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Datasheet

AC/DC Converter IC

Non-isolated Type PWM DC/DC Converter IC Built-in Switching MOSFET

BM2Pxx1Y-Z Series

General Description

The PWM type DC/DC converter for AC/DC provides an optimum system for all products that include an electrical outlet. It enables simpler design of a high effective converter specializing in non-isolation.
By a built-in startup circuit that tolerates 650 V, this IC contributes to low power consumption. A current detection resistor as internal device realizes the small power supply designs. Since a current mode control is utilized, the current can be restricted in each cycle and an excellent performance is demonstrated in the bandwidth and transient response. The switching frequency is fixed to 25 kHz / 65 kHz. A frequency hopping function is also on chip, and it contributes to low EMI. In addition, a built-in super junction MOSFET with 650 V withstand voltage makes the design easy.

Features

- PWM Current Mode Method
- Frequency Hopping Function
- Burst Operation at Light Load
- Built-in 650 V Startup Circuit
- Built-in 650 V Super Junction MOSFET
- VCC UVLO (Under Voltage Lockout)
- VCC OVP (Over Voltage Protection)
- Over Current Detection Function per Cycle
- Soft Start Function
- Sleep Mode

Applications

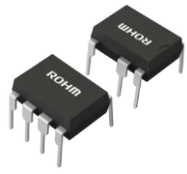
- Household Appliances such as Washing Machines, Air-conditioners, and Cleaners

Key Specifications

- Power Supply Voltage Range
  VCC Pin: 11.10 V to 26.00 V
  DRAIN Pin: 730 V (Max)
- Current at Switching Operation: 650 µA (Typ)
- Current at Burst Operation: 350 µA (Typ)
- Switching Frequency: 25 kHz / 65 kHz (Typ)
- Operation Temperature Range: -40 °C to +105 °C
- MOSFET ON Resistor: 1.2 Ω (Typ)

Package

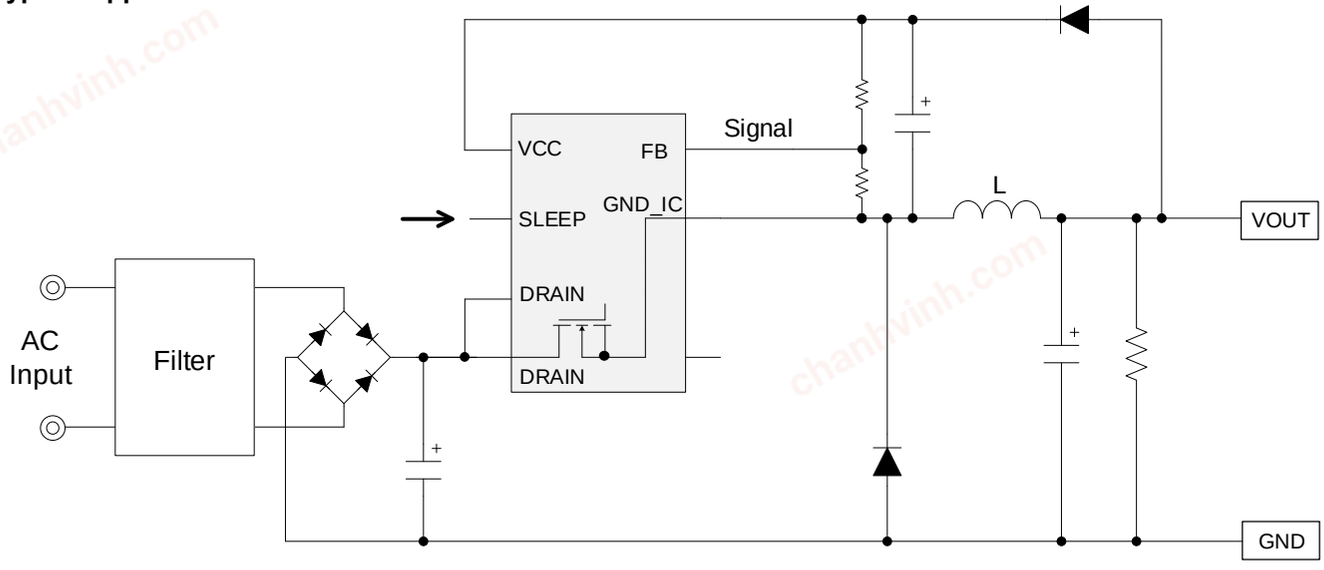
Package	W (Typ) x D (Typ) x H (Max)
DIP7K	9.27 mm x 6.35 mm x 8.63 mm pitch 2.54 mm



Lineup

Product Name	Switching Frequency	Frequency Reduction	Over Current Detection Current
BM2PAA1Y-Z	65 kHz	Yes	1.76 A
BM2PAB1Y-Z	25 kHz	No	
BM2PDA1Y-Z	65 kHz	Yes	0.93 A
BM2PDB1Y-Z	25 kHz	No	

Typical Application Circuit

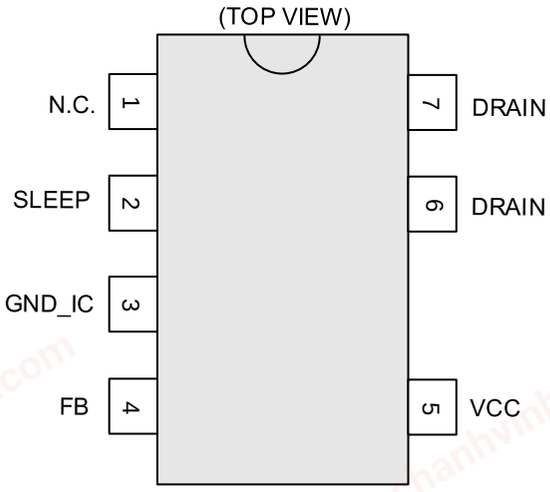


○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays.

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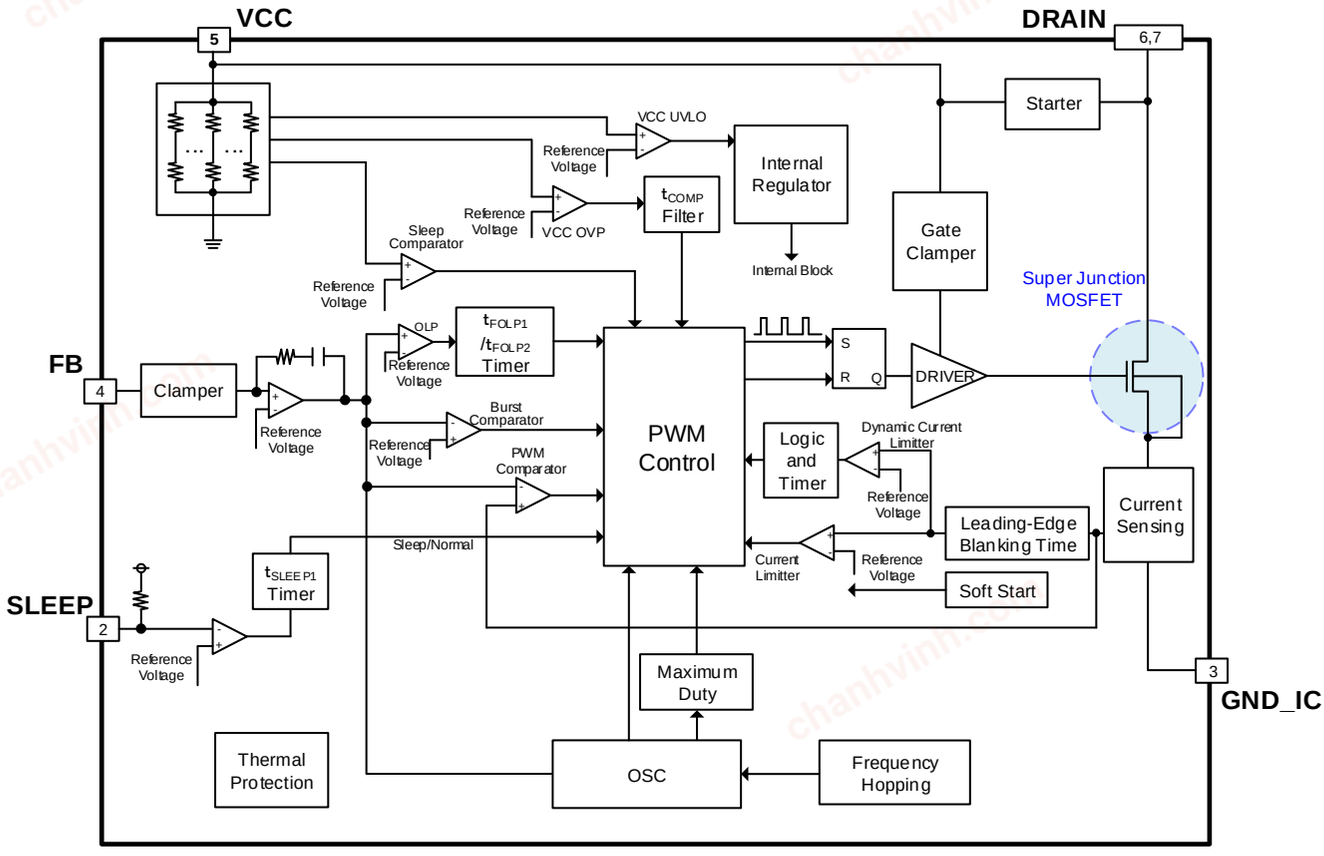
Pin Configuration



Pin Descriptions

Pin No.	Pin Name	I/O	Function	ESD Diode	
				VCC	GND_IC
1	N.C.	-	Non connection	-	-
2	SLEEP	I	Sleep/Normal mode exchange control	-	✓
3	GND_IC	I/O	GND pin	✓	-
4	FB	I	Output voltage feedback pin	-	✓
5	VCC	I	Power supply input pin	-	✓
6	DRAIN	I/O	MOSFET DRAIN pin	-	✓
7	DRAIN	I/O	MOSFET DRAIN pin	-	✓

Block Diagram



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Description of Blocks

1 Buck Converter

This IC is for exclusive use of non-isolated type buck converter.
Basic operations of buck converter are as shown below.

1.1 When the Switching MOSFET is ON

Current I_L flows to coil L and energy is stored when the MOSFET turns ON. At this moment, the GND_IC pin voltage becomes near the DRAIN pin voltage, and the diode D1 is OFF.
In discontinuous mode, the formula of I_L when MOSFET turns ON is as shown below.

$$I_L = \frac{(V_{IN} - V_{OUT})}{L} \times t_{ON} \quad [A]$$

Where:

I_L is the current flowing to the coil.
V_{IN} is the voltage applied to the DRAIN pin.
V_{OUT} is the output voltage.
L is the inductance value of coil.
t_{ON} is the time after MOSFET turns on.

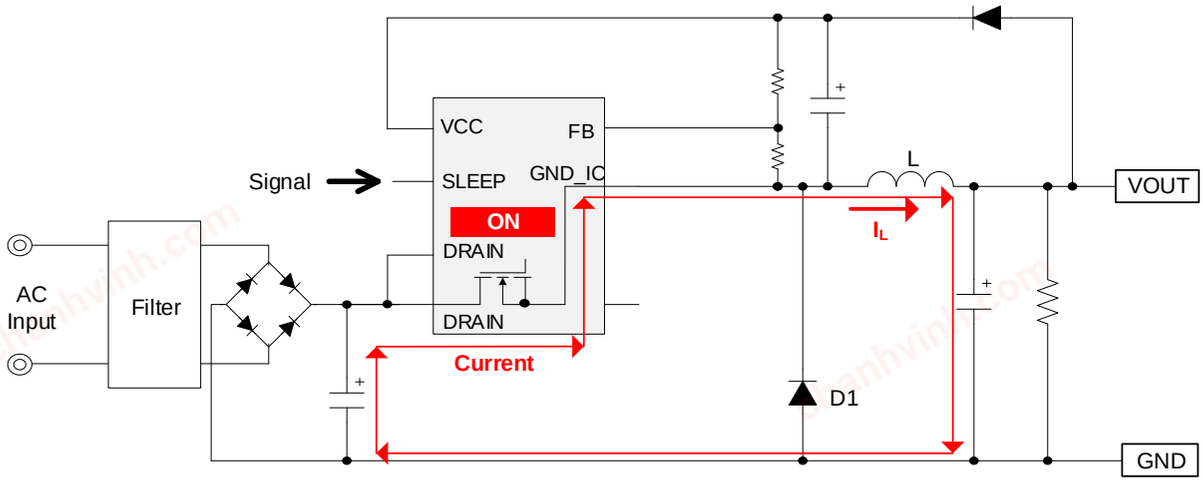


Figure 1. Buck Converter Operation (MOSFET = ON)

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1 Buck Converter – continued

1.2 When the Switching MOSFET is OFF

The energy stored in coil L is output via diode D1 when the MOSFET turns OFF.
In discontinuous mode, the formula of I_L when MOSFET turns OFF is as shown below.

$$I_L = \frac{V_{OUT}}{L} \times t_{OFF} \quad [A]$$

Where:

I_L is the current flowing to the coil.
V_{OUT} is the output voltage.
L is the inductance value of coil.
t_{OFF} is the time from the MOSFET turns off to I_L becomes 0.

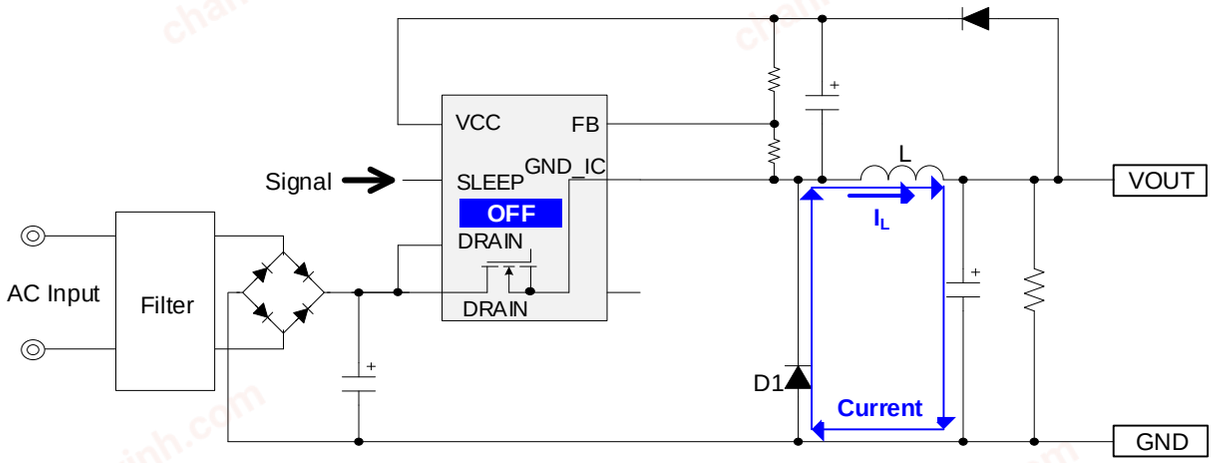


Figure 2. Buck Converter Operation (MOSFET = OFF)

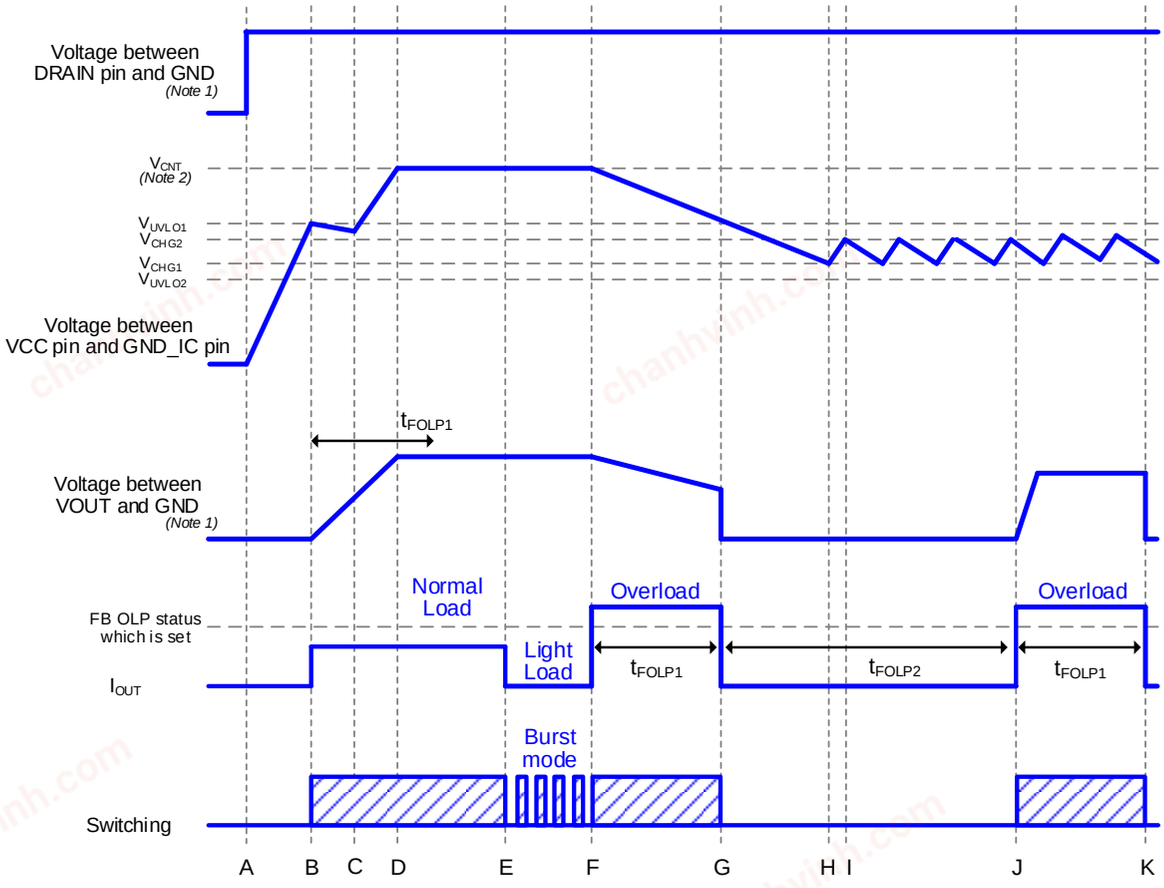
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Description of Blocks – continued

2 Startup Sequences

Startup sequences are as shown in Figure 3. See the sections below for detailed descriptions.



(Note 1) This GND does not mean the GND_IC pin of the IC.
(Note 2) V_{CNT} is the set output voltage of normal mode. It is calculated by the formula below.

$$V_{CNT} = V_{FB} \times \frac{R_{FB1} + R_{FB2}}{R_{FB2}} \quad [V]$$

Figure 3. Startup Sequences Timing Chart

A: The input voltage is applied to the DRAIN pin and the VCC pin voltage rises.
B: If the VCC pin voltage exceeds V_{UVLO1}, the IC starts to operate. In addition, if the IC judges the other protection functions as normal, it starts the switching operation. The soft start function limits the over current detection voltage and the switching frequency to prevent any excessive voltage or current rising. When the switching operation starts, the output voltage rises.
C: Until the output voltage becomes a constant value or more from startup, the VCC pin voltage drops by the VCC pin current consumption.
D: After the switching operation starts, it is necessary to make sure that the output voltage reaches the set voltage within t_{FOLP1} by setting the external components.
E: At light load, the IC starts the burst operation to reduce the power consumption.
F: When the load exceeds a certain electric power, the IC starts the overload operation.
G: If the set overload state lasts for t_{FOLP1}, the switching operation is turned off.
H: When the VCC pin voltage drops to less than V_{CHG1}, the VCC recharge function operates.
I: When the VCC pin voltage rises to more than V_{CHG2}, the recharge function stops operating.
J: After t_{FOLP2} period from G, the switching operation starts.
K: Same as G.

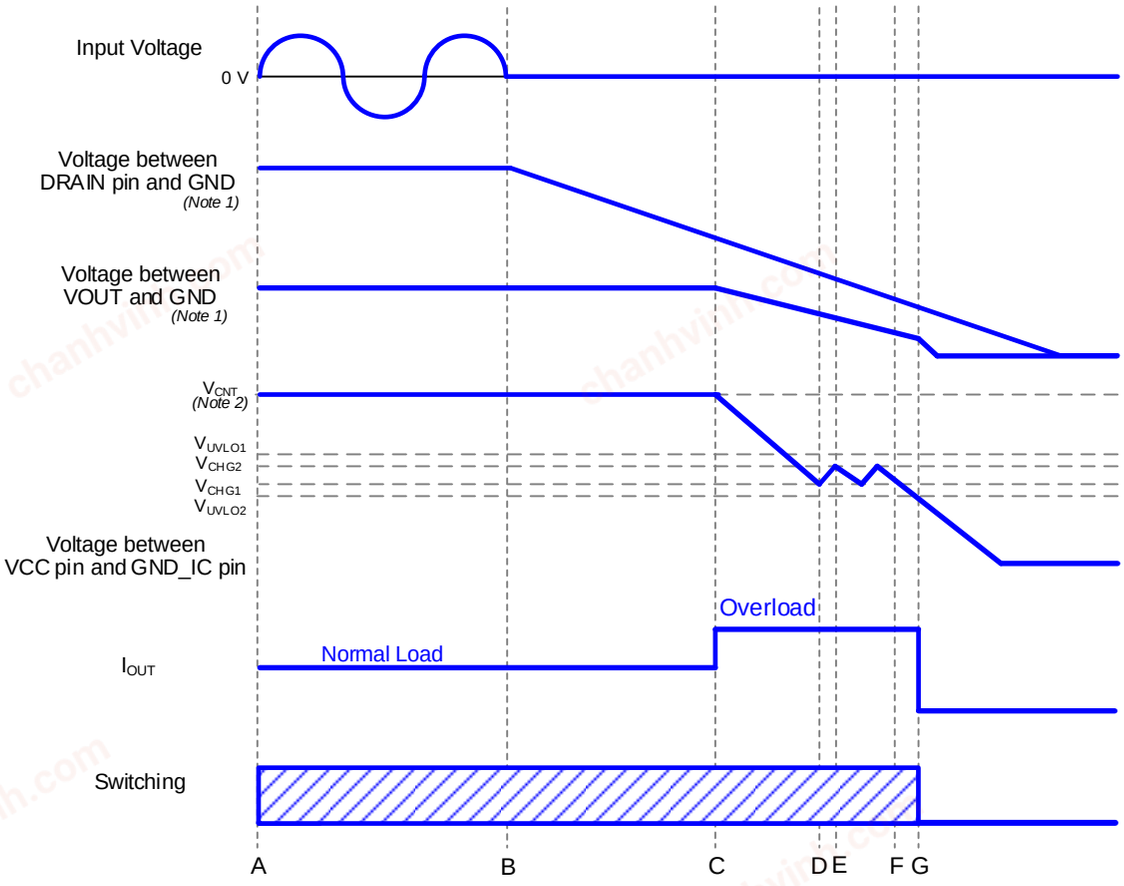
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Description of Blocks – continued

3 Stop Sequences

Stop sequences are as shown in Figure 4.



(Note 1) This GND does not mean the GND_IC pin of the IC.

(Note 2) V_{CNT} is the set output voltage of normal mode. It is calculated by the formula below.

$$V_{CNT} = V_{FB} \times \frac{R_{FB1} + R_{FB2}}{R_{FB2}} \quad [V]$$

Figure 4. Stop Sequences Timing Chart

A: Normal operation
B: When the input voltage is stopped, the DRAIN pin voltage starts to drop.
C: If the DRAIN pin voltage drops under a certain level, the ON duty of the switching becomes maximum and FB OLP operates. The VCC pin voltage starts to drop because of the drop of output voltage.
D: When the VCC pin voltage drops to less than V_{CHG1}, the VCC recharge function operates.
E: When the VCC pin voltage rises to more than V_{CHG2}, the VCC recharge function stops operating.
F: When the VCC pin voltage drops to less than V_{CHG1}, the VCC recharge function operates. However, the current supply to the VCC pin decreases and the VCC pin voltage continues dropping, because the DRAIN pin voltage is low.
G: When the VCC pin voltage drops to less than V_{UVLO2}, the switching operation stops.

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Description of Blocks – continued

4 Startup Circuit

Owing to a built-in startup circuit, this IC achieves low standby electric power and high-speed startup. The current consumption after startup is only OFF current I_{START3}. The startup current flows from the DRAIN pin.

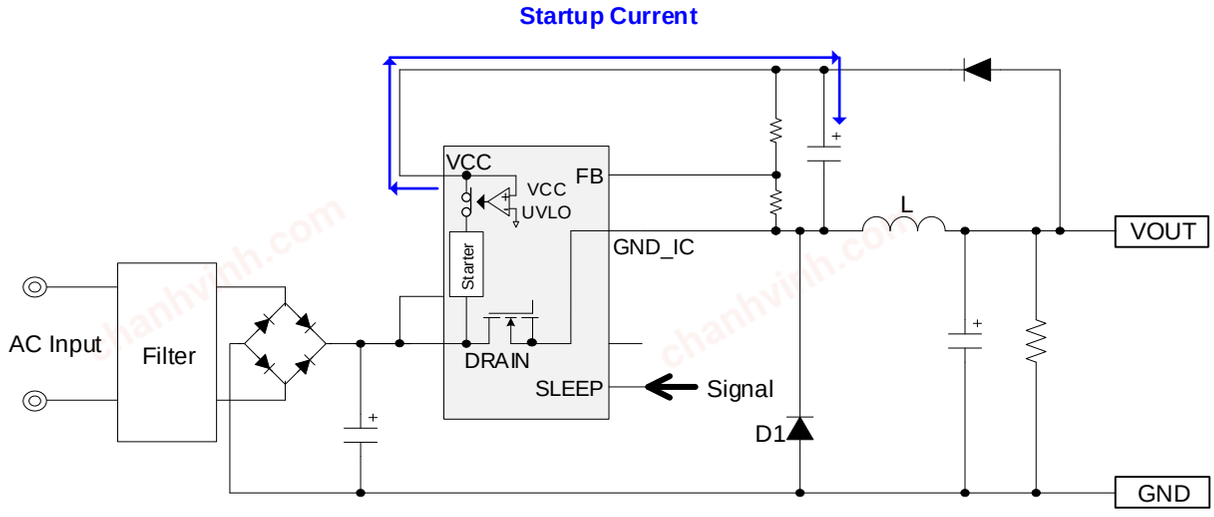


Figure 5. Startup Circuit

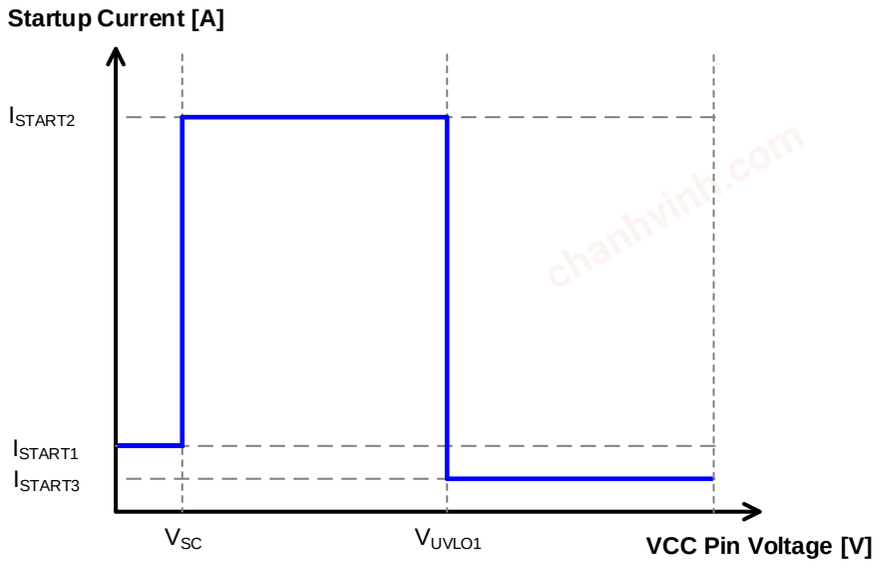


Figure 6. Startup Current vs VCC Pin Voltage

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Description of Blocks – continued

5 The VCC Pin Protection Function

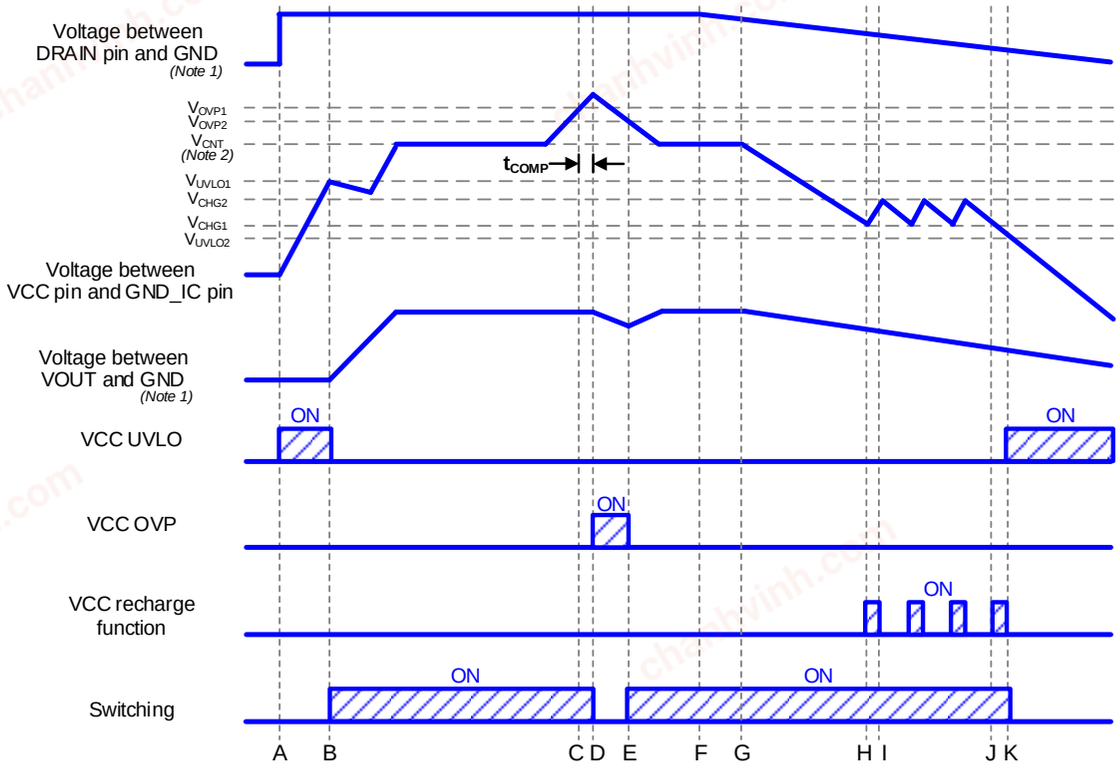
This IC has the internal protection functions at the VCC pin as shown below.

5.1 VCC UVLO / VCC OVP

VCC UVLO and VCC OVP are auto-recovery typed comparators that have voltage hysteresis. VCC OVP has an internal mask time, and it is detected when the state which VCC pin voltage exceeds V_{OVP1} lasts for t_{COMP}. The recovery condition is that the VCC pin voltage drops under V_{OVP2}.

5.2 VCC Recharge Function

Once the VCC pin voltage exceeds V_{UVLO1}, and the IC starts up, then if it drops under V_{CHG1}, the VCC recharge function operates. At this time, the VCC pin is recharged from the DRAIN pin through the startup circuit. When the VCC pin voltage rises to more than V_{CHG2}, the recharge stops.



(Note 1) This GND dose not mean the GND_IC pin of the IC.

(Note 2) V_{CNT} is the set output voltage of normal mode. It is calculated by the formula below.

$$V_{CNT} = V_{FB} \times \frac{R_{FB1} + R_{FB2}}{R_{FB2}} \quad [V]$$

Figure 7. VCC UVLO/VCC OVP/VCC Recharge Function Timing Chart

A: The input voltage is applied to the DRAIN pin and the VCC pin voltage rises.

B: When the VCC pin voltage exceeds V_{UVLO1}, the IC starts operating. If the IC judges the other protection functions as normal, it starts switching operation. The soft start function limits the over current detection current and the switching frequency to prevent excessive voltage or current rising. When the switching operation starts, the output voltage rises.

C: When the VCC pin voltage exceeds V_{OVP1} by some anomaly, VCC OVP timer starts to operate.

D: When the condition that the VCC pin voltage exceeds V_{OVP1} lasts for t_{COMP}, the IC detects VCC OVP and stops switching operation.

E: When the VCC pin voltage drops to less than V_{OVP2}, VCC OVP is released and the switching operation restarts.

F: When the input power supply is turned OFF, the DRAIN pin voltage drops.

G: If the DRAIN pin voltage drops under a certain level, the output voltage drops. The VCC pin voltage starts to drop because of the drop of the output voltage.

H: When the VCC pin voltage drops to less than V_{CHG1}, the VCC recharge function is started.

I: When the VCC pin voltage rises to more than V_{CHG2}, the VCC recharge function is stopped.

J: When the VCC pin voltage drops to less than V_{CHG1}, the VCC recharge function is started. However, the current supply to the VCC pin decreases and the VCC pin voltage continues to drop because of the low DRAIN pin voltage.

K: When the VCC pin voltage drops to less than V_{UVLO2}, VCC UVLO starts operating.

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Description of Blocks – continued

6 DC/DC Driver

This IC performs current mode PWM control. An internal oscillator fixes the switching frequency f_{SW}. This IC has a built-in switching frequency hopping function. The maximum duty is D_{MAX}. To achieve the low power consumption at light load, it also has an internal burst mode circuit.

6.1 Setting of the Output Voltage V_{OUT}

Because of adopting the non-isolated type without optocoupler, it operates to keep the FB pin voltage at the regulated value. This FB pin voltage means the voltage between the FB pin and the GND_IC pin.
The output voltage V_{OUT} is defined using R_{FB1} and R_{FB2} by the formula below.
The voltage when the MOSFET is off is as shown in Figure 8.

$$V_{OUT} = V_{FB} \times \frac{R_{FB1} + R_{FB2}}{R_{FB2}} + V_{FD2} - V_{FD1} \quad [V]$$

Where:

V_{FD1} is the forward voltage of diode D1.
V_{FD2} is the forward voltage of diode D2.
V_{FB} is the FB pin control voltage.
R_{FB1} is the upside divider resistor for V_{OUT} setting.
R_{FB2} is the downside divider resistor for V_{OUT} setting.

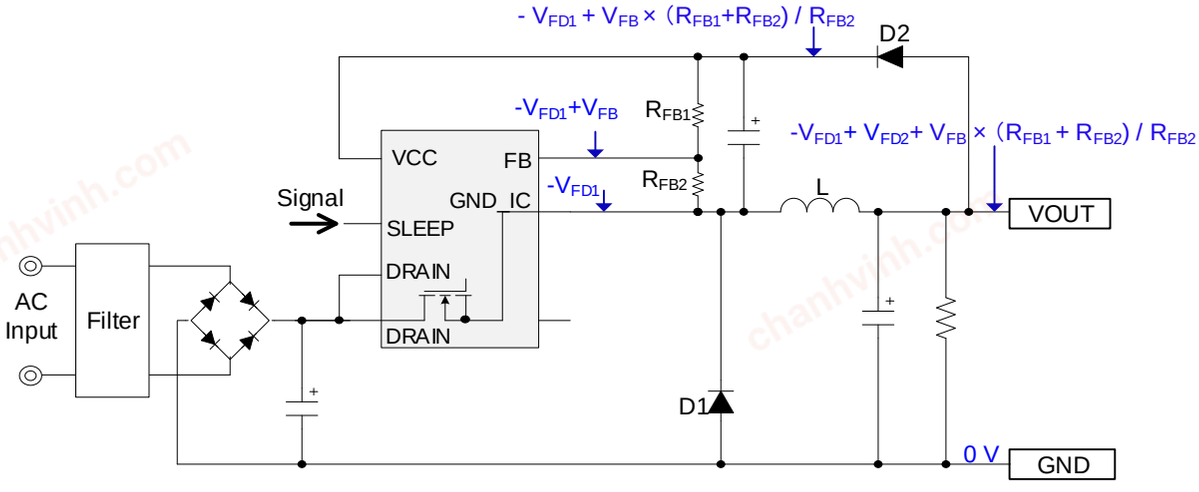


Figure 8. Output Voltage Setting

The output voltage may rise at light load because it is different from the VCC pin voltage. In this case, the output voltage should be dropped by adjusting the value of the resistor R_{OUT} that is connected to the VOUT. The position of the resistor R_{OUT} is as shown in Figure 9.

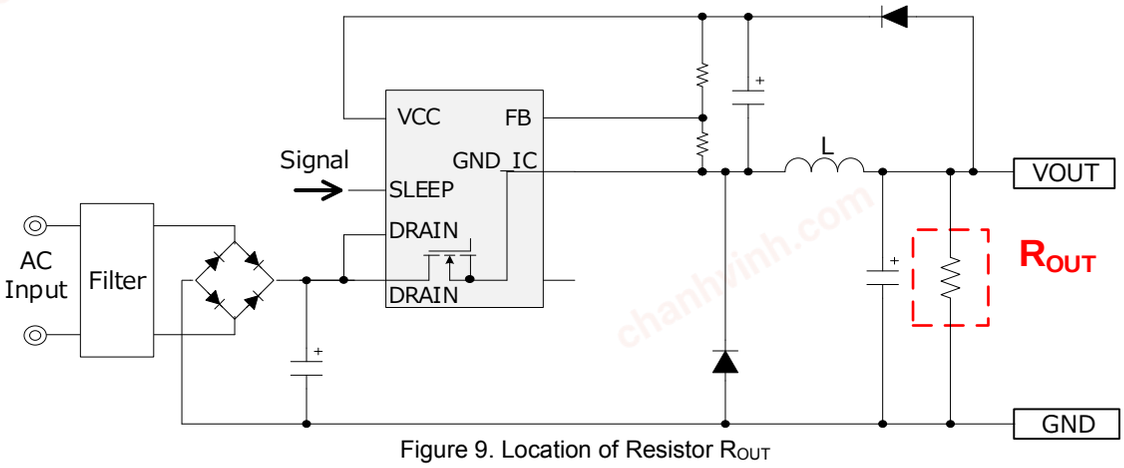


Figure 9. Location of Resistor R_{OUT}

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6 DC/DC Driver – continued

6.2 Frequency Circuit

6.2.1 With the Frequency Reduction Operation (BM2PAA1Y-Z, BM2PDA1Y-Z)

mode 1: Burst Mode (The intermittent operation starts.)
mode 2: Frequency Reduction Mode (It reduces the frequency.)
mode 3: Fixed Frequency Mode (It operates at the maximum frequency.)
mode 4: Overload Mode (The intermittent operation starts.)

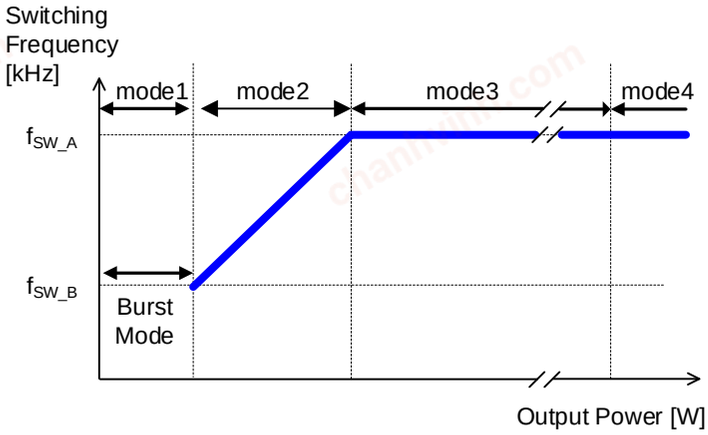


Figure 10. State Transition of Switching Frequency (BM2PAA1Y-Z, BM2PDA1Y-Z)

6.2.2 Without the Frequency Reduction Operation (BM2PAB1Y-Z, BM2PDB1Y-Z)

mode 1: Burst Mode (The intermittent operation starts.)
mode 2: Fixed Frequency Mode (It operates in the maximum frequency.)
mode 3: Overload Mode (The intermittent operation starts.)

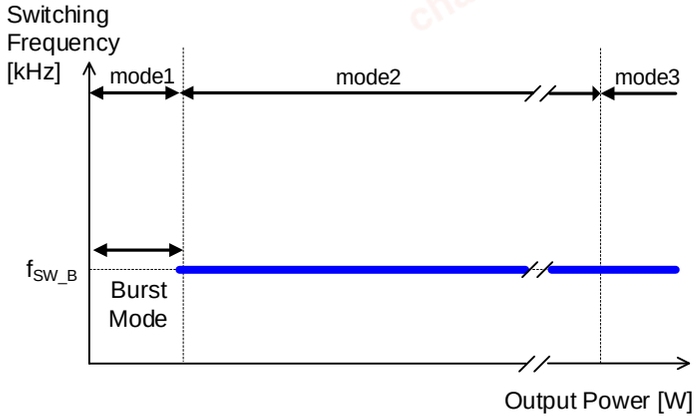


Figure 11. State Transition of Switching Frequency (BM2PAB1Y-Z, BM2PDB1Y-Z)

6.3 Frequency Hopping Function

Frequency hopping function achieves low EMI by changing the frequency randomly.
The upper limit of the frequency's hopping is ±6 % (Typ) to the basic frequency.

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6 DC/DC Driver – continued

6.4 Over Current Detection Function

This IC has a built-in cycle-by-cycle over current detection function. This function stops the switching operation if the coil current I_L rises to I_{PEAK_A} or I_{PEAK_D} or more. Additionally, an internal current detection resistor contributes to the reduction of parts count and improvement on efficiency. The peak current while the IC is in overload mode is determined by the formula below.

$$Peak\ current = I_{PEAK} + \frac{(V_{DRAIN} - V_{OUT})}{L} \times tdelay \quad [A]$$

Where:

I_{PEAK} is the over current detection current. (I_{PEAK_A}, I_{PEAK_D})
V_{DRAIN} is the DRAIN pin voltage.
V_{OUT} is the output voltage.
L is the inductance value of coil.
$tdelay$ is the delay time after the over current detection.

6.5 Dynamic Over Current Detection Function

This IC has a built-in dynamic over current detection function.
In the case that the coil current I_L exceeds I_{DPEAK_A} or I_{DPEAK_D} two times consecutively, it stops the switching operation for t_{DPEAK}.

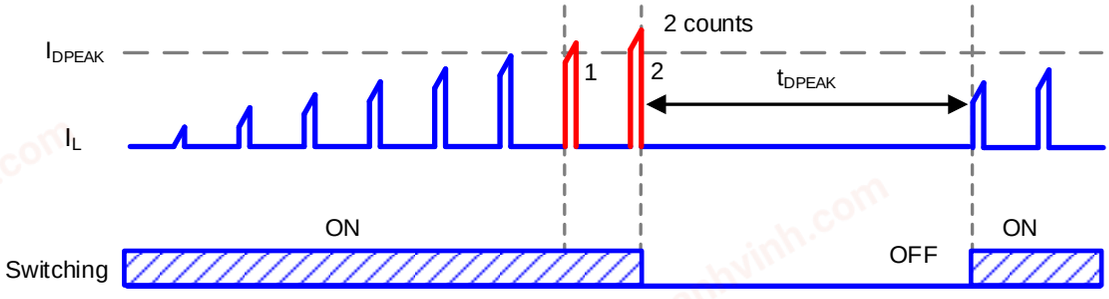


Figure 12. Dynamic Over Current Detection

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6 DC/DC Driver – continued

6.6 Soft Start Function

This function restricts the over current detection value and the switching frequency to prevent excessive voltage or current rising at startup. The details are as shown in Figure 13, 14. The IC achieves the soft start operation by changing the over current detection value and switching frequency with time.

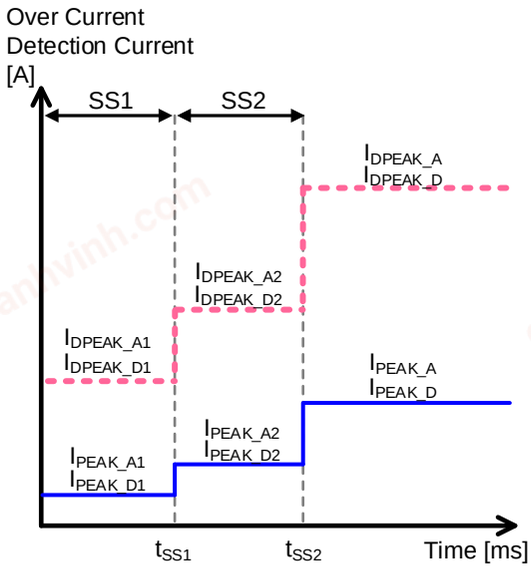


Figure 13. Over Current Detection Current vs Time

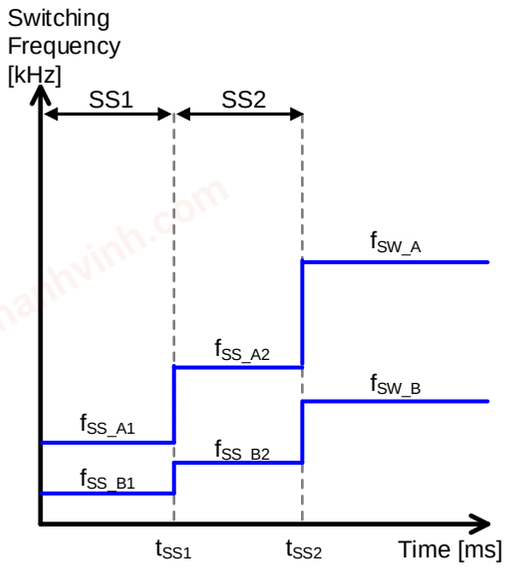


Figure 14. Switching Frequency vs Time

7 FB OLP (Overload Protection)

FB OLP is a function that monitors load state and stops the switching operation at the overload state. In the overload condition, the output voltage drops. Therefore, this function judges the state as overload and the switching operation is stopped when the state of the setting electricity power or more lasts for t_{FOLP1}. The switching operation recovers t_{FOLP2} later after the detection of FB OLP.

8 TSD (Thermal Shutdown)

TSD is a function that stops the switching operation if the temperature of IC becomes T_{SD1} or more.

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Description of Blocks – continued

9 Sleep Mode

This IC goes into sleep mode by controlling the SLEEP pin voltage with the optocoupler.
The low standby power consumption is achieved by the sleep mode.

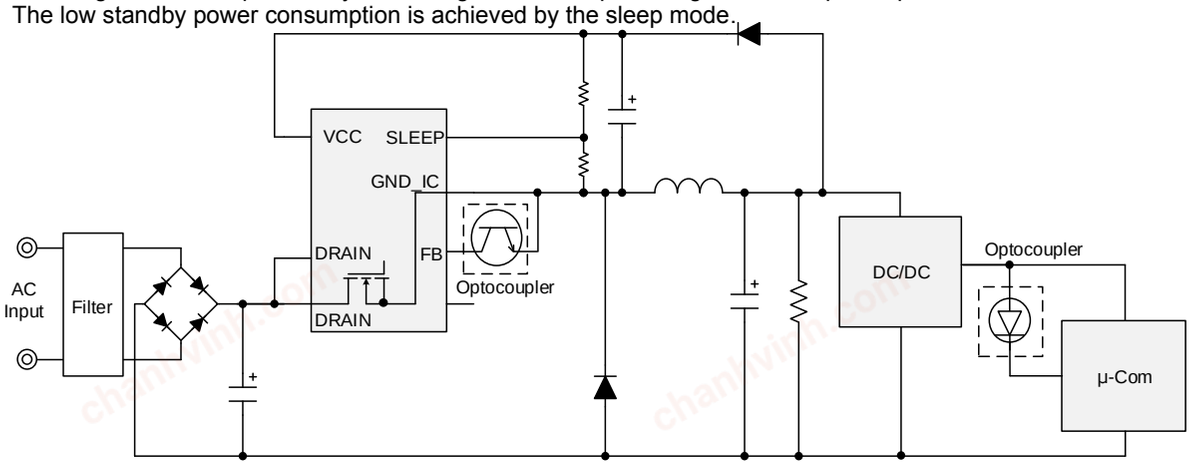


Figure 15. Application Circuit (Sleep Mode)

9.1 Settings of Switching the Modes

The SLEEP pin is controlled by an inverter input. The operation states are determined by the settings shown below. Short the SLEEP pin to the GND_IC if it is not used.

Table 1. Control of Sleep Operation

SLEEP pin voltage	Mode
Open	Sleep
< V_{INL}	Normal

9.2 Timing Chart

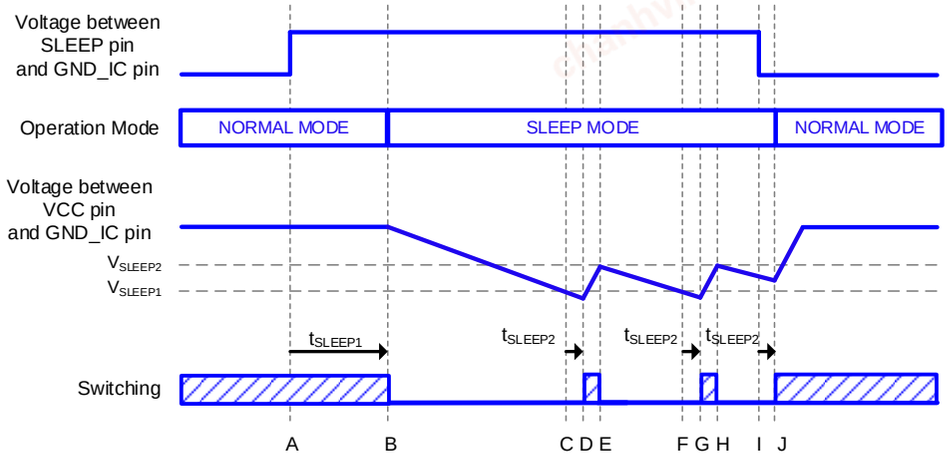


Figure 16. Mode Transition Sequences Timing Chart

A: The SLEEP pin voltage changes from Low to High.
B: When t_{SLEEP1} passes from A, switching operation stops and is contained in a sleep mode. The IC reduces the current consumption in sleep mode and the over current detection value and the switching frequency shifts to I_{PEAK_D} and f_{SW_B}. *(Note)*
C: When the VCC pin voltage drops to less than V_{SLEEP1}, the switching recovery delay timer starts to operate.
D: The switching operation starts after t_{SLEEP2} from C.
E: When the VCC pin voltage exceeds V_{SLEEP2}, the switching operation is stopped.
F: Same as C.
G: Same as D.
H: Same as E.
I: The SLEEP pin voltage changes from High to Low.
J: The IC returns to normal mode after t_{SLEEP2} with the soft start operation.

(Note) This I_{PEAK_D} and f_{SW_B} are not only for BM2PDB1Y-Z but also for all of this series.

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Description of Blocks – continued

10 Operation Modes of Protection Functions

The operation modes of each protection function are as shown in Table 2.

Table 2. The Operation Modes of Protection Functions

	VCC UVLO	VCC OVP	TSD	FB OLP
Detection Condition	VCC pin voltage < V_{UVLO2} (while the voltage is dropping)	VCC pin voltage > V_{OVP1} (while the voltage is rising)	Junction temperature > T_{SD1} (while the temperature is rising)	Coil current I_L ≥ I_{PEAK_A} or I_{PEAK_D}
Release Condition	VCC pin voltage > V_{UVLO1} (while the voltage is rising)	VCC pin voltage < V_{OVP2} (while the voltage is dropping)	Junction temperature < T_{SD2} (while the temperature is dropping) or VCC UVLO detection	Coil current I_L < I_{PEAK_A} or I_{PEAK_D} or VCC UVLO detection
Detection Timer (Reset Condition)	–	t_{COMP} (VCC pin voltage < V_{OVP2})	t_{COMP} (Junction temperature < T_{SD2})	t_{FOLP1} (Coil current I_L < I_{PEAK_A} or I_{PEAK_D})
Release Timer (Reset Condition)	–	–	–	t_{FOLP2} (Coil current I_L ≥ I_{PEAK_A} or I_{PEAK_D})
Auto Recovery or Latch	Auto recovery	Auto recovery	Auto recovery	Auto recovery

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Description of Blocks – continued

11 External Components

Use the parts that match the input and load conditions.
Figure 17 shows the application circuit.

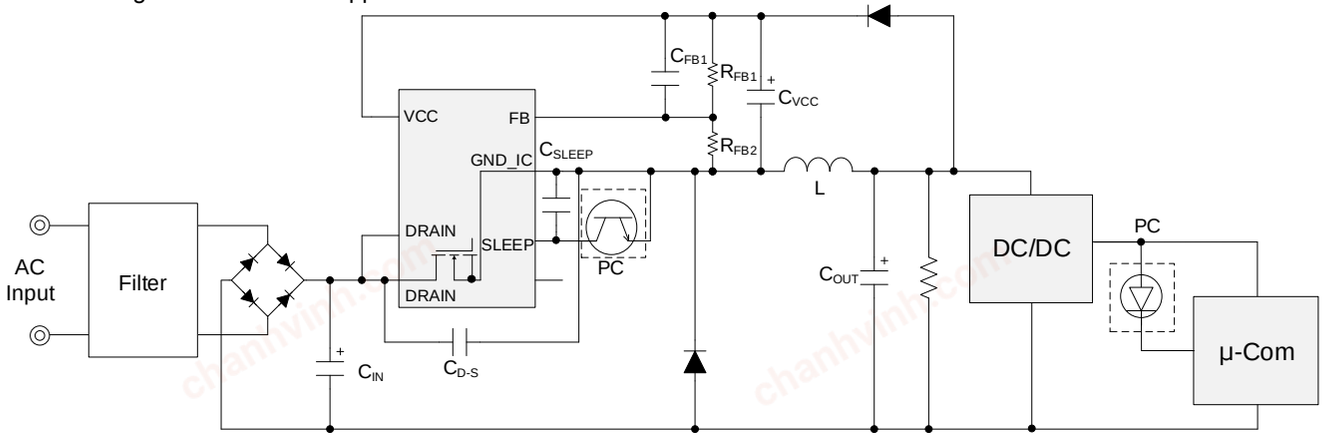


Figure 17. Application Circuit

11.1 Output Capacitor C_{OUT}

The output capacitor C_{OUT} should be set to satisfy the specification of the ripple voltage, and guarantee that the output voltage rises to the set value within t_{FOLP1} after startup. It is recommended to set C_{OUT} to 100 µF or more.

11.2 Inductance Value of Coil L

The inductance value of coil L should be set depending on the input voltage and output voltage. If the inductance value is too large, the switching operation becomes continuous mode that deteriorates the heat. In the other hand, if the inductance value is too small, the control of IC is impossible during ON time < t_{MINON}, so there is a possibility that the over current detection operates even under a normal load condition.

11.3 VCC Pin Capacitor C_{VCC}

The VCC pin capacitor C_{VCC} adjusts the startup time of the IC and the response of Error AMP.
It is recommended to be set to 1/100 of C_{OUT} or less.

11.4 Output Voltage Feedback Resistor R_{FB1}, R_{FB2}

For reducing the electronic power consumption, R_{FB1} is recommended to be set to 1 MΩ to 3 MΩ as a reference.
For restricting the tolerance of output voltage, use high precision resistors for R_{FB1} and R_{FB2}.

11.5 Phase Compensation Capacitor C_{FB1}

According to the input and output conditions, the phase compensation capacitor **C_{FB1}** may be used.
It is recommended to be set to 1 nF to 10 nF.
Evaluate with sufficient consideration of the tolerances and temperature characteristics of the components.

11.6 Noise Filter Capacitor C_{SLEEP}

In case of using an optocoupler to control the SLEEP pin, for preventing the malfunction on mode transition, it is recommended to use the noise filter capacitor C_{SLEEP}.
It is recommended to be set to 10 nF to 100 nF.
Notice that the time of mode transitions may become longer by using C_{SLEEP}.

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Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit	Conditions
Maximum Applied Voltage 1	V_{MAX1}	650	V	DRAIN pin voltage
		730	V	DRAIN pin voltage (tpulse < 10 µs) *(Note 1)*
Maximum Applied Voltage 2	V_{MAX2}	-0.3 to +32	V	VCC pin voltage
DRAIN Pin Current (Pulse)	I_{DD}	12.00	A	Consecutive operation
Power Dissipation	Pd	1.00	W	*(Note 2)*
Maximum Junction Temperature	Tjmax	150	°C	
Storage Temperature Range	Tstg	-55 to +150	°C	

Caution 1: *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.*

Caution 2: *Should by any chance the maximum junction temperature 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, design a PCB with power dissipation taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

(Note 1) Duty is less than 1 %.

(Note 2) In case of being mounted on a glass epoxy single layer PCB (70 mm x 70 mm x 1.6 mm). Derate by 8 mW/°C if the IC is used at the ambient temperature 25 °C or above.

Thermal Dissipation

Make the thermal design by making the IC operates in the following conditions.
(Because the following temperature is guaranteed value, it is necessary to consider a margin.)

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

The thermal abatement characteristic is as follows.
(In case of being mounted on a glass epoxy single layer PCB with size of 70 mm x 70 mm x 1.6 mm)

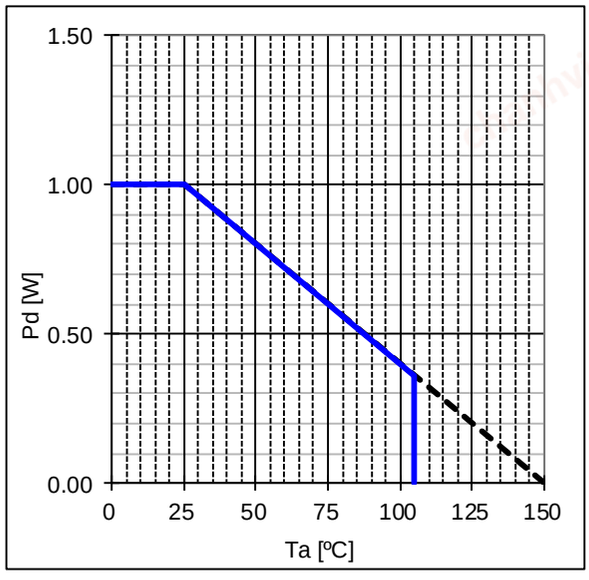


Figure 18. Thermal Abatement Characteristic

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Power Supply Voltage Range 1	V_{DRAIN}	-	-	650	V	DRAIN pin voltage
		-	-	730	V	DRAIN pin voltage (tpulse < 10 µs) *(Note 1)*
Power Supply Voltage Range 2	V_{CC}	11.10	-	26.00	V	VCC pin voltage
Operating Temperature	Topr	-40	-	+105	°C	Surrounding temperature

(Note 1) Duty is less than 1 %.

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Electrical Characteristics in MOSFET Section

(Unless noted otherwise, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Voltage between DRAIN and SOURCE	$V_{(BR)DDS}$	650	-	-	V	I_D = 1 mA, V_{GS} = 0 V
		730	-	-	V	I_D = 1 mA, VGS = 0 V tpulse < 10 µs
DRAIN Pin Leak Current	I_{DSS}	-	0	100	µA	V_{DS} = 650 V, V_{GS} = 0 V
ON Resistor	$R_{DS(ON)}$	-	1.2	2.2	Ω	I_D = 0.25 A, V_{GS} = 10 V

Electrical Characteristics in Startup Circuit Section

(Unless noted otherwise, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Startup Current 1	I_{START1}	0.150	0.300	0.600	mA	V_{CC} = 0 V
Startup Current 2	I_{START2}	1.000	3.000	6.000	mA	V_{CC} = 7 V
OFF Current	I_{START3}	-	10	20	µA	After UVLO is released
Startup Current Transition Voltage	V_{SC}	0.4	0.8	1.2	V	

Electrical Characteristics in Control IC Section

(Unless noted otherwise, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Circuit Current (Common throughout the series)						
Current at Switching Operation	I_{ON1}	-	650	950	µA	DRAIN pin = open
Current at Burst Operation	I_{ON2}	-	350	550	µA	
Current at Sleep Mode	I_{SLEEP}	-	65	95	µA	SLEEP pin = open
VCC Pin (Common throughout the series)						
VCC UVLO Release Voltage	V_{UVLO1}	9.70	10.40	11.10	V	At VCC pin voltages rising
VCC UVLO Detection Voltage	V_{UVLO2}	8.20	8.90	9.60	V	At VCC pin voltage dropping
VCC UVLO Hysteresis	V_{UVLO3}	-	1.50	-	V	V_{UVLO3} = V_{UVLO1} - V_{UVLO2}
VCC Recharge Start Voltage	V_{CHG1}	8.60	9.30	10.00	V	At VCC pin voltage dropping
VCC Recharge Stop Voltage	V_{CHG2}	9.00	9.70	10.40	V	At VCC pin voltage rising
VCC Recharge Hysteresis	V_{CHG3}	-	0.40	-	V	V_{CHG3} = V_{CHG2} - V_{CHG1}
VCC Sleep Voltage 1	V_{SLEEP1}	11.10	11.50	11.90	V	At VCC pin voltage rising
VCC Sleep Voltage 2	V_{SLEEP2}	10.20	10.50	10.80	V	At VCC pin voltage dropping
VCC Sleep Hysteresis	V_{SLEEP3}	-	1.00	-	V	V_{SLEEP3} = V_{SLEEP1} - V_{SLEEP2}
VCC OVP Detection Voltage	V_{OVP1}	27.00	28.00	29.00	V	At VCC pin voltage rising
VCC OVP Release Voltage	V_{OVP2}	26.00	27.00	28.00	V	At VCC pin voltage dropping
VCC OVP Hysteresis	V_{OVP3}	-	1.00	-	V	V_{OVP3} = V_{OVP1} - V_{OVP2}
VCC OVP / TSD Timer	t_{COMP}	50	100	150	µs	
Thermal Shutdown (Common throughout the series)						
TSD Temperature 1	T_{SD1}	150	175	200	°C	At temperature rising *(Note 1)*
TSD Temperature 2	T_{SD2}	-	100	-	°C	At temperature dropping *(Note 1)*
TSD Hysteresis	T_{SD3}	-	65	-	°C	*(Note 1)*

(Note 1) Not 100 % tested.

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Electrical Characteristics in Control IC Section – continued

(Unless noted otherwise, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
DC/DC Driver Section (BM2PxA1Y-Z)						
Switching Frequency A	f_{SW_A}	60.0	65.0	70.0	kHz	After soft start
Frequency Hopping Width A	f_{DEL_A}	-	4.0	-	kHz	After soft start
Switching Frequency A1	f_{SS_A1}	-	15.0	-	kHz	*(Note 1, 2)*
Switching Frequency A2	f_{SS_A2}	-	30.0	-	kHz	*(Note 1, 2)*
DC/DC Driver Section (BM2PxB1Y-Z)						
Switching Frequency B	f_{SW_B}	22.5	25.0	27.5	kHz	After soft start
Frequency Hopping Width B	f_{DEL_B}	-	1.5	-	kHz	After soft start
Switching Frequency B1	f_{SS_B1}	-	6.0	-	kHz	*(Note 1, 2)*
Switching Frequency B2	f_{SS_B2}	-	12.0	-	kHz	*(Note 1, 2)*
DC/DC Driver Section (Common throughout the series)						
Maximum Duty	D_{MAX}	35	40	45	%	
FB OLP Detection Timer	t_{FOLP1}	52	64	76	ms	
FB OLP OFF Timer	t_{FOLP2}	416	512	608	ms	
Soft Start Time 1	t_{SS1}	6.8	8.0	9.2	ms	
Soft Start Time 2	t_{SS2}	13.6	16.0	18.4	ms	
FB Pin Control Voltage	V_{FB}	1.98	2.00	2.02	V	
Over Current Detection Section (BM2PAx1Y-Z)						
Over Current Detection Current A	I_{PEAK_A}	1.57	1.76	1.94	A	
Over Current Detection Current A1	I_{PEAK_A1}	-	0.88	-	A	*(Note 1, 3)*
Over Current Detection Current A2	I_{PEAK_A2}	-	1.32	-	A	*(Note 1, 3)*
Dynamic Over Current Detection Current A	I_{DPEAK_A}	2.73	3.08	3.43	A	
Dynamic Over Current Detection Current A1	I_{DPEAK_A1}	-	1.54	-	A	*(Note 1, 3)*
Dynamic Over Current Detection Current A2	I_{DPEAK_A2}	-	2.31	-	A	*(Note 1, 3)*
Over Current Detection Section (BM2PDx1Y-Z)						
Over Current Detection Current D	I_{PEAK_D}	0.83	0.93	1.04	A	
Over Current Detection Current D1	I_{PEAK_D1}	-	0.46	-	A	*(Note 1, 3)*
Over Current Detection Current D2	I_{PEAK_D2}	-	0.69	-	A	*(Note 1, 3)*
Dynamic Over Current Detection Current D	I_{DPEAK_D}	1.43	1.62	1.81	A	
Dynamic Over Current Detection Current D1	I_{DPEAK_D1}	-	0.81	-	A	*(Note 1, 3)*
Dynamic Over Current Detection Current D2	I_{DPEAK_D2}	-	1.21	-	A	*(Note 1, 3)*
Over Current Detection Section（BM2PAA1Y-Z）						
Power Coefficient AA	$I^2_{F_AA}$	149	191	233	A^2kHz	
Over Current Detection Section（BM2PAB1Y-Z）						
Power Coefficient AB	$I^2_{F_AB}$	51	73	96	A^2kHz	
Over Current Detection Section（BM2PDA1Y-Z）						
Power Coefficient DA	$I^2_{F_DA}$	33	48	62	A^2kHz	
Over Current Detection Section（BM2PDB1Y-Z）						
Power Coefficient DB	$I^2_{F_DB}$	11	18	26	A^2kHz	

(Note 1) Not 100 % tested.
(Note 2) Refer to Figure 14.
(Note 3) Refer to Figure 13.

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Electrical Characteristics in Control IC Section – continued

(Unless noted otherwise, Ta = 25 °C)

Over Current Detection Section (Common throughout the series)						
Dynamic Over Current Enforced OFF Time	t_{DPEAK}	-	128	-	µs	*(Note 1)*
Minimum ON Width	t_{MINON}	-	200	-	ns	*(Note 1)*
Sleep Pin (Common throughout the series)						
Sleep Pin Low Voltage	V_{INL}	-	-	1.0	V	
Sleep Pin High Voltage	V_{INH}	3.5	-	-	V	SLEEP pin = open
Sleep Pin Pull Up Resistor	R_{SLEEP}	1.2	2.0	2.8	MΩ	
Sleep Operation Start Mask Time	t_{SLEEP1}	1.0	2.0	3.0	ms	
Switching Recovery Delay Time	t_{SLEEP2}	50	200	350	µs	

(Note 1) Not 100 % tested.

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Typical Performance Curves
(Reference Data)

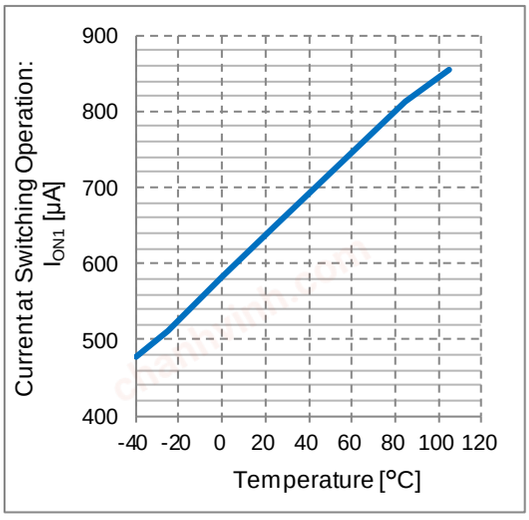


Figure 19. Current at Switching Operation vs Temperature

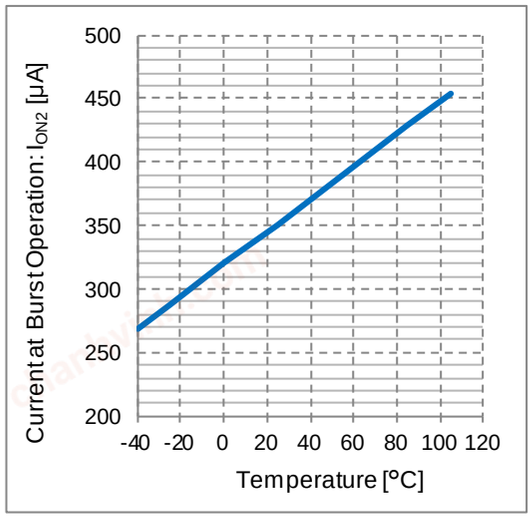


Figure 20. Current at Burst Operation vs Temperature

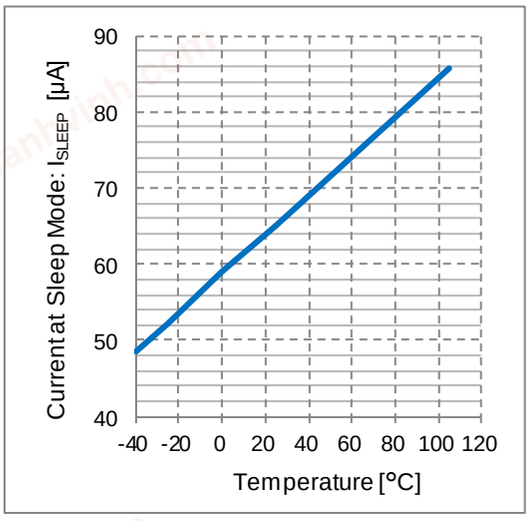


Figure 21. Current at Sleep Mode vs Temperature

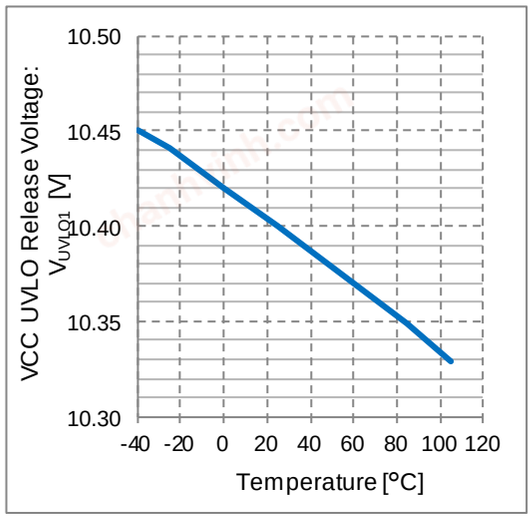


Figure 22. VCC UVLO Release Voltage vs Temperature

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Typical Performance Curves – continued
(Reference Data)

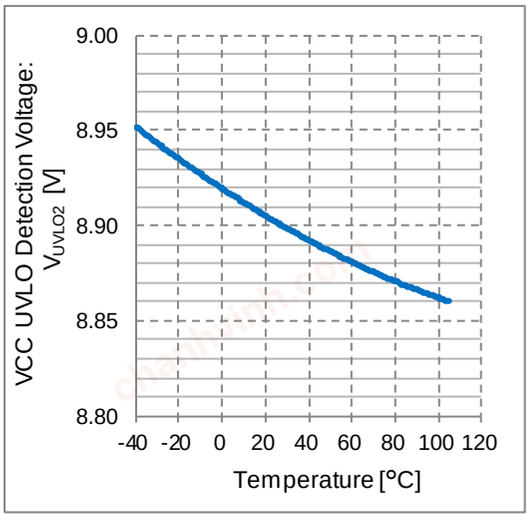


Figure 23. VCC UVLO Detection Voltage vs Temperature

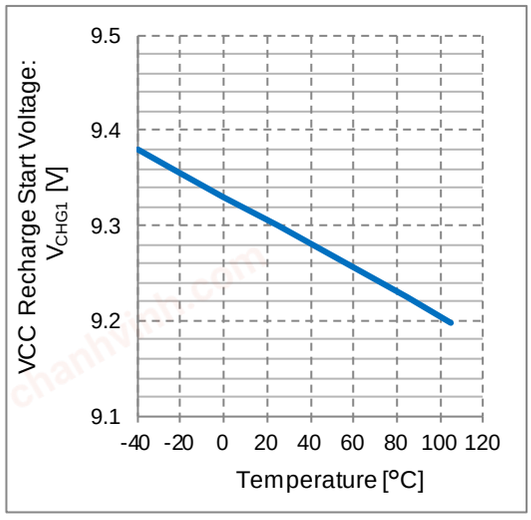


Figure 24. VCC Recharge Start Voltage vs Temperature

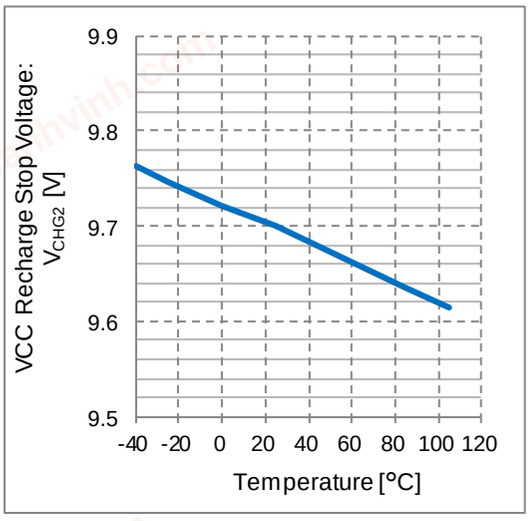


Figure 25. VCC Recharge Stop Voltage vs Temperature

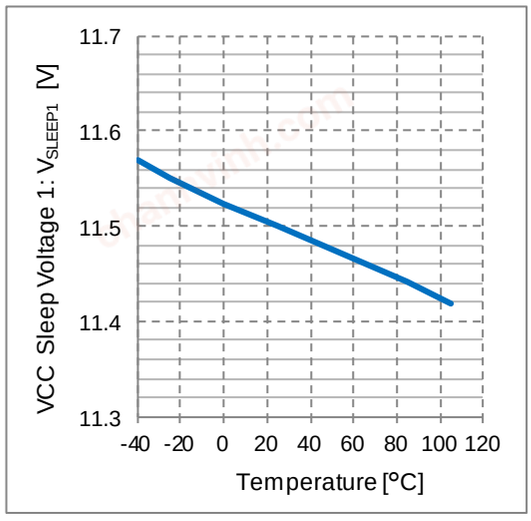


Figure 26. VCC Sleep Voltage 1 vs Temperature

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Typical Performance Curves – continued
(Reference Data)

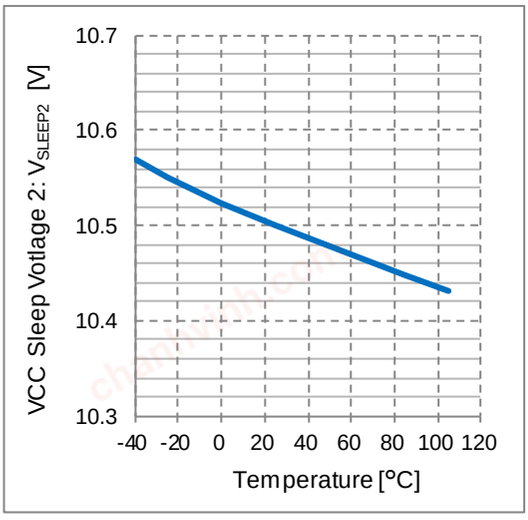


Figure 27. VCC Sleep Voltage 2 vs Temperature

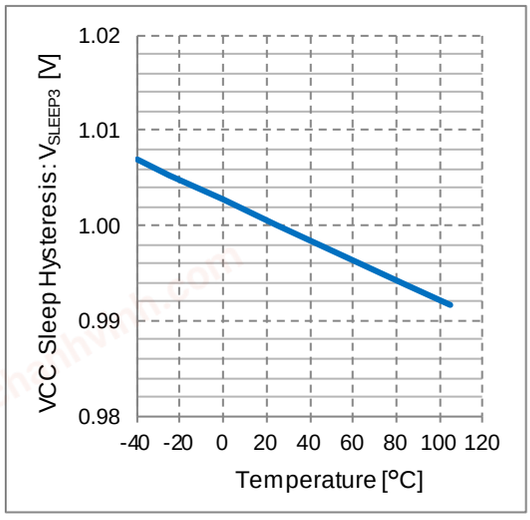


Figure 28. VCC Sleep Hysteresis vs Temperature

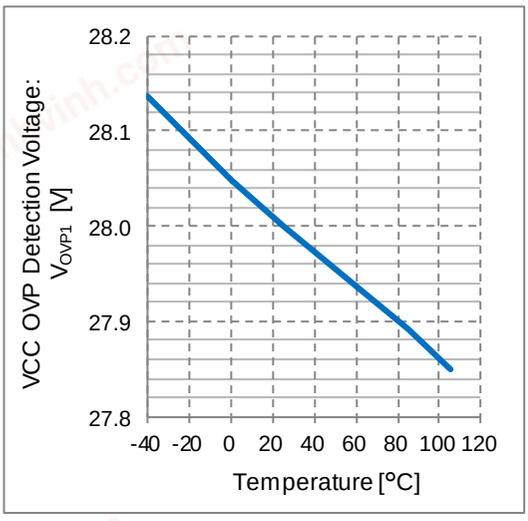


Figure 29. VCC OVP Detection Voltage vs Temperature

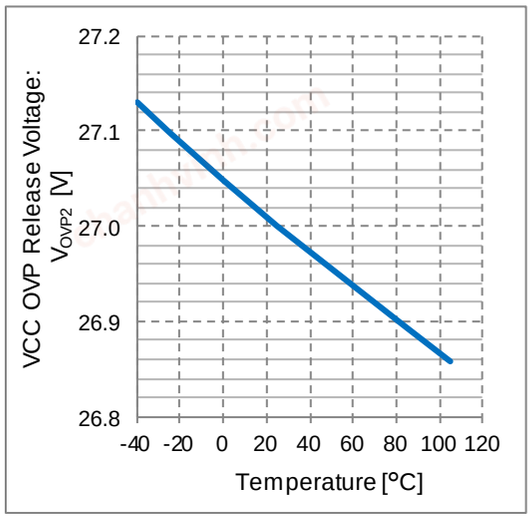


Figure 30. VCC OVP Release Voltage vs Temperature

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Typical Performance Curves – continued
(Reference Data)

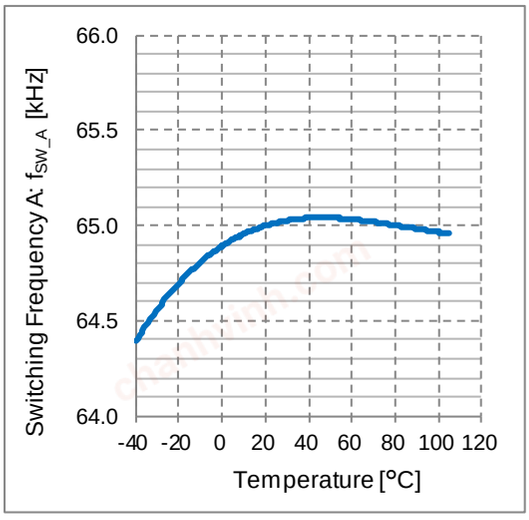


Figure 31. Switching Frequency A vs Temperature

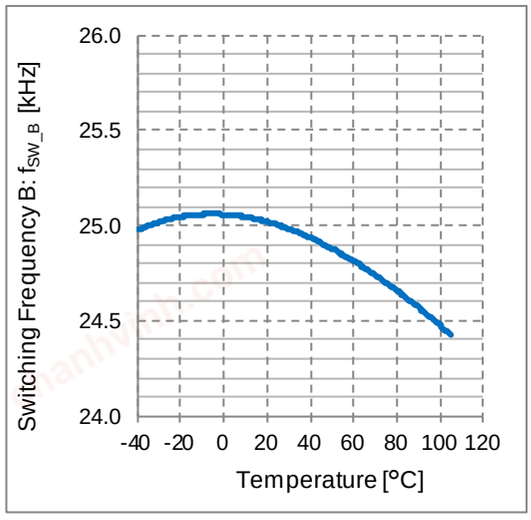


Figure 32. Switching Frequency B vs Temperature

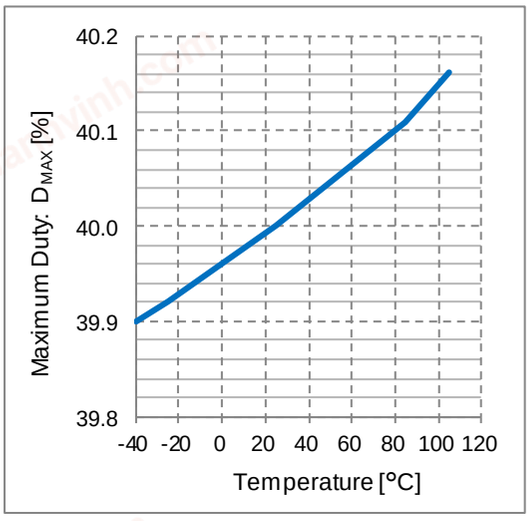


Figure 33. Maximum Duty vs Temperature

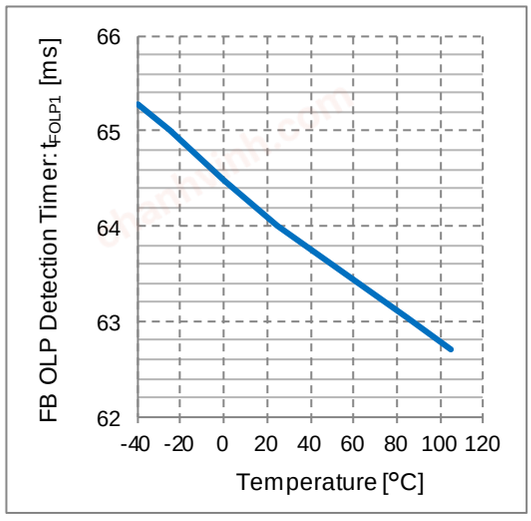


Figure 34. FB OLP Detection Timer vs Temperature

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Typical Performance Curves – continued
(Reference Data)

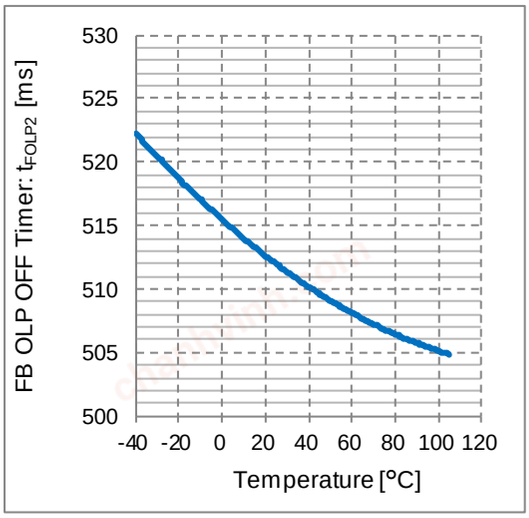


Figure 35. FB OLP OFF Timer vs Temperature

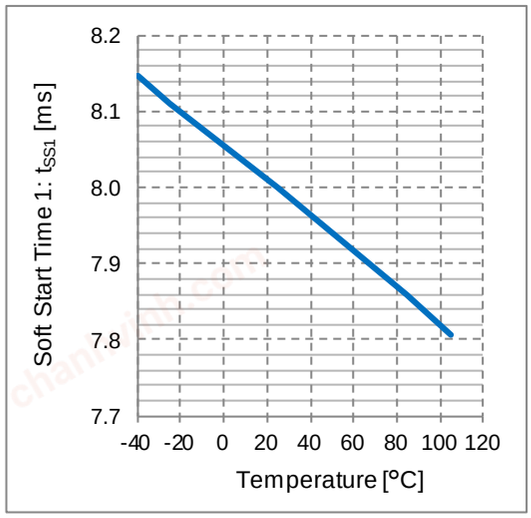


Figure 36. Soft Start Time 1 vs Temperature

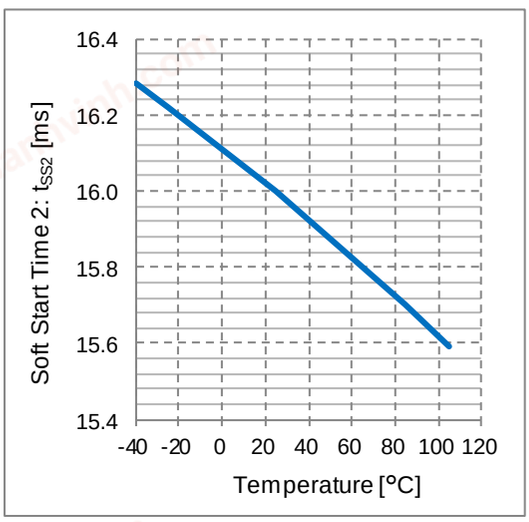


Figure 37. Soft Start Time 2 vs Temperature

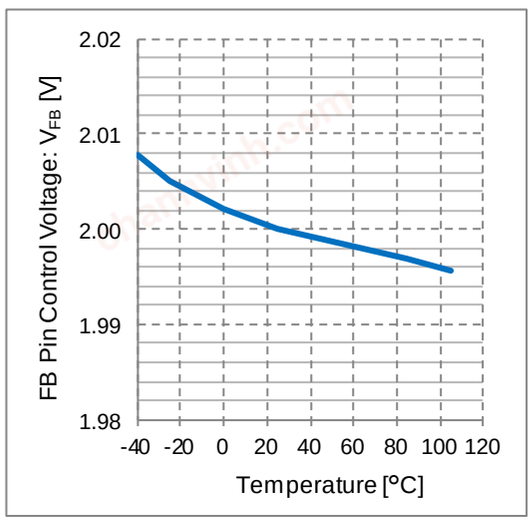


Figure 38. FB Pin Control Voltage vs Temperature

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Typical Performance Curves – continued
(Reference Data)

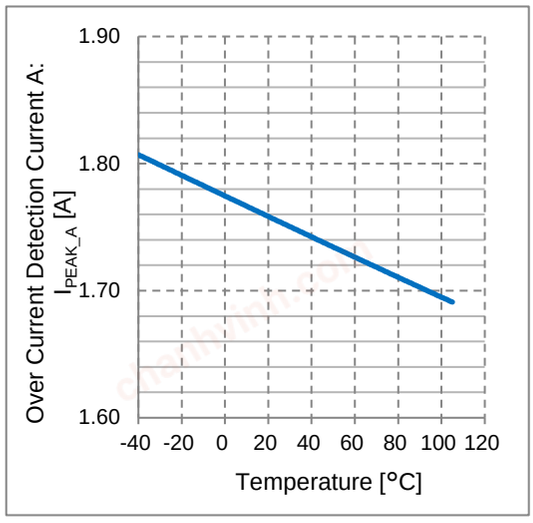


Figure 39. Over Current Detection Current A vs Temperature

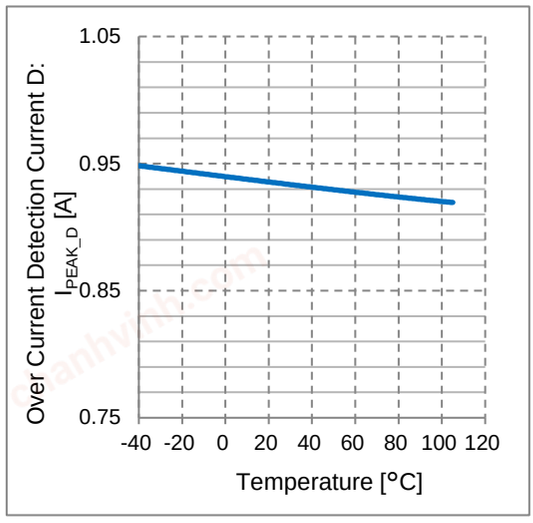


Figure 40. Over Current Detection Current D vs Temperature

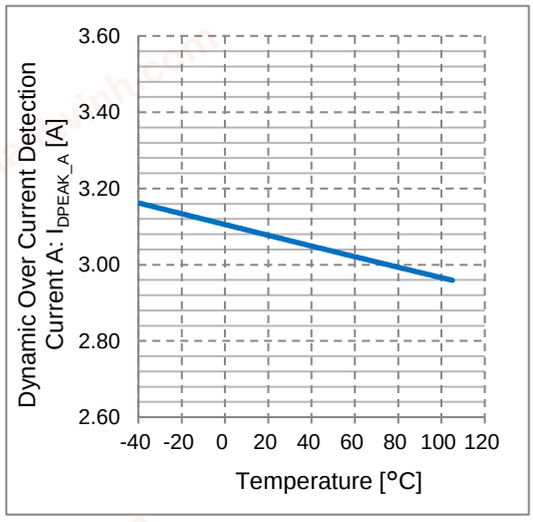


Figure 41. Dynamic Over Current Detection Current A vs Temperature

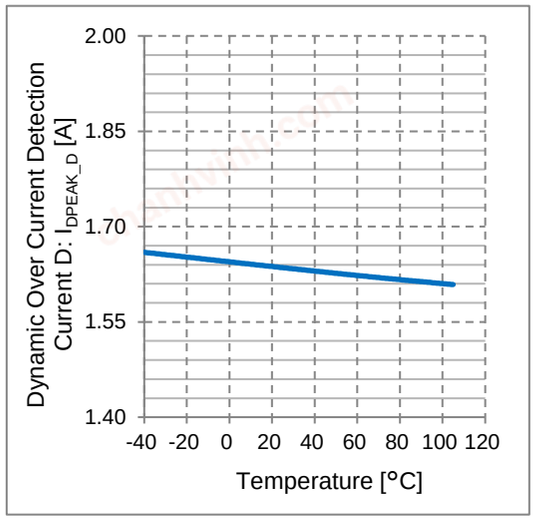


Figure 42. Dynamic Over Current Detection Current D vs Temperature

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Application Examples

Show a flyback circuitry example in Figure 43.
High voltage is produced by such as ringing in turn OFF at the DRAIN pin. The voltage during this ringing can be tolerated up to 730 V.

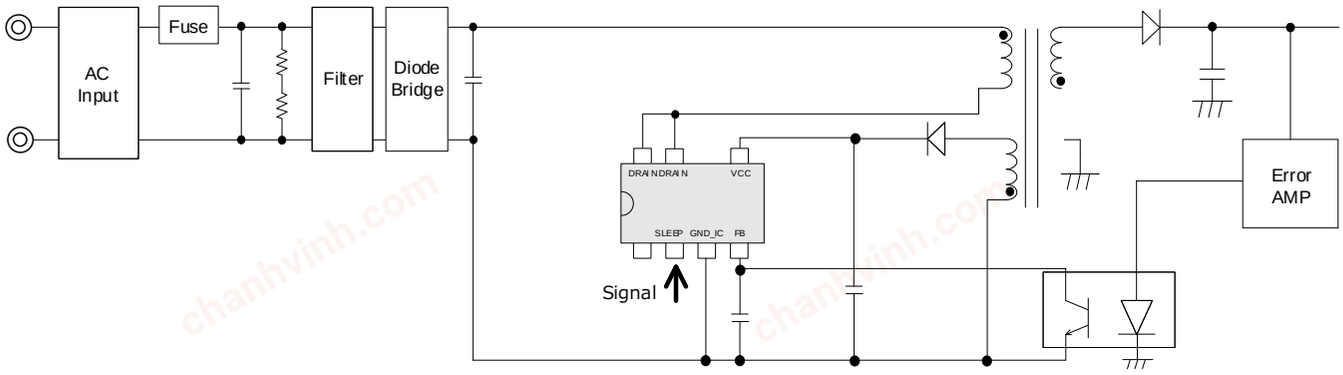


Figure 43. Flyback Application Circuit Diagram

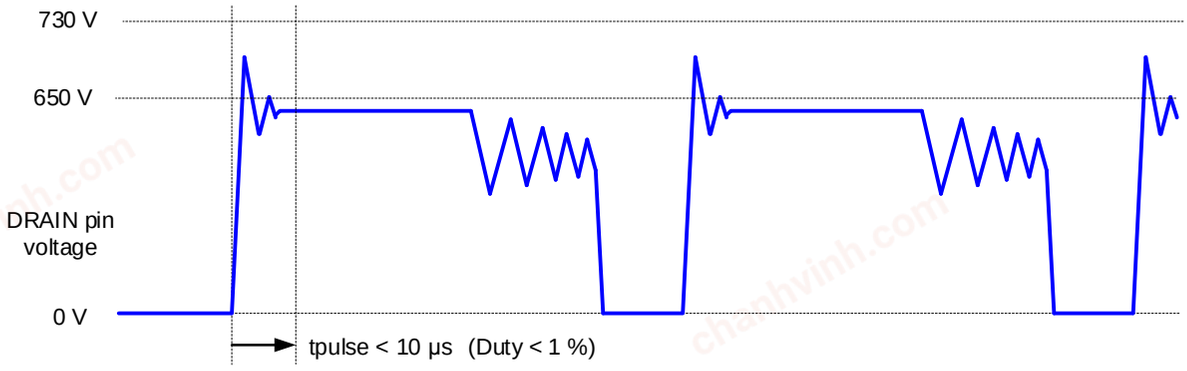
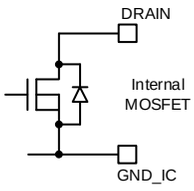
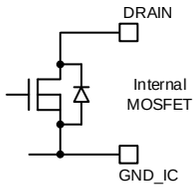
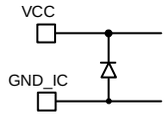
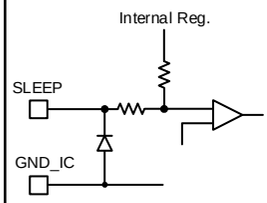
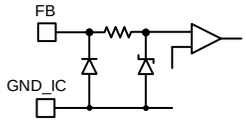


Figure 44. Drain Pin Ringing Waveform

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I/O Equivalence Circuit

7	DRAIN	6	DRAIN	-	-	5	VCC
				-			
1	N. C.	2	SLEEP	3	GND_IC	4	FB
-							

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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. 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. **Recommended Operating Conditions**
The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **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.

7. **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.

8. **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.

9. **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

10. Regarding the Input Pin of the IC

This 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.

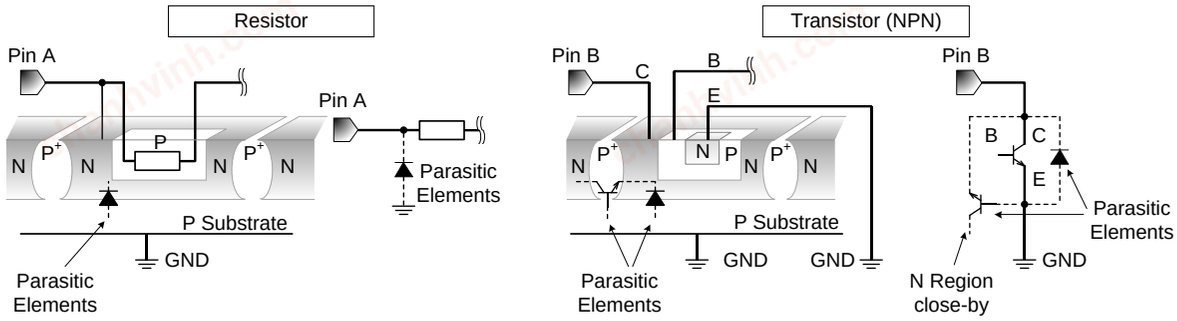


Figure 45. Example of IC Structure

11. Ceramic Capacitor

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

12. 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 maximum junction temperature 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 power 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.

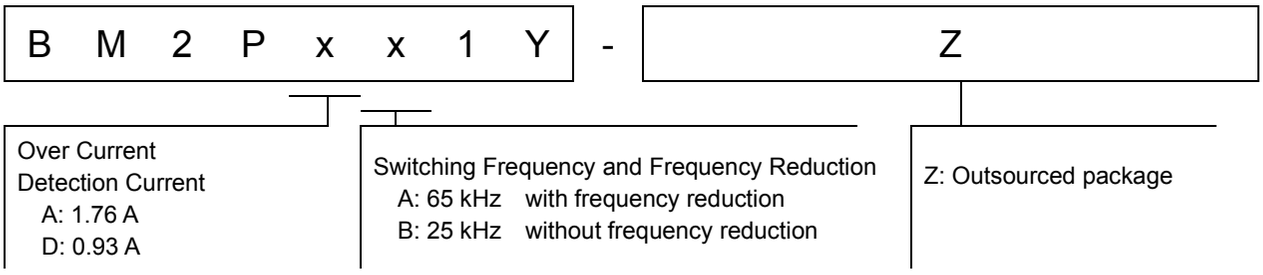
13. Over Current Protection Circuit (OCP)

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.

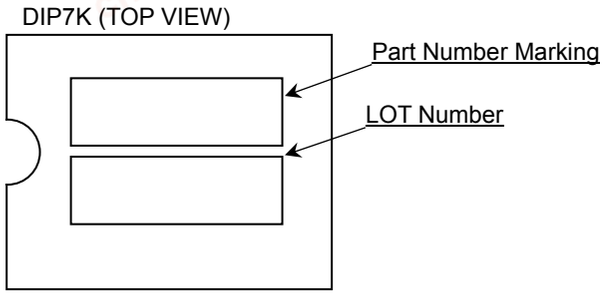
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Ordering Information



Marking Diagram



Lineup

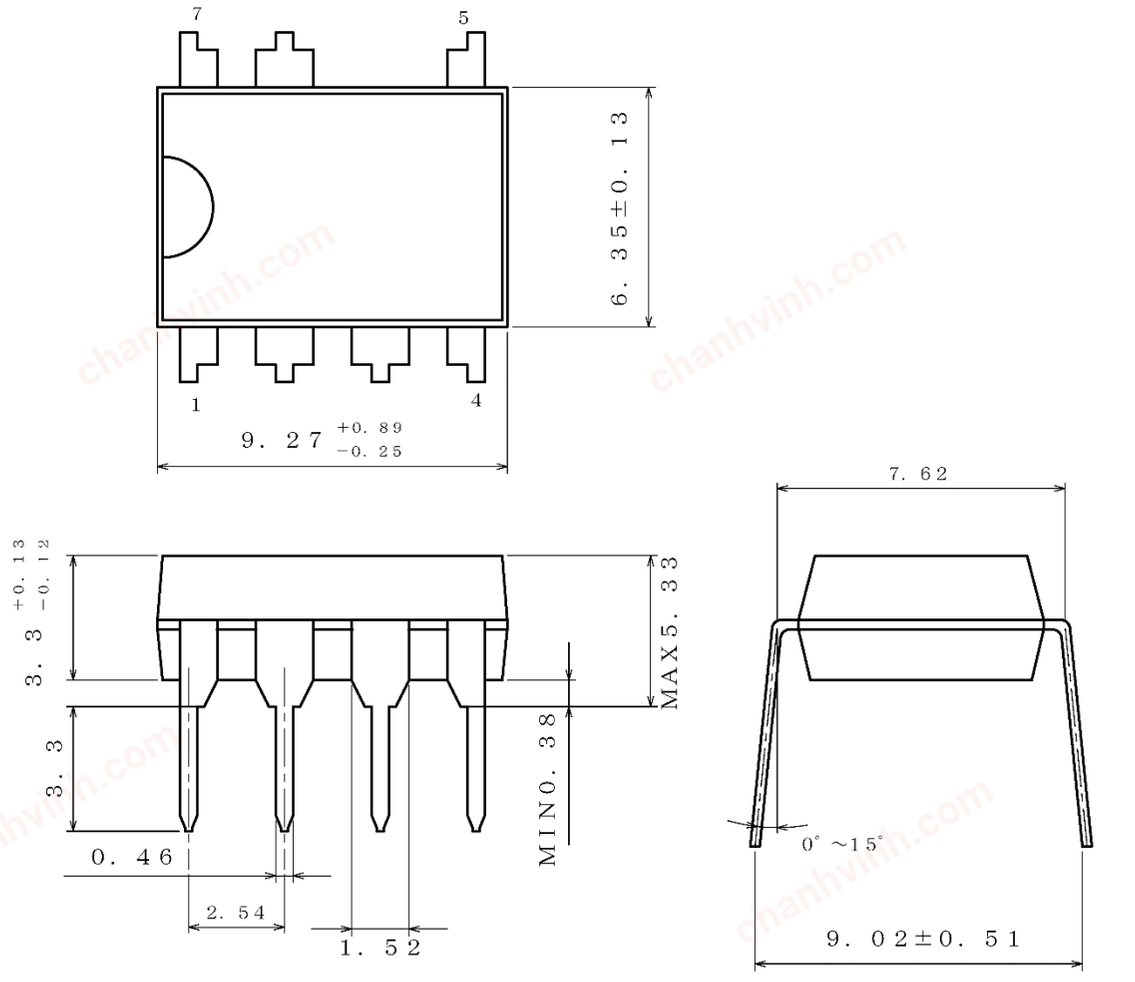
Part Number Marking	Orderable Part Number	Oscillatory Frequency	Frequency Reduction	Over Current Detection Current
BM2PAA1Y	BM2PAA1Y-Z	65 kHz	Yes	1.76 A
BM2PAB1Y	BM2PAB1Y-Z	25 kHz	No	
BM2PDA1Y	BM2PDA1Y-Z	65 kHz	Yes	0.93 A
BM2PDB1Y	BM2PDB1Y-Z	25 kHz	No	

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Physical Dimension and Packing Information

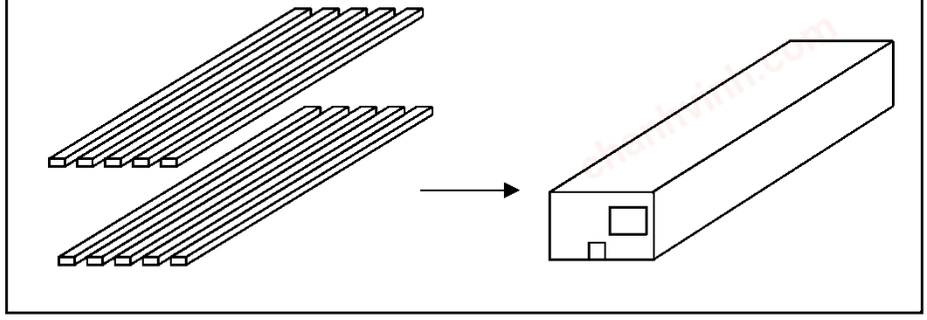
Package Name	DIP7K



(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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Revision History

Date	Revision	Changes
17.Jun.2021	001	New release

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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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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [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 (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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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 Cl_2, H_2S, NH_3, SO_2, and NO_2
   - [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.

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