

AC/DC Converter IC

PWM Type DC/DC Converter IC With Integrated Switching MOSFET

BM2P060MF-Z BM2P061MF-Z BM2P063MF-Z

General Description

The PWM Type DC/DC Converter for AC/DC provides an optimal system for all products that include an electrical outlet. This IC supports isolated power supply and enables simpler designs of various low power consumption electrical converters.

It realizes the high flexibility in power supply design by incorporating a switching MOSFET and with external current detection resistor.

This IC can make high efficiency power supply because it has AC low voltage protection function and X capacitor discharge function and operates frequency reduction, minimum ON width adjustment and burst operation at light load.

This IC has following various protection functions.

Features

- AC Low Voltage Protection Function (AC UVLO)
- X Capacitor Discharge Function
- VCC Pin Low Voltage Protection (VCC UVLO)
- PWM Type Current Mode Control
- Frequency Reduction Function
- Burst Operation at Light Load
- Burst Voltage Setting Function
- Minimum ON Width Adjustment at Light Load
- Soft Start Function
- FB Pin Overload Protection Function (FB OLP)
- Over Current Protection Function by cycle
- Over Current Detection Compensation Function by AC Voltage Detection
- External Stop Function
- Dynamic Over Current Protection
- Leading Edge Blanking Function

Key Specifications

- Operating Power Supply Voltage Range
VCC Pin Voltage: 11 V to 60 V
VH Pin Voltage: 650 V (Max)
DRAIN Pin Voltage: 730 V (Max)
- Current at Switching Operation:
BM2P060MF-Z: 1400 μ A (Typ)
BM2P061MF-Z: 1100 μ A (Typ)
BM2P063MF-Z: 850 μ A (Typ)
- Current at Burst Operation: 400 μ A (Typ)
- Switching Frequency: 65 kHz (Typ)
- Operating Temperature Range: -40 °C to +105 °C
- MOSFET ON Resistor: BM2P060MF-Z: 0.70 Ω (Typ)
BM2P061MF-Z: 1.00 Ω (Typ)
BM2P063MF-Z: 3.00 Ω (Typ)

Package

SOP20A

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

12.8 mm x 10.3 mm x 2.65 mm



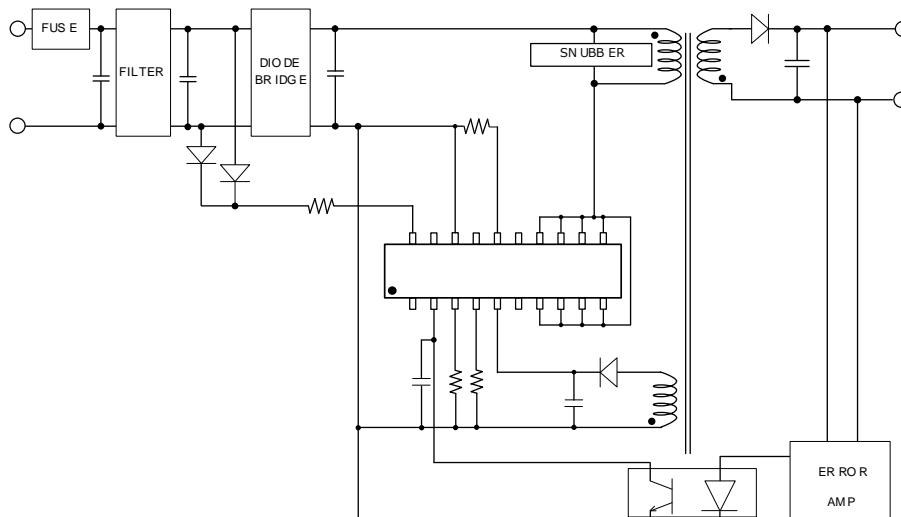
Lineup

Product Name	MOSFET ON Resistor
BM2P060MF-Z	0.70 Ω
BM2P061MF-Z	1.00 Ω
BM2P063MF-Z	3.00 Ω

Applications

AC Adapters, Each Household Applications and Power Supplies for Motor

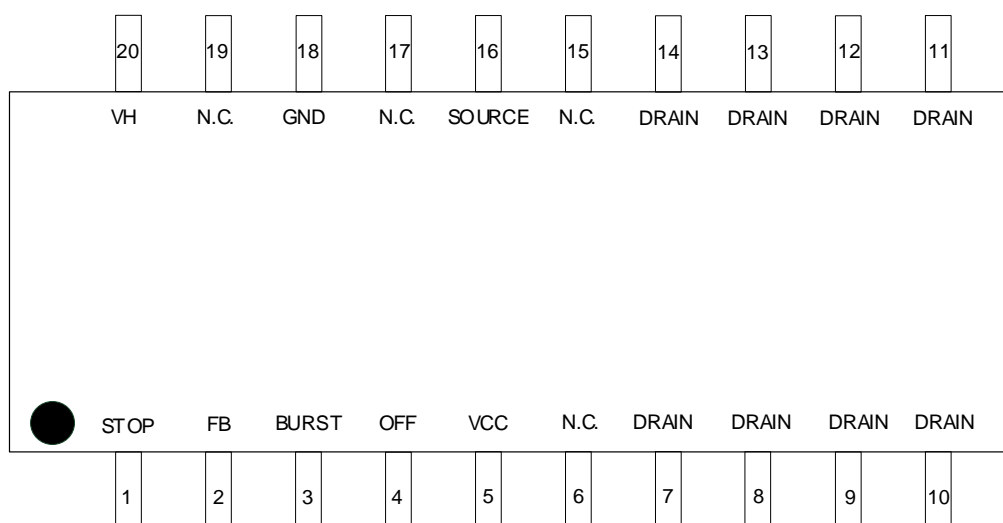
Typical Application Circuit



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

Pin Configuration

(TOP VIEW)

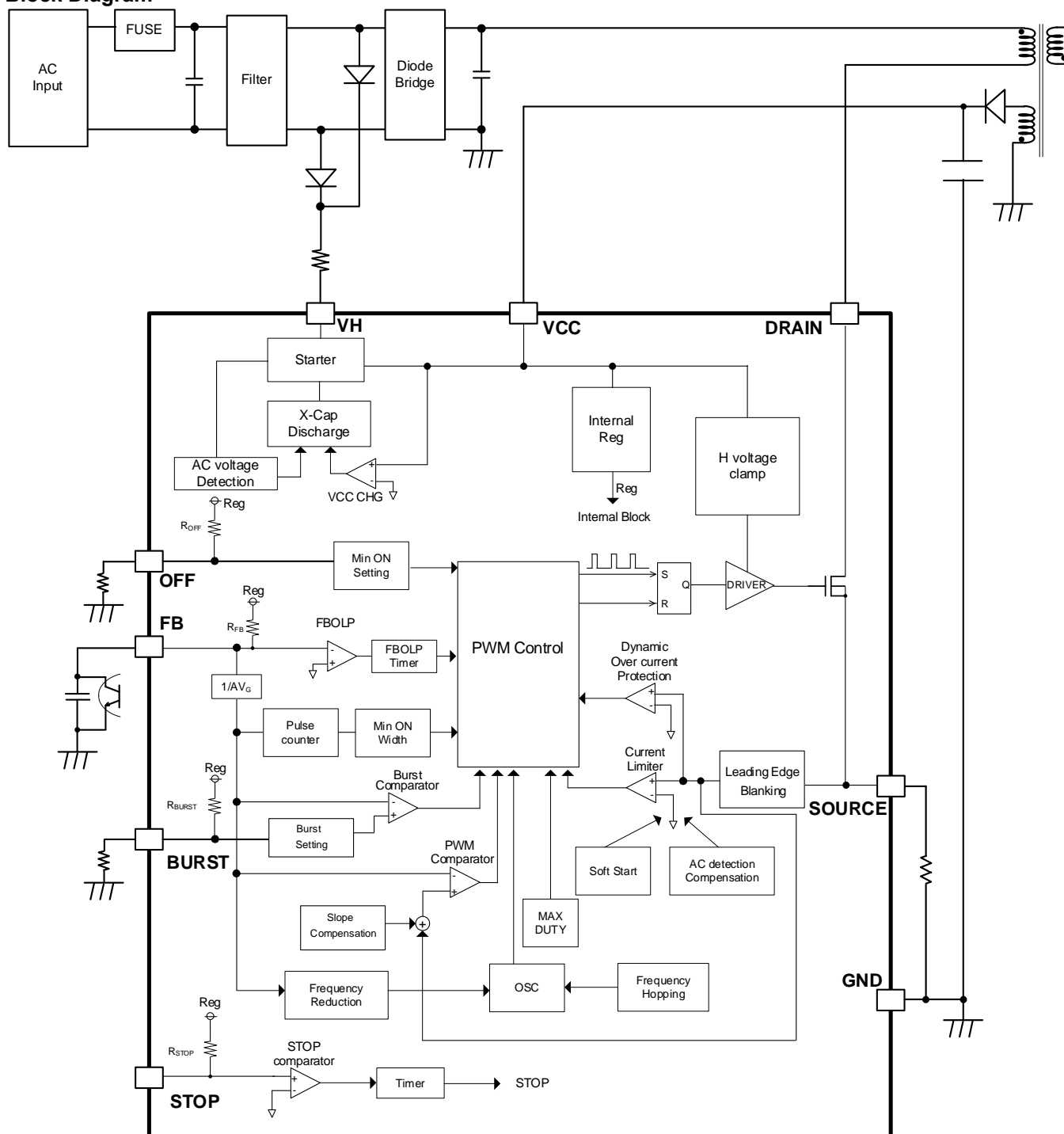


Pin Descriptions

No	Pin name	I/O	Function	ESD Diode	
				VCC	GND
1	STOP	I	External stop pin	-	○
2	FB	I/O	Feedback pin	-	○
3	BURST	I	Burst setting pin	-	○
4	OFF	I	MIN on setting pin	-	○
5	VCC	I/O	Power supply input pin	-	○
6	N.C.	-	No connection <i>(Note 1)</i>	-	-
7	DRAIN	I/O	MOSFET Drain pin	-	○
8	DRAIN				
9	DRAIN				
10	DRAIN				
11	DRAIN				
12	DRAIN				
13	DRAIN				
14	DRAIN				
15	N.C.	-	No connection <i>(Note 1)</i>	-	-
16	SOURCE	I/O	MOSFET source pin	-	○
17	N.C.	-	No connection <i>(Note 1)</i>	-	-
18	GND	I/O	GND pin	○	-
19	N.C.	-	No connection <i>(Note 1)</i>	-	-
20	VH	I	AC voltage start-up pin	-	○

(Note 1) The N.C. pin must be open on the board. It means not to connect GND etc.

Block Diagram



Description of Blocks

1 Start-up Circuit

This IC has a built-in start-up circuit. When the AC input voltage is applied, the VH pin is also applied the voltage. Then the VCC pin voltage is charged by applied current to the VCC pin through the start-up circuit. This charge is stopped after the VCC pin voltage rises and VCC UVLO is released.

2 AC UVLO (Under Voltage Lockout), X Capacitor Discharge Function

AC UVLO: At start-up, the voltage occurs at the VH pin when the AC input voltage is applied. The VCC pin waits the detection of AC input voltage remaining applied voltage and IC switching is stopped until the VH pin peak voltage becomes more than V_{INLVP} while this IC charges the VCC pin through the start-up circuit. IC does not work switching operation in AC UVLO operation. When the VH pin peak voltage is more than V_{INLVP} , AC UVLO function is released and IC works switching operation. After stopping AC input voltage supply, the VH pin peak voltage is V_{INLVP} or less for t_{INLVP} , IC stops switching operation.

X Capacitor Discharge Function: When the status of the VH pin peak voltage is V_{INLVP} or less continues for t_{INLVP} and the switching operation is stopped by AC UVLO function, X capacitor discharge function starts to operate. Since the VH pin detects the voltage change, even if the VH pin peak voltage is more than V_{INLVP} , If the VH pin does not detect voltage rising or falling for t_{INLVP} , IC does not work switching operation.

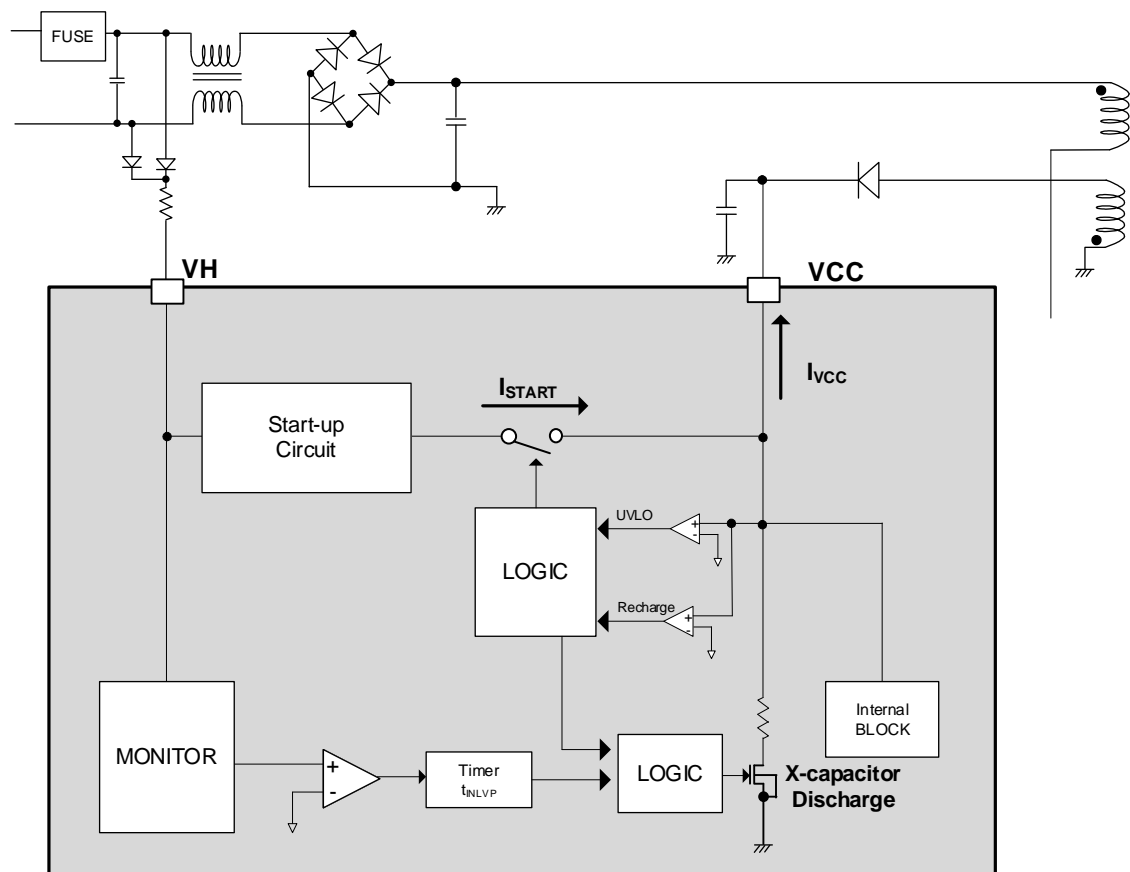


Figure 1. Block Diagram of VH Pin and VCC Pin

2 AC UVLO (Under Voltage Lockout), X Capacitor Discharge Function – continued

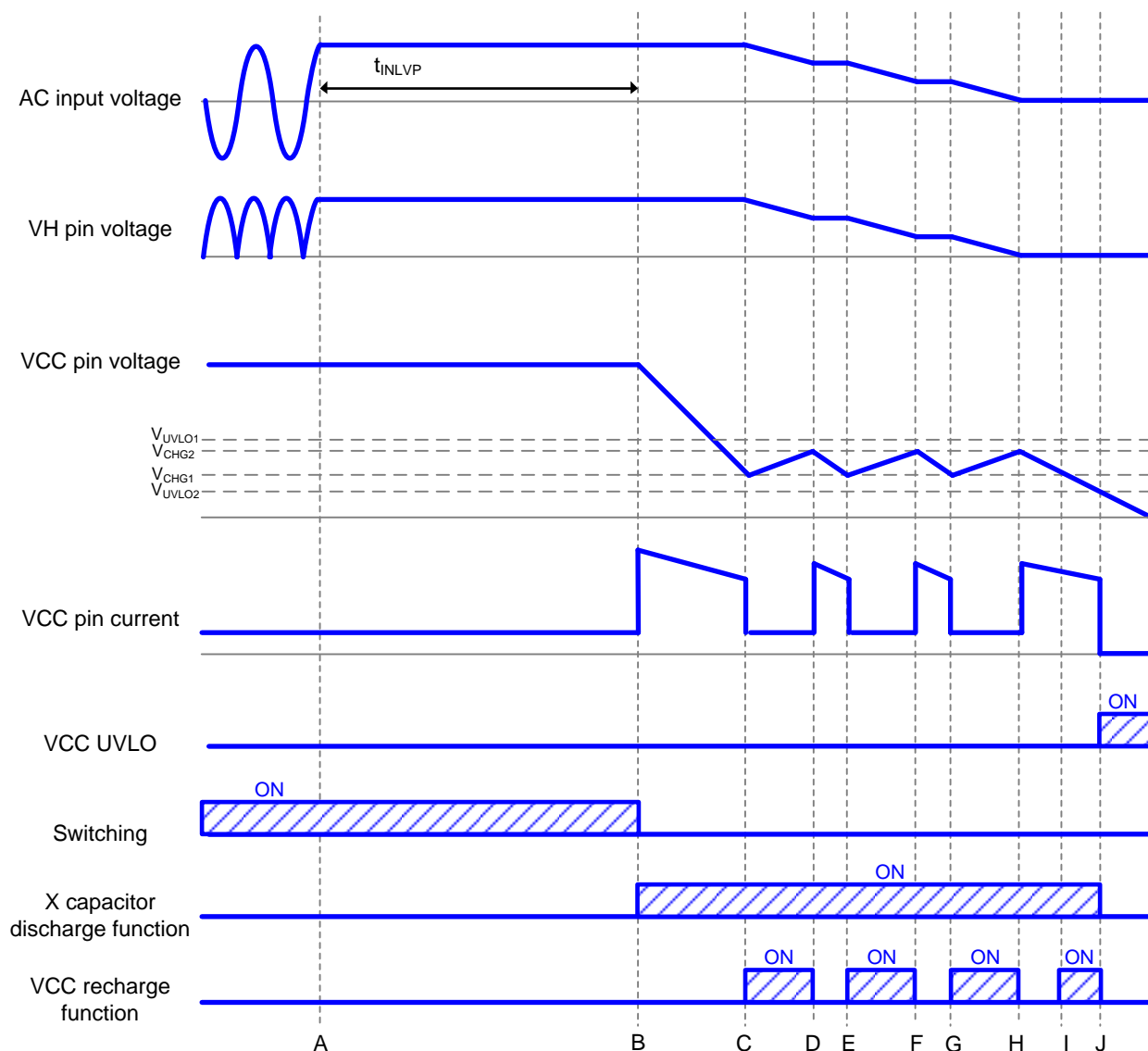


Figure 2. Timing Chart of X Capacitor Discharge Function

- A: The AC input voltage is turned OFF.
- B: After t_{INLVP} from A, the switching operation stops. VCC capacitor is discharged because of the VCC pin voltage more than V_{CHG1} .
- C: When the VCC pin voltage becomes less than V_{CHG1} , the VCC recharge operation starts.
- D: When the VCC pin voltage becomes more than V_{CHG2} , the VCC recharge operation stops.
- E: The Same as C.
- F: The Same as D.
- G: The Same as C.
- H: The Same as D.
- I: When the VCC pin voltage becomes less than V_{CHG1} , the VCC recharge function operates. However, the current supply to the VCC pin decreases and the VCC pin voltage continues to drop because of the low VH pin voltage.
- J: When the VCC pin voltage becomes less than V_{UVLO2} , VCC UVLO operates.

Description of Blocks – continued

3 VCC Pin Protection Function

This IC has VCC UVLO and VCC recharge function at the VCC pin.

3.1 VCC UVLO (Under Voltage Lockout)

This is an auto recovery comparator with a voltage hysteresis. When the VCC pin voltage becomes less than V_{UVLO2} , the IC stops the operation. And, when the VCC pin voltage becomes more than V_{UVLO1} , the operation is restarted.

3.2 VCC Recharge Function

If the VCC pin voltage drops to less than V_{CHG1} after once the VCC pin becomes more than V_{UVLO1} and the IC starts to operate, the VCC recharge function operates. At this time, the VCC pin is recharged from the VH pin through the start-up circuit. When the VCC pin voltage becomes more than V_{CHG2} , this recharge is stopped.

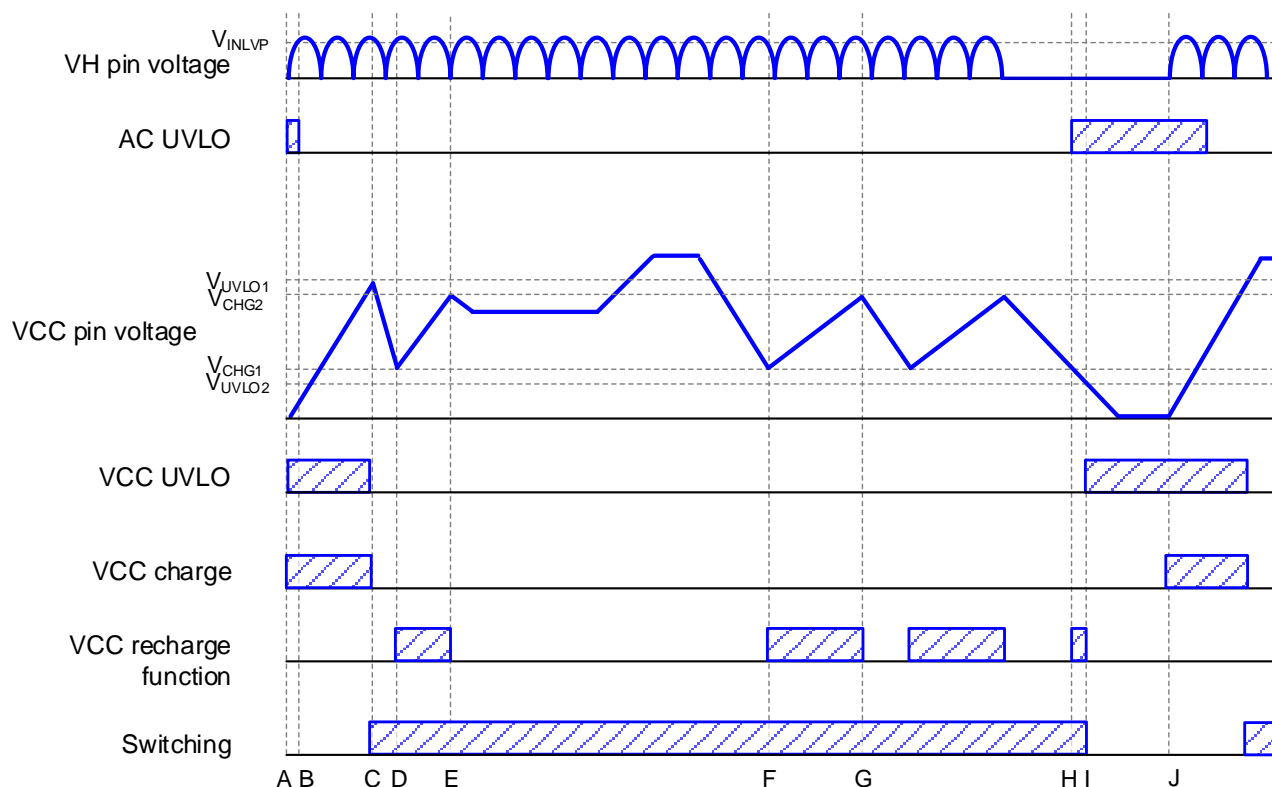


Figure 3. Timing Chart of VCC UVLO and VCC Recharge Function

- A: The VH pin is applied voltage and the VCC pin voltage rises.
- B: When the VH pin voltage becomes more than V_{INLVP} , AC UVLO is released.
- C: When the VCC pin voltage becomes more than V_{UVLO1} , the switching operation starts.
- D: When the VCC pin voltage becomes less than V_{CHG1} , the VCC pin is recharged from the VH pin by VCC recharge function.
- E: When the VCC pin voltage becomes more than V_{CHG2} , the VCC recharge function is stopped.
- F: When the VCC pin voltage becomes less than V_{CHG1} , the VCC recharge function operates.
- G: When the VCC pin voltage becomes more than V_{CHG2} , the VCC recharge function stops. By the operation of F and G, the VCC pin voltage is maintained constantly.
- H: When the VCC pin voltage becomes less than V_{CHG1} , the VCC recharge function operates. However, the current supply to the VCC pin decreases and the VCC pin voltage continues to drop because the VH pin voltage dropped.
- I: When the VCC pin voltage becomes less than V_{UVLO2} , VCC UVLO operates.
- J: The VH pin is applied voltage and the IC operation restarts.

Description of Blocks – continued

4 DC/DC Driver Block

This IC performs a current mode PWM control and it has the following characteristics.

- The switching frequency operates in the range of f_{SW2} to f_{SW1} by an internal oscillator. It has a built-in frequency hopping function and the fluctuation cycle is at random. It makes the EMI low by swaying the switching frequency within $\pm 6\%$.
- This IC controls the ON width by detecting the peak current using the SOURCE pin voltage correspond to the FB pin voltage. The SOURCE pin voltage is restricted to $1/AV_G$ of the FB pin voltage.
- Maximum duty is fixed at D_{MAX} .
- In the current mode control, a sub-harmonic oscillation may occur when the duty cycle exceeds 50%. As a countermeasure, this IC has a built-in slope compensation circuit.
- It has a built-in burst mode and frequency reduction circuit to achieve lower power consumption at light load.
- The FB pin is pulled up to the internal power supply by R_{FB} .
- The FB pin voltage is changed by the secondary output power. This IC monitors this and changes a switching operation status.

4.1 Transition of Switching Frequency by FB Pin Voltage

IC works burst operation which moves between mode a and mode b by repetition.

IC enables to set burst stop voltage at the BURST pin.

V_{BST*} means V_{BST1} to V_{BST8} and it is able to select by the BURST pin.

Refer to the description of 4.6.3 about setting by AC voltage.

IC does not work switching operation when the FB pin voltage is less than burst stop voltage at light load.

After burst stop status, as the FB pin voltage is more than burst release voltage, IC rework switching operation.

IC switching frequency increases from f_{SW2} to f_{SW1} in proportion to the FB voltage at mode c.

mode a:	Burst operation	(Operate intermittently)
mode b:	Fix frequency operation	(Operate for f_{SW2})
mode c:	Frequency modulated operation	(Change switching frequency)
mode d:	Fix frequency operation	(Operate for f_{SW1})

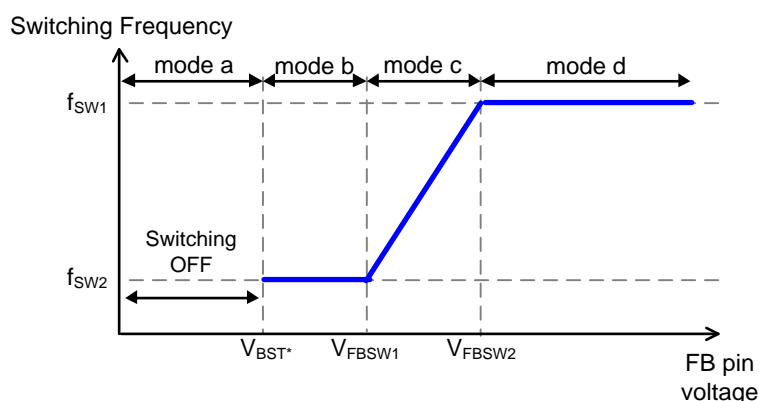


Figure 4. State Transition of Switching Frequency

4 DC/DC Driver Block - continued

4.2 Transition of SOURCE Pin Voltage by FB Pin Voltage

This IC operates as shown below.

Over current detection protection voltage (V_{OCP}) means from V_{OCP1} to V_{OCP8} , the value is set by AC voltage. The setting by AC voltage refers to 4.5.1.

V_{BST*} means from V_{BST1} to V_{BST8} , the value is set by the BURST pin voltage.

The setting by AC voltage refers to 4.6.3.

- mode A: Burst operation
 mode B: Normal load operation (The SOURCE pin voltage is changed by the FB pin voltage.)
 mode C: Overload operation (The SOURCE pin peak voltage is limited by V_{OCP} .
 When the status continues for t_{FBOLP1} , IC is stopped by FB OLP.)

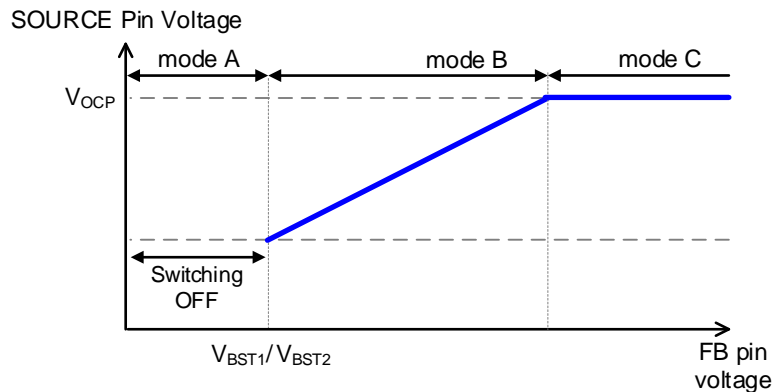


Figure 5. State Transition of SOURCE Pin Voltage by FB Pin Voltage

4.3 Soft Start Function

This function controls the over current protection voltage in order to prevent any excessive voltage or current rising at start-up. This IC enables the soft start operation by changing the over current protection voltage with time.

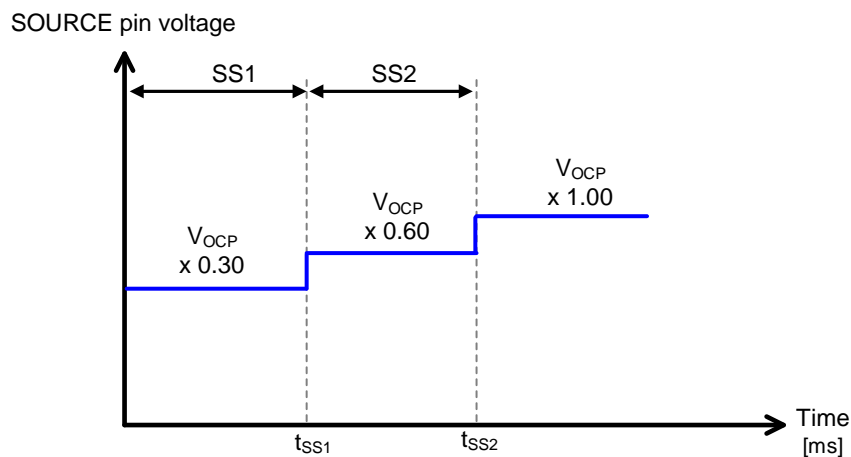


Figure 6. Soft Start Function

4 DC/DC Driver Block - continued

4.4 FB Pin Overload Protection Function (FB OLP)

This IC is switched off when status that the FB pin voltage more than V_{FBOLP1} during t_{FBOLP1} .
 When the FB pin voltage is less than V_{FBOLP2} during t_{FBOLP1} , the detection timer t_{FBOLP1} is released.
 It restarts with soft start after t_{FBOLP2} when switching off.

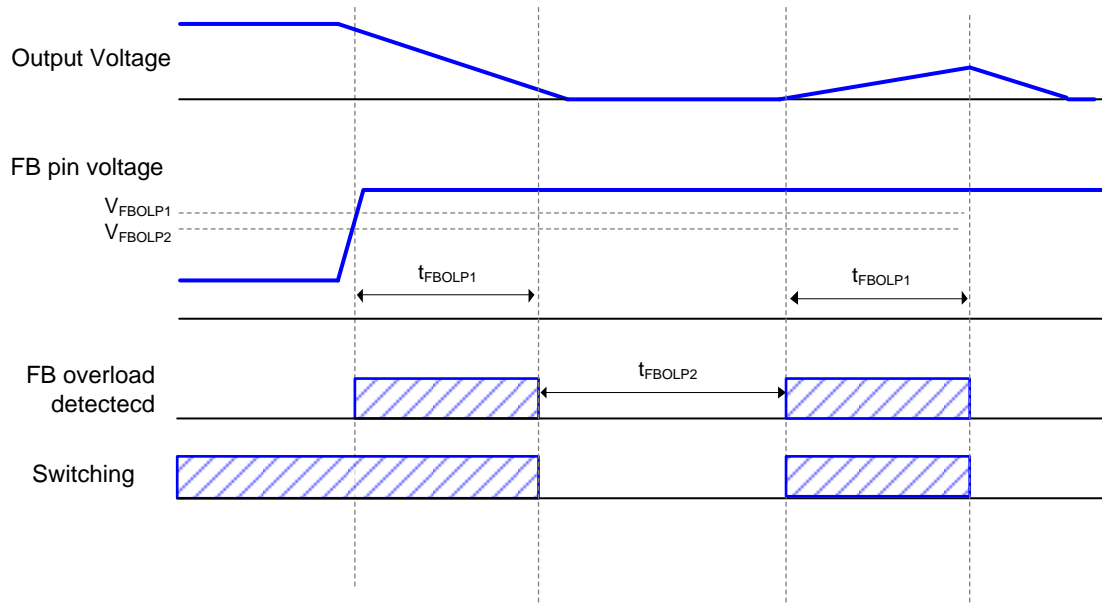


Figure 7. FB Overload Protection Function

4 DC/DC Driver Block – continued

4.5 SOURCE Pin Protection Function

This IC has a built-in OCP for cycle and Dynamic OCP in the SOURCE pin.

Table 1. Operation Status of SOURCE Pin Protection Functions

Function	Load Status at Operation to Protect	Detection Voltage	Operation to Protect
OCP	Over the peak load (Lowering the output voltage)	SOURCE pin peak voltage > V_{OCP} (V_{OCP} : It is set from V_{OCP1} to V_{OCP8})	Turned off by pulse
Dynamic OCP	SOURCE pin voltage is increased for CCM operation	SOURCE pin peak voltage > V_{DOC} Operate at the time of the detection in two continuations. (V_{DOC} : set by from V_{DOC1} to V_{DOC8})	Switching stop for t_{DOC}

4.5.1 Over Current Protection function (OCP)

This IC is built-in OCP function by switching cycle.

As the SOURCE pin peak voltage is more than V_{OCP1} to V_{OCP8} , MOSFET is turned to OFF.

OCP is built-in AC voltage compensation function. IC detects the VH pin peak voltage, OCP voltage is switched from V_{OCP1} to V_{OCP8} according to Table 2.

This function compensates the AC voltage dependency of overload protection power.

At this time, the maximum power has the characteristics shown in Figure 9.

Table 2. OCP voltage by AC voltage detection

VH peak Voltage[V]	OCP Symbol	OCP[V] (Typ)
to 85	V_{OCP1}	0.680
85 to 127	V_{OCP2}	0.670
127 to 170	V_{OCP3}	0.640
170 to 212	V_{OCP4}	0.615
212 to 255	V_{OCP5}	0.600
255 to 297	V_{OCP6}	0.590
297 to 339	V_{OCP7}	0.580
339 to	V_{OCP8}	0.570

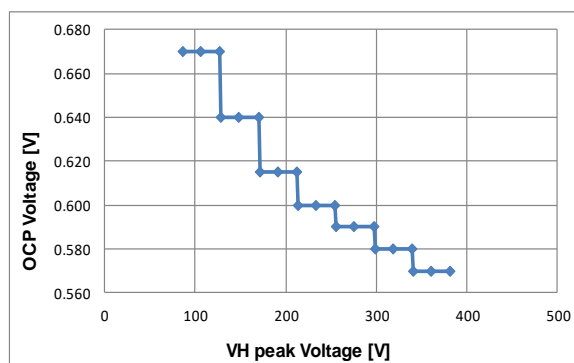
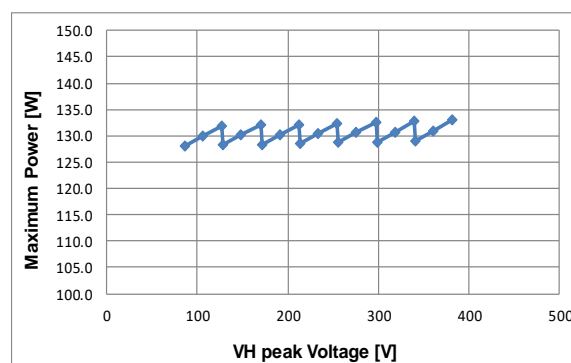


Figure 8. OCP Voltage vs VH peak Voltage

Figure 9. (Note 2) Example of Maximum Power
($L_p = 450 \mu\text{H}$, $R_s = 0.22 \Omega$)

(Note 2) Figure 9 is reference graph. It changes to depend on external condition.

4.5 SOURCE pin protection function – continued

4.5.2 Dynamic over current protection function

This IC is built-in dynamic over current protection.

When the SOURCE pin voltage detects over V_{DOC} voltage in continuous two pulses, IC stops switching operation for t_{DOC} .

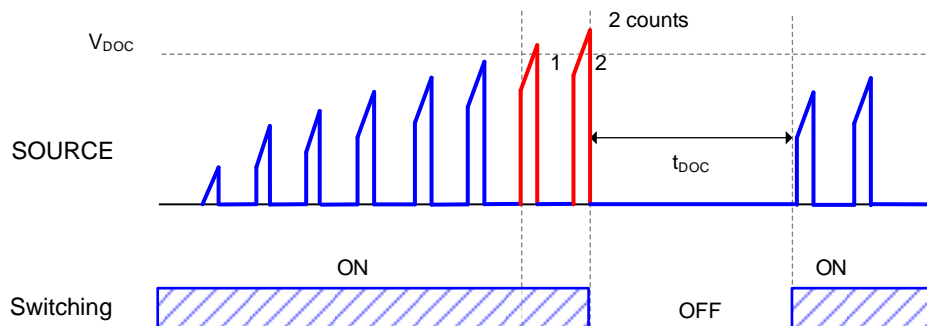


Figure 10. Dynamic OCP Timing Chart

4.5.3 Leading Edge Blanking

Normally, when the MOSFET for switching is turned to ON, surge current is generated at each capacitor component and drive current and so on. At this time, detection errors may occur in the over current protection function because the SOURCE pin voltage rises temporary. To prevent these errors, Leading Edge Blanking function is built-in this IC. This function masks the SOURCE pin voltage for t_{LEB} from the switch of the Drain pin H to L.

4.6 Minimum ON width function

This IC is built-in minimum ON width function.

4.6.1 Minimum ON width switching function by FB pin pulse count of burst period

Normally, the minimum ON width of this IC is t_{MIN1} . When the operation is burst operation at light load, IC counts the number of switching from the start of switching after the burst stop is released to the burst stop again. When switching number is 3 pulses or less IC operates low stand-by mode, and IC switches minimum ON width. The switching of minimum ON width is decided from t_{MIN2} to t_{MIN4} to correspond to the OFF pin resistor value. As minimum ON width is switched, the number of switching is low. When it is low standby power mode, if the load is increased, the number of switching increases. When the number of switching after the burst operation is stopped is 2 pulses or more, the low standby power mode is switched to the normal mode. Then minimum ON width function is released, minimum ON width is to t_{MIN1} .

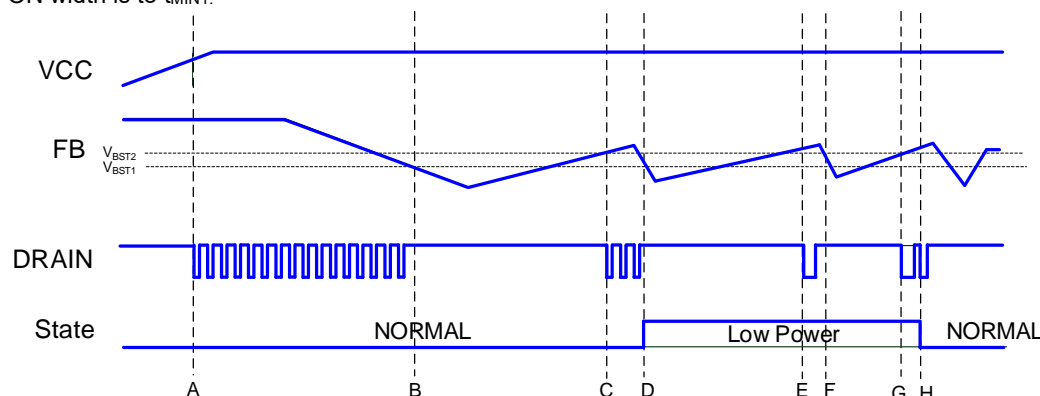


Figure 11. MIN ON Width Function

- A: VCC voltage rises, and IC works switching operation.
- B: When the FB pin voltage is less than V_{BST1} , IC does not work switching operation by burst function.
- C: When the FB pin voltage is more than V_{BST2} , IC works switching operation.
- D: Because the number of switching is 3 times for one burst period, IC changes low standby mode. And pulse width is increased after the next burst release.
- E: Burst stop function is released, the minimum ON width increases.
- F: Because the power of one switching increases, pulse number is reduced.
- G: Because IC detects burst stop in the state of one switching number, IC maintains low standby mode.
- H: The burst stop is released, IC works switching operation.
- H: Because IC detects second pulse in one burst period, IC changes from low standby mode to normal mode.

4.6 Minimum ON width function - continued

4.6.2 Minimum ON width switching function by OFF pin

Minimum ON width in burst operation is able to switch external resistor at the OFF pin. IC detects the OFF pin resistor value at the timing of t_{STSET2} from VCC UVLO released. Then IC sets minimum ON width below.

When the OFF pin is connected to GND, MIN ON width is set to t_{MIN4} , the number of switching pulse increases by +1.

The function is reset when VCC UVLO is detected.

Table 3. MIN ON Setting Width

R_1 (k Ω)	MIN ON width	Number of Low Standby Mode Switching Pulse	Number of Normal Mode Switching Pulse
OPEN	t_{MIN2}	3	1
180	t_{MIN3}	3	1
47	t_{MIN4}	3	1
GND	t_{MIN4}	4	2

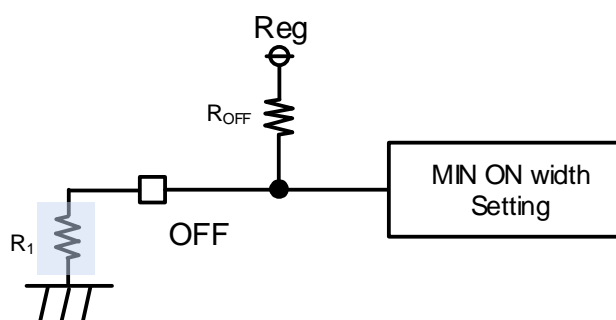


Figure 12. OFF Setting Circuit

4.6.3 BURST voltage switching function by BURST pin

Burst operation voltage is able to switch external resistor at the BURST pin.

IC sets the BURST voltage as follows by BURST pin voltage at the timing of t_{STSET1} from VCC UVLO released.

The function is reset when VCC UVLO is detected.

Table 4. BURST Voltage Setting

R_2 (k Ω)	Burst Detection Voltage Symbol	Burst Release Voltage Symbol
OPEN	V_{BST1}	V_{BST2}
180	V_{BST3}	V_{BST4}
47	V_{BST5}	V_{BST6}
GND	V_{BST7}	V_{BST8}

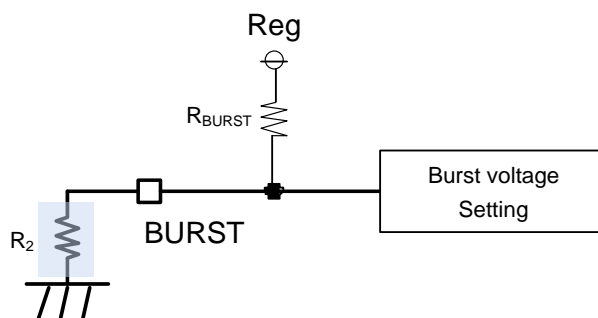


Figure 13. BURST Setting Circuit

Description of Blocks – continued

5 External stop function by the STOP pin

This IC is switched off when status that the STOP pin voltage less than V_{STOP} for t_{STOP} .
 This IC incorporates a mask timer of t_{STOP} to prevent the false detection by the noise.
 When the STOP pin voltage more than V_{STOP} , the switching is reopened.
 The STOP pin is pulled up in the IC inside by R_{STOP} .

Example for use to the STOP pin

The STOP pin can perform outside stop.

Show a case stopping from the microcomputer of the secondary as an example in figure 14.

This is stopped by transmitting a signal from the microcomputer on the secondary side to the primary side with a photocoupler.

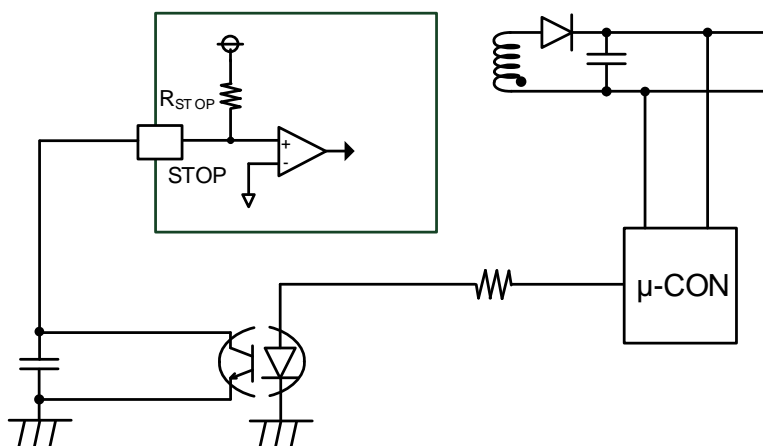


Figure 14. External Stop Circuit

Operation Mode of Protection Functions

The operation modes of each protection function are shown in Table 5.

Table 5. Operation Modes of Protection Functions

	AC UVLO	VCC UVLO	Dynamic OCP
Detection Conditions	VH pin peak voltage $\leq V_{INLVP}$	VCC pin voltage $< V_{UVLO2}$ (voltage drop)	SOURCE pin voltage $> V_{DOC}$
Release Conditions	VH pin peak voltage $> V_{INLVP}$	VCC pin voltage $> V_{UVLO1}$ (voltage rise)	Release after past for t_{DOC}
Detection Timer (Reset Conditions)	t_{INLVP} (VH pin peak voltage $> V_{INLVP}$)	—	Detect continuous two pulses
Auto restart or Latch	Auto restart	Auto restart	Auto restart

	STOP	FB OLP	TSD (Thermal Protection)
Detection Conditions	STOP pin voltage $< V_{STOP}$ (Voltage drop)	FB pin voltage $> V_{FBOLP1}$ (Voltage rise)	$T_j > T_{TSD1}$ (Temperature rise)
Release Conditions	STOP pin voltage $> V_{STOP}$ (Voltage rise)	Elapsed period by t_{FBOLP2}	$T_j < T_{TSD2}$ (Temperature drop)
Detection Timer (Reset Conditions)	t_{STOP} (STOP pin voltage $> V_{STOP}$)	t_{FBOLP1} (FB pin voltage $< V_{FBOLP2}$)	t_{TSD} ($T_j < T_{TSD2}$)
Auto restart or Latch	Auto restart	Auto restart	Auto restart

Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit	Condition
Maximum Applied Voltage 1	V _{MAX1}	-0.3 to +650	V	DRAIN
		730	V	DRAIN (tpulse < 10 μs) (Note 3)
Maximum Applied Voltage 2	V _{MAX2}	-0.3 to +6.5	V	SOURCE, FB, OFF, BURST, STOP
Maximum Applied Voltage 3	V _{MAX3}	-0.3 to +62.0	V	VCC
Maximum Applied Voltage 4	V _{MAX4}	-0.3 to +650.0	V	VH
Drain Current 1 (Pulse)	I _{DP1}	21	A	P _w = 10 μs, Duty cycle = 1 % (BM2P060MF-Z)
Drain Current 2 (Pulse)	I _{DP2}	12	A	P _w = 10 μs, Duty cycle = 1 % (BM2P061MF-Z)
Drain Current 3 (Pulse)	I _{DP3}	4	A	P _w = 10 μs, Duty cycle = 1 % (BM2P063MF-Z)
Power Dissipation	P _d	2.30	W	(Note 4)
Maximum Junction Temperature	T _{jmax}	150	°C	
Storage Temperature Range	T _{stg}	-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 3) Duty is less than 1 %

(Note 4) When IC mounted singly. Derate by 18.3 mW / °C if the IC is used in the ambient temperature 25 °C or more.

Thermal Dissipation

Make the thermal design so that the IC operates in the following conditions.

(Because the following temperature is guarantee value, it is necessary to consider margin.)

1. The ambient temperature Ta 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.

(At mounting singly)

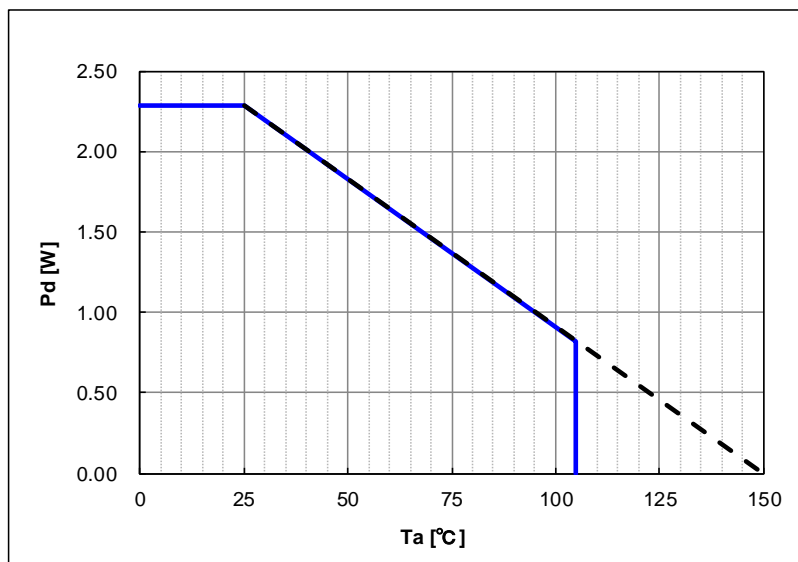


Figure 15. SOP20A Thermal Dissipation Characteristic

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating VCC Pin Voltage Range	V _{CC}	11	-	60	V
VH Pin Range at AC Voltage	V _H	-	-	300 (Note 5)	V
VCC Pin Capacitor	C _{VCC}	4.7	-	-	μF
VH Pin Resistor	R _{VH}	-	-	4.7	kΩ
Operating Temperature	T _{opr}	-40	-	+105	°C

(Note 5) The recommendation maximum operating voltage shows AC 300 V which is the input AC voltage in the application.
Apply the input AC voltage which is full-wave-rectified to the VH pin.

Electrical Characteristics in MOSFET Part (Unless otherwise specified T_j = 25 °C, VCC = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Drain Voltage	V _{DS}	650	-	-	V	I _D = 1 mA, V _{GS} = 0 V
		730	-	-	V	I _D = 1 mA, V _{GS} = 0 V t _{pulse} < 10 μs (Note 6)
DRAIN Pin Leak Current	I _{DSS}	-	-	100	μA	V _{DS} = 650 V, V _{GS} = 0 V
ON Resistor 1	R _{DS(ON)1}	-	0.70	0.86	Ω	BM2P060MF-Z
ON Resistor 2	R _{DS(ON)2}	-	1.00	1.35	Ω	BM2P061MF-Z
ON Resistor 3	R _{DS(ON)3}	-	3.00	4.00	Ω	BM2P063MF-Z

(Note 6) Duty is less than 1 %.

Electrical Characteristics in Start Up VH Part (Unless otherwise specified T_j = 25 °C, VCC = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Start-up Current	I _{START1}	8	15	25	mA	V _H = 100 V, VCC = 10 V
VH Pin OFF Current	I _{START2}	5	12	20	μA	V _H = 100 V, VCC = 15 V
AC UVLO Detection Voltage	V _{INLVP}	75	85	95	V	
Discharge ON Delay Timer	t _{INLVP}	105	150	195	ms	

Electrical Characteristics in Control IC Part (Unless otherwise specified T_j = -40 °C to +105 °C, VCC = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Current at Switching Operation 1A	I _{ON1A}	900	1400	2000	μA	BM2P060MF-Z, FB = 3.0 V (Note 7)
Current at Switching Operation 1B	I _{ON1B}	500	1100	1700	μA	BM2P061MF-Z, FB = 3.0 V (Note 7)
Current at Switching Operation 1C	I _{ON1C}	300	850	1450	μA	BM2P063MF-Z, FB = 3.0 V (Note 7)
Current at Burst Operation	I _{ON2}	250	400	550	μA	FB = 0.2 V (Note 7)
Current at STOP	I _{STOP}	70	150	230	μA	Stop by the STOP pin (Note 7)
VCC UVLO Release Voltage	V _{UVLO1}	13.0	14.0	15.0	V	VCC rising (Note 7)
VCC UVLO Detection Voltage	V _{UVLO2}	8.2	9.0	9.8	V	VCC falling (Note 7)
VCC UVLO Hysteresis	V _{UVLO3}	-	5.0	-	V	V _{UVLO3} = V _{UVLO1} - V _{UVLO2} (Note 7)
VCC Recharge Start Voltage	V _{CHG1}	9	10	11	V	(Note 7)
VCC Recharge Stop Voltage	V _{CHG2}	11	12	13	V	(Note 7)
TSD Temperature 1	T _{TSD1}	150	-	-	°C	
TSD Temperature 2	T _{TSD2}	-	T _{TSD1} -25	-	°C	
TSD Timer	t _{TSD}	-	100	-	μs	

(Note 7) T_j = 25 °C guaranteed.

Electrical Characteristics – continued (Unless otherwise specified, Tj = -40 °C to +105 °C, V_{CC} = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
DC/DC Driver Block						
Switching Frequency 1	f _{SW1}	60	65	70	kHz	(Note 7)
Switching Frequency 2	f _{SW2}	20	25	30	kHz	
Frequency Hopping Width	f _{DEL}	-	4	-	kHz	FB = 3.0 V
Voltage Gain (FB/SOURCE)	AV _G	-	5	-	V/V	
Maximum Duty	D _{MAX}	67	75	83	%	(Note 7)
FB Pin Burst Voltage 1	V _{BST1}	0.20	0.25	0.30	V	FB Falling
FB Pin Burst Voltage 2	V _{BST2}	-	0.28	-	V	FB Rising
FB Pin Burst Voltage 3	V _{BST3}	0.25	0.30	0.35	V	FB Falling
FB Pin Burst Voltage 4	V _{BST4}	-	0.33	-	V	FB Rising
FB Pin Burst Voltage 5	V _{BST5}	0.30	0.35	0.40	V	FB Falling
FB Pin Burst Voltage 6	V _{BST6}	-	0.40	-	V	FB Rising
FB Pin Burst Voltage 7	V _{BST7}	0.40	0.45	0.50	V	FB Falling
FB Pin Burst Voltage 8	V _{BST8}	-	0.50	-	V	FB Rising
Frequency Reduction Start FB Pin Voltage	V _{FBSW1}	0.75	0.90	1.05	V	(Note 7)
Frequency Reduction End FB Pin Voltage	V _{FBSW2}	1.15	1.30	1.45	V	(Note 7)
Leading Edge Blanking Time	t _{LEB}	-	0.25	-	μs	
SOURCE Pin Pull up Resistor	R _{SOCE}	1.4	2.0	2.6	MΩ	During normal operation (Note 7)
FB Pin Pull up Resistor	R _{FB}	24	30	36	kΩ	(Note 7)
Minimum ON Width 1	t _{MIN1}	-	0.50	-	μs	Normal
Minimum ON Width 2	t _{MIN2}	1.30	1.50	1.70	μs	OFF: OPEN (Note 7)
Minimum ON Width 3	t _{MIN3}	1.55	1.70	1.85	μs	OFF: 180 kΩ (Note 7)
Minimum ON Width 4	t _{MIN4}	1.70	1.90	2.10	μs	OFF: or less 47 kΩ (Note 7)
DC/DC Driver Block (SOURCE Pin Over Current Protection Function)						
SOURCE Pin OCP Voltage 1	V _{OCP1}	0.645	0.680	0.715	V	VH peak < 85 V
SOURCE Pin OCP Voltage 2	V _{OCP2}	0.635	0.670	0.705	V	85 V < VH peak < 127 V
SOURCE Pin OCP Voltage 3	V _{OCP3}	0.605	0.640	0.675	V	127 V < VH peak < 170 V
SOURCE Pin OCP Voltage 4	V _{OCP4}	0.580	0.615	0.640	V	170 V < VH peak < 212 V
SOURCE Pin OCP Voltage 5	V _{OCP5}	0.565	0.600	0.635	V	212 V < VH peak < 255 V
SOURCE Pin OCP Voltage 6	V _{OCP6}	0.555	0.590	0.625	V	255 V < VH peak < 297 V
SOURCE Pin OCP Voltage 7	V _{OCP7}	0.545	0.580	0.615	V	297 V < VH peak < 339 V
SOURCE Pin OCP Voltage 8	V _{OCP8}	0.535	0.570	0.605	V	VH peak > 339 V
SOURCE Pin Dynamic OCP Voltage 1	V _{DOC1}	0.934	1.005	1.076	V	VH peak < 85 V
SOURCE Pin Dynamic OCP Voltage 2	V _{DOC2}	0.920	0.990	1.060	V	85 V < VH peak < 127 V
SOURCE Pin Dynamic OCP Voltage 3	V _{DOC3}	0.886	0.953	1.020	V	127 V < VH peak < 170 V
SOURCE Pin Dynamic OCP Voltage 4	V _{DOC4}	0.858	0.923	0.988	V	170 V < VH peak < 212 V
SOURCE Pin Dynamic OCP Voltage 5	V _{DOC5}	0.837	0.900	0.963	V	212 V < VH peak < 255 V
SOURCE Pin Dynamic OCP Voltage 6	V _{DOC6}	0.823	0.885	0.947	V	255 V < VH peak < 297 V
SOURCE Pin Dynamic OCP Voltage 7	V _{DOC7}	0.809	0.870	0.931	V	297 V < VH peak < 339 V
SOURCE Pin Dynamic OCP Voltage 8	V _{DOC8}	0.795	0.855	0.915	V	VH peak > 339 V
SOURCE Pin Dynamic OCP Stop Timer	t _{DOC}	100	160	220	μs	(Note 7)

(Note 7) Tj = 25 °C guaranteed.

Electrical Characteristics – continued (Unless otherwise specified Tj = -40 °C to +105 °C, V_{CC} = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
DC/DC Driver Block (Soft Start Function)						
Soft Start Timer 1	t _{SS1}	1.79	2.56	3.33	ms	
Soft Start Timer 2	t _{SS2}	7.17	10.24	13.31	ms	
DC/DC Driver Block (FB Pin Overload Protection Function)						
FB OLP Detection Voltage	V _{FBOLP1}	3.9	4.2	4.5	V	
FB OLP Release Voltage	V _{FBOLP2}	-	4.0	-	V	
FB OLP Detection Timer	t _{FBOLP1}	60	82	104	ms	(Note 7)
FB OLP STOP Timer	t _{FBOLP2}	484	656	828	ms	(Note 7)
External Stop Function by the STOP Pin						
STOP Pin by Stop Voltage	V _{STOP}	0.4	0.5	0.6	V	
STOP Pin Pull up Resistor	R _{STOP}	19.4	25.9	32.3	kΩ	(Note 7)
STOP Detection Timer	t _{STOP}	75	150	250	μs	(Note 7)
BURST Pin Setting Block						
BURST Pin Pull up Resistor	R _{BURST}	150	200	250	kΩ	(Note 7)
BURST Pin External Resistor Detection Timer in Start-up	t _{STSET1}	160	320	480	μs	(Note 7)
OFF Pin Setting Block						
OFF Pin Pull up Resistor	R _{OFF}	150	200	250	kΩ	(Note 7)
OFF Pin External Resistor Detection Timer in Start-up	t _{STSET2}	160	320	480	μs	(Note 7)

(Note 7) Tj = 25 °C guaranteed.

Application Examples

Show a flyback circuitry example in Figure 16.
Be careful that when the DRAIN voltage turn off it occur high voltage with ringing.
With this IC, it become able to operate to 730 V.

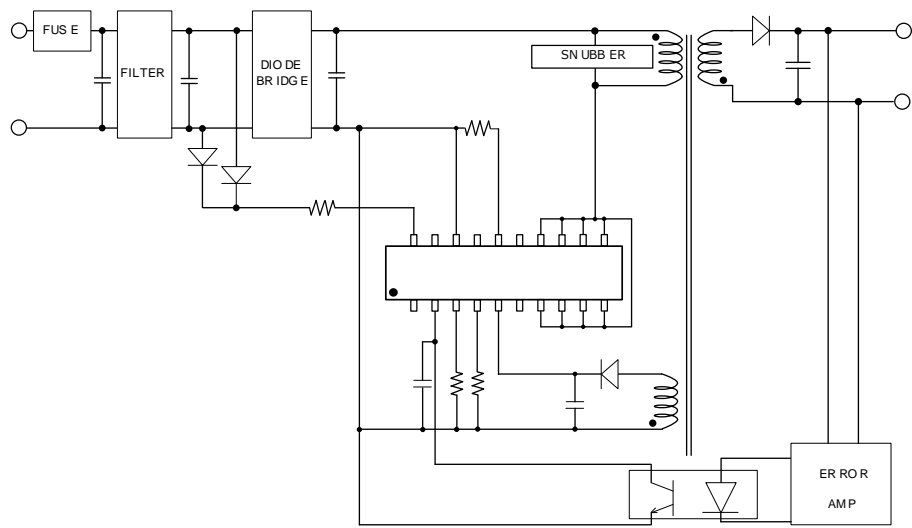


Figure 16. Flyback Application Diagram

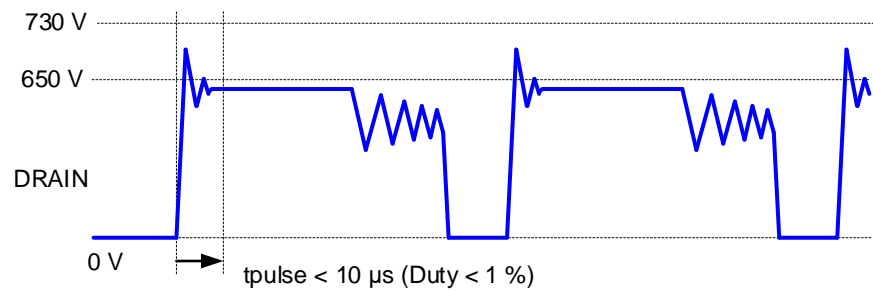


Figure 17. DRAIN pin Ringing Waveform

Typical Performance Curves

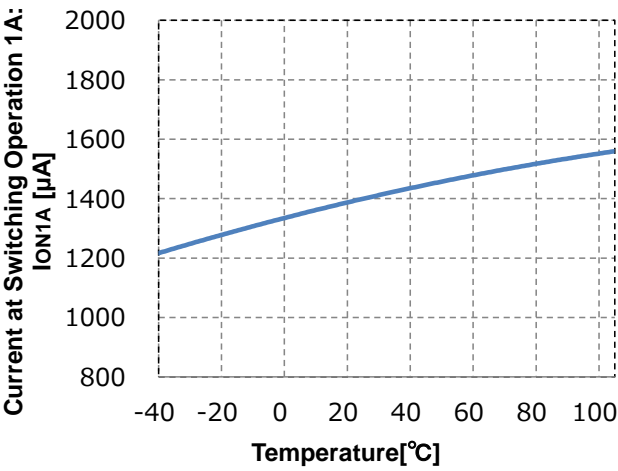


Figure 18. Current at Switching Operation 1A vs Temperature

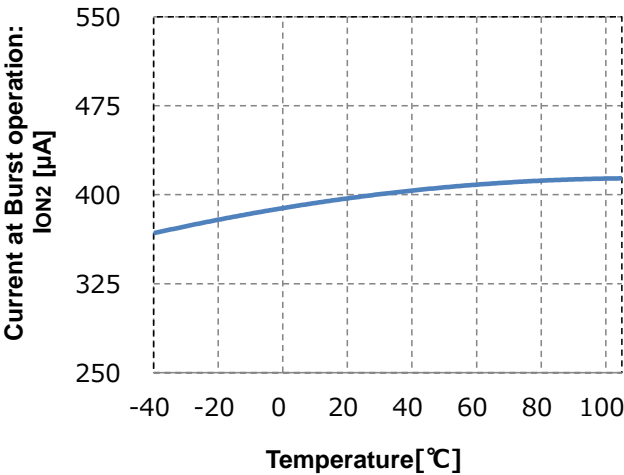


Figure 19. Current at Burst Operation vs Temperature

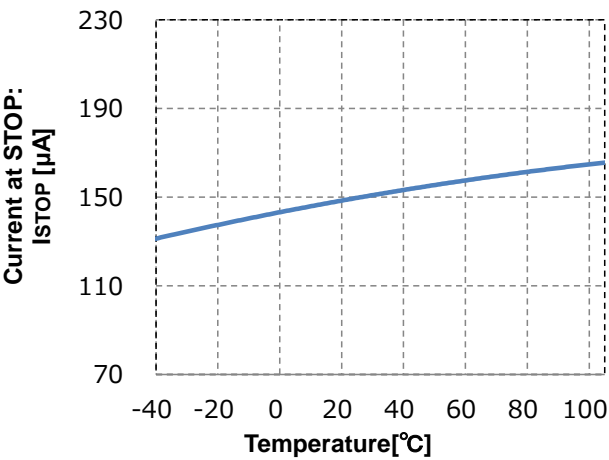


Figure 20. Current at STOP vs Temperature

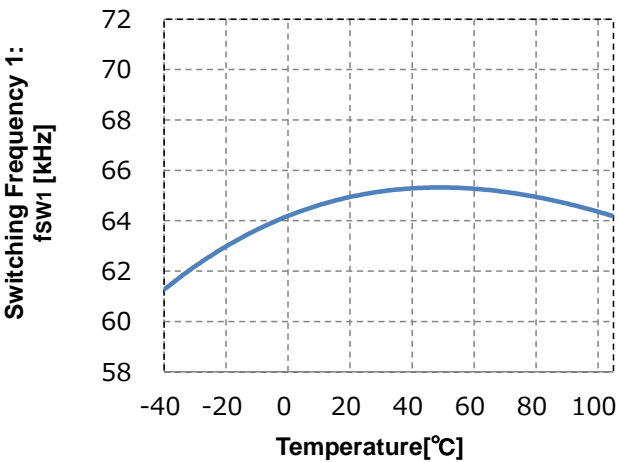


Figure 21. Switching Frequency 1 vs Temperature

Typical Performance Curves – continued

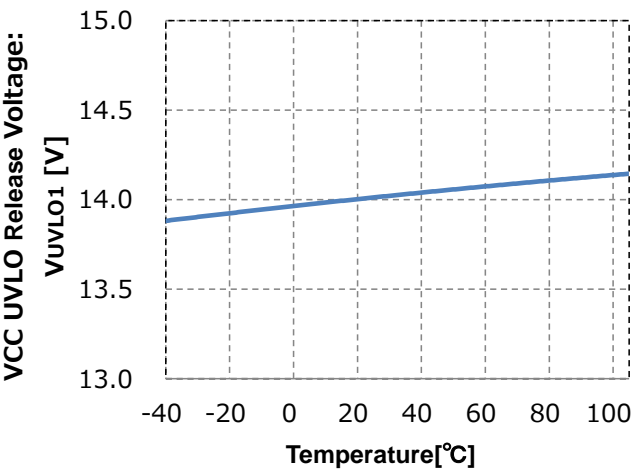


Figure 22. VCC UVLO Release Voltage vs Temperature

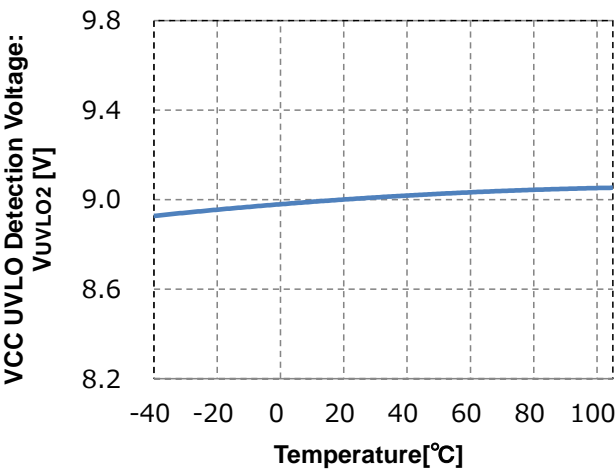


Figure 23. VCC UVLO Detection Voltage vs Temperature

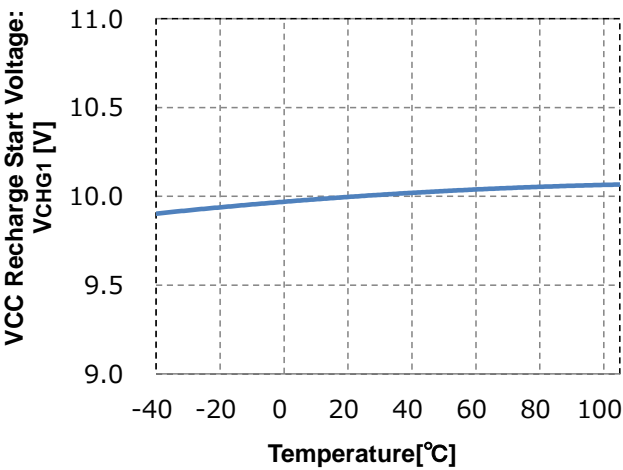


Figure 24. VCC Recharge Start Voltage vs Temperature

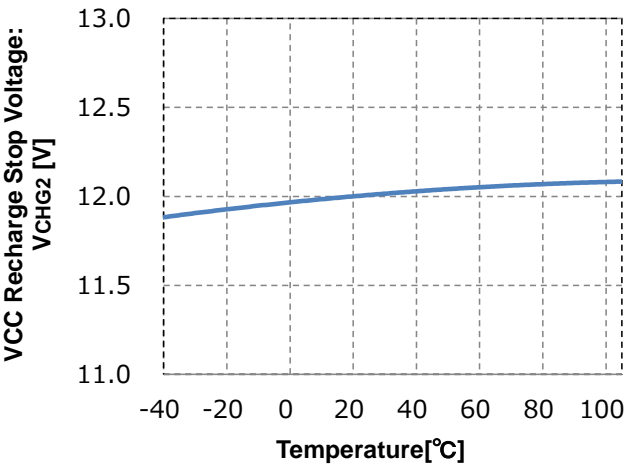


Figure 25. VCC Recharge Stop Voltage vs Temperature

Typical Performance Curves – continued

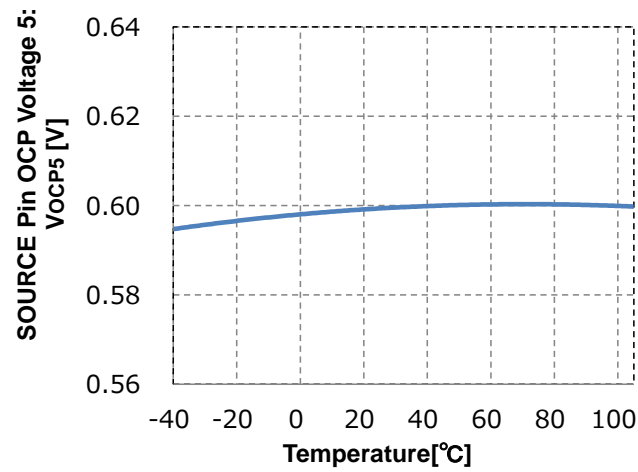


Figure 26. SOURCE Pin OCP Voltage 5 vs Temperature

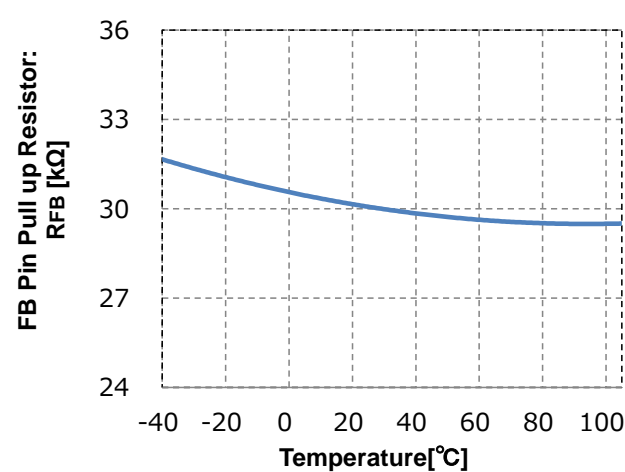


Figure 27. FB Pin Pull up Resistor vs Temperature

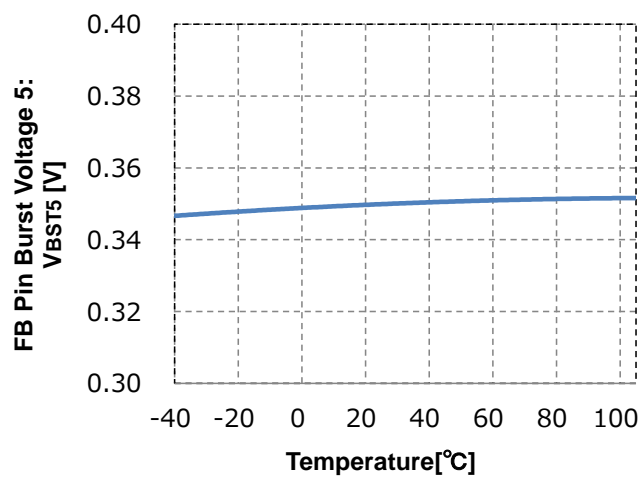


Figure 28. FB Pin Burst Voltage 5 vs Temperature

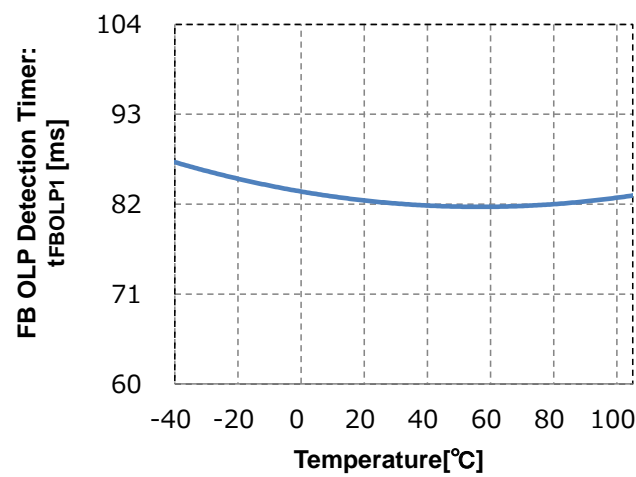
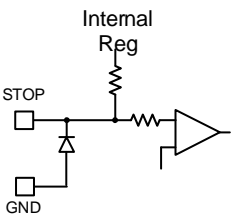
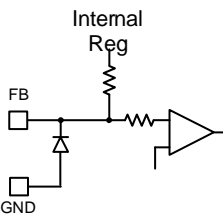
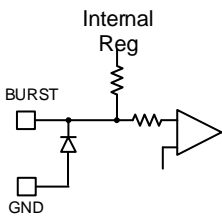
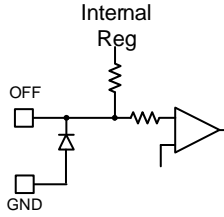
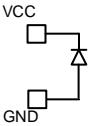
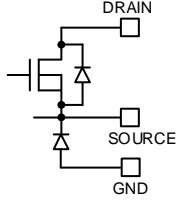
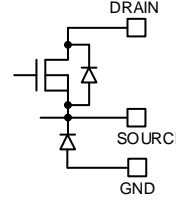
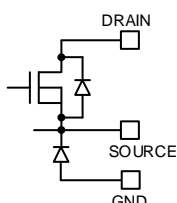
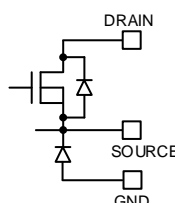
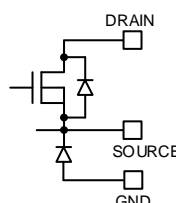
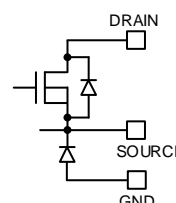
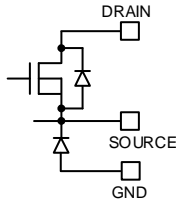
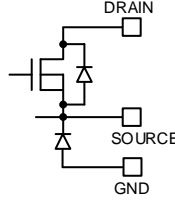
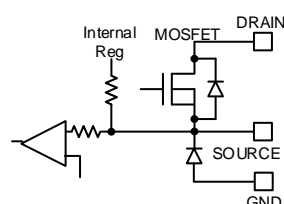
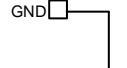
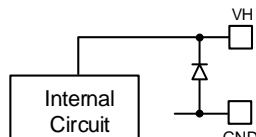


Figure 29. FB OLP Detection Timer vs Temperature

I/O Equivalence Circuit

1	STOP	2	FB	3	BURST	4	OFF
							
5	VCC	6	N.C.	7	DRAIN	8	DRAIN
		-					
9	DRAIN	10	DRAIN	11	DRAIN	12	DRAIN
							
13	DRAIN	14	DRAIN	15	N.C.	16	SOURCE
				-			
17	N.C.	18	GND	19	N.C.	20	VH
-				-			

(Note) The N.C. pin must be open on the board. It means not to connect GND etc.

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.

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.

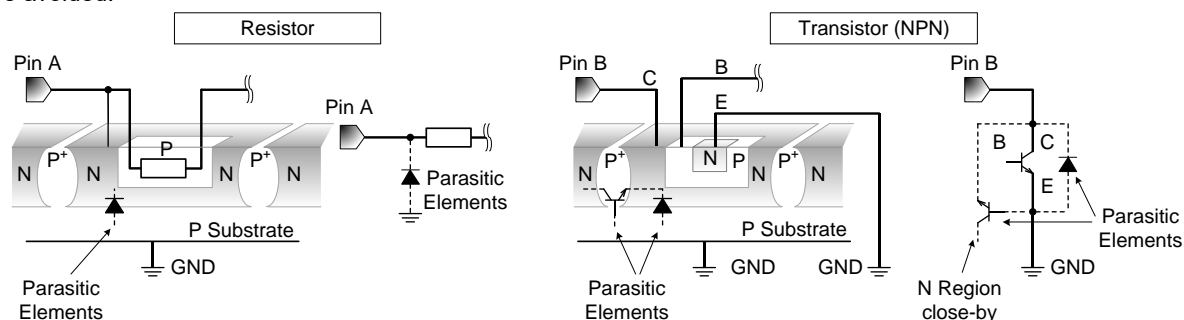


Figure 30. Example of IC Structure

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)

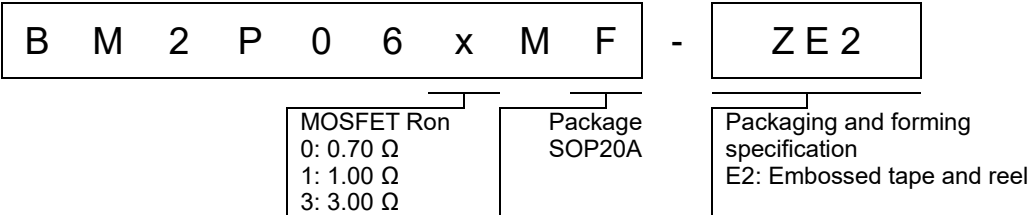
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (T_j) will rise which will activate the TSD circuit that will turn OFF power output pins. When the T_j 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.

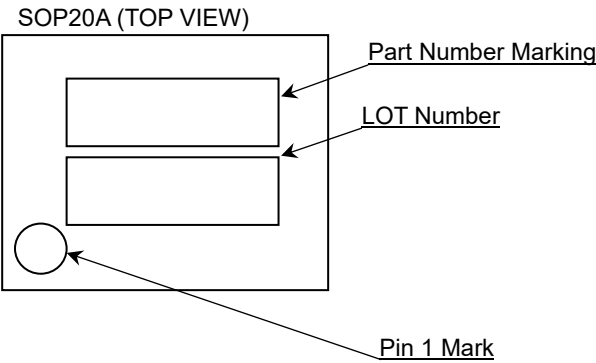
Ordering Information



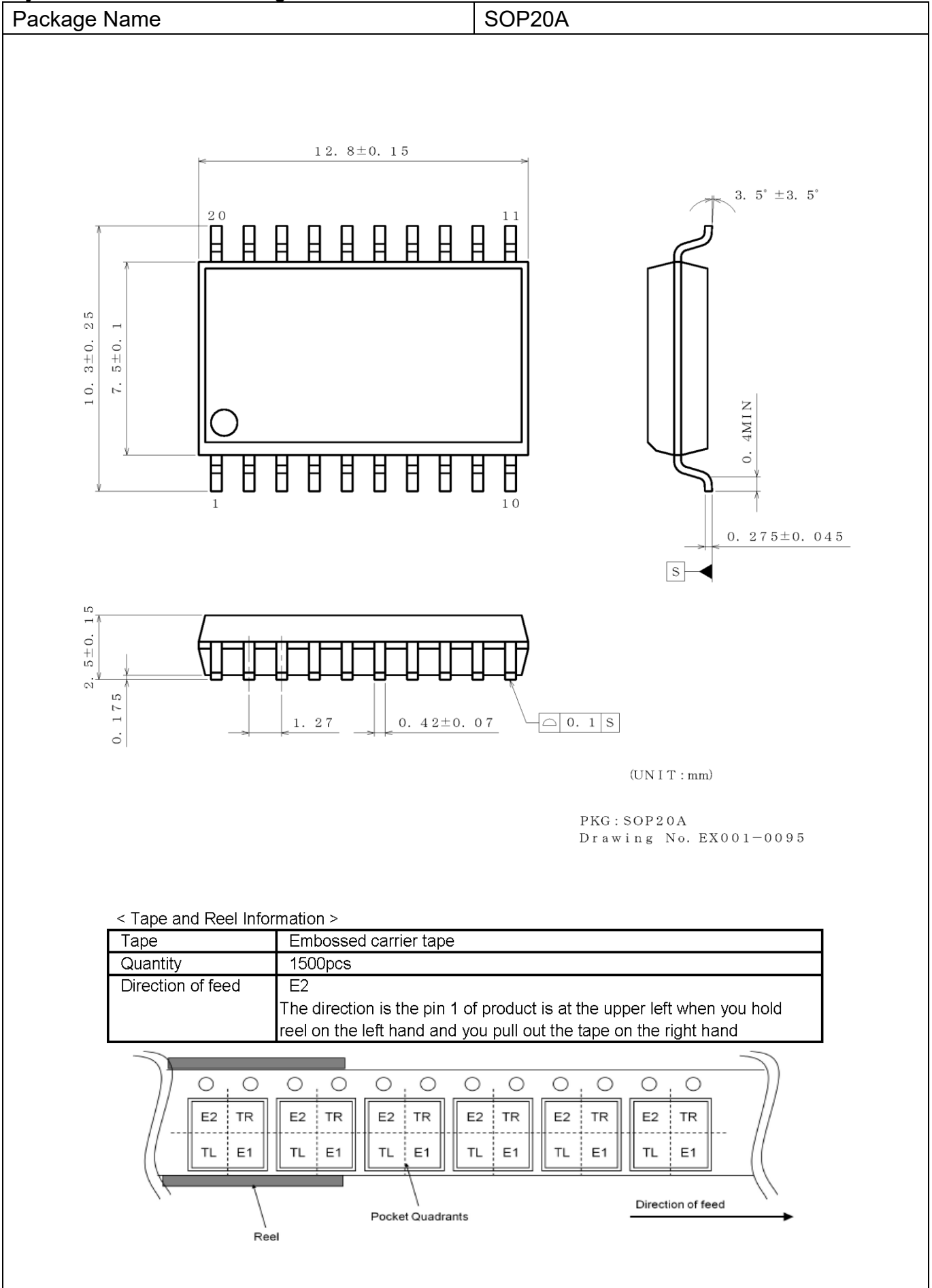
Lineup

Part Number Marking	MOSFET Ron	Package	Orderable Part Number
BM2P060MF	0.70 Ω	SOP20A	BM2P060MF-ZE2
BM2P061MF	1.00 Ω		BM2P061MF-ZE2
BM2P063MF	3.00 Ω		BM2P063MF-ZE2

Marking Diagram



Physical Dimension and Packing Information



Revision History

Date	Revision	Changes
21.Apr.2021	001	New Release

Notice

Precaution on using ROHM Products

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

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASS III	CLASS III	CLASS II b	CLASS III
CLASS IV		CLASS III	

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
 - Installation of protection circuits or other protective devices to improve system safety
 - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
 - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
 - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
 - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - Sealing or coating our Products with resin or other coating materials
 - Use of our Products without cleaning residue of flux (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
 - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- 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.
- 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.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

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

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
 - [a] the Products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [b] the temperature or humidity exceeds those recommended by ROHM
 - [c] the Products are exposed to direct sunshine or condensation
 - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

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

Precaution for Disposition

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

Precaution for Foreign Exchange and Foreign Trade act

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

Precaution Regarding Intellectual Property Rights

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General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
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