AC/DC Drivers

PWM type DC/DC converter IC Included a Switching MOSFET

BM2P015-Z BM2P016-Z

General Description

The PWM type DC/DC converter BM2P015-Z and BM2P016-Z for AC/DC provides an optimal system for all products that include an electrical outlet.

This IC supports both isolated and non -isolated devices, enabling simpler design of various types of low-power electrical converters.

The built-in 650V HV starter circuit contributes to low-power consumption.

A higher degree of design freedom can be achieved with current detection resistors as external devices. Current is restricted in each cycle and excellent performance is demonstrated in bandwidth and transient response since current mode control is utilized. The switching frequency is 65 kHz. At light load, the switching frequency is reduced and high efficiency is achieved. A frequency hopping function that contributes to low EMI is also included on chip.

Design can be easily implemented because includes a 650V switching MOSFET.

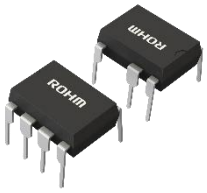
Features

- PWM frequency : 65kHz
- PWM current mode control
- Burst operation when load is light
- Frequency reduction function
- Built-in 650V starter circuit
- Built-in 650V switching MOSFET
- VCC pin Under-Voltage protection
- VCC pin Over-Voltage protection
- SOURCE pin Open Protection
- SOURCE pin Short Protection
- SOURCE pin Leading Edge Blanking function
- Per-cycle Over-Current Protection Circuit
- Soft start
- Secondary Over-Current Protection Circuit

Basic specifications

- Operating Power Supply Voltage Range:
  - VCC: 8.9V to 26.0V
  - DRAIN: to 650V
- Normal Operating Current: 0.950mA (Typ.)
- Burst Operating Current: 0.30mA(Typ.)
- Oscillation Frequency: 65kHz(Typ.)
- Operating Ambient Temperature: - 40°C to +105°C
- MOSFET ON Resistance: 1.4Ω (Typ.)

Package	W (Typ) x D (Typ) x H (Max)
DIP7K	9.27 mm x 6.35 mm x 8.63 mm pitch 2.54 mm
DIP7WF	9.35mm x 6.35mm x 8.10mm Pitch 2.54mm



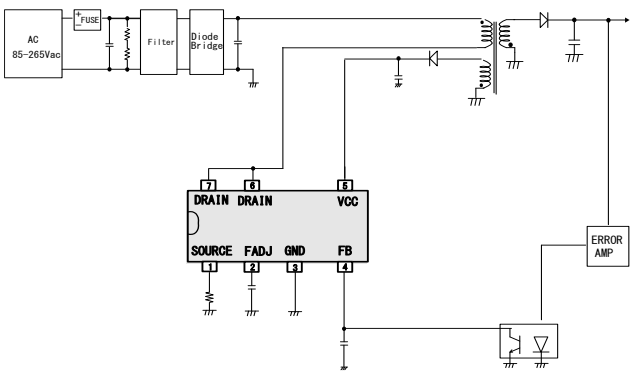
Applications

For AC adapters and household appliances (vacuum cleaners, humidifiers, air cleaners, air conditioners, IH cooking heaters, rice cookers, etc.)

Lineup

Product name	VCC OVP
BM2P015-Z	Latch
BM2P016-Z	Auto Restart

Application Circuit



○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays.

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Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit	Conditions
Maximum applied voltage 1	V_{max1}	-0.3 to 32.0	V	VCC
Maximum applied voltage 2	V_{max2}	-0.3 to 6.5	V	SOURCE, FB, FADJ
Maximum applied voltage 3	V_{max3}	650	V	DRAIN
Drain current pulse	I_{DP}	10.40	A	P_W=10us, Duty cycle=1%
Allowable dissipation	Pd	1.00	W	When implemented
Operating ambient temperature range	T_{opr}	-40 to +105	°C	
MAX junction temperature	T_{jmax}	150	°C	
Storage temperature range	T_{str}	-55 to +150	°C	

(Note1): When mounted (on 74.2 mm × 74.2 mm, 1.6 mm thick, glass epoxy on single-layer substrate).
Reduce to 8 mW/°C when Ta = 25°C or above.

Operating Conditions (Ta=25°C)

Parameter	Symbol	Rating	Unit	Conditions
Power supply voltage range 1	V_{CC}	8.9 to 26.0	V	VCC pin voltage
Power supply voltage range 2	V_{DRAIN}	650	V	DRAIN pin voltage

Electrical Characteristics of MOSFET (unless otherwise noted, Ta = 25°C, VCC = 15V)

Parameter	Symbol	Specifications			Unit	Conditions
		Min	Typ	Max		
[MOSFET Block]						
Between drain and source voltage	$V_{(BR)DDS}$	650	-	-	V	I_D=1mA / V_{GS}=0V
Drain leak current	I_{DSS}	-	-	100	uA	V_{DS}=650V / V_{GS}=0V
On resistance	$R_{DS(ON)}$	-	1.4	2.0	Ω	I_D=0.25A / V_{GS}=10V

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Electrical Characteristics (unless otherwise noted, Ta = 25°C, VCC = 15 V)

Parameter	Symbol	Specifications			Unit	Conditions
		Min	Typ	Max		
[Circuit Current]						
Circuit current (ON) 1	I_{ON1}	700	950	1200	μA	FB=2.0(at pulse operation)
Circuit current (ON) 2	I_{ON2}	200	300	400	μA	FB=0.0V(at burst operation)
[VCC Protection Function]						
VCC UVLO voltage 1	V_{UVLO1}	12.50	13.50	14.50	V	VCC rise
VCC UVLO voltage 2	V_{UVLO2}	7.50	8.20	8.90	V	VCC fall
VCC UVLO hysteresis	V_{UVLO3}	-	5.30	-	V	V_{UVLO3}= V_{UVLO1}- V_{UVLO2}
VCC OVP voltage 1	V_{OVP1}	26.0	27.5	29.0	V	VCC rise
VCC OVP voltage 2	V_{OVP2}	22.0	23.5	25.0	V	BM2P016-Z VCC fall
VCC OVP hysteresis	V_{OVP3}	-	4.0	-	V	BM2P016-Z
Latch released VCC voltage	V_{LATCH}	7.0	7.7	8.4	V	
VCC recharge start voltage	V_{CHG1}	7.70	8.70	9.70	V	
VCC recharge stop voltage	V_{CHG2}	12.00	13.00	14.00	V	
Latch mask time	t_{LATCH}	50	100	150	us	
Thermal shut down temperature1	T_{SD1}	120	145	170	°C	Control IC, temp rise
Thermal shut down temperature2	T_{SD2}	90	115	140	°C	Control IC, temp fall
[PWM Type DCDC Driver Block]						
Oscillation frequency 1	F_{SW1}	60	65	70	KHz	FB=2.00V
Oscillation frequency 2	F_{SW2}	20	25	30	KHz	FB=0.30V
Frequency hopping width 1	F_{DEL1}	-	4.0	-	KHz	FB=2.0V
Hopping fluctuation frequency	F_{CH}	75	125	175	Hz	
FADJ source current	I_{BST}	0.80	1.00	1.20	uA	FADJ=0.0V
FADJ comparator voltage	V_{BST}	1.13	1.20	1.27	V	
FADJ max burst frequency	F_{BST}	-	0.833	-	KHz	CFADJ=1000pF
Soft start time 1	t_{SS1}	0.30	0.50	0.70	ms	
Soft start time 2	t_{SS2}	0.60	1.00	1.40	ms	
Soft start time 3	t_{SS3}	1.20	2.00	2.80	ms	
Soft start time 4	t_{SS4}	4.80	8.00	11.20	ms	
Maximum duty	D_{max}	68.0	75.0	82.0	%	
Minimum ON time	T_{min}	150	400	650	ns	
FB pin pull-up resistance	R_{FB}	23	30	37	kΩ	
ΔFB / ΔSOURCE gain	Gain	-	4.00	-	V/V	
FB burst voltage 1	V_{BST1}	0.220	0.280	0.340	V	FB fall
FB burst voltage 2	V_{BST2}	0.260	0.320	0.380	V	FB rise
FB burst hysteresis	V_{BST3}	-	0.040	-	V	V_{BST3}= V_{BST2}- V_{BST1}
FB voltage of starting frequency reduction mode	V_{DLT}	1.100	1.250	1.400	V	
FB OLP voltage 1a	V_{FOLP1A}	2.60	2.80	3.00	V	Overload is detected (FB rise)
FB OLP voltage 1b	V_{FOLP1B}	2.40	2.60	2.80	V	Overload is detected (FB fall)
FB OLP ON time	T_{FOLP1}	80	128	176	ms	
FB OLP OFF time	T_{FOLP2}	332	512	692	ms	
[Over Current Detection Block]						
Over-current detection voltage	V_{SOURCE}	0.375	0.400	0.425	V	Ton=0us
Over-current detection voltage SS1	V_{S_SS1}	0.050	0.100	0.150	V	0[ms] to Tss1 [ms]
Over-current detection voltage SS2	V_{S_SS2}	0.080	0.150	0.220	V	TSS1 [ms] to TSS2 [ms]
Over-current detection voltage SS3	V_{S_SS3}	0.130	0.200	0.270	V	TSS2 [ms] to TSS3 [ms]
Over-current detection voltage SS4	V_{S_SS4}	0.230	0.300	0.370	V	TSS3 [ms] to TSS4 [ms]
Leading edge blanking time	t_{LEB}	(120)	250	(380)	ns	Design assurance
Over current detection AC voltage compensation factor	K_{SOURCE}	12	20	28	mV/us	
SOURCE pin short protection voltage	V_{SHT}	0.020	0.050	0.080	V	
SOURCE pin short protection time	$T_{SOURCESHT}$	1.80	3.00	4.20	us	

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Parameter	Symbol	Specifications			Unit	Conditions
		Min	Typ	Max		
[Circuit Current]						
Start current 1	I_{START1}	0.100	0.500	1.000	mA	VCC= 0V
Start current 2	I_{START2}	1.000	3.000	6.000	mA	VCC=10V
OFF current	I_{START3}	-	10	20	uA	Inflow current from Drain pin after UVLO is released and when MOSFET is OFF
Start current switching voltage	V_{SC}	0.800	1.500	2.100	V	

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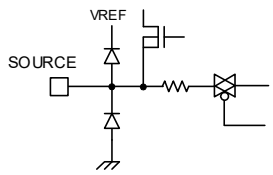
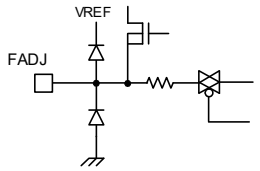
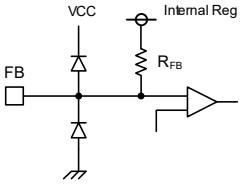
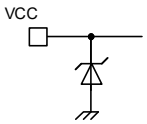
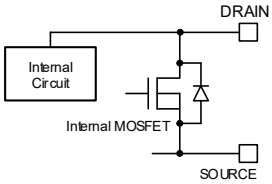
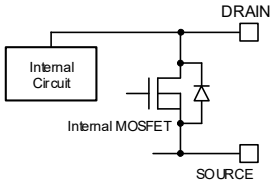
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Pin Descriptions

Table 1. Pin Description

NO.	Pin Name	I/O	Function	ESD Diode	
				VCC	GND
1	SOURCE	I/O	MOSFET SOURCE pin	✔	✔
2	FADJ	I	MAX Burst Frequency setting pin	✔	✔
3	GND	I/O	GND pin	✔	-
4	FB	I	Feedback signal input pin	✔	✔
5	VCC	I	Power supply input pin	-	✔
6	DRAIN	I/O	MOSFET DRAIN pin	-	-
7	DRAIN	I/O	MOSFET DRAIN pin	-	-

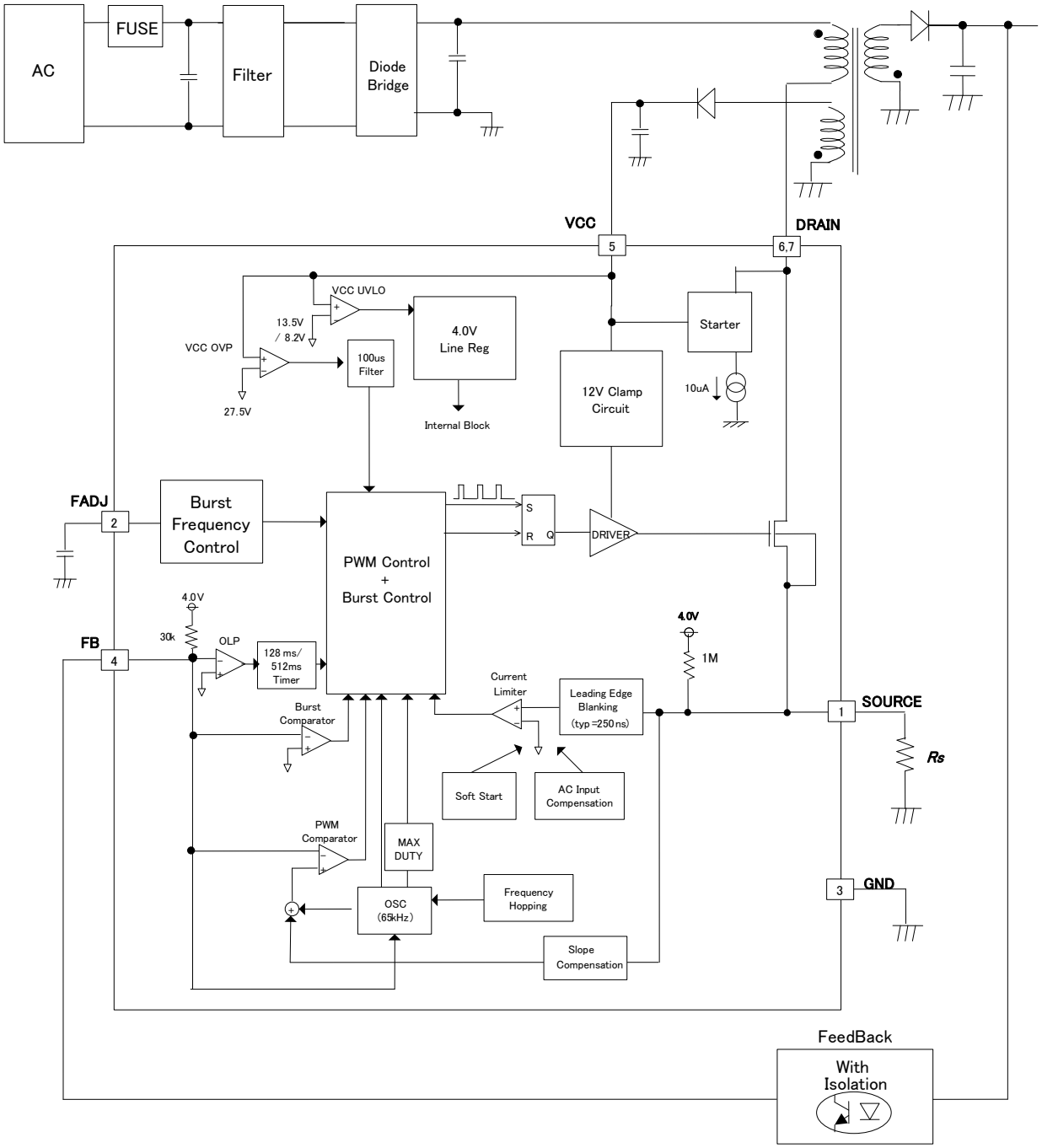
I/O Equivalent Circuit Diagram

1 SOURCE	2 FADJ	3 GND	4 FB
			
5 VCC	**- -**	**6 DRAIN**	**7 DRAIN**
	-		

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Block Diagram



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Block Description

(1) Start circuit (DRAIN: Pin 6,7)

This IC has a built-in start circuit. It enables low standby mode electricity and high speed start.
After start up, consumption power is determined by idling current I_{START3} (Typ=10uA) only.
Reference values of starting time are shown in Figure 3. When C_{vcc}=10uF it can start in less than 0.1 sec.

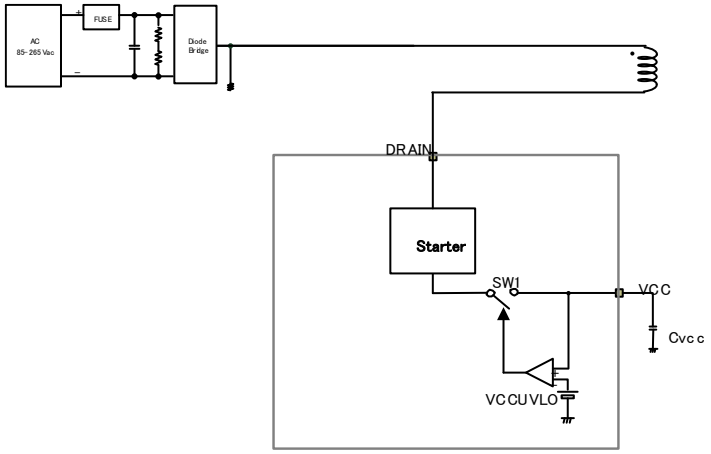


Figure 1. Block Diagram of Start Circuit

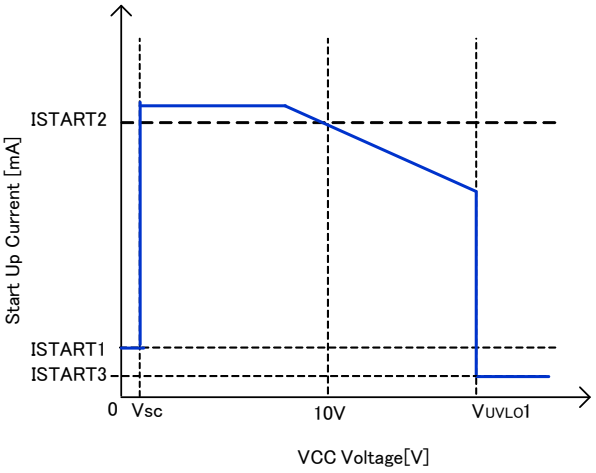


Figure 2. Start Current vs VCC Voltage

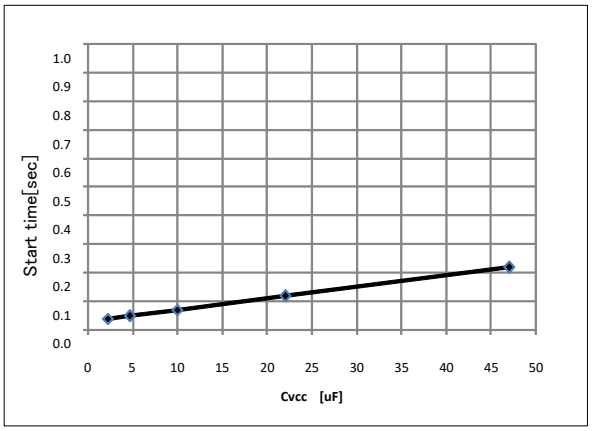


Figure 3. Start Time (reference value)

* Start current flows from the DRAIN pin

Ex) Consumption power of start circuit only when Vac=100V
PVH=100V*√2*10uA=1.41mW

Ex) Consumption power of start circuit only when Vac=240V
PVH=240V*√2*10uA=3.38mW

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(2) Start sequences

(Soft start operation, light load operation, and auto recovery operation during overload protection)
Start sequences are shown in Figure 4. See the sections below for detailed descriptions.

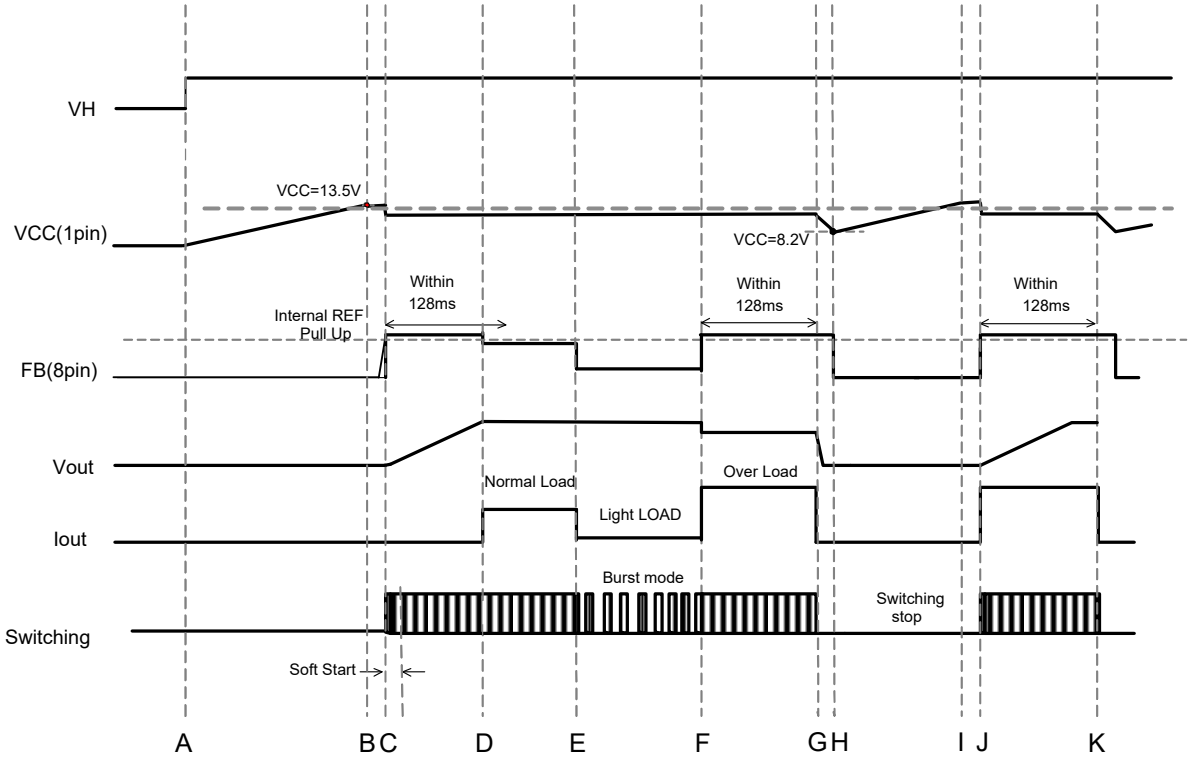


Figure 4. Start Sequences Timing Chart

A: Input voltage VH is applied.
B: This IC starts operating when VCC > V_{UVLO1} (13.5 V Typ).
Switching function starts when other protection functions are judged as normal.
When the secondary output voltage becomes constant, VCC pin current causes the VCC voltage to drop. As a result, IC should be set to start switching until VCC<V_{UVLO2} (8.2V Typ).
C: With the soft start function, over current limit value is restricted to prevent any excessive rise in voltage or current.
D: When the switching operation starts, VOUT rises.
Once the output voltage starts, set the rated voltage within the T_{FOLP} period (128ms Typ).
E: When there is a light load, it makes FB voltage < V_{BST} (0.3V Typ). Burst operation is used to keep power consumption down. During burst operation, it operates at low-power consumption mode.
F: When the FB pin Voltage>V_{FOLP1A}(2.8V Typ), it overloads.
G: When the FB pin voltage keeps V_{FOLP1A} (= 2.8V Typ) at or goes above T_{FOLP} (128ms Typ), the overload protection function is triggered and the switching stops. During the T_{FOLP} period (128ms Typ), if the FB pin voltage becomes <V_{FOLP1B} even once, the IC's internal timer is reset.
H: If the VCC voltage drops to < V_{UVLO2} (7.7V Typ) or below, restart is executed.
I: The IC's circuit current is reduced and the VCC pin value rises. (same as B)
J: Same as F
K: Same as G

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(3) VCC pin protection function

These ICs have a built-in VCC low voltage protection function VCCUVLO (Under Voltage Lock Out), over voltage protection function VCCOVP (Over Voltage Protection), and a VCC recharge function that operates in case of a drop in VCC voltage.

VCC charge function stabilizes the secondary output voltage, charged from high voltage lines by the start circuit when VCC voltage drops.

(3-1) VCC UVLO / VCC OVP function

VCCUVLO is an auto recovery comparator. And VCCOVP is a latch type (BM2P015-Z) or auto restart type (BM2P016-Z) comparator.

VCCOVP operates in case of continuing VCC pin voltage > V_{OVP} (Typ=27.5V).

This function has a built-in mask time T_{LATCH}(Typ=100us). Through this function, the IC is protected from pin generated surge, etc. Figure 5 is showed about VCC OVP auto recovery type.

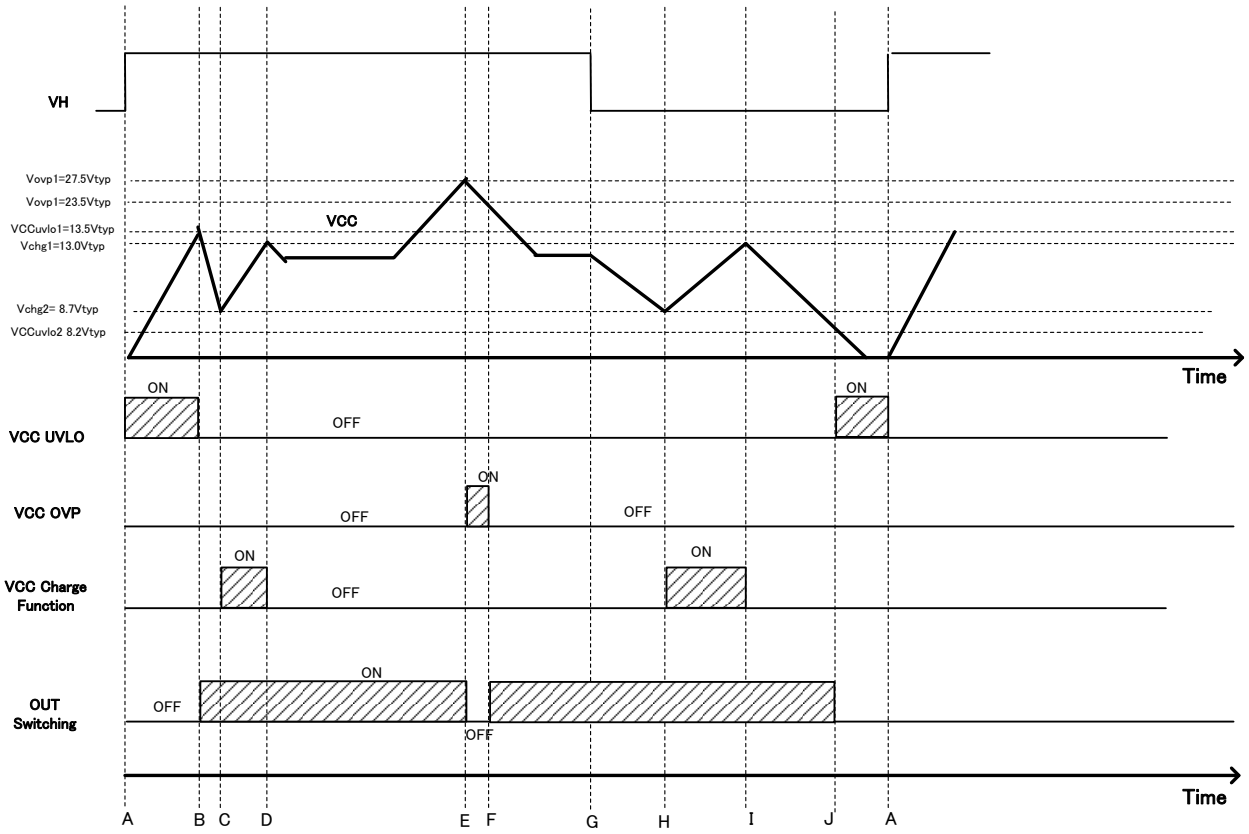


Figure 5. VCC UVLO / OVP Timing Chart

A: DRAIN voltage input, VCC pin voltage starts rising.
B: VCC>V_{uvlo1}, DC/DC operation starts.
C: VCC< V_{CHG1}, VCC charge function operates and the VCC voltage rises.
D: VCC > V_{CHG2}, VCC charge function stops.
E: VCC > V_{OVP1}, T_{LATCH} (Typ =100us) continues, switching is stopped by the VCCOVP function.
F: VCC < V_{OVP2}, DC/DC operation restarts by auto recovery.
G: VH is OPEN. VCC Voltage falls.
H: Same as C
I: Same as D
J: VCC<V_{uvlo2}, DC/DC operation stops.

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(3-2) VCC charge function

This IC has the recharge function.

VCC charge function operates once the VCC pin >V_{UVLO1} and when the DC/DC operation starts. The VCC pin voltage then drops to <V_{CHG1}. At that time the VCC pin is charged from the DRAIN pin through the start circuit. Through this operation, these series prevent failure.

VCC pin voltage rises until VCC >V_{CHG2}. The operation is shown in figure 6.

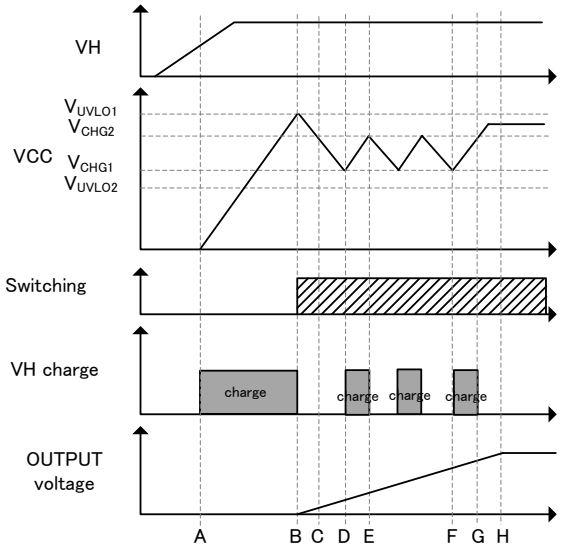


Figure 6. VCC Pin Charge Operation

A: DRAIN pin voltage rises, charges VCC pin through the VCC charge function.
B: VCC > $V_{UVLO1,}$ VCC UVLO function releases, VCC charge function stops, DC/DC operation starts.
C: When the DC/DC operation starts, the VCC voltage drops.
D: VCC < $V_{CHG1,}$ VCC recharge function operates.
E: VCC > $V_{CHG2,}$ VCC recharge function stops.
F: VCC < $V_{CHG1,}$ VCC recharge function operates.
G: VCC > $V_{CHG2,}$ VCC recharge function stops.
H: After the output voltage is finished rising, VCC is charged by the auxiliary winding, and VCC pin stabilizes.

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(4) DCDC driver (PWM comparator, frequency hopping, slope compensation, OSC, burst)

This IC has a current mode PWM control.
An internal oscillator sets a fixed switching frequency (65 kHz Typ).
This IC has an integrated switching frequency hopping function, which causes the switching frequency to fluctuate as shown in Figure 7 below.
The fluctuation cycle is 125 Hz (Typ).

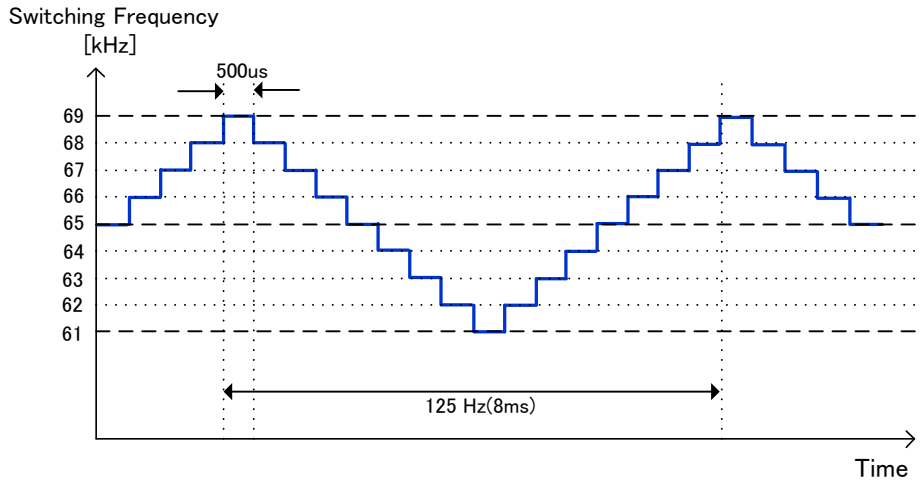


Figure 7. Frequency Hopping Function

Maximum duty cycle is fixed at 75% (Typ) and minimum pulse width is fixed at 400 ns (Typ).
In current mode control, sub-harmonic oscillation may occur when the duty cycle exceeds 50%.
As a countermeasure, this IC has built-in slope compensation circuits.

This IC has built-in burst mode and frequency reduction circuits to achieve lower power consumption when the load is light. FB pin is pulled up by R_{FB} (30 kΩ Typ). FB pin voltage is changed by secondary output voltage (secondary load power).FB pin is monitored, burst mode operation and frequency detection start.
Figure 8 shows the FB voltage, and the DCDC switching frequency operation.

mode1 : Burst operation
mode2 : Frequency reduction operation (operates at max frequency)
mode3 : Fixed frequency operation (operates at max frequency)
mode4 : Overload operation (detects the overload state and stops the pulse operation)

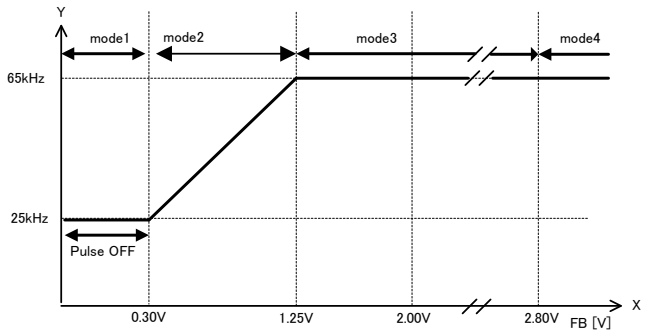


Figure 8. Switching Operation State Changes by FB Pin Voltage

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(4-1) MAX Burst frequency setting

This IC can reduce a burst sound to fix a burst frequency.
This IC has two clocks, so this IC can fix the burst frequency.

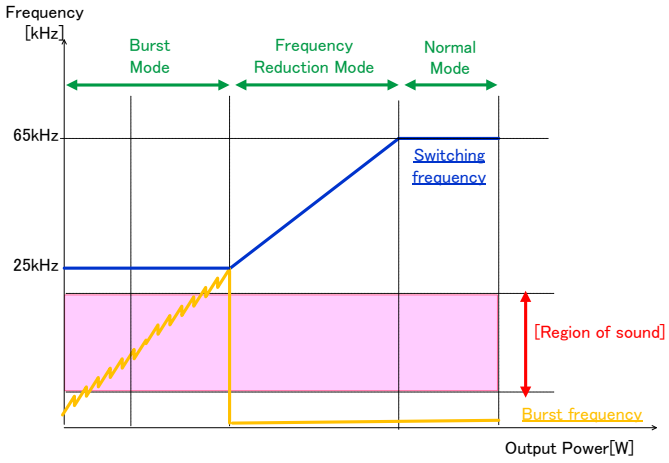


Figure 9-1. No setting

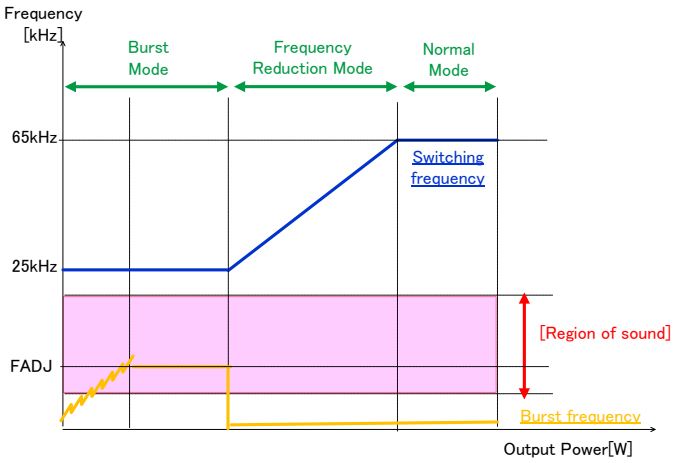


Figure 9-2. setting

Setting external capacitor of FADJ pin, the burst frequency is fixed.
It is showed an example of max burst frequency setting using FADJ pin
This frequency is decided by FADJ source current, FADJ comparator voltage and external capacitor.

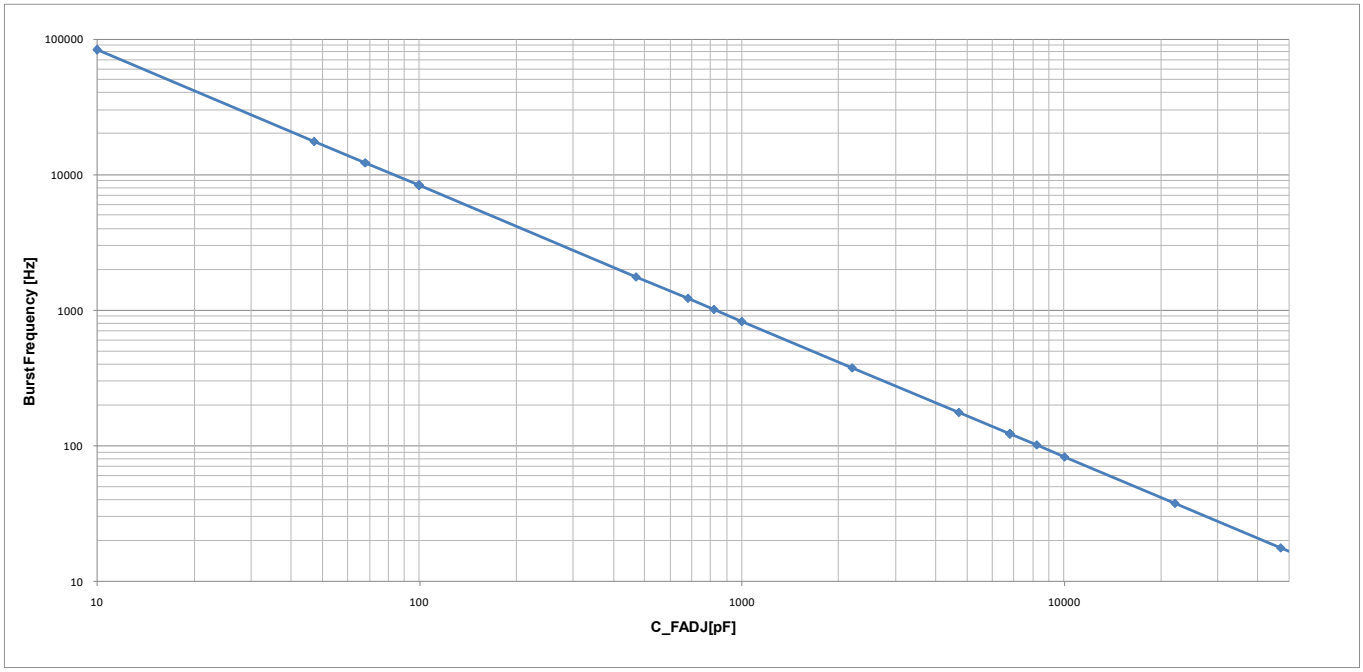


Figure 10. Example of max burst frequency setting using FADJ pin

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(5) Over Current limiter

This IC has a built-in over current limiter per cycle. If the SOURCE pin exceeds a certain voltage, switching stops. It also has a built-in AC voltage compensation function. With this function, the over current limiter level is high until the time the AC voltage is compensated.

Shown in figure-11, 12, and 13.

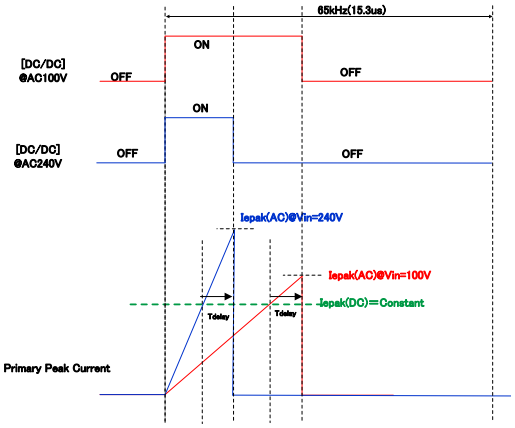


Figure 11. No AC Voltage Compensation Function

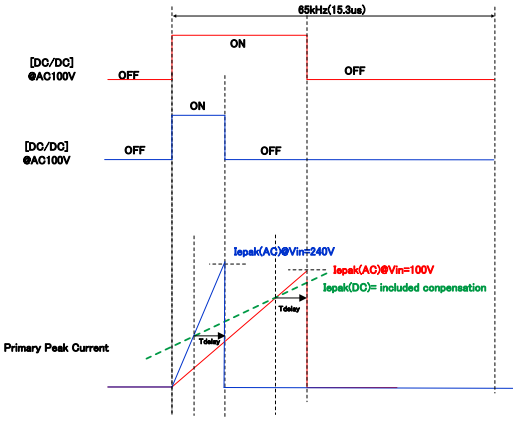


Figure12. Built-in AC Compensation Voltage

Primary peak current is calculated using the formula below.

$$Ipeak = \frac{V_{SOURCE}}{Rs} + \frac{Vdc}{Lp} \times tdelay$$

Where:
V_{SOURCE} is the over current limiter voltage (internal).
Rs is the current detection resistance.
Vdc is the input DC voltage.
Lp is the primary inductance.
$tdelay$ is the delay time after detection of over current limiter.

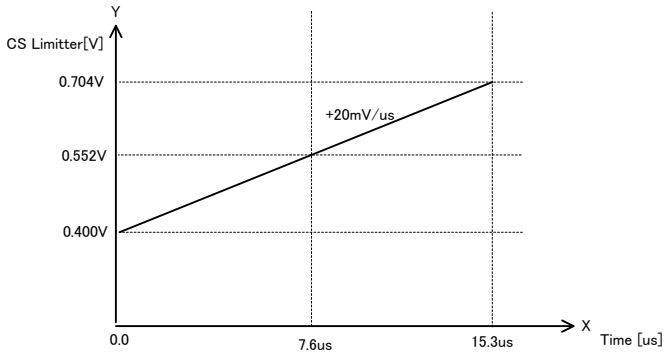


Figure 13. Over Current Limiter Voltage

(6) L. E. B. Blanking Period

When the MOSFET driver is turned ON, surge current flows through each capacitor component and drive current is generated. Therefore, when the SOURCE pin voltage rises temporarily, detection errors may occur in the over current limiter circuit. To prevent detection errors, DRAIN is switched from high to low and the SOURCE signal is masked for 250ns by the on-chip LEB (Leading Edge Blanking) function.

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(7) SOURCE pin (pin 1) short protection function

When the SOURCE pin (pin 1) is shorted, this IC overheats.
This IC has a built-in short protection function to prevent destruction.

(8) SOURCE pin (pin 1) open protection

If the SOURCE pin becomes OPEN, this IC may be damaged.
To prevent it from being damaged, this IC has a built-in OPEN protection circuit (auto recovery protection).

(9) Output over load protection function (FB OLP Comparator)

The output overload protection function monitors the secondary output load status at the FB pin and stops switching whenever overload occurs. When there is an overload, the output voltage is reduced and current no longer flows to the photo coupler, so the FB pin voltage rises.
When the FB pin voltage > V_{FOLP1A} (2.8 V Typ) continuously for the period T_{FOLP} (128ms Typ), it is judged as an overload and switching stops.
When the FB pin > V_{FOLP1A} (2.8 V Typ), if the voltage goes lower than V_{FOLP1B} (2.6V Typ) during the period T_{FOLP} (128ms Typ), the overload protection timer is reset. The switching operation is performed during this period T_{FOLP} (128ms Typ).
At startup, the FB voltage is pulled up to the IC's internal voltage, so operation starts at a voltage of V_{FOLP1A} (2.8 V Typ) or above. Therefore, at startup the FB voltage must be set to V_{FOLP1B} (2.6 V Typ) or below during the period T_{FOLP} (128ms Typ), and the secondary output voltage's start time must be set within the period T_{FOLP} (128ms Typ) following startup of the IC.
Recovery is after the period T_{FOLP2}(512 ms Typ), from the detection of FBOLP.

Operation mode of protection circuit

Operation mode of protection functions are shown in Table 2.

Table 2. Operation Mode of Protection Circuit

Function	Operation mode
VCC Under Voltage Locked Out	Auto recovery
VCC Over Voltage Protection	BM2P015-Z: Latch(with 100us timer) BM2P016-Z: Auto recovery
TSD	Auto recovery
FB Over Limited Protection	Auto recovery (with 128ms timer)
SOURCE Short Protection	Auto recovery
SOURCE Open Protection	Auto recovery

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Thermal loss

The thermal design should set operation for the following conditions.
(Since the temperature shown below is the guaranteed temperature, be sure to take a margin into account.)

1. The ambient temperature Ta must be 105°C or less.
2. The IC's loss must be within the allowable dissipation Pd.

The thermal abatement characteristics are as follows.
(PCB: 74.2 mm × 74.2mm × 1.6 mm, mounted on glass epoxy on single-layer substrate)

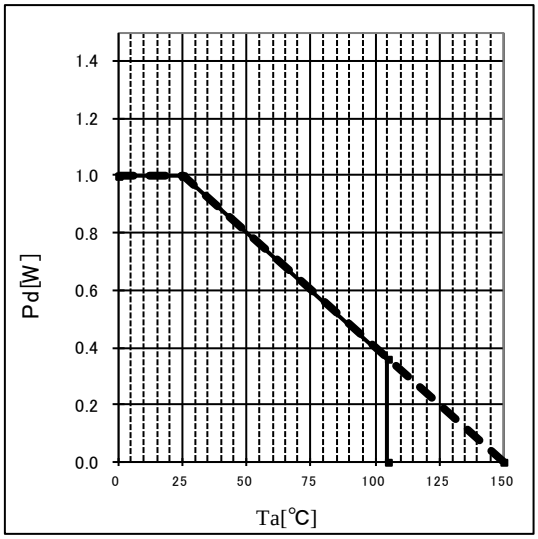
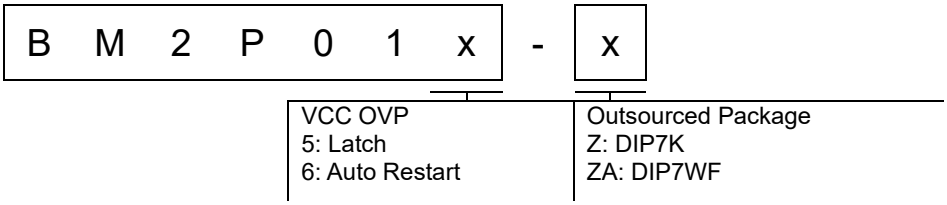


Figure 14. Thermal Abatement Characteristics

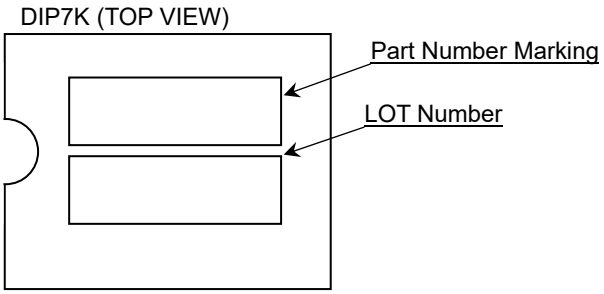
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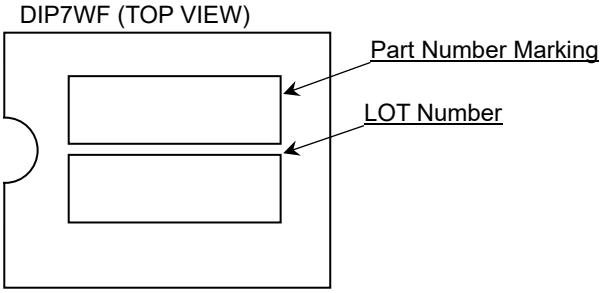
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Ordering Information



Making Diagram





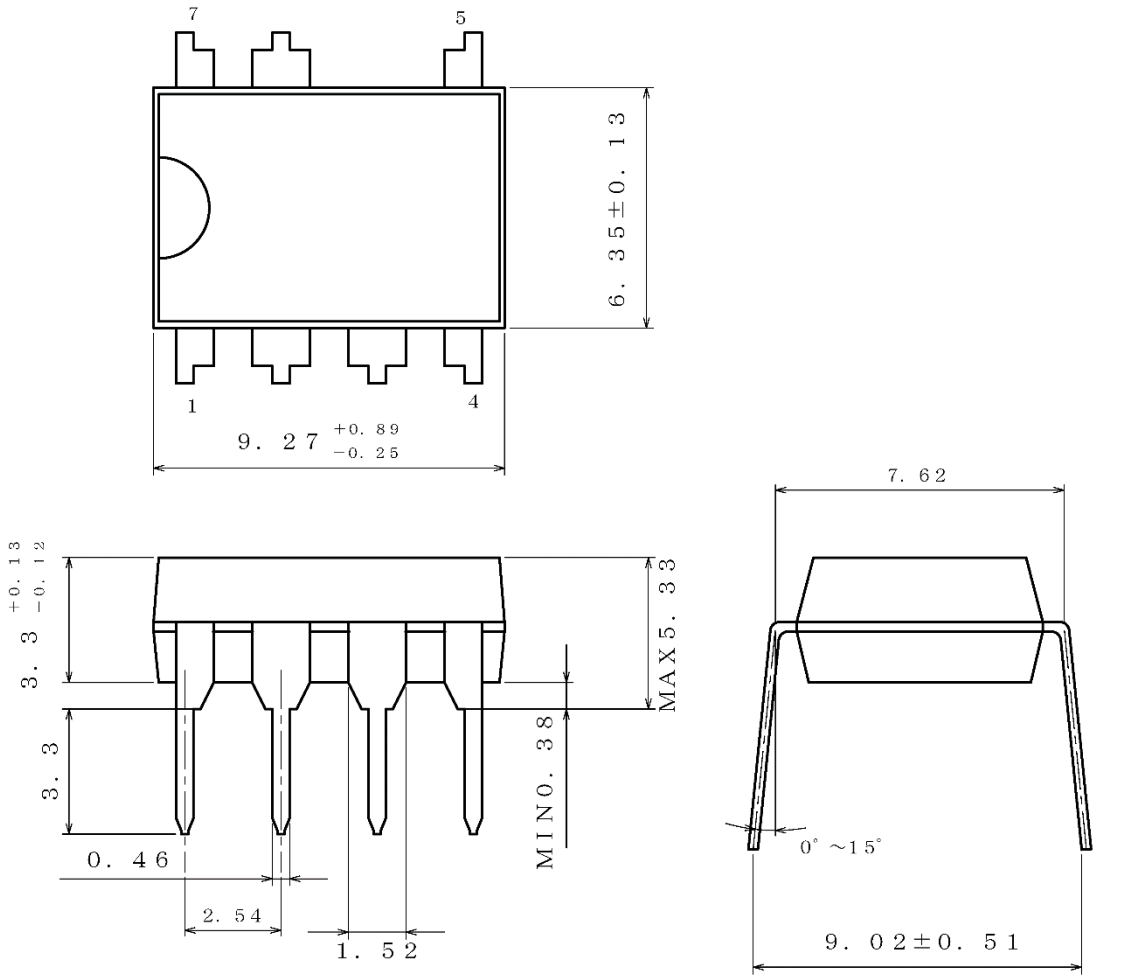
Part Number Marking	Product Name	VCC OVP
BM2P015	BM2P015-Z	Latch
BM2P016	BM2P016-Z	Auto Restart

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Physical Dimension and Packing Information

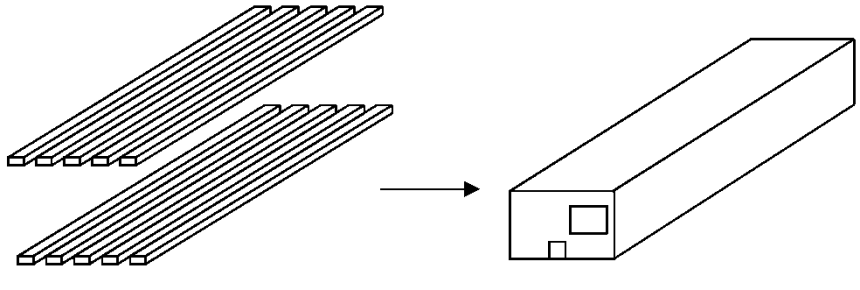
Package Name	DIP7K



(UNIT:mm)
PKG:DIP7K
Drawing No. EX001-0076

< Container Information >

Container	Tube
Quantity	2000pcs
Direction of feed	Packing orientation is same in tube

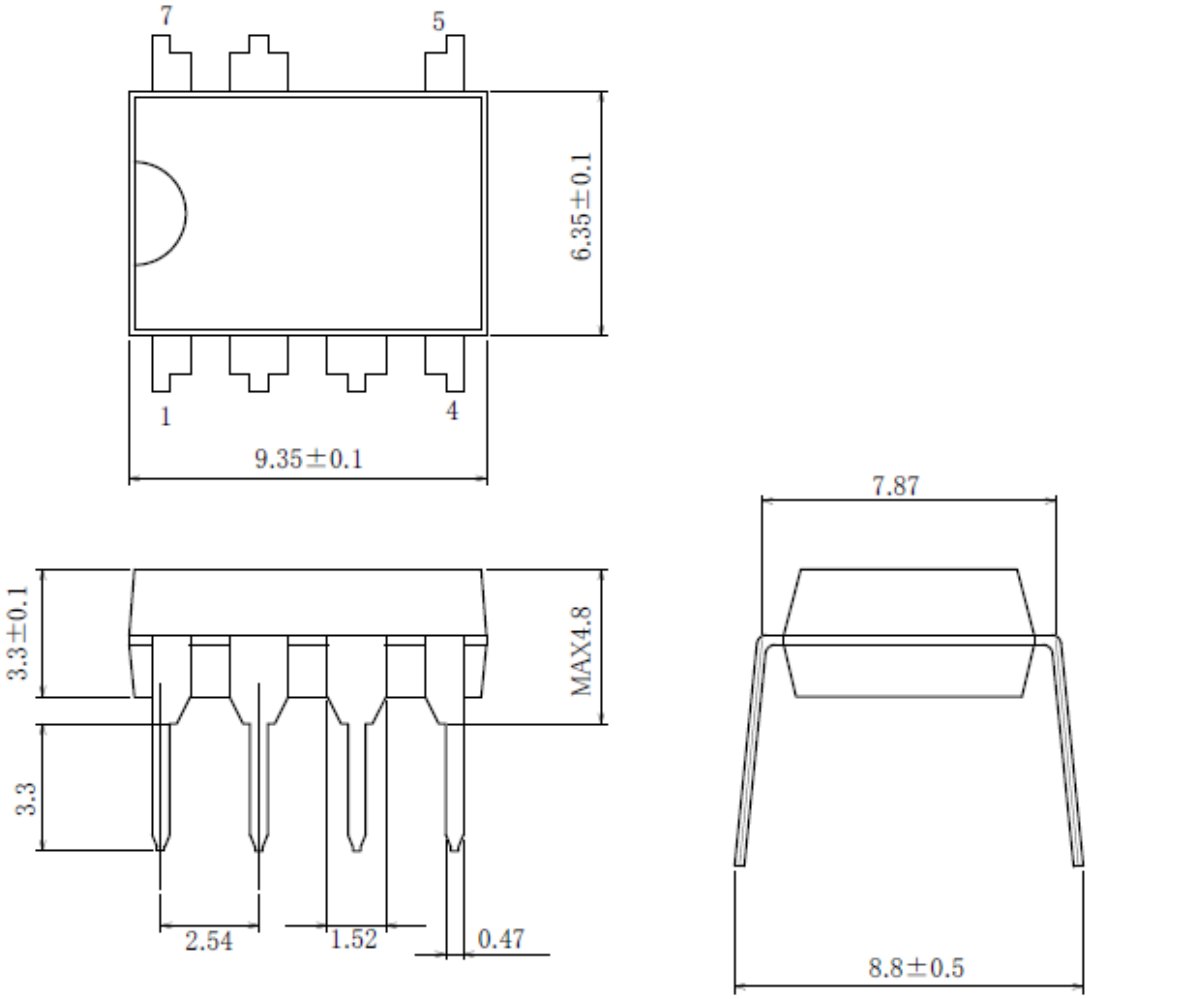


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Physical Dimension and Packing Information

Package Name	DIP7WF

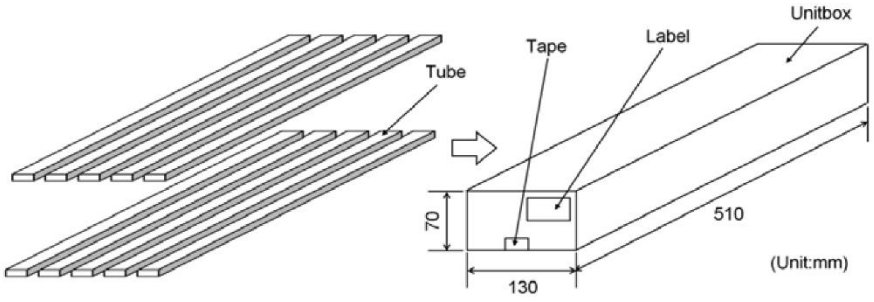


(UNIT:mm)

PKG:DIP7WF
Drawing No.EX001-0120

< Container Information >

Container	Tube
Quantity	2000pcs
Direction of feed	Direction of products is fixed in a container tube



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Operational Notes

1. **Reverse Connection of Power Suppl**
   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. The absolute maximum rating of the Pd stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. 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.

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.

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Operational Notes – continued

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.

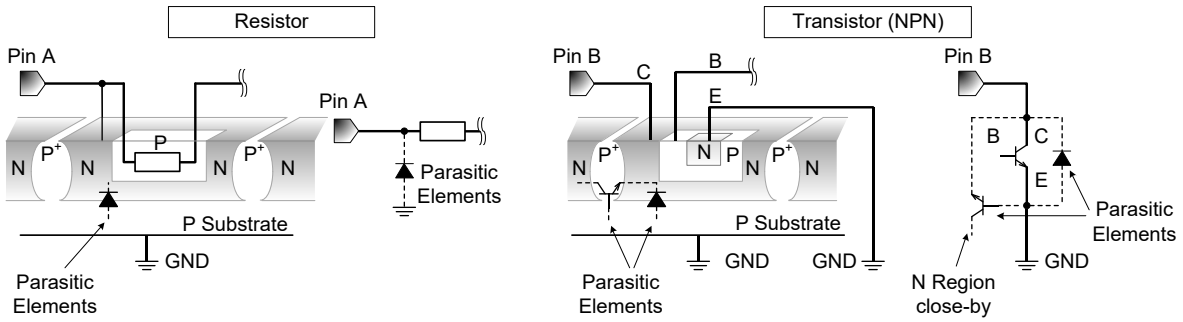


Figure 15. Example of monolithic IC structure

13. Ceramic Capacitor

When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

14. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

15. 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. The IC should be powered down and turned ON again to resume normal operation because the TSD circuit keeps the outputs at the OFF state even if the TJ falls below the TSD threshold.

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.

16. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

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Revision History

Date	Rev.	Changes
01.Dec.2013	001	New Release
18.Mar.2019	002	P1 Modify the size of package P16 Modify the physical dimension and packing information
13.Dec.2019	003	Revise Japanese datasheet.
13.Jul.2020	004	P.2 Modify the I/O Equivalent Circuit Diagram P.9 Modify the sentence from latch to auto recovery P.13 Modify the Numerical formula format and description of the Lp
26.Oct.2021	005	P1 Add the package variation P16 Add the package variation P18 Add the physical dimension

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(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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   [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 (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; 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

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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:
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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.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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