BD9227F, it is recommended the inductance value more than 4.7uH.

Recommended Inductor **CoilCraft** LPS5030 **Series**

※When current that exceeds Coil rating flows to the coil, the Coil causes a Magnetic Saturation, and there are cases wherein a decline in efficiency, oscillation of output happens. Please have sufficient margin and select so that Peak Current does not exceed Rating Current of Coil.

(2) Output Capacitor

In order for capacitor to be used in output to reduce output ripple, Low ceramic capacitor of ESR is recommended.
Also, for capacitor rating, on top of putting into consideration DC Bias characteristics, please use something whose maximum rating has sufficient margin with respect to the Output Voltage. Output ripple voltage is looked for using the following formula. The actual value of the output capacitor is not critical, but some practical limits do exist. Consider the relationship between the crossover frequency of the design and LC corner frequency of the output filter. In general, it is desirable to keep the crossover frequency at less than 1/20 of the switching frequency. With high switching frequencies such as the 1.0MHz frequency of this design, internal circuit limitations of the BD9227F limit the practical maximum crossover frequency to about 50kHz. In general, the crossover frequency should be higher than the corner frequency determined by the load impedance and the output capacitor. This limits the minimum capacitor value for the output filter to:

$$COUT\_min = \frac{1}{2\pi \times Rl \times fc\_max} \quad (3)$$

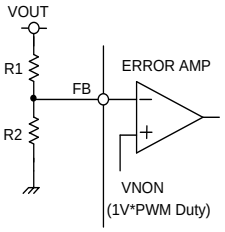
Where: Rl is the output load resistance and fc_max is the maximum crossover frequency. The output ripple voltage can be estimated by:

$$Vpp = \Delta IL \times \frac{1}{2\pi \times f \times COUT} + \Delta IL \times R_{ESR} \quad (4)$$

Please design in a way that it is held within Capacity Ripple Voltage.
In the BD9227F, it is recommended a ceramic capacitor more than 4.7μF.

(3) Output Voltage Setting

ERROR AMP internal Standard Voltage is 1V, VNON=1V x PWM Duty. Output Voltage is determined by



$$VOUT = \frac{R1 + R2}{R2} * PWM\ Duty \quad (5)$$

Figure 27. Output Voltage

(PWM Duty: the duty of the waveform inputted into PWM terminal)

(4) VB Capacitor

Please connect from 0.047μF~0.22uF (Laminate Ceramic Capacitor) between VCC Pin and VB Pin.(**caution:** Don't connect Capacitor between VB pin to GND pin that cause destroy the chip)

(5) Catch Diode

The BD9227F is designed to operate using an external catch diode between LX and GND. The selected diode must meet the absolute maximum ratings for the application: Reverse voltage must be higher than the maximum voltage at the LX pin, which is VCCMAX + 0.5 V. Peak current must be greater than IOUTMAX+ΔIL plus on half the peak to peak inductor current. Forward voltage drop should be small for higher efficiencies. It is important to note that the catch diode conduction time is typically longer than the high-side FET on time, so attention paid to diode parameters can make a marked improvement in overall efficiency. Additionally, check that the device chosen is capable of dissipating the power losses. It's recommanded to use schottky barrier diode with the BD9227F.

(6) Input Capacitor

The BD9227F requires an input capacitor for decoupling and depending on the application. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but low-ESR electrolytic capacitors may also suffice. Please place this capacitor as possible as close to the VCC pin. In the BD9227F, it is recommended a ceramic capacitor more than 4.7μF. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta VCC = \frac{IOUT}{f \times CVCC} \times \frac{VOUT}{VCC} \times \left[1 - \frac{VOUT}{VCC}\right] \quad (6)$$

Since the input capacitor (CVCC) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{CVCC} = IOUT \times \sqrt{\frac{VOUT}{VCC} \times \left[1 - \frac{VOUT}{VCC}\right]} \quad (7)$$

The worst case condition occurs at VCC = 2VOUT, where

$$I_{CVCC\_max} = \frac{IOUT}{2} \quad (8)$$

(7) Recommended CNON (vs PWM Frequency) setting

The PWM signal control ON/OFF of BD9227F(PWM>1.5V ON, PWM<0.5V OFF) , and PWM duty determine the NON value, In order to get proper NON ripple value, according PWM frequency to select proper CNON capacitor.
Below is the relationship of PWM frequency, CNON and NON ripple:
NON ripple=D*(1-D)/(R*CNON*PWM Frequency). (9)
When D=0.5, NON ripple=NON ripple(max)
NON ripple(max)=0.25/(R*CNON*PWM Frequency) (10)

D: PWM Duty; R: Inner 250kΩ resistor

NON ripple=1mV condition
NON value=1V*PWM Duty

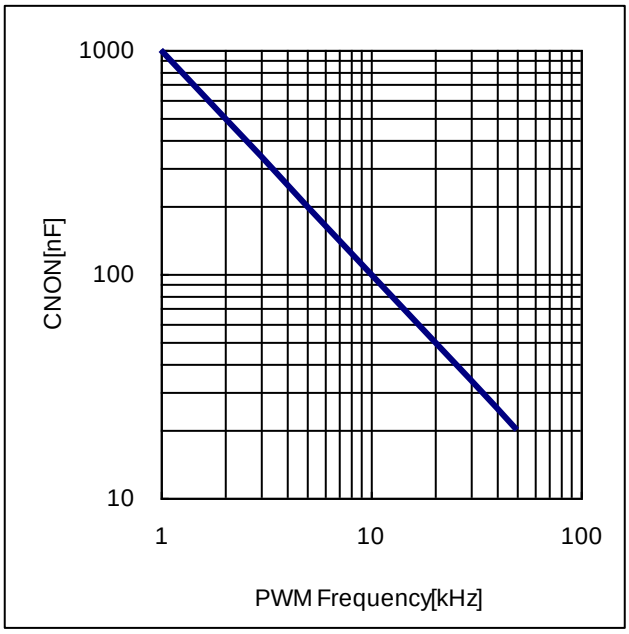


Figure 28. Recommended PWM Frequency vs CNON

(8) Recommended Tss selection vs CNON

BD9227F Softstart time Tss is determined by NON rising speed, Tss have relation with CNON.
Below is the relationship of Tss and CNON

Tss=4.61*R*CNON (11) NON reach 99% of Target NON value R: Inner 250kΩ resistor

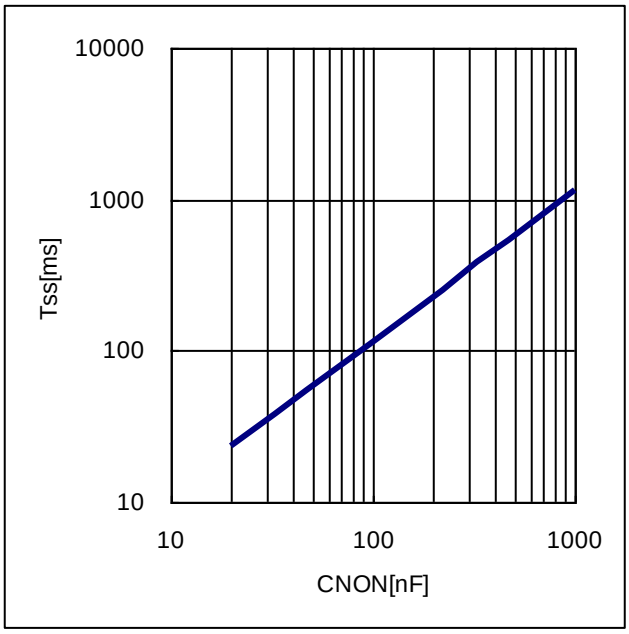


Figure 29. Recommended CNON vs Tss

(9) About Adjustment of DC/DC Comparator Frequency Characteristics

Role of Phase compensation element C2, C3, R3 (See P.11 Figure15. Example of Reference Application Circuit)

Stability and Responsiveness of Loop are controlled through COMP Pin which is the output of Error Amp.
The combination of zero and pole that determines Stability and Responsiveness is adjusted by the combination of resistor and capacitor that are connected in series to the COMP Pin.
DC Gain of Voltage Return Loop can be calculated for using the following formula.

$$Adc = Rl \times Gcs \times A_{EA} \times \frac{VFB}{VOUT} \qquad (12)$$

Here, VFB is Feedback Voltage (1.0V*PWM Duty).A_{EA} is Voltage Gain of Error amplifier (typ : 66.8 dB),
G_{CS} is the Trans-conductance of Current Detect (typ : 2.2A/V), and Rl is the Output Load Resistance value.

There are 2 important poles in the Control Loop of this DC/DC.
The first occurs with/ through the output resistance of Phase compensation Capacitor (C3) and Error amplifier.
The other one occurs with/through the Output Capacitor and Load Resistor.
These poles appear in the frequency written below.

$$fp1 = \frac{G_{EA}}{2 \times \pi \times C2 \times A_{EA}} \qquad (13)$$

$$fp2 = \frac{1}{2 \times \pi \times COUT \times Rl} \qquad (14)$$

Here, G_{EA} is the trans-conductance of Error amplifier (typ : 115uA/V).
Here, in this Control Loop, one zero becomes important.

With the zero which occurs because of Phase compensation Capacitor C2 and Phase compensation Resistor R3, the Frequency below appears.

$$fz1 = \frac{1}{2 \times \pi \times C2 \times R3} \qquad (15)$$

Also, if Output Capacitor is big, and that ESR (RESR) is big, in this Control Loop, there are cases when it has an important, separate zero (ESR zero).
This ESR zero occurs due to ESR of Output Capacitor and Capacitance, and exists in the Frequency below.

$$fz_{ESR} = \frac{1}{2 \times \pi \times COUT \times RESR} \qquad (16) \quad \text{(ESR zero)}$$

In this case, the 3rd pole determined with the 2nd Phase compensation Capacitor (C3) and Phase Correction Resistor (R3) is used in order to correct the ESR zero results in Loop Gain.
This pole exists in the frequency shown below.

$$fp3 = \frac{1}{2 \times \pi \times C3 \times R3} \qquad (17) \quad \text{(pole that corrects ESR zero)}$$

The target of Phase compensation design is to create a communication function in order to acquire necessary bandwidth and Phase margin.

Cross-over Frequency (bandwidth) at which Loop gain of Return Loop becomes “0” is important.
When Cross-over Frequency becomes low, Power supply Fluctuation Response, Load Response, etc worsens.
On the other hand, when Cross-over Frequency is too high, instability of the Loop can occur.
Tentatively, Cross-over Frequency is targeted to be made 1/20 or below of Switching Frequency. Selection method of Phase Compensation constant is shown below.

1. Phase Compensation Resistor (R3) is selected in order to set to the desired Cross-over Frequency.
   Calculation of RC is done using the formula below.

$$R3 = \frac{2 \times \pi \times COUT \times fc}{G_{EA} \times G_{CS}} \times \frac{VOUT}{VFB} \qquad (18)$$

   Here, fc is the desired Cross-over Frequency. It is made about 1/20 and below of the Switching Frequency (F_{SW}).

2. Phase compensation Capacitor (C2) is selected in order to achieve the desired phase margin.
   In an application that has a representative Inductance value (more than 4.7uH), by matching zero of compensation to 1/4 and below of the Cross-over Frequency, sufficient Phase margin can be acquired.C2 can be calculated using the following formula.

$$C2 > \frac{4}{2 \times \pi \times R3 \times fc} \qquad (19)$$

3. Examination whether the second Phase compensation Capacitor C3 is necessary or not is done.
If the ESR zero of Output Capacitor exists in a place that is smaller than half of the Switching Frequency, a second Phase compensation Capacitor is necessary. In other words, it is the case wherein the formula below happens.

$$\frac{1}{2\times\pi\times COUT\times RESR} < \frac{F_{SW}}{2} \qquad (20)$$

In this case, add the second phase compensation Capacitor C3, and match the frequency of the third pole to the Frequency fp3 of ESR zero.
C3 is looked for using the following formula:

$$C3 = \frac{COUT\times RESR}{R3} \qquad (21)$$

(10) About PWM Duty adjustable range of BD9227F

BD9227F VOUT voltage is determined by LX duty, but BD9227F Ton-min limited Duty range. The Ton-min(max)=210ns, Tperiod(min)=833ns, then the Duty worst=210/833=25.2%, then the 25.2%<VOUT/VCC<100%.

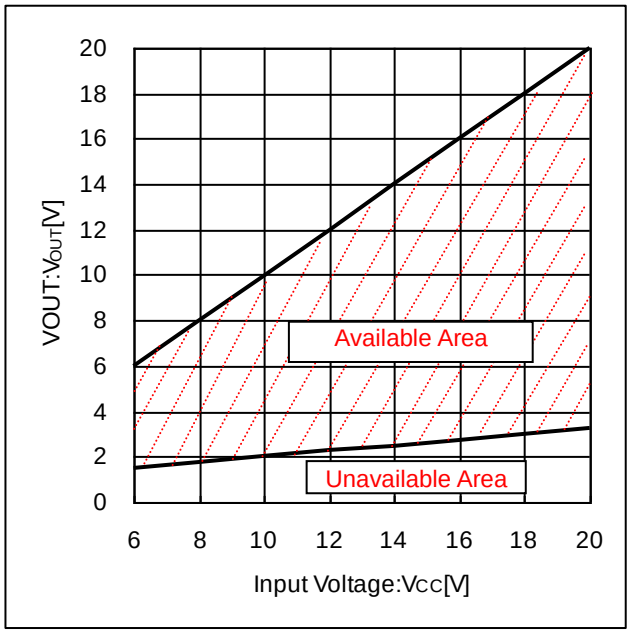


Figure 30. VOUT vs VCC available range

Cautions on PCB board layout

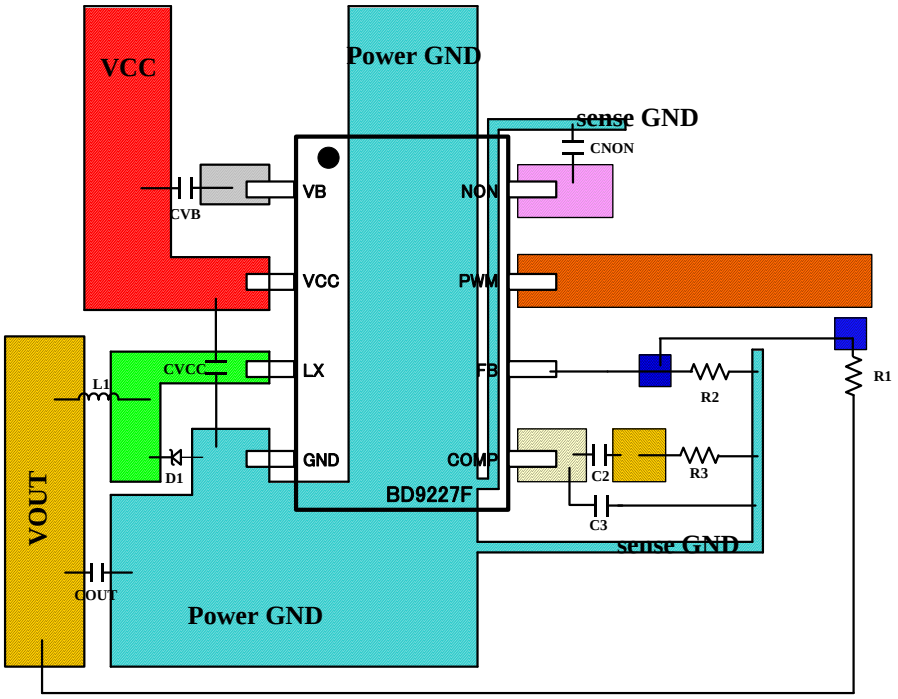


Figure 31. Reference PCB

Layout is a critical portion of good power supply design. There are several signals paths that conduct fast changing currents or voltages that can interact with stray inductance or parasitic capacitance to generate noise or degrade the power supplies performance. To help eliminate these problems, the VCC pin should be bypassed to ground with a low ESR ceramic bypass capacitor with B dielectric. Care should be taken to minimize the loop area formed by the bypass capacitor connections, the VCC pin, and the anode of the catch diode. See Figure31 for a PCB layout example.
In the BD9227F, since the LX connection is the switching node, the catch diode and output inductor should be located close to the LX pins, and the area of the PCB conductor minimized to prevent excessive capacitive coupling. And GND area should be connected directly to power GND for avoiding the external connect which causes the different GND voltage. The additional external components can be placed approximately as shown.

Power Dissipation

It is shown below reducing characteristics of power dissipation to mount 114.3mm×76.2mm×1.57mm^t (1 layer) and 114.3mm×76.2mm×1.6mm^t (4layer) PCB. Junction temperature must be designed not to exceed 150℃.

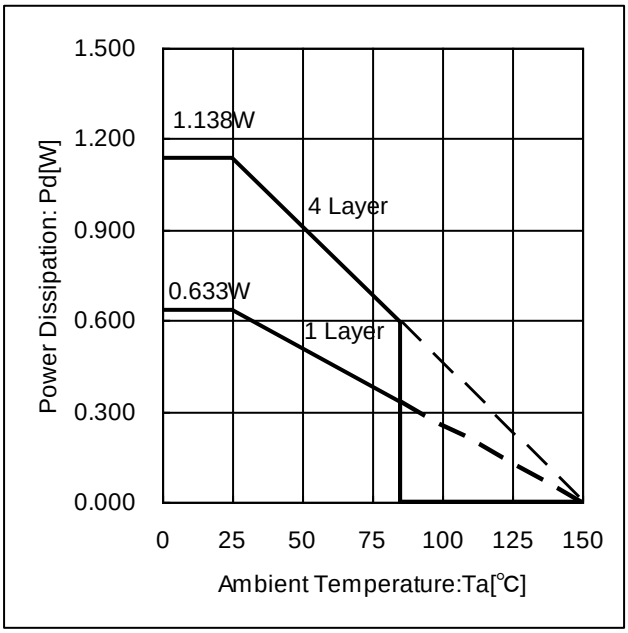


Figure 32. Power Dissipation
(114.3mm×76.2mm×1.57mm^t 1layer / 114.3mm×76.2mm×1.6mm^t 4layer PCB)

Power Dissipation Estimate

The following formulas show how to estimate the device power dissipation under continuous mode operations. They should not be used if the device is working in the discontinuous conduction mode.
The device power dissipation includes:

1) Conduction loss： $Pcon = IOUT^2 \times Ron \times VOUT / VCC + Vf \times IOUT \times (VCC-VOUT) / VCC$

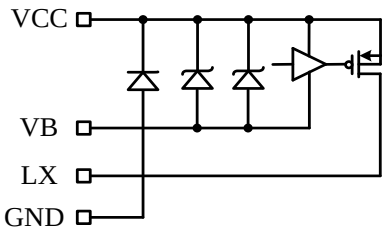
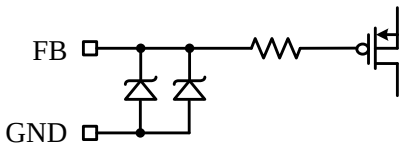
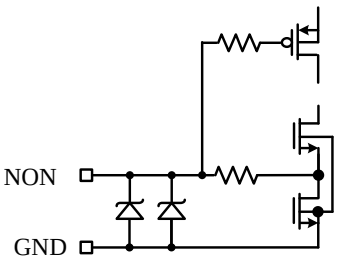
2) Switching loss: $Psw = 6 \times 10^{-9} \times VCC \times IOUT \times Fsw$

3) Gate charge loss： $Pgc = (5.78 \times 10^{-9} + 197.67 \times 10^{-12} \times VCC \times VCC) \times Fsw$

4) Quiescent current loss： $Pq = 0.4 \times 10^{-3} \times VCC$

Where:
IOUT is the output current (A), Ron is the on-resistance of the Power MOSFET(Ω), VOUT is the output voltage (V).
VCC is the input voltage (V), Fsw is the switching frequency (Hz).
Therefore
Power dissipation of IC is the sum of above dissipation.
$Pd = Pcon + Psw + Pgc + Pq$
For given Tj, $Tj = Ta + \theta ja \times Pd$
Where:
Pd is the total device power dissipation (W), Ta is the ambient temperature (°C)
Tj is the junction temperature (°C), θja is the thermal resistance of the package (°C)

I/O Equivalent Circuit

Pin. No	Pin Name	Pin Equivalent Circuit
1 2 3 4	VB VCC LX GND	
6	FB	
8	NON	

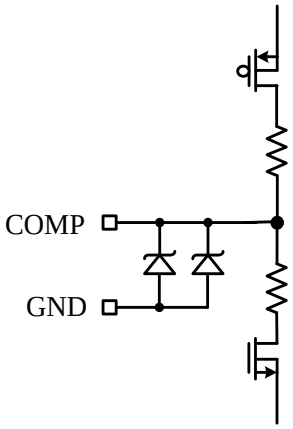
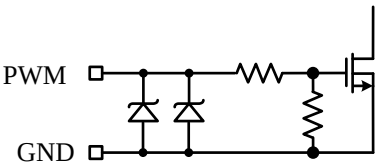
Pin. No	Pin Name	Pin Equivalent Circuit
5	COMP	
7	PWM	

Figure 33. I/O Equivalent Circuit

Operational Notes

1) About Absolute Maximum Rating
When the absolute maximum ratings of application voltage, operating temperature range, etc. was exceeded, there is possibility of deterioration and destruction. Also, the short Mode or open mode, etc. destruction condition cannot be assumed. When the special mode where absolute maximum rating is exceeded is assumed, please give consideration to the physical safety countermeasure for the fuse, etc.

2) About GND Electric Potential
In every state, please make the electric potential of GND Pin into the minimum electrical potential. Also, include the actual excessive effect, and please do it such that the pins, excluding the GND Pin do not become the voltage below GND.

3) About Heat Design
Consider the Power Dissipation (Pd) in actual state of use, and please make Heat Design with sufficient margin.

4) About short circuit between pins and erroneous mounting
When installing to set board, please be mindful of the direction of the IC, phase difference, etc. If it is not installed correctly, there is a chance that the IC will be destroyed. Also, if a foreign object enters the middle of output, the middle of output and power supply GND, etc., even for the case where it is shorted, there is a change of destruction.

5) About the operation inside a strong electro-magnetic field
When using inside a strong electro-magnetic field, there is a possibility of error, so please be careful.

6) About checking with Set boards
When doing examination with the set board, during connection of capacitor to the pin that has low impedance, there is a possibility of stress in the IC, so for every 1 process, please make sure to do electric discharge. As a countermeasure for static electricity, in the process of assembly, do grounding, and when transporting or storing please be careful. Also, when doing connection to the jig in the examination process, please make sure to turn off the power supply, then connect. After that, turn off the power supply then take it off.

7) About common impedance
For the power supply and the wire of GND, lower the common impedance, then, as much as possible, make the ripple smaller (as much as possible make the wire thick and short, and lower the ripple from L・C), etc., then and please consider it sufficiently.

8) In the application, when the mode where the VCC and each pin electrical potential becomes reversed exists, there is a possibility that the internal circuit will become damaged. For example, during cases wherein the condition when charge was given in the external capacitor, and the VCC was shorted to GND, it is recommended to insert the bypass diode to the diode of the back current prevention in the VCC series or the middle of each Pin-VCC.

9) About IC Pin Input
This IC is a Monolithic IC, and between each element, it has P^+ isolation for element separation and P board. With the N layer of each element and this, the P-N junction is formed, and the parasitic element of each type is composed.
For example, like the diagram below, when resistor and transistor is connected to Pin,

○When GND > (PinA) in Resistor, when GND > (PinA), when GND > (PinB) in Transistor (NPN),
the P-N junction will operate as a parasitic diode.

○Also, during GND > (Pin B) in the Transistor (NPN), through the N layer of the other elements connected to the above-mentioned parasitic diode , the parasitic NPN Transistor will operation.

On the composition of IC, depending on the electrical potential, the parasitic element will become necessary. Through the operation of the parasitic element interference of circuit operation will arouse, and error, therefore destruction can be caused. Therefore please be careful about the applying of voltage lower than the GND (P board) in I/O Pin, and the way of using when parasitic element operating.

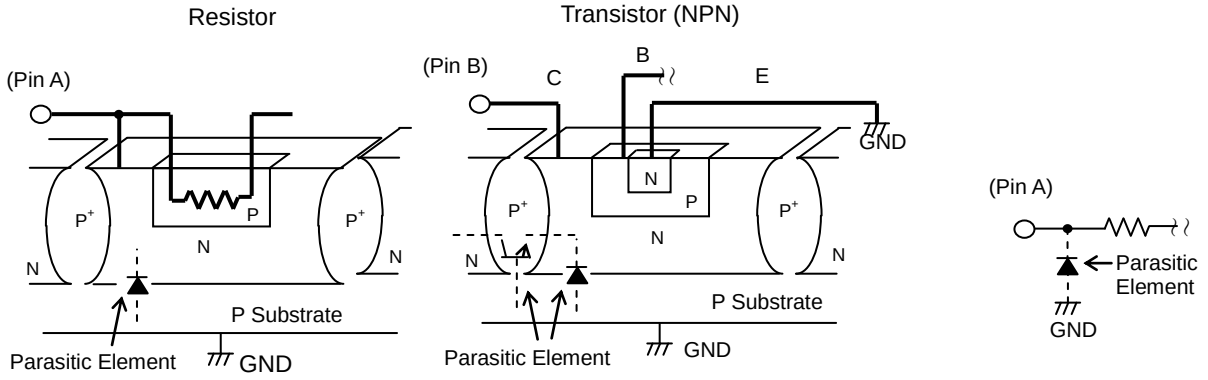
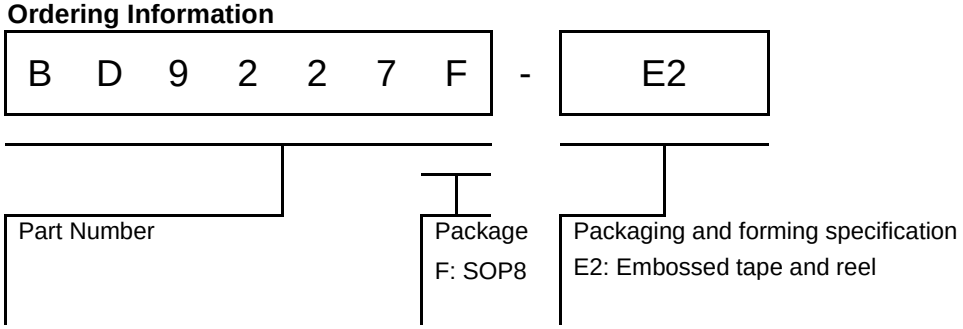


Figure 34. Example of simple structure of Bipolar IC

Ordering Information



Marking Diagram

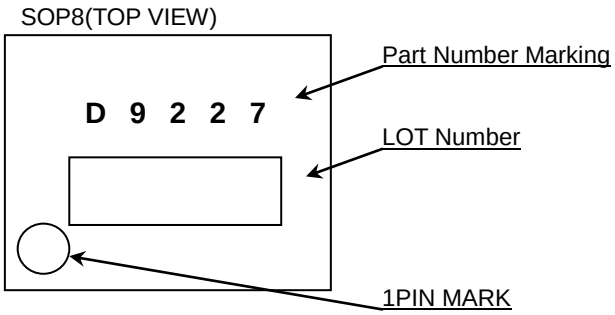
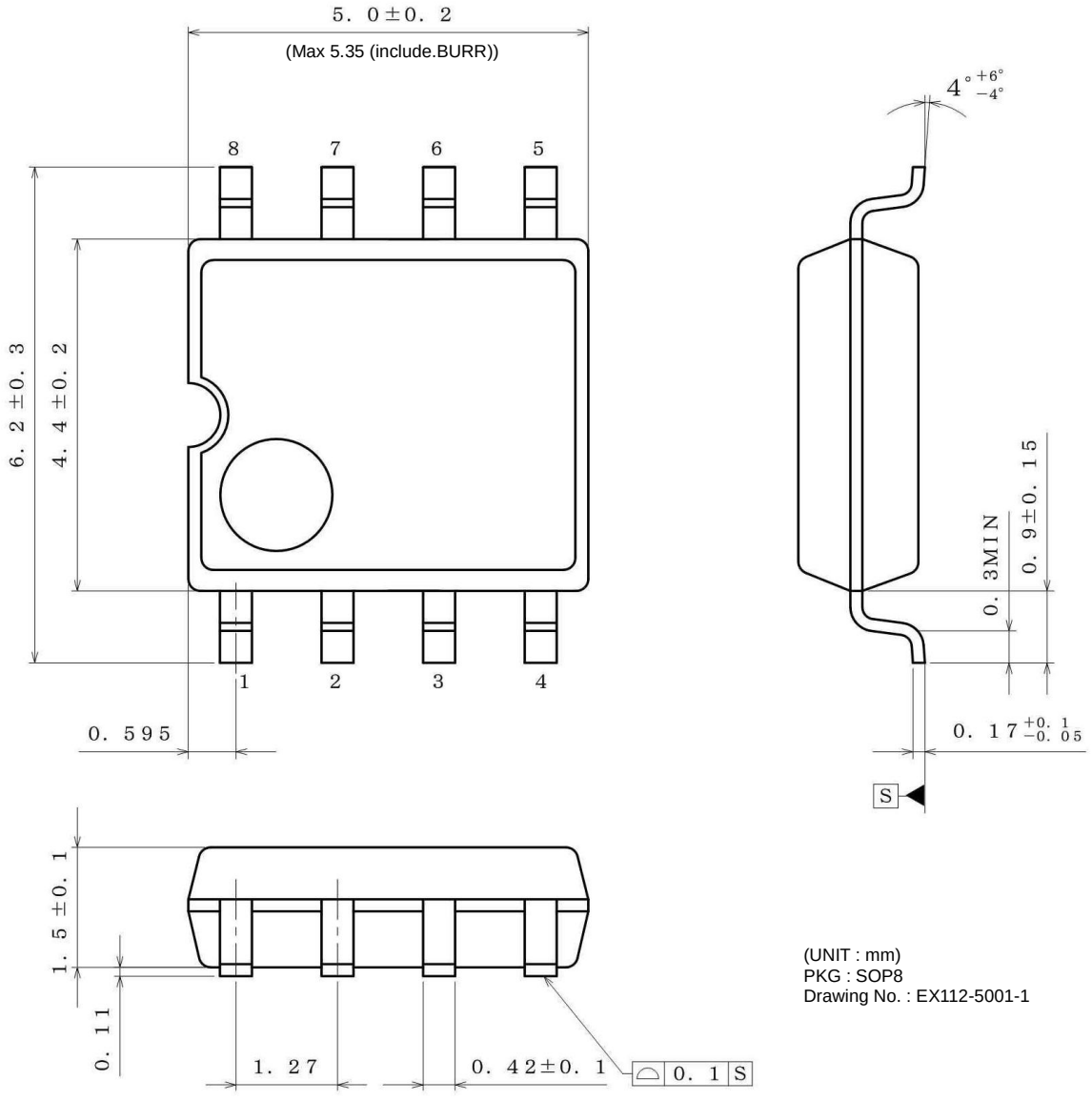


Figure 35. Marking Diagram

Physical Dimension, Tape and Reel Information

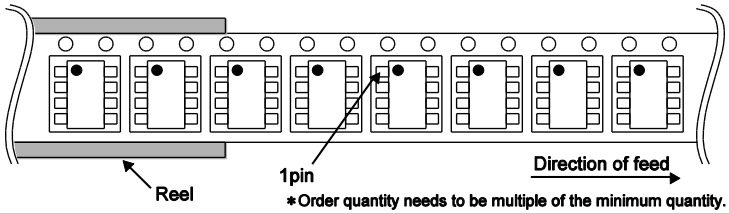
Package Name	SOP8



(UNIT : mm)
PKG : SOP8
Drawing No. : EX112-5001-1

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (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)



*Order quantity needs to be multiple of the minimum quantity.

Revision History

Data	Modification point	Content
8.Jun.2016	-	New Release

Notice

Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] 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
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. 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.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

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.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

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