4.0V to 5.5V, 1.2A 1ch Synchronous Buck Converter with Integrated FET

BD8964FVM

General Description

The BD8964FVM is ROHM's high efficiency step-down switching regulator designed to produce a voltage as low as 1V from a supply voltage of 5V. It offers high efficiency by using synchronous switches and provides fast transient response to sudden load changes by implementing current mode control.

Features

- Fast Transient Response because of Current Mode PWM Control System
- High Efficiency for All Load Ranges with Synchronous Rectifier (Nch/Pch FET)
- Soft-Start Function
- Thermal Shutdown and UVLO Functions
- Short-Circuit Protection with Time Delay Function
- Shutdown Function

Application

Power Supply for LSI including DSP, Microcomputer and ASIC

Key Specifications

- Input Voltage Range: 4.0V to 5.5V
- Output Voltage Range: 1.0V to 1.8V
- Output Current: 1.2A (Max)
- Switching Frequency: 1.0MHz (Typ)
- Pch FET ON-Resistance: 350mΩ(Typ)
- Nch FET ON-Resistance: 250mΩ(Typ)
- Standby Current: 0μA (Typ)
- Operating Temperature Range: -25°C to +85°C

Package

W(Typ) x D(Typ) x H(Max)



MSOP8
2.90 mm x 4.00 mm x 0.90 mm

Typical Application Circuit

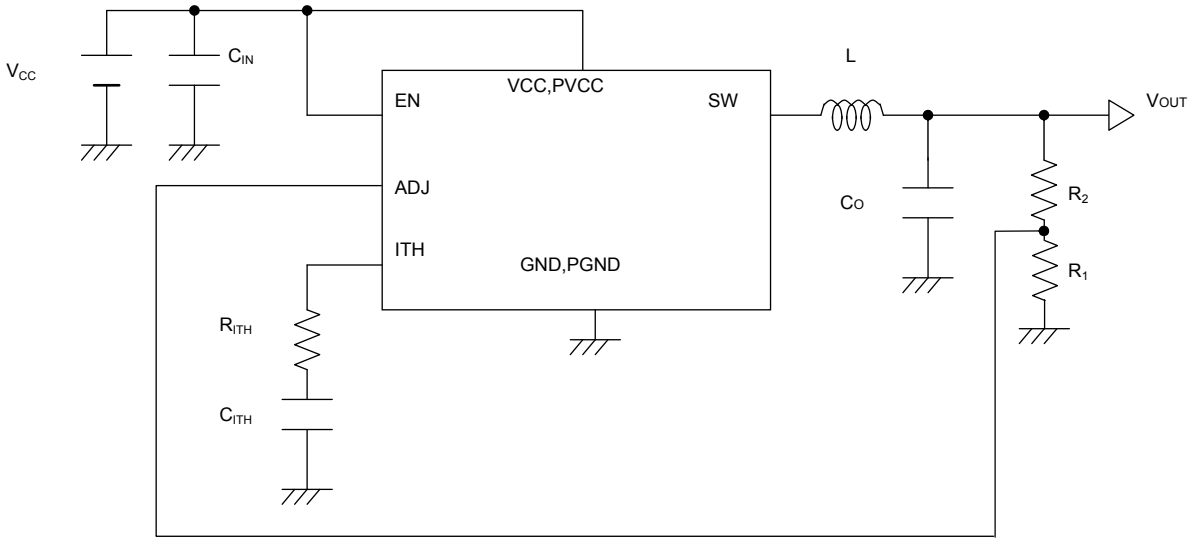


Figure 1. Typical Application Circuit

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Pin Configuration

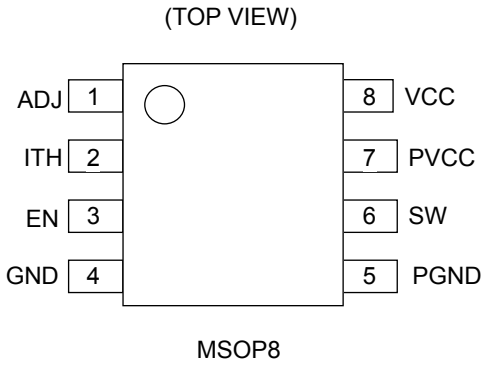


Figure 2. Pin Configuration

Pin Description

Pin No.	Pin Name	Function
1	ADJ	Output voltage detection pin
2	ITH	GmAmp output pin/connected to phase compensation capacitor
3	EN	Enable pin (Active High)
4	GND	Ground pin
5	PGND	Power switch ground pin
6	SW	Power switch node
7	PVCC	Power switch supply pin
8	VCC	Power supply input pin

Block Diagram

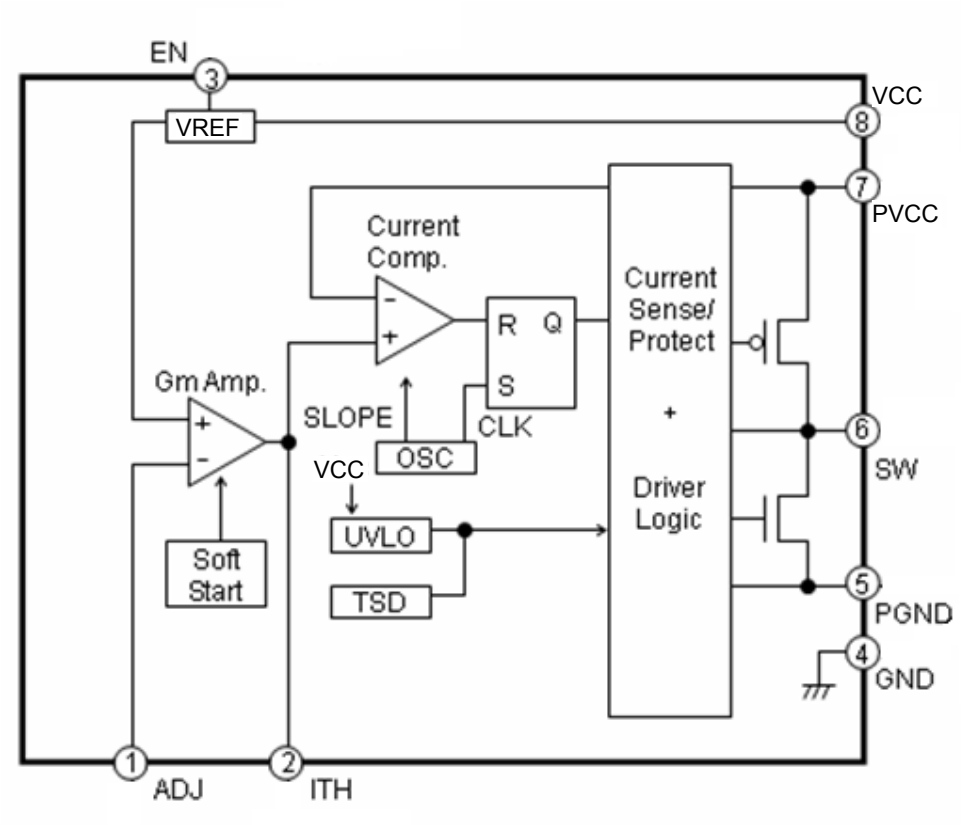


Figure 3. Block Diagram

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Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
VCC Voltage	V_{CC}	-0.3 to +7 (Note 1)	V
PVCC Voltage	PV_{CC}	-0.3 to +7 (Note 1)	V
EN Voltage	V_{EN}	-0.3 to +7	V
SW, ITH Voltage	V_{SW}, V_{ITH}	-0.3 to +7	V
Power Dissipation 1	Pd1	0.38 (Note 2)	W
Power Dissipation 2	Pd2	0.58 (Note 3)	W
Operating Temperature Range	Topr	-25 to +85	°C
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C

(Note 1) Pd should not be exceeded.
(Note 2) Reduced by 3.1mW/°C over Ta=25°C.
(Note 3) Reduced by 4.7mW/°C over Ta=25°C, Mounted on 1 layer 70mmx70mmx1.6mm Glass Epoxy PCB.
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.

Recommended Operating Conditions (Ta=25°C)

Parameter	Symbol	Limit			Unit
		Min	Typ	Max	
VCC Voltage	V_{CC} (Note 4)	4.0(Note 5)	5.0	5.5	V
PVCC Voltage	PV_{CC} (Note 4)	4.0(Note 5)	5.0	5.5	V
EN Voltage	V_{EN}	0	-	V_{CC}	V
Output Voltage Setting Range	V_{OUT}	1.0	-	1.8	V
SW Average Output Current	I_{SW} (Note 4)	-	-	1.2	A

(Note 4) Pd should not be exceeded.
(Note 5) In case of setting the output voltage to 1.6V or more, V_{CC}Min= V_{OUT} +1.3V

Electrical Characteristics (Ta=25°C, V_{CC}=5V, V_{EN}=V_{CC}, R_1=20kΩ, R_2=10kΩ unless otherwise specified.)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Standby Current	I_{STB}	-	0	10	μA	EN=GND
Bias Current	I_{CC}	-	250	450	μA	
EN Low Voltage	V_{ENL}	-	GND	0.8	V	Standby mode
EN High Voltage	V_{ENH}	2.0	V_{CC}	-	V	Active mode
EN Input Current	I_{EN}	-	1	10	μA	V_{EN}=5V
Oscillation Frequency	f_{OSC}	0.8	1	1.2	MHz	
Pch FET ON-Resistance	R_{ONP}	-	350	600	mΩ	PV_{CC}=5V
Nch FET ON-Resistance	R_{ONN}	-	250	500	mΩ	PV_{CC}=5V
ADJ Voltage	V_{ADJ}	0.78	0.80	0.82	V	
ITH Sink Current	I_{THSI}	10	20	-	μA	V_{ADJ}=H
ITH Source Current	I_{THSO}	10	20	-	μA	V_{ADJ}=L
UVLO Threshold Voltage	V_{UVLO1}	3.6	3.8	4.0	V	V_{CC}=4V to 0V
UVLO Release Voltage	V_{UVLO2}	3.65	3.90	4.2	V	V_{CC}=0V to 4V
Soft Start Time	t_{SS}	0.5	1	2	ms	V_{ADJ}=H
Timer Latch Time	t_{LATCH}	1	2	3	ms	SCP/TSD operated

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Typical Performance Curves

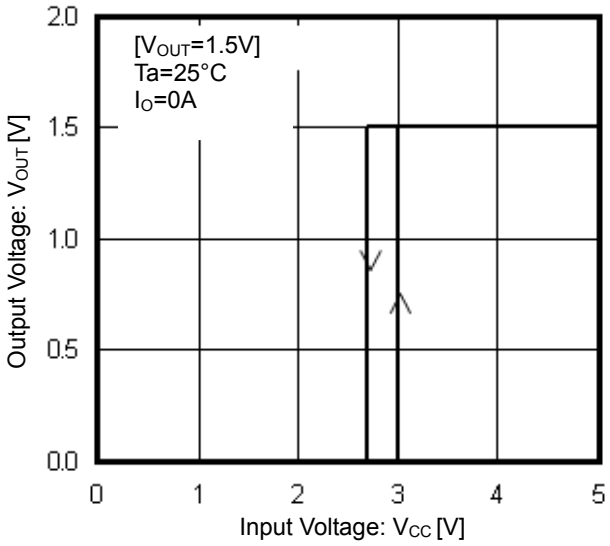


Figure 4. Output Voltage vs Input Voltage

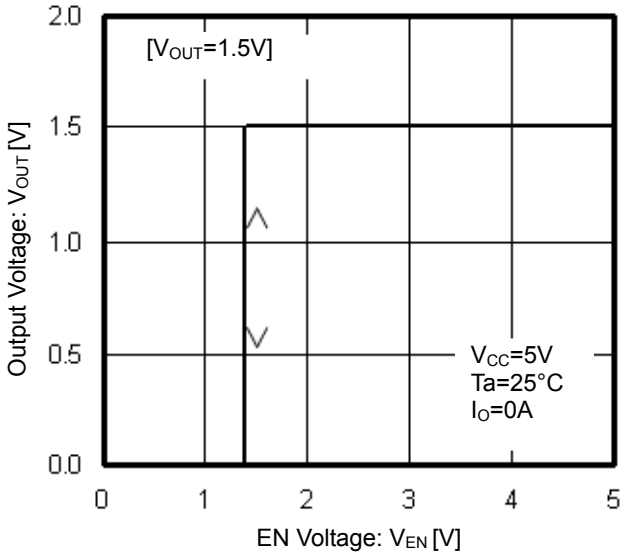


Figure 5. Output Voltage vs EN Voltage

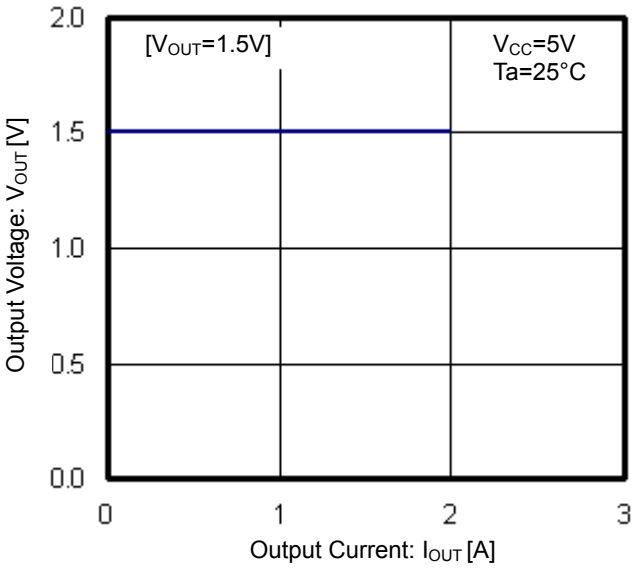


Figure 6. Output Voltage vs Output Current

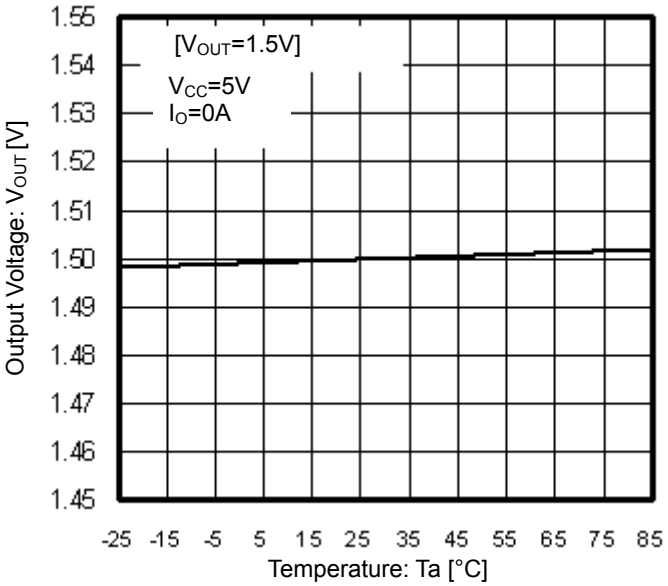


Figure 7. Output Voltage vs Temperature

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Typical Performance Curves – continued

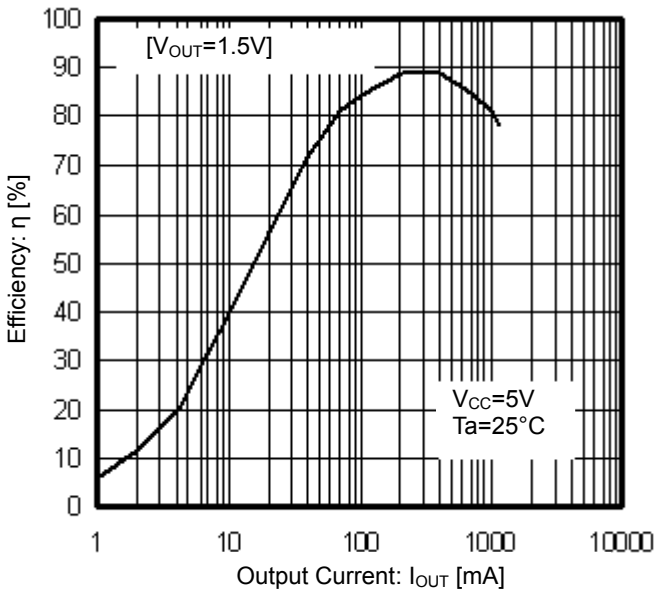


Figure 8. Efficiency vs Output Current

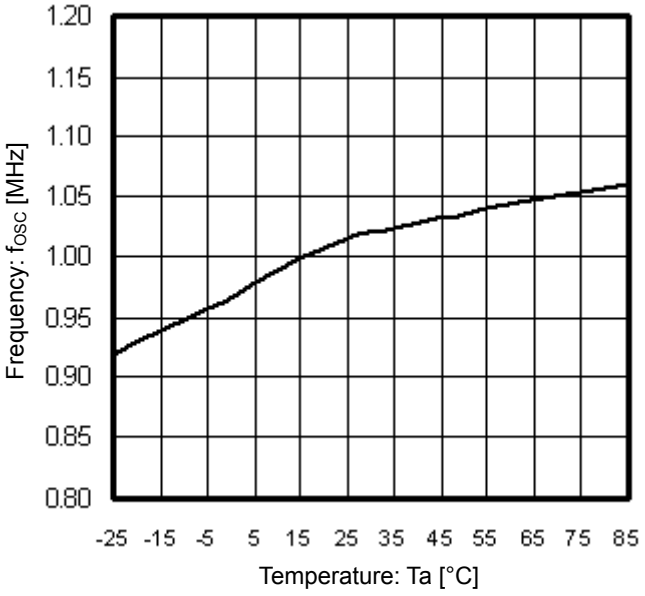


Figure 9. Frequency vs Temperature

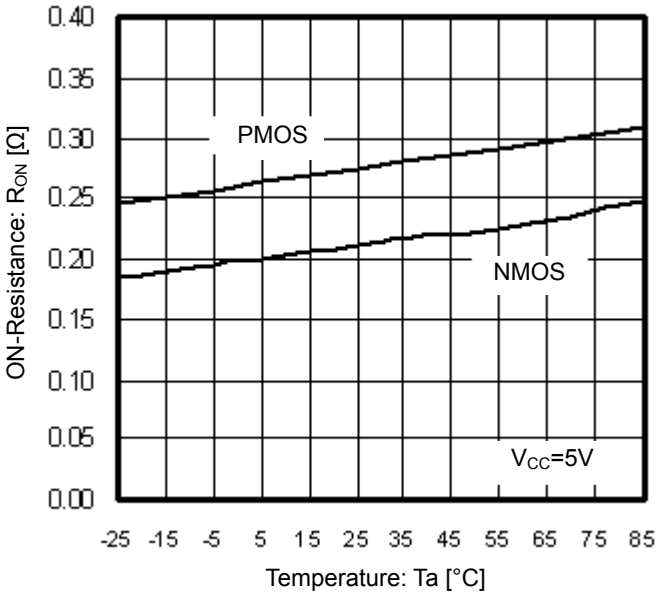


Figure 10. ON-Resistance vs Temperature

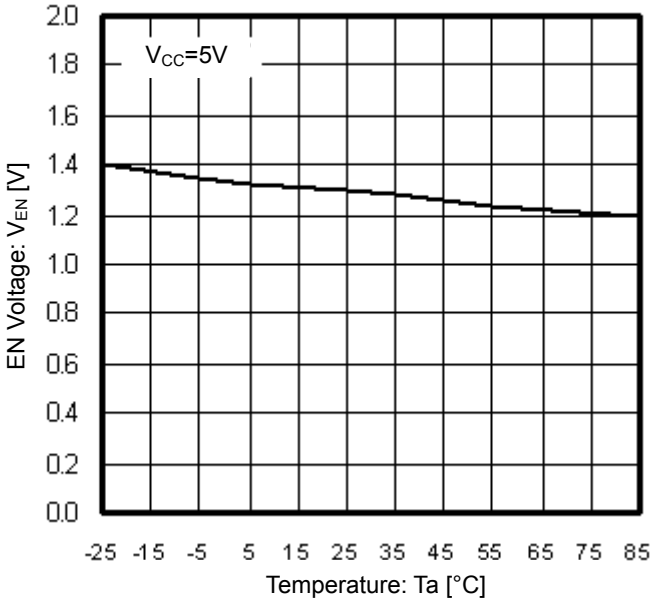


Figure 11. EN Voltage vs Temperature

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Typical Performance Curves – continued

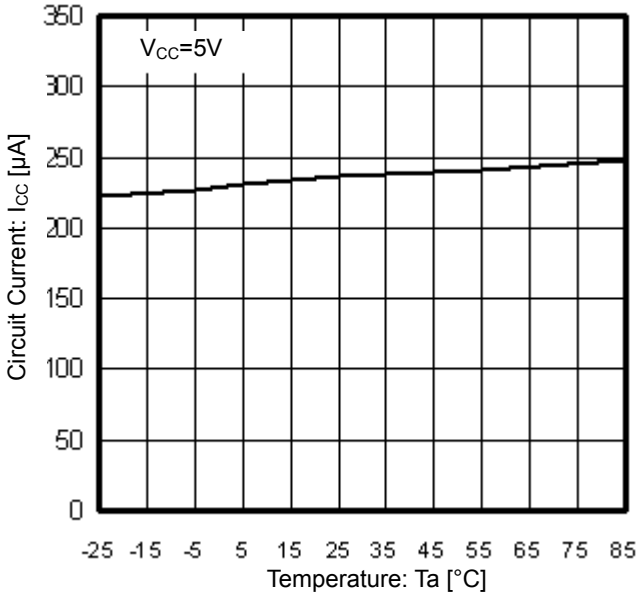


Figure 12. Circuit Current vs Temperature

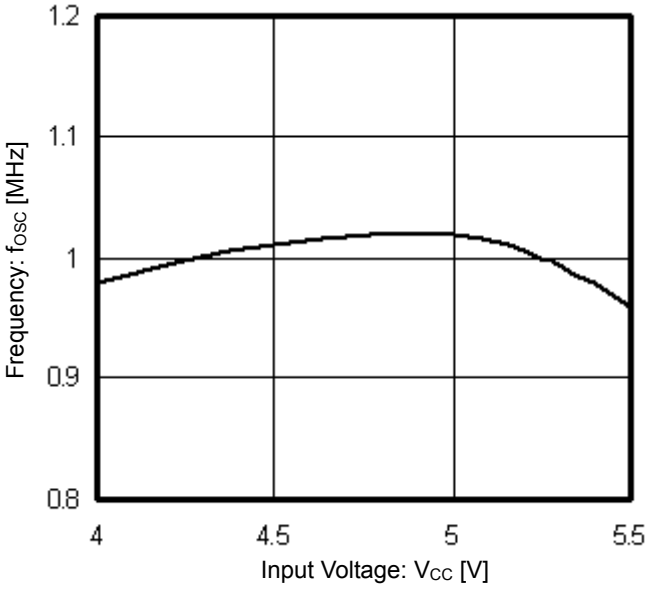


Figure 13. Frequency vs Input Voltage

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Typical Waveforms

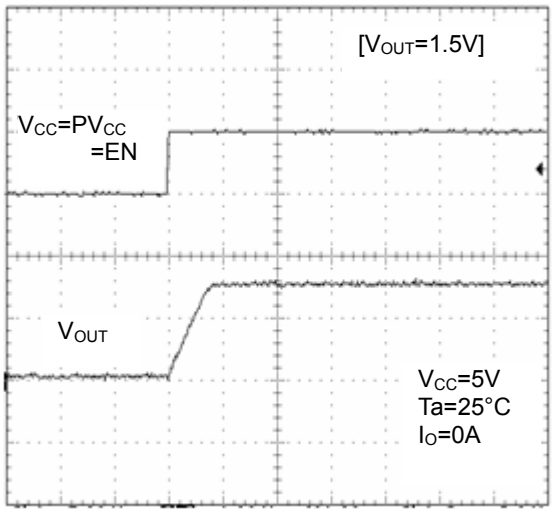


Figure 14. Soft Start Waveform

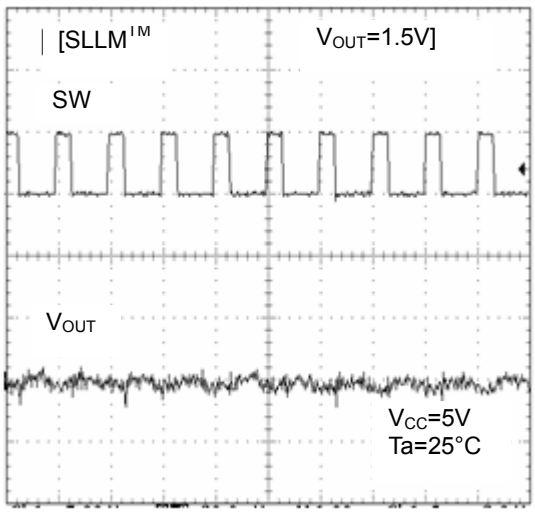


Figure 15. SW Waveform

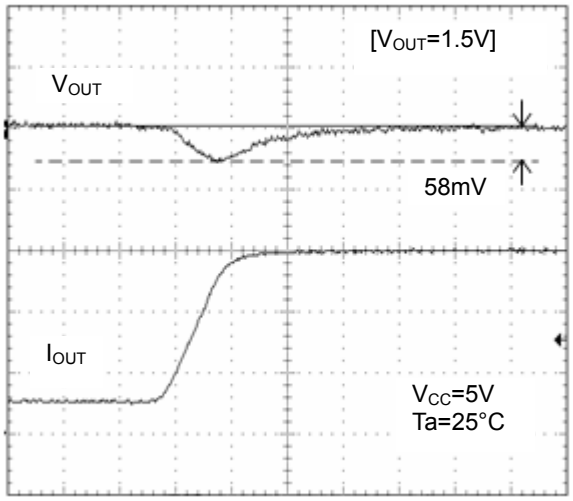


Figure 16. Transient Response
(I_O=100mA to 600mA, 10µs)

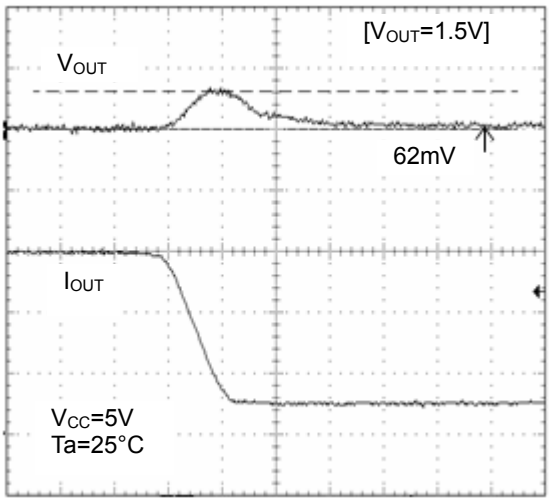


Figure 17. Transient Response
(I_O=600mA to100mA, 10µs)

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Application Information

1. Operation

BD8964FVM is a synchronous step-down switching regulator that achieves fast transient response by employing current mode PWM control system.

(1) Synchronous Rectifier

Integrated synchronous rectification using two MOSFETS reduces power dissipation and increases efficiency when compared to converters using external diodes. Internal shoot-through current limiting circuit further reduces power dissipation.

(2) Current Mode PWM Control

The PWM control signal of this IC depends on two feedback loops, the voltage feedback and the inductor current feedback.

(a) PWM (Pulse Width Modulation) Control

The clock signal coming from OSC has a frequency of 1Mhz. When OSC sets the RS latch, the P-Channel MOSFET is turned on and the N-Channel MOSFET is turned OFF. The opposite happens when the current comparator (Current Comp) resets the RS latch i.e. the P-Channel MOSFET is turned OFF and the N-Channel MOSFET is turned on. Current Comp's output is a comparison of two signals, the current feedback control signal "SENSE" which is a voltage proportional to the current I_L, and the voltage feedback control signal, FB.

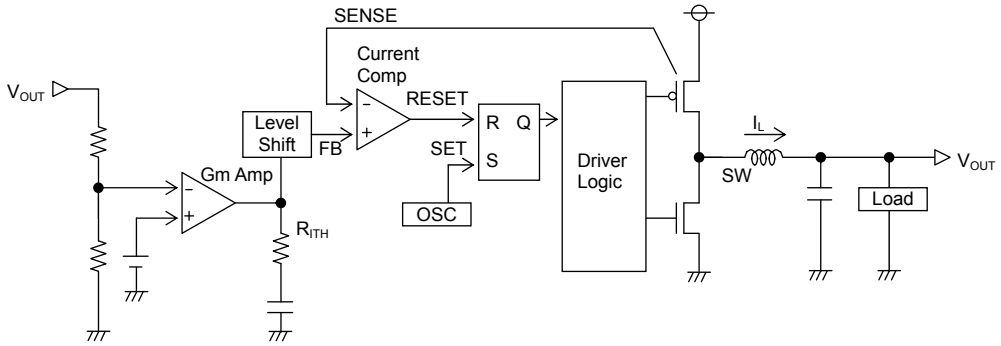


Figure 18. Diagram of Current Mode PWM Control

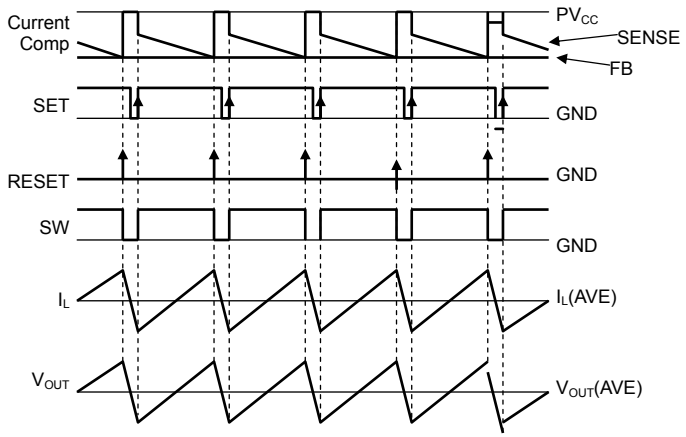


Figure 19. PWM Switching Timing Diagram

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2. Description of Functions

(1) Soft-Start Function
During start-up, the soft-start circuit gradually establishes the output voltage to limit the input current. This prevents the overshoot in the output voltage and inrush current.

(2) Shutdown Function
When EN terminal is “Low”, the device operates in Standby Mode, and all functional blocks such as the reference voltage circuit, internal oscillator, and drivers, are turned OFF. Circuit current during standby is 0μA (Typ).

(3) UVLO Function
The UVLO circuit detects whether the supplied input voltage is sufficient to obtain the output voltage of this IC. The UVLO threshold has a hysteresis of 100mV (Typ) to prevent the output from chattering.

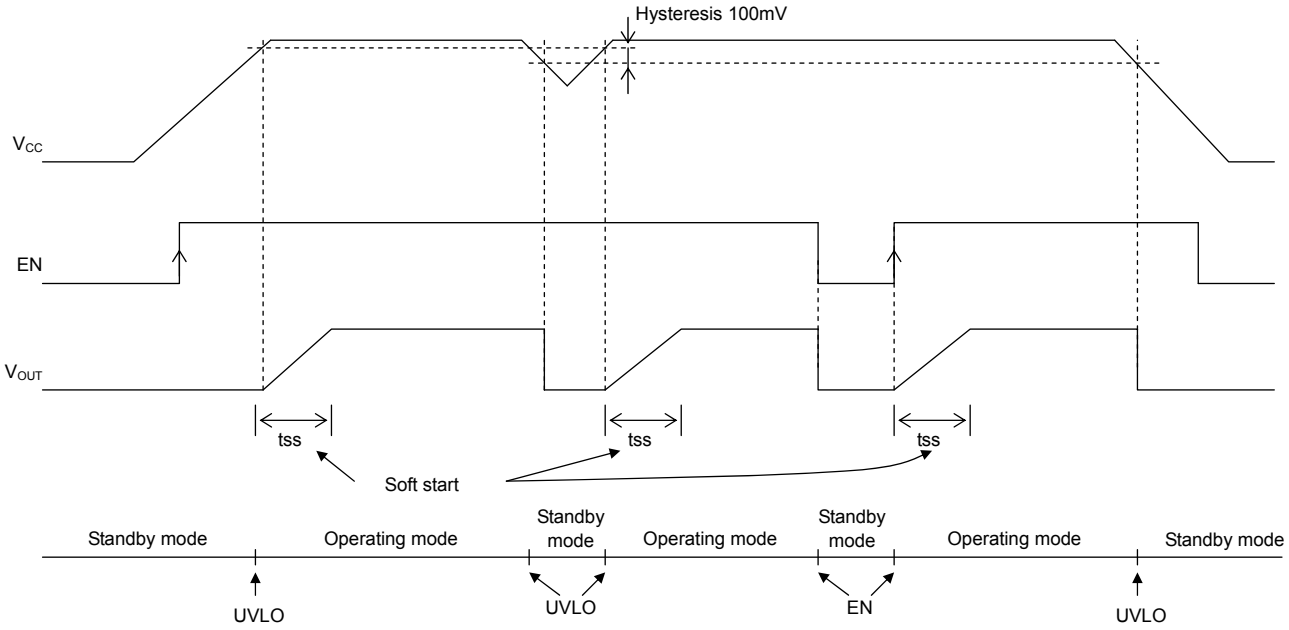


Figure 20. Soft Start, Shutdown, UVLO Timing Chart

(4) Short-Circuit Current Protection with Time Delay Function
To protect the IC from breakdown, the short-circuit protection turns the output OFF when the internal current limiter is activated continuously for at least 1 ms. The output that is held OFF may be turned ON again by restarting EN or by resetting UVLO.

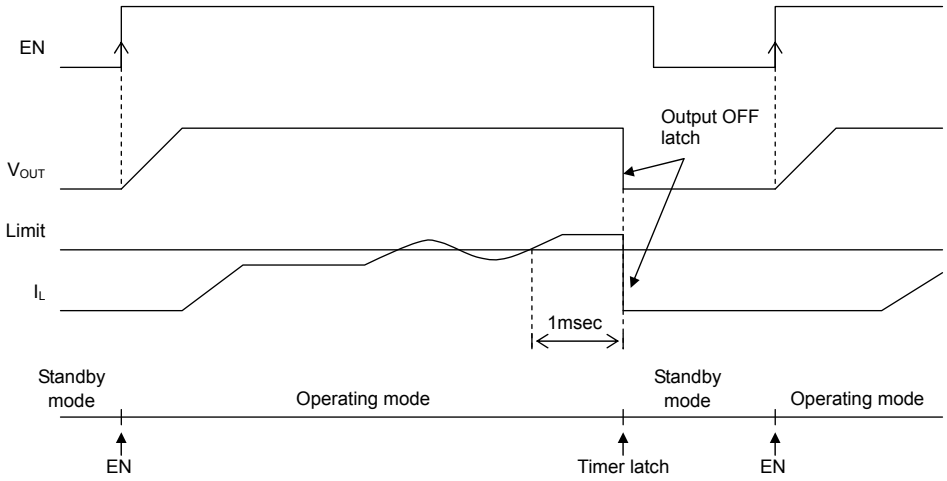


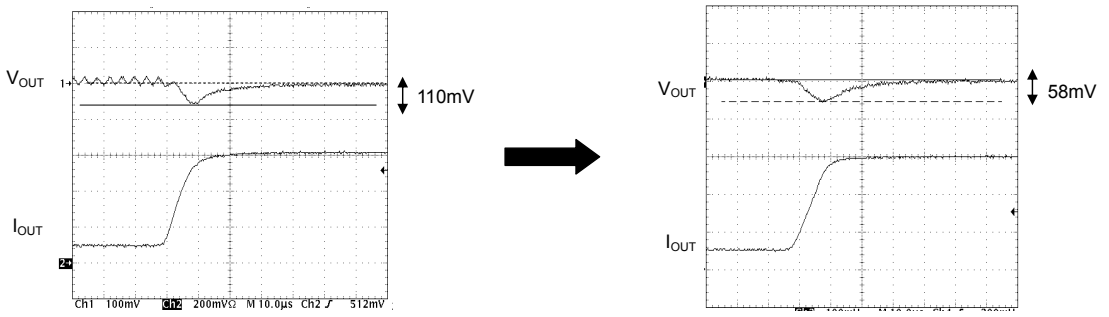
Figure 21. Short-Current Protection with Time Delay Diagram

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3. Information on Advantages

Advantage 1 : Offers fast transient response by using current mode control system.

Conventional product (Load response I_O=0.1A to 0.6A) BD8964FVM (Load response I_O=0.1A to 0.6A)



Voltage drop due to sudden change in load was reduced

Figure 22. Comparison of Transient Response

Advantage 2 : Offers high efficiency because of synchronous rectifiers

For heavier load:
This IC utilizes the synchronous rectifying mode and uses low ON-Resistance power MOSFETs.

{ ON-Resistance of P-Channel MOSFET: 350mΩ(Typ)
{ ON-Resistance of N-Channel MOSFET: 250mΩ(Typ)

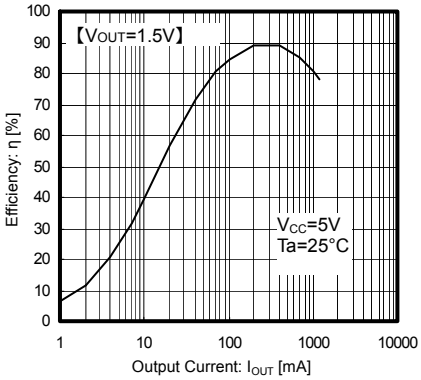


Figure 23. Efficiency

Advantage 3 : ・ Supplied in smaller package due to small-sized power MOSFETs

・Output capacitor C_O required for current mode control: 10μF ceramic capacitor
・Inductance L required for the operating frequency of 1 MHz: 4.7μH inductor

Reduces mounting area requirement

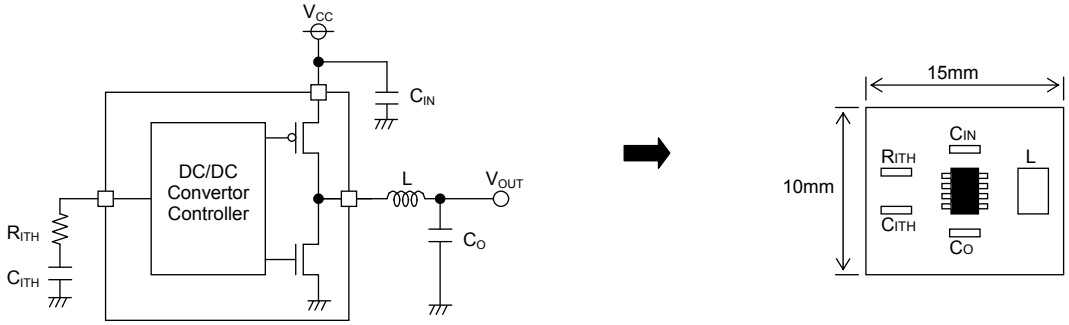


Figure 24. Example Application

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4. Switching Regulator Efficiency

Efficiency η may be expressed by the equation shown below:

$$\eta = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}} \times 100 = \frac{P_{OUT}}{P_{IN}} \times 100 = \frac{P_{OUT}}{P_{OUT} + Pd\alpha} \times 100 \qquad [\%]$$

Efficiency may be improved by reducing the switching regulator power dissipation factors Pdα as follows:

Dissipation factors:

(1) ON-Resistance dissipation of inductor and FET : Pd(I^2R)

$$Pd\left(I^2R\right) = {I_{OUT}}^2 \times \left(R_{COIL} + R_{ON}\right)$$

Where:
R_{COIL} is the DC resistance of inductor
R_{ON} is the ON-Resistance of FET
I_{OUT} is the Output current

(2) Gate charge/discharge dissipation : Pd(Gate)

$$Pd\left(Gate\right) = C_{gs} \times f \times V^2$$

Where:
C_{gs} is the gate capacitance of FET
f is the switching frequency
V is the gate driving voltage of FET

(3) Switching dissipation : Pd(SW)

$$Pd\left(SW\right) = \frac{{V_{IN}}^2 \times C_{RSS} \times I_{OUT} \times f}{I_{DRIVE}}$$

Where:
C_{RSS} is the reverse transfer capacitance of FET
I_{DRIVE} is the peak current of gate

(4) ESR dissipation of capacitor : Pd(ESR)

$$Pd\left(ESR\right) = {I_{RMS}}^2 \times ESR$$

Where:
I_{RMS} is the ripple current of capacitor
ESR is the equivalent series resistance

(5) Operating Current Dissipation of IC : Pd(IC)

$$Pd\left(IC\right) = V_{IN} \times I_{CC}$$

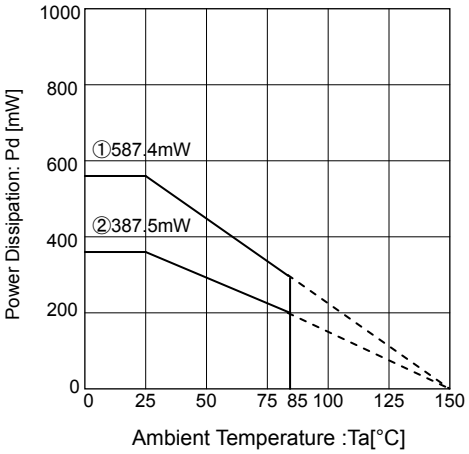
Where:
I_{CC} is the circuit current

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5. Consideration on Permissible Dissipation and Heat Generation

Since this IC functions with high efficiency without significant heat generation in most applications, no special consideration is needed on permissible dissipation or heat generation. In case of extreme conditions, however, including lower input voltage, higher output voltage, heavier load, and/or higher temperature, the permissible dissipation and/or heat generation must be carefully considered.

For dissipation, only conduction losses due to the DC resistance of inductor and ON-Resistance of FET are considered. This is because conduction losses are most significant among other dissipations mentioned above such as gate charge/discharge dissipation and switching dissipation.



①mounted on glass epoxy PCB
θj-a=212.8°C/W
②using an IC alone
θj-a=322.6°C/W

$$P = I_{OUT}{}^2 \times R_{ON}$$
$$R_{ON} = D \times R_{ONP} + (1-D)R_{ONN}$$

Where:
D is the ON duty (=V_{OUT}/V_{CC})
R_{ONP} is the ON-Resistance of P-Channel MOS FET
R_{ONN} is the ON-Resistance of N-Channel MOS FET
I_{OUT} is the Output current

Figure 25 Thermal Derating Curve
(MSOP8)

If V_{CC}=5V, V_{OUT}=1.5V, R_{COIL}=0.15Ω, R_{ONP}=0.35Ω, R_{ONN}=0.25Ω
I_{OUT}=0.8A, for example,
$D=V_{OUT}/V_{CC}=1.5/5=0.3$
$R_{ON}=0.3 \times 0.35+(1-0.3) \times 0.25$
$=0.105+0.175$
$=0.28[\Omega]$

$P=0.8^2 \times (0.15+0.28) \approx 275.2[mW]$

Since R_{ONP} is greater than R_{ONN} in this IC, the dissipation increases as the ON duty becomes higher. Taking into consideration the dissipation shown above, thermal design must be carried out with allowable sufficient margin.

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6. Selection of Components Externally Connected

(1) Selection of Inductor (L)

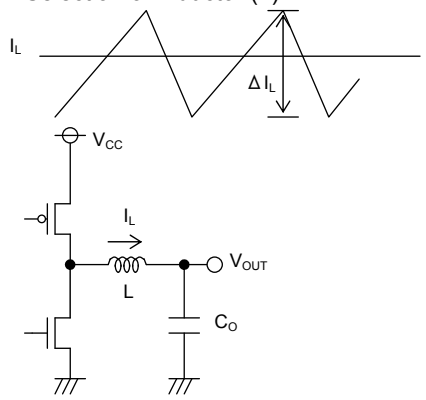


Figure 26. Output Ripple Current

The inductance significantly depends on output ripple current. As shown in equation (1), the ripple current decreases as the inductor and/or switching frequency increases.

$$\Delta I_L = \frac{(V_{CC} - V_{OUT}) \times V_{OUT}}{L \times V_{CC} \times f} \quad [A] \quad \cdot \cdot \cdot (1)$$

Appropriate ripple current at output should be +/-30% of the maximum output current.

$$\Delta IL = 0.3 \times I_{OUTMax} \quad [A] \cdot \cdot \cdot (2)$$

$$L = \frac{(V_{CC} - V_{OUT}) \times V_{OUT}}{\Delta I_L \times V_{CC} \times f} \quad [H] \quad \cdot \cdot \cdot (3)$$

Where:
ΔI_L is the Output ripple current, and
f is the Switching frequency

Note: Current exceeding the current rating of the inductor results in magnetic saturation of the inductor, which decreases efficiency.
The inductor must be selected allowing sufficient margin with which the peak current may not exceed its current rating.
If V_{CC}=5V, V_{OUT}=1.5V, f=1MHz, ΔI_L=0.3A x 0.8A=0.24A, for example,

$$L = \frac{(5 - 1.5) \times 1.5}{0.24 \times 5 \times 1M} = 4.375\mu \rightarrow 4.7 \quad [\mu H]$$

Note: Select an inductor with low resistance component (such as DCR and ACR) to minimize dissipation in the inductor for better efficiency.

(2) Selection of Output Capacitor (C_O)

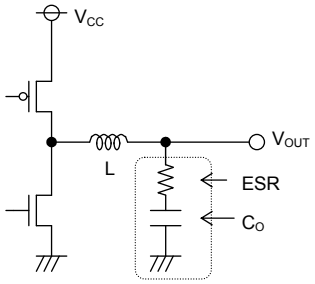


Figure 27. Output Capacitor

Output capacitor should be selected with the consideration on the stability region and the equivalent series resistance required to minimize ripple voltage. Output ripple voltage is determined by the equation (4)

$$\Delta V_{OUT} = \Delta I_L \times ESR \quad [V] \quad \cdot \cdot \cdot (4)$$

Where:
ΔI_L is the Output ripple current, and
ESR is the Equivalent series resistance of output capacitor

Note: Rating of the capacitor should be determined allowing sufficient margin against output voltage. Less ESR allows reduction in output ripple voltage.

Since output rise time is designed to fall within the soft-start time, the capacitance of output capacitor should be determined by the requirements of equation (5):

$$C_O \leq \frac{t_{SS} \times (I_{LIMIT} - I_{OUT})}{V_{OUT}} \quad \cdot \cdot \cdot (5)$$

Where:
t_{SS}: Soft-Start time
I_{LIMIT}: Over current detection level, 2A(Typ)

In case of BD8964FVM, for instance, and if V_{OUT}=1.5V, I_{OUT}=0.8A, and t_{SS}=1ms,

$$C_O \leq \frac{1m \times (2 - 0.8)}{1.5} \approx 800 \quad [\mu F]$$

Rating of the capacitor should be determined to allow a sufficient margin against output voltage. A 10µF to 100µF ceramic capacitor is recommended.

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(3) Selection of input capacitor (C_{IN})

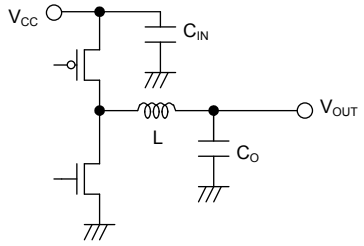


Figure 28. Input Capacitor

Input capacitor must be a low ESR capacitor with a capacitance sufficient to cope with high ripple current to prevent high transient voltage. The ripple current I_{RMS} is given by the equation (5):

$$I_{RMS} = I_{OUT} \times \frac{\sqrt{V_{OUT}(V_{CC} - V_{OUT})}}{V_{CC}} \quad [A] \cdots (6)$$

< Worst case > I_{RMSMax}

When V_{CC} is twice the V_{OUT}, $I_{RMS} = \frac{I_{OUT}}{2}$

If V_{CC}=5.0V, V_{OUT}=1.5V, and I_{OUTMax}=0.8A

$$I_{RMS} = 0.8 \times \frac{\sqrt{1.5(5-1.5)}}{5} \approx 0.37 \quad [A_{RMS}]$$

A low ESR 10μF/10V ceramic capacitor is recommended to reduce ESR dissipation of input capacitor for better efficiency.

(4) Calculating R_{ITH}, C_{ITH} for Phase Compensation

Since the Current Mode Control is designed to limit the inductor current, a pole (phase lag) appears in the low frequency area due to a CR filter consisting of the output capacitor and the load resistance, while a zero (phase lead) appears in the high frequency area due to the output capacitor and its ESR. Therefore, the phases are easily compensated by adding a zero to the power amplifier output with C and R as described below to cancel a pole at the power amplifier.

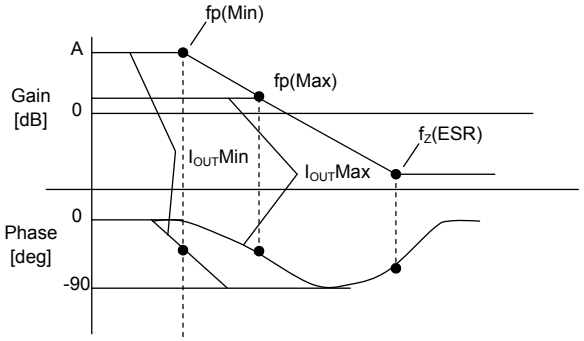


Figure 29. Open Loop Gain Characteristics

$$fp = \frac{1}{2\pi \times R_O \times C_O}$$

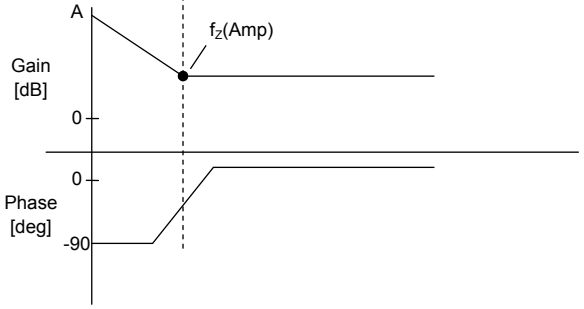
$$f_{Z(ESR)} = \frac{1}{2\pi \times ESR \times C_O}$$

Pole at power amplifier

When the output current decreases, the load resistance R_O increases and the pole frequency decreases.

$$fp_{(Min)} = \frac{1}{2\pi \times R_{OMax} \times Co} \quad [Hz] \leftarrow \textit{with lighter load}$$

$$fp_{(Max)} = \frac{1}{2\pi \times R_{O\,MIN} \times Co} \quad [Hz] \leftarrow \textit{with heavier load}$$



Zero at power amplifier

Increasing the capacitance of the output capacitor lowers the pole frequency while the zero frequency does not change. (This is because when the capacitance is doubled, the capacitor ESR is reduced to half.)

$$f_{Z(Amp)} = \frac{1}{2\pi \times R_{ITH} \times C_{ITH}}$$

Figure 30. Error Amp Phase Compensation Characteristics

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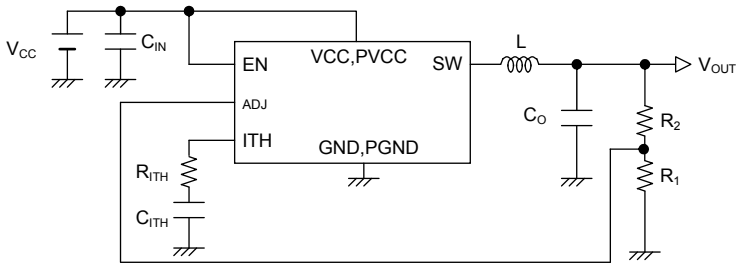


Figure 31. Typical Application

Stable feedback loop may be achieved by canceling the pole fp (Min) produced by the output capacitor and the load resistance with CR zero correction by the error amplifier.

$$f_{Z(Amp)} = f_{P(Min)}$$

$$\rightarrow \frac{1}{2\pi \times R_{ITH} \times C_{ITH}} = \frac{1}{2\pi \times R_{OMax} \times C_O}$$

(5) Setting the output voltage

The output voltage V_{OUT} is determined by the equation (7):

$$V_{OUT} = (R_2 / R_1 + 1) \times V_{ADJ} \quad \cdot \cdot \cdot (7)$$

Where:
V_{ADJ} is the Voltage at ADJ terminal (0.8V Typ)
The required output voltage may be determined by adjusting R_1 and R_2.

(Adjustable output voltage range : 1.0V to 1.8V)

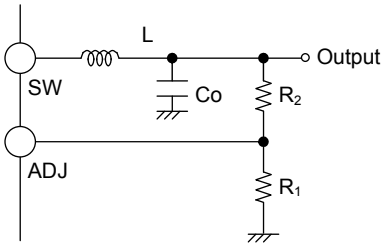


Figure 32. 出力電圧設定抵抗

Figure 32. Determination of Output Voltage

Use 1 kΩ to 100kΩ resistor for R_1. If a resistor higher than 100kΩ is used, check the assembled set carefully for ripple voltage etc.

7. BD8964FVM Cautions on PC Board Layout

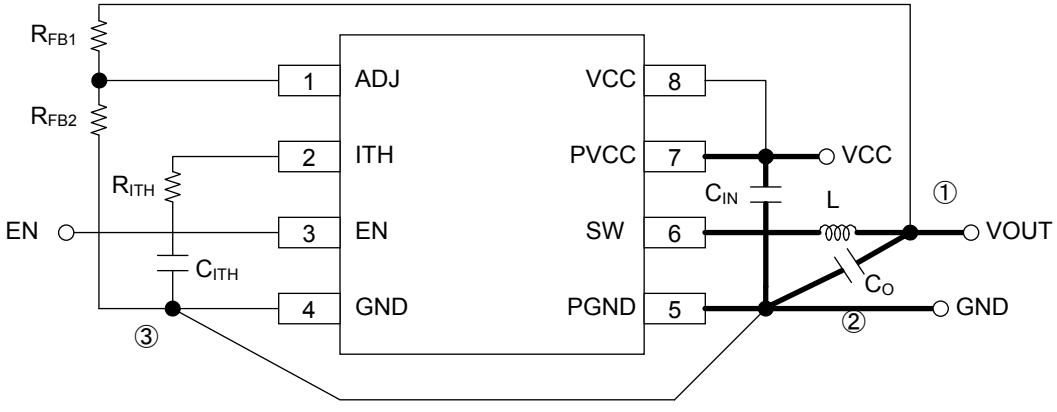


Figure 33. Layout Diagram

① For the sections drawn with heavy line, use thick conductor pattern as short as possible.
② Layout the input ceramic capacitor C_{IN} closer to the pins PVCC and PGND, and the output capacitor C_O closer to the pin PGND.
③ Layout C_{ITH} and R_{ITH} between the pins ITH and GND as near as possible with least necessary wiring.

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8. Recommended Components Lists on Above Application

Symbol	Part	Value		Manufacturer	Series
L	Coil	4.7μH		Sumida	CMD6D11B
				TDK	VLF5014AT-4R7M1R1
C_{IN}	Ceramic capacitor	10μF		Kyocera	CM316X5R106K10A
C_O	Ceramic capacitor	10μF		Kyocera	CM316X5R106K10A
C_{ITH}	Ceramic capacitor	1000pF		Murata	GRM18 series
R_{ITH}	Resistance	V_{OUT}=1.0V	4.3kΩ	ROHM	MCR10 4301
		V_{OUT}=1.2V	6.8kΩ	ROHM	MCR10 6801
		V_{OUT}=1.5V	9.1kΩ	ROHM	MCR10 9101
		V_{OUT}=1.8V	12kΩ	ROHM	MCR10 1202

Note: The parts list presented above is an example of recommended parts. Although the parts are standard, actual circuit characteristics should be checked on your application carefully before use. Be sure to allow sufficient margins to accommodate variations between external devices and this IC when employing the depicted circuit with other circuit constants modified. Both static and transient characteristics should be considered in establishing these margins. When switching noise is significant and may affect the system, a low pass filter should be inserted between the VCC and PVCC pins, and a schottky barrier diode established between the SW and PGND pins.

I/O Equivalent Circuit

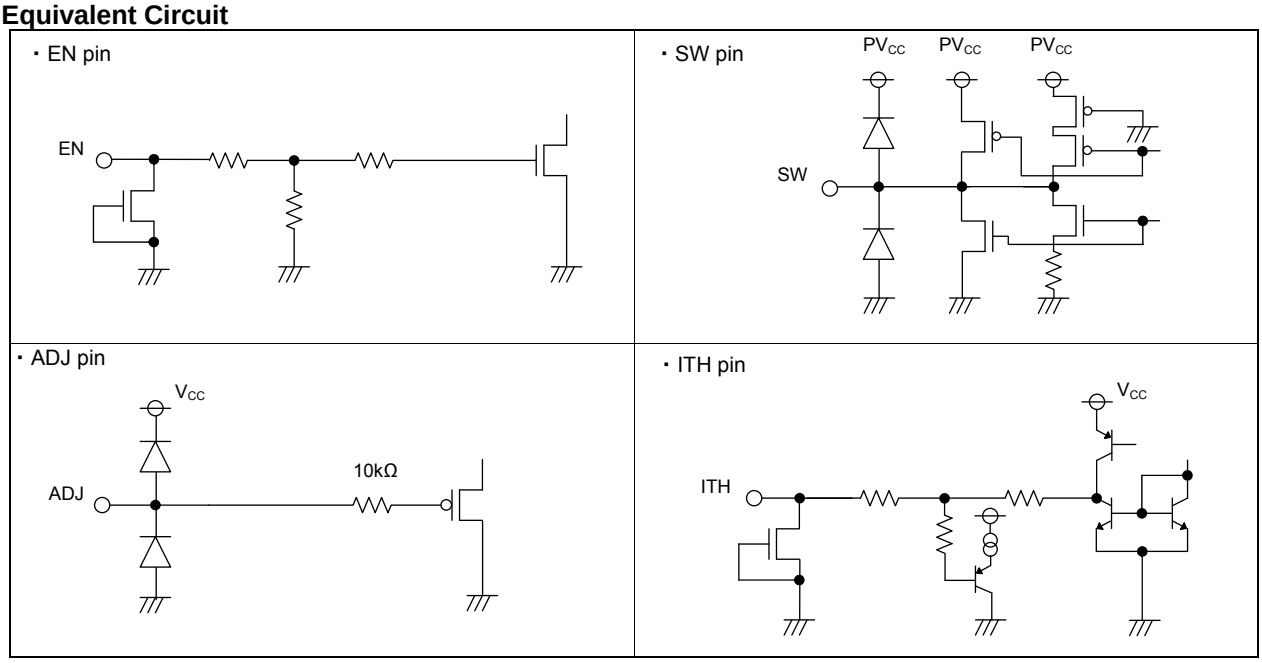


Figure 34. I/O Equivalent Circuit

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Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Thermal Consideration**
   Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

6. **Recommended Operating Conditions**
   These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. **Operation Under Strong Electromagnetic Field**
   Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output 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 the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. **Inter-pin Short and Mounting Errors**
    Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

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Operational Notes – continued

11. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

12. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

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

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, 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.

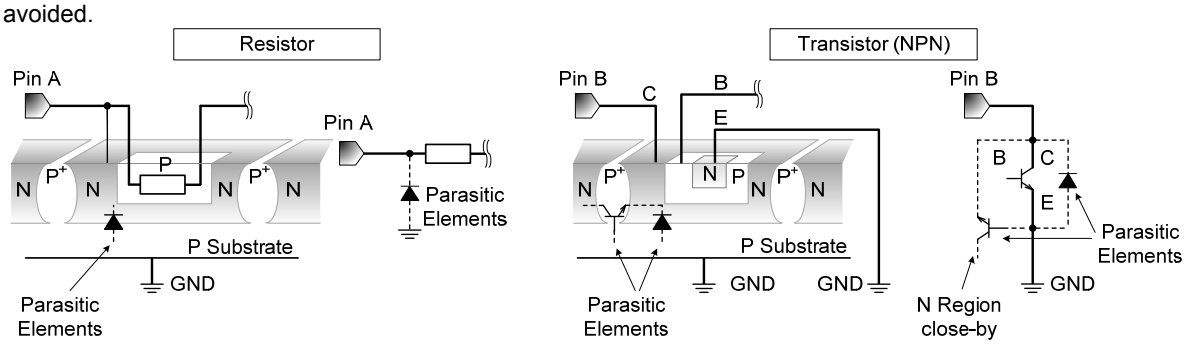


Figure 35. Example of monolithic IC structure

13. Thermal Shutdown Circuit(TSD)

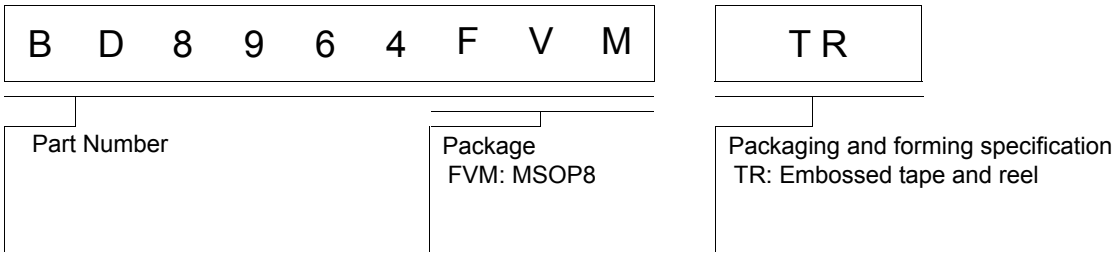
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF all output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

14. Selection of Inductor

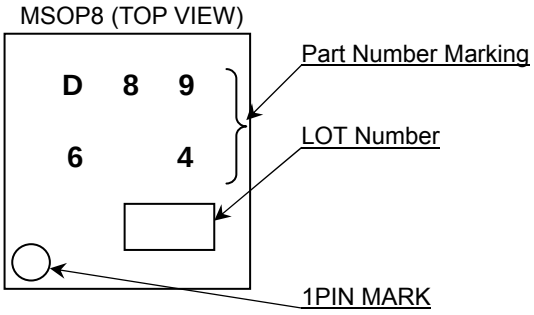
It is recommended to use an inductor with a series resistance element (DCR) 0.1Ω or less. Especially, note that use of a high DCR inductor will cause an inductor loss, resulting in decreased output voltage. Should this condition continue for a specified period (soft start time + timer latch time), output short circuit protection will be activated and output will be latched OFF. When using an inductor over 0.1Ω, be careful to ensure adequate margins for variation between external devices and this IC, including transient as well as static characteristics. Furthermore, in any case, it is recommended to start up the output with EN after supply voltage is within.

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Ordering Information



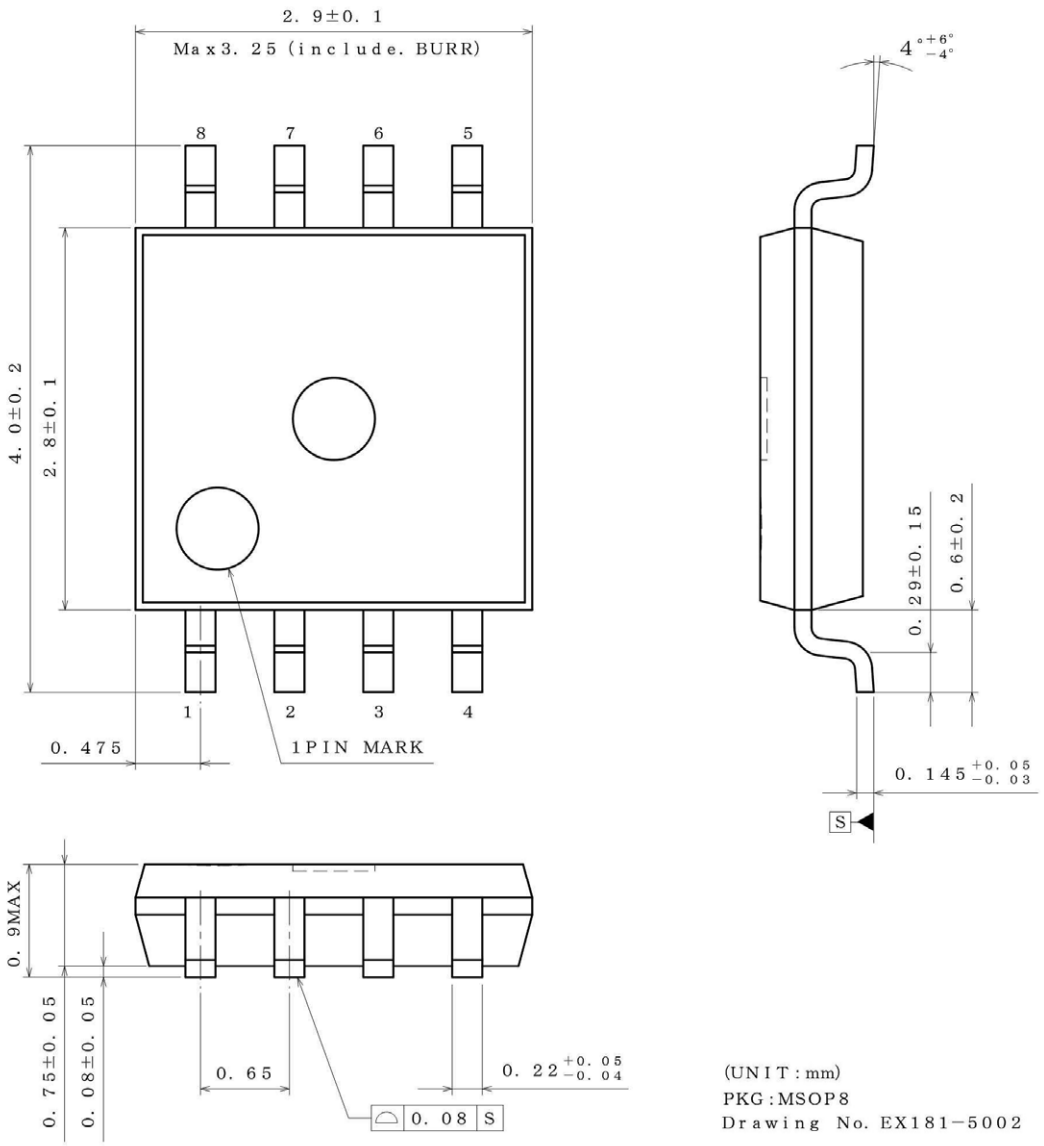
Marking Diagram



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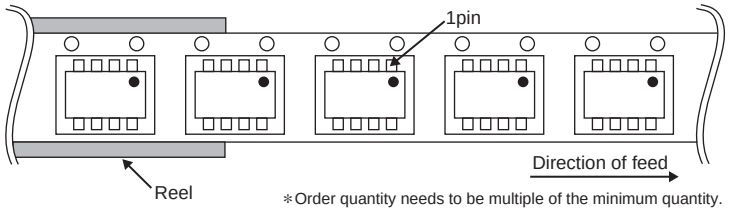
Physical Dimension Tape and Reel information

Package Name	MSOP8



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



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

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Revision History

Date	Revision	Changes
02.Mar.2012	001	New Release
02.Oct.2014	002	Applied the ROHM Standard Style and improved understandability.
22.Jan.2015	003	Modify Page15 Figure 33. Layout Diagram

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CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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   [f] Sealing or coating our Products with resin or other coating materials
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   [h] Use of the Products in places subject to dew condensation

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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.

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

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   - [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.

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Distribution Inventory

Part Number	BD8964FVM
Package	MSOP8
Unit Quantity	3000
Minimum Package Quantity	3000
Packing Type	Taping
Constitution Materials List	inquiry
RoHS	Yes