AC/DC Convertor IC

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

BM2P139T2F

General Description

The PWM type DC/DC converter for AC/DC, this IC provides an optimum system for all products that include an electrical outlet. It enables simpler design of a high effective converter specializing in non-isolated devices. This IC has a built-in starter circuit that tolerates 650 V, and it contributes to low power consumption. With a current detection resistor as internal device, it can be designed as small power supply. Since current mode control is utilized, current is restricted in each cycle and excellent performance is demonstrated in bandwidth and transient response. The oscillation frequency is fixed to 100 kHz. A frequency hopping function is also on chip, and it contributes to low EMI. In addition, a built-in super junction MOSFET which tolerates 650 V makes the design easy.

Features

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

Key Specifications

- Power Supply Voltage Range
  VCC Voltage (The VCC Pin - The GND_IC Pin): 10.60 V to 14.05 V
  DRAIN Pin Voltage: 650 V (Max)
- Pulse Operation Current: 0.50 mA (Typ)
- Burst Operation Current: 0.25 mA (Typ)
- Oscillation Frequency: 100 kHz (Typ)
- Operating Temperature Range: -40 °C to +105 °C
- MOSFET ON Resistor: 9.5 Ω (Typ)

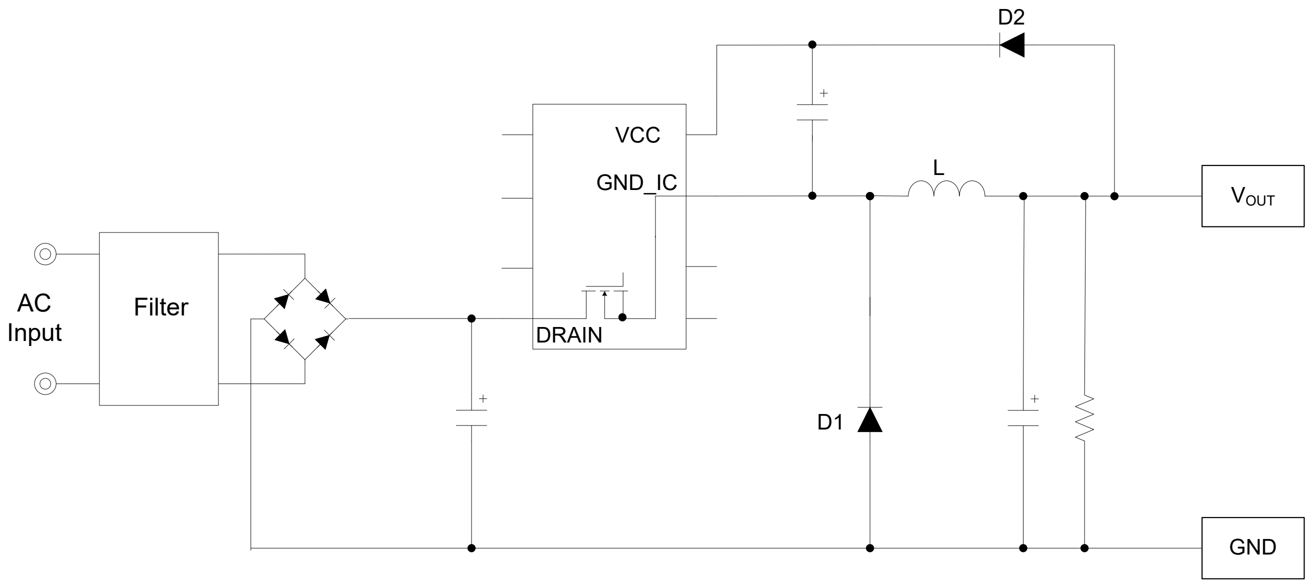
Package

Package	W (Typ) x D (Typ) x H (Max)
SOP8	5.0 mm x 6.2 mm x 1.71 mm

Applications

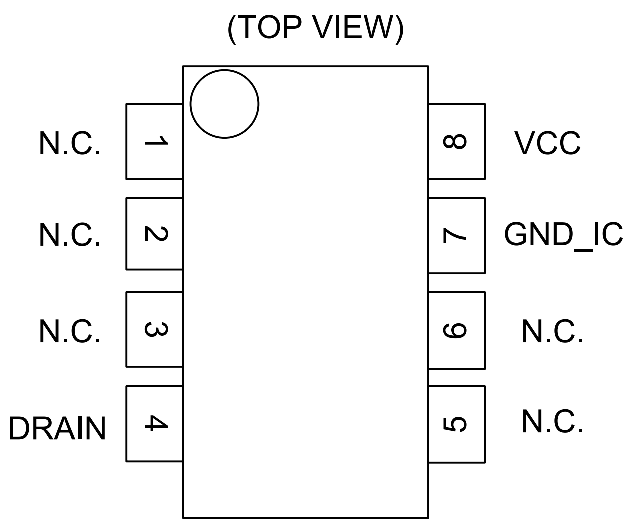
- LED Lights, Air Conditioners, Cleaners

Typical Application Circuit



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

Pin Configuration

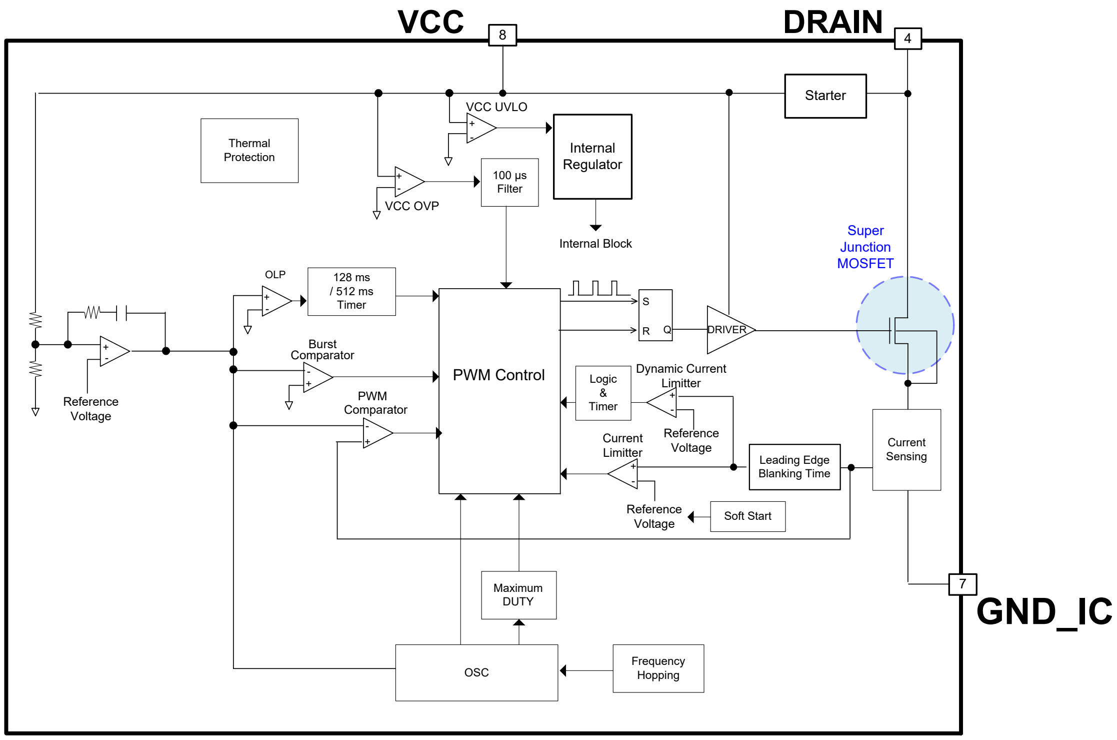


Pin Description

Pin No.	Pin Name	I/O	Function	ESD Diode	
				VCC	GND_IC
1	N.C.	-	Non Connection*(Note 1)*	-	-
2	N.C.	-	Non Connection*(Note 1)*	-	-
3	N.C.	-	Non Connection*(Note 1)*	-	-
4	DRAIN	I/O	MOSFET DRAIN pin	-	○
5	N.C.	-	Non Connection*(Note 1)*	-	-
6	N.C.	-	Non Connection*(Note 1)*	-	-
7	GND_IC	I/O	GND pin	○	-
8	VCC	I	Power Supply pin	-	○

(Note 1) N.C. pins should be mounted on the board considering the insulation distance.

Block Diagram



Description of Blocks

1 Buck Converter
This IC is exclusively for non-isolated type buck converter.

<Basic operation of buck converter>

1.1 When the MOSFET for Switching is ON
When the MOSFET turns on, current I_L flows to coil L and energy is stored. At this moment, the voltage of the GND_IC pin becomes the voltage near the DRAIN pin voltage, and the diode D1 is off.

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

where:

V_{IN} is the DRAIN pin voltage
V_{OUT} is the output voltage
I_L is the inductor current
t_{ON} is ON time of MOSFET

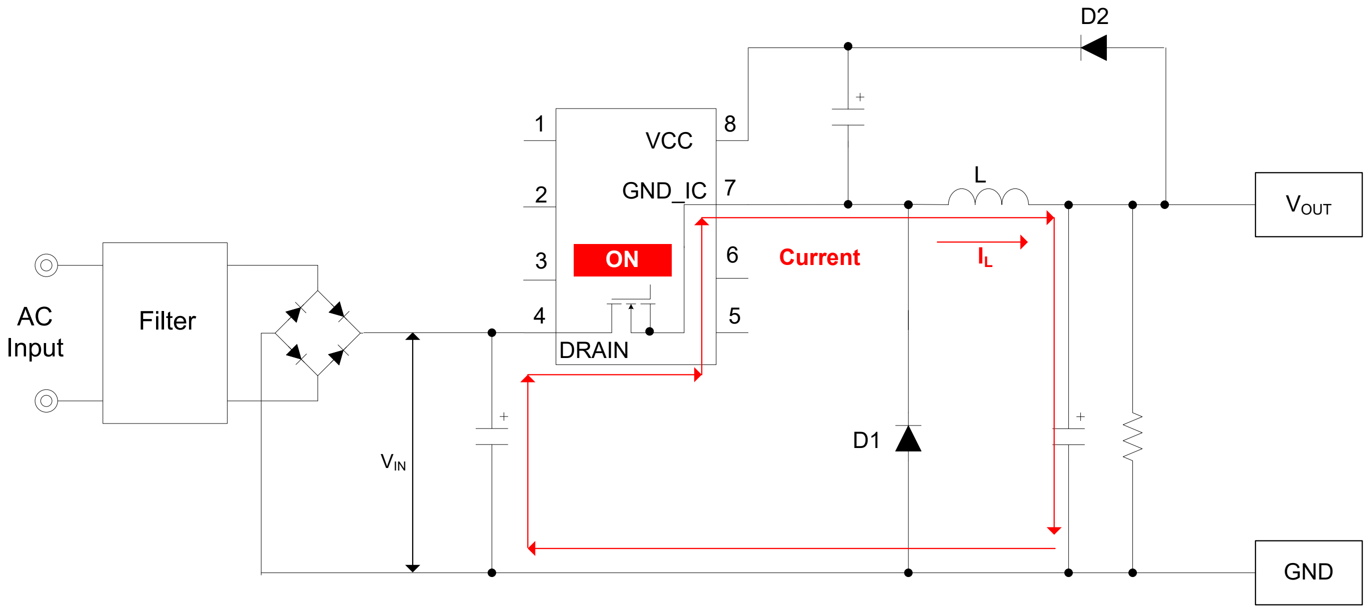


Figure 1. Buck Converter Operation (MOSFET = ON)

1 Buck Converter – continued

1.2 When the MOSFET for Switching is OFF

When the MOSFET turns off, the energy stored in coil is output via diode. At the moment, the MOSFET is OFF.

$$I_L = \frac{V_{OUT}}{L} \times t_{OFF}$$

where:
V_{OUT} is the output voltage
I_L is the inductor current
t_{OFF} is OFF time of MOSFET

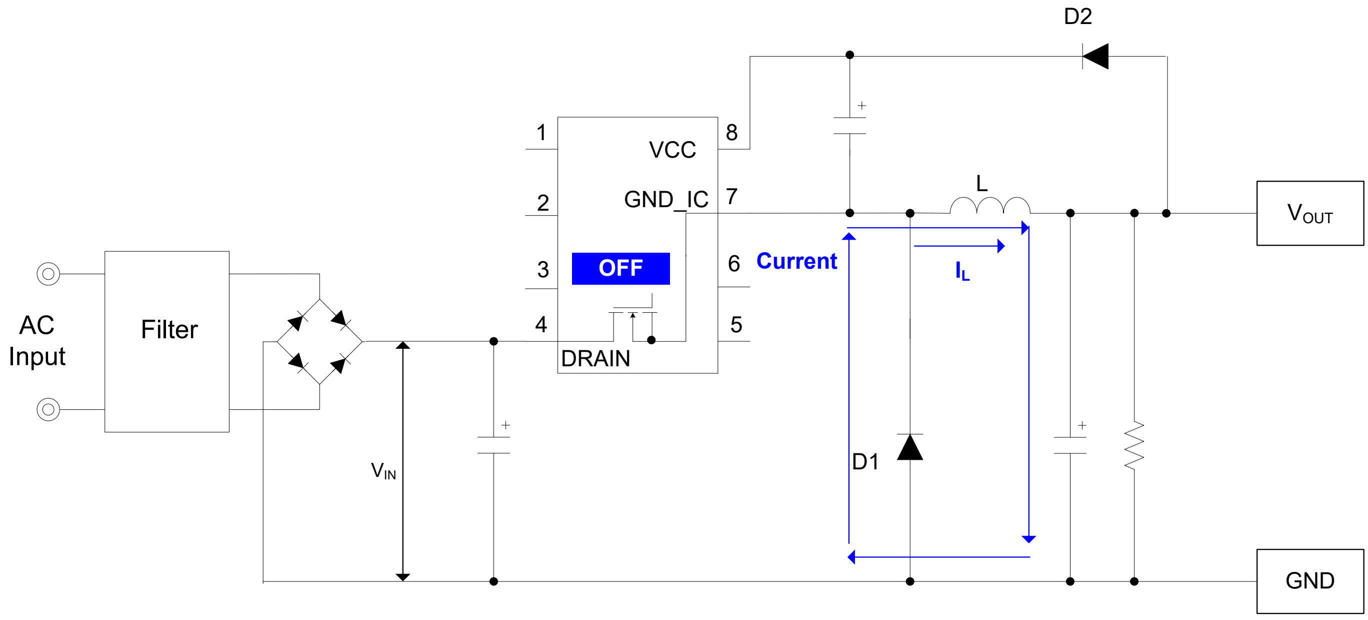


Figure 2. Buck Converter Operation (MOSFET = OFF)

Description of Blocks – continued

2 Start Sequences

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

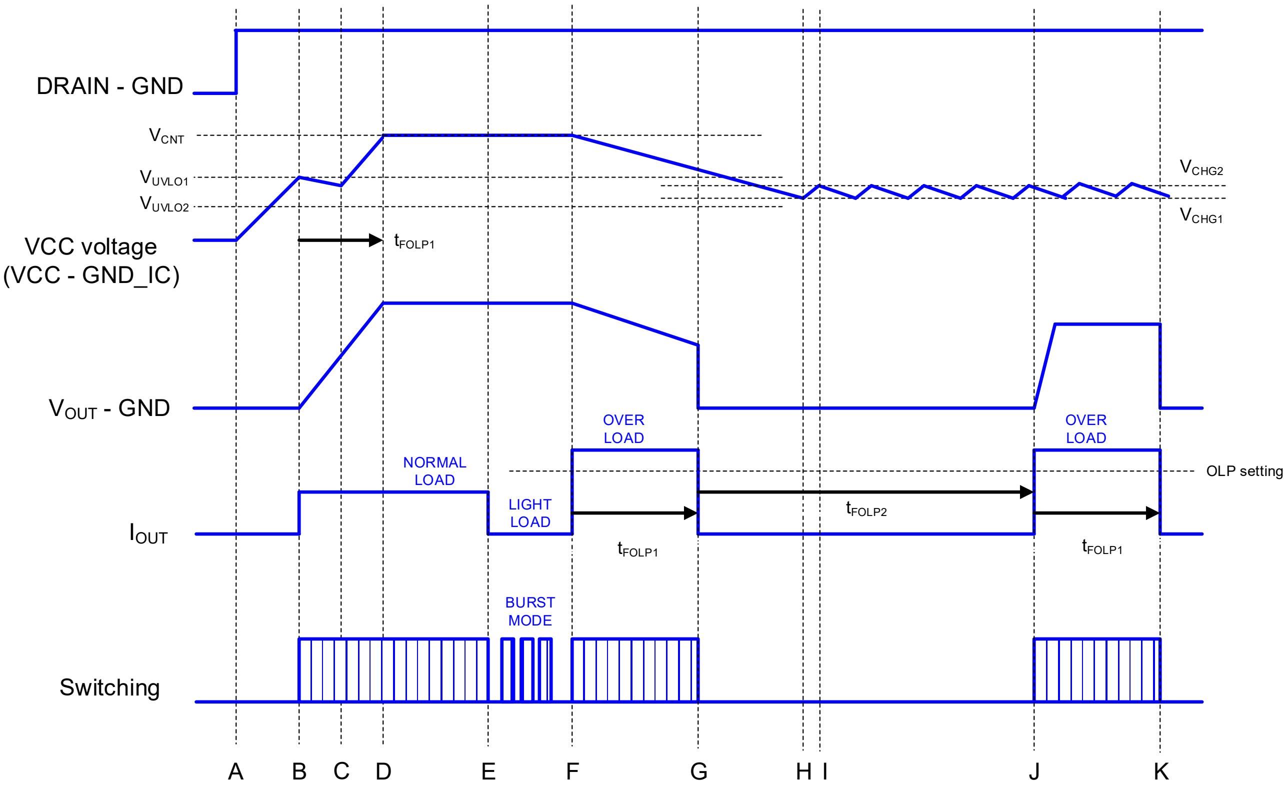


Figure 3. Start Sequences Timing Chart

A: Input voltage is applied to the DRAIN pin and the VCC voltage rises.
B: If the VCC voltage becomes more than V_{UVLO1}, the IC starts to operate. And if the IC judges the other protection functions as normal condition, it starts switching operation.
The soft start function limits the over current limiter current to prevent any excessive voltage or current rising.
When the switching operation starts, the V_{OUT} rises.
C: Until the V_{OUT} becomes constant value from startup, the VCC voltage drops by the VCC pin consumption current.
D: After switching starts, it is necessary that the output voltage is set to rating voltage within t_{FOLP1}.
E: At light load, the IC starts burst operation to restrict the consumption power.
F: When the load exceeds a certain electric power, the IC starts over load operation.
G: If the setting over load status lasts for t_{FOLP1}, switching is turned off.
H: When the VCC voltage becomes less than V_{CHG1}, recharge operation is started.
I: When the VCC voltage becomes more than V_{CHG2}, recharge operation is stopped.
J: After t_{FOLP2}, the over load protection circuit starts switching.
K: Same as G.

(Note) VCC voltage means the voltage between the VCC pin and the GND_IC pin

Description of Blocks – continued

3 Stop Sequences

Stop sequences are shown in Figure 4.

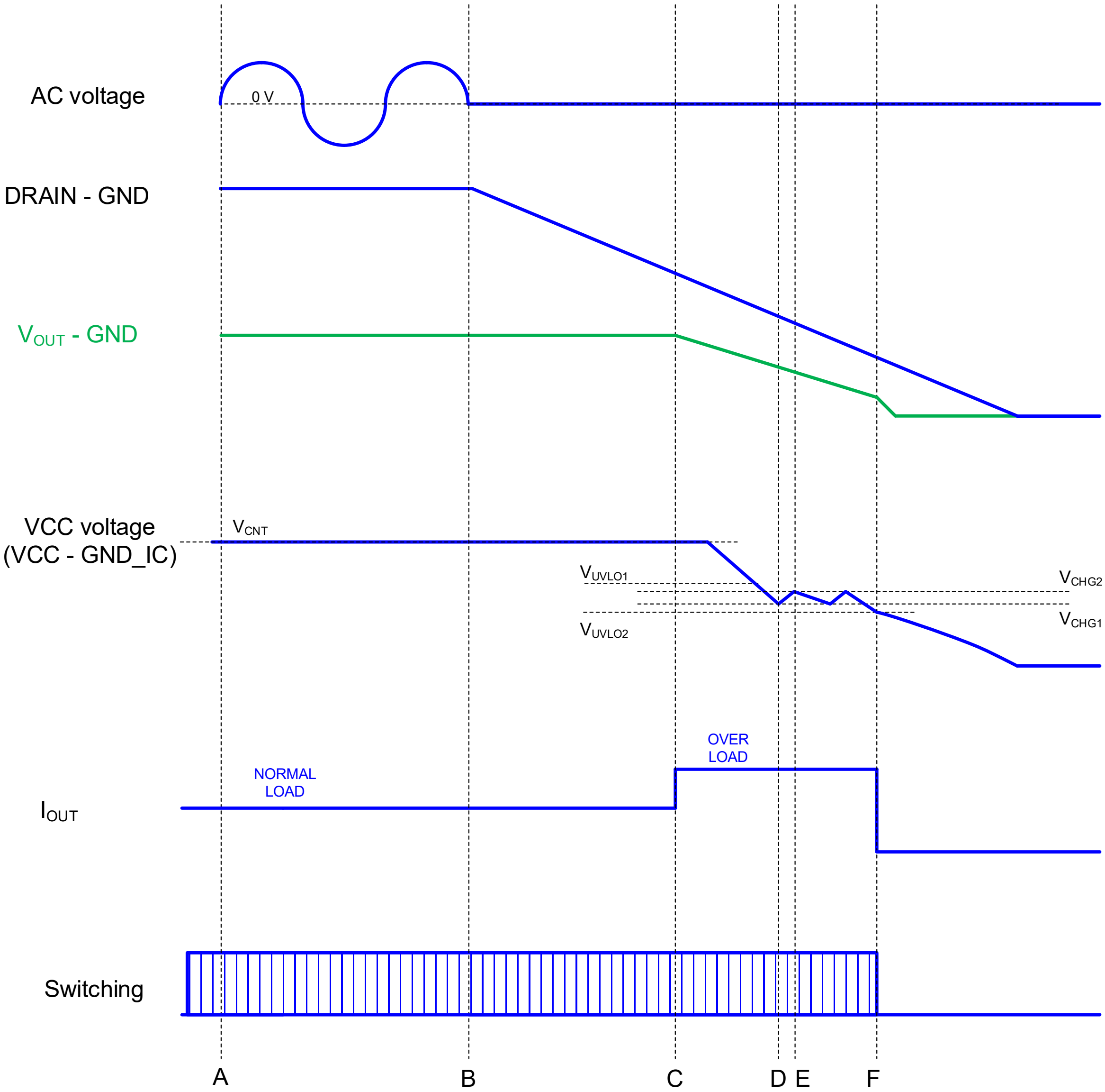


Figure 4. Stop Sequences Timing Chart

A: Normal operation
B: The input AC voltage is stopped. The DRAIN pin voltage starts to drop.
C: If the DRAIN pin voltage drops below a certain voltage, it becomes maximum DUTY and over load protection operates.
D: If the output voltage drops, the VCC voltage drops too. And recharge operation is started.
E: The recharge operation is stopped.
F: If the DRAIN pin voltage drops below a certain voltage, the VCC voltage less than V_{UVLO2} in order to stop recharge operation and switching stops.

(Note) VCC voltage means the voltage between the VCC pin and the GND_IC pin

Description of Blocks – continued

4 Start Circuit

This IC enables low standby electric power and high-speed startup because it has a built-in start circuit.
The consumption current after startup is only idling current I_{START3}. The startup current flows from the DRAIN pin.

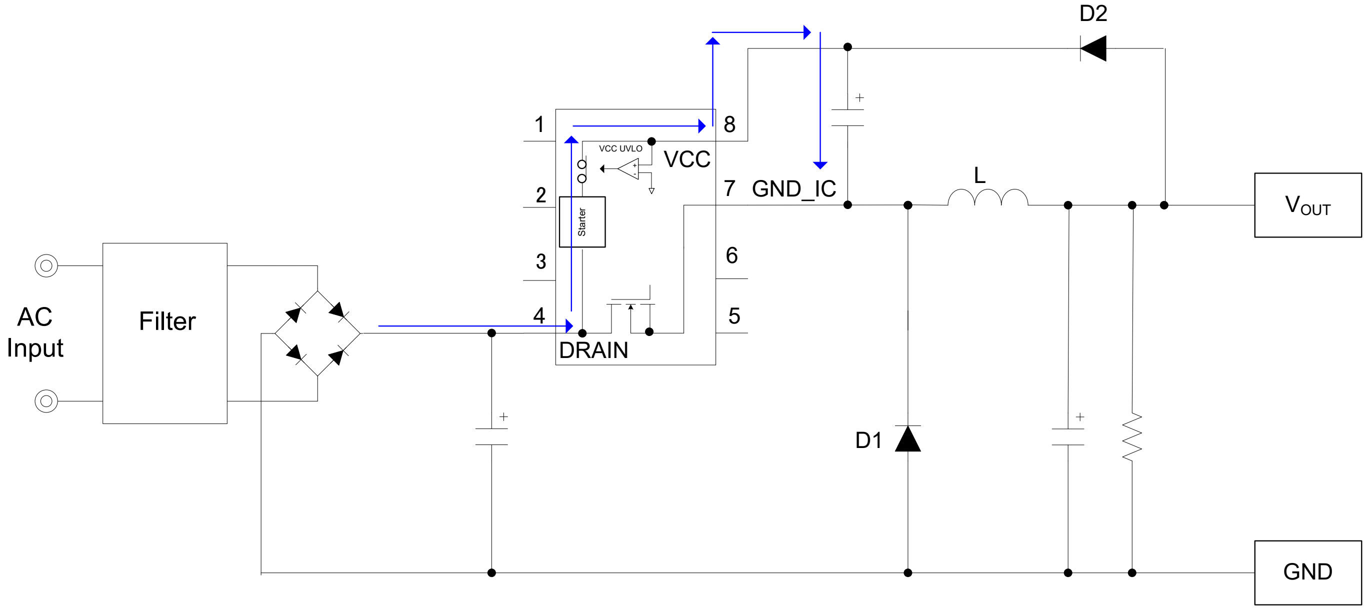


Figure 5. Start Circuit

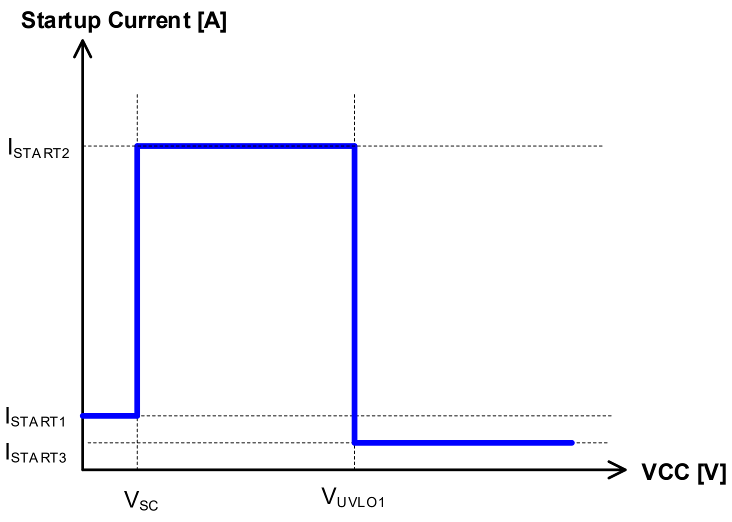


Figure 6. Startup Current vs VCC Voltage

Description of Blocks – continued

5 The VCC Pin Protection Function

This IC has the internal protection function at the VCC pin shown in below.

1) Under voltage lockout function (VCC UVLO).
2) Over voltage protection function (VCC OVP).
3) VCC recharge function.

5.1 VCC UVLO / VCC OVP Function

VCC UVLO and VCC OVP are auto recovery type comparators that have voltage hysteresis. VCC UVLO is released by VCC voltage more than V_{UVLO1}. The detection condition is VCC voltage less than V_{UVLO2}. VCC OVP has an internal mask time. If the condition that the VCC voltage is more than V_{OVP1} lasts for t_{COMP}, it performs detection. The recovery requirements are that the VCC voltage is less than V_{OVP2}.

(Note) VCC voltage means the voltage between the VCC pin and the GND_IC pin

5.2 VCC Recharge Function

If the VCC voltage drops to V_{CHG1} after once the VCC voltage becomes more than V_{UVLO1} and the IC starts to operate, the VCC recharge function operates. At that time, the VCC voltage is charged from the DRAIN pin voltage through start circuit. When the VCC voltage is more than V_{CHG2}, charge is stopped.

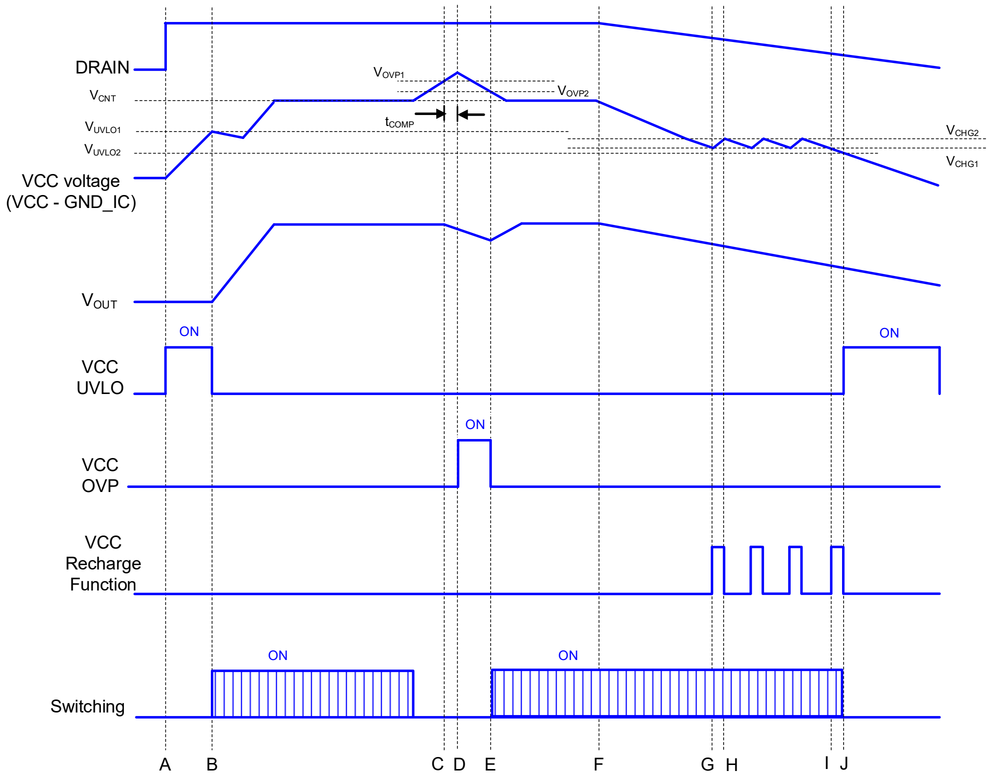


Figure 7. VCC UVLO / VCC OVP / VCC Recharge Function Timing Chart

A: Input voltage is applied to the DRAIN pin voltage and the VCC voltage rises.
B: When the VCC voltage becomes more than V_{UVLO1}, the IC starts operating. And if the IC judges the other protection functions as normal condition, it starts switching operation. The soft start function limits the over current limiter value to prevent any excessive voltage or current rising. When the switching operation starts, the V_{OUT} rises. When the VCC voltage becomes more than V_{CNT}, the IC stops switching.
C: When the VCC voltage becomes more than V_{OVP1}, VCC OVP timer operates.
D: When the condition that the VCC voltage is more than V_{OVP1} lasts for t_{COMP}, the IC detects VCC OVP.
E: When the VCC voltage becomes less than V_{OVP2}, VCC OVP is released.
F: When the input power supply is turned off, the DRAIN pin voltage drops.
G: When the VCC voltage becomes less than V_{CHG1}, recharge function is started.
H: When the VCC voltage becomes more than V_{CHG2}, recharge function is stopped.
I: When the VCC voltage becomes less than V_{CHG1}, recharge function is started. However, the supply to the VCC voltage decrease and the VCC voltage drops because of low the DRAIN pin voltage.
J: When the VCC voltage becomes less than V_{UVLO2}, VCC UVLO function starts operating.

(Note) VCC voltage means the voltage between the VCC pin and the GND_IC pin

Description of Blocks – continued

6 DC/DC Driver

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

6.1 Setting of the Output Voltage

Adopting the non-isolated type without photo coupler, the VCC voltage should be set to rating value. The VCC voltage means the voltage between the VCC pin and the GND_IC pin. The output voltage V_{OUT} is defined by the formula below. The voltage when the MOSFET is OFF is shown in Figure 8.

$$V_{OUT} = V_{CNT} + V_{FD2} - V_{FD1}$$

where:
V_{FD1} is the forward voltage of diode D1.
V_{FD2} is the forward voltage of diode D2.
V_{CNT} is the VCC control voltage

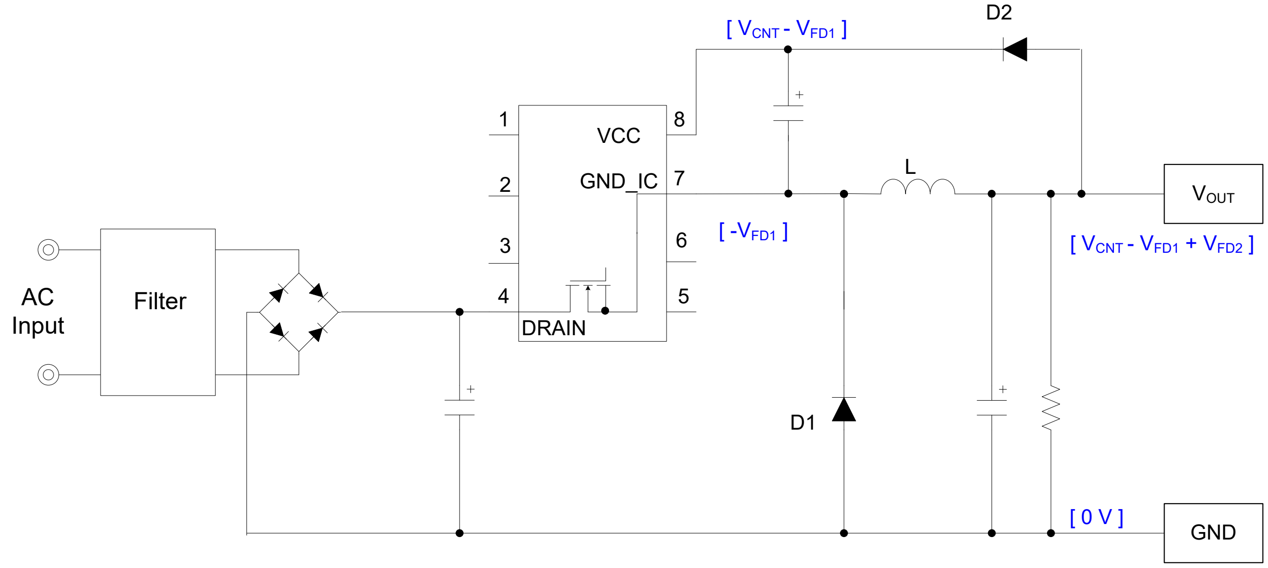


Figure 8. Buck Converter Circuit (MOSFET = OFF)

At light load, the output voltage may rise because the VCC voltage is difference from the output voltage. Insert a resistor R_1 to V_{OUT} to prevent it from being completely unloaded. The circuit diagram is shown in Figure 9.

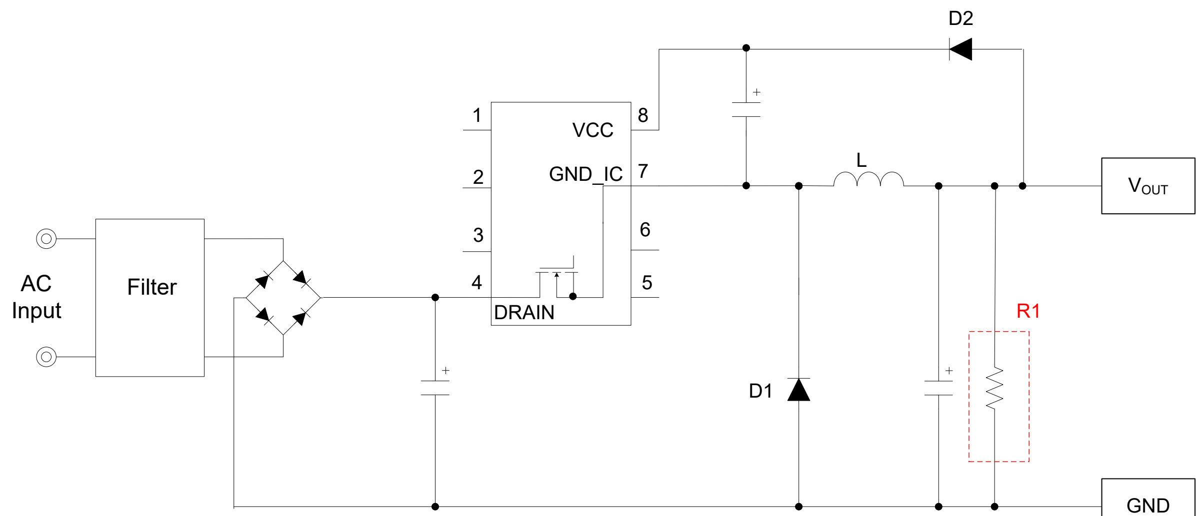


Figure 9. Circuit to Take Measure against Voltage Rising at Light Load

6.1 Setting of the Output Voltage – continued

This IC has a few external parts by fixing the VCC voltage and it enables simpler design. If you adjust the output voltage, it can become the output voltage variable by adding zener diodes. However, it is necessary to consider the dispersion of the diodes. The output voltage V_{OUT} is defined by the formula below.
The voltage when the MOSFET is OFF is shown in Figure 10.

$$V_{OUT} = V_{CNT} + V_{FD2} - V_{FD1} + V_{ZD1}$$

where:
V_{FD1} is the forward voltage of diode D1.
V_{FD2} is the forward voltage of diode D2.
V_{ZD1} is the zener diode ZD1 voltage.
V_{CNT} is the VCC control voltage

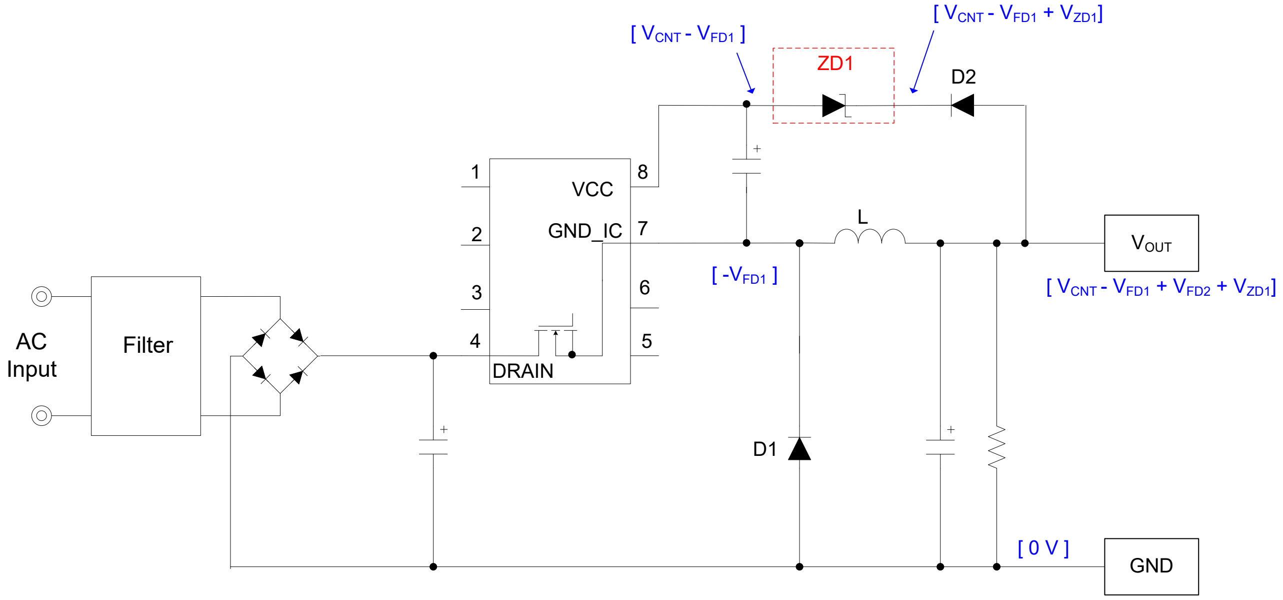


Figure 10. Buck Converter Output Variable Circuit (MOSFET = OFF)

6.2 Frequency Circuit

mode1: burst operation
mode2: fixed frequency operation
mode3: over load operation (pulse operation is stopped.)

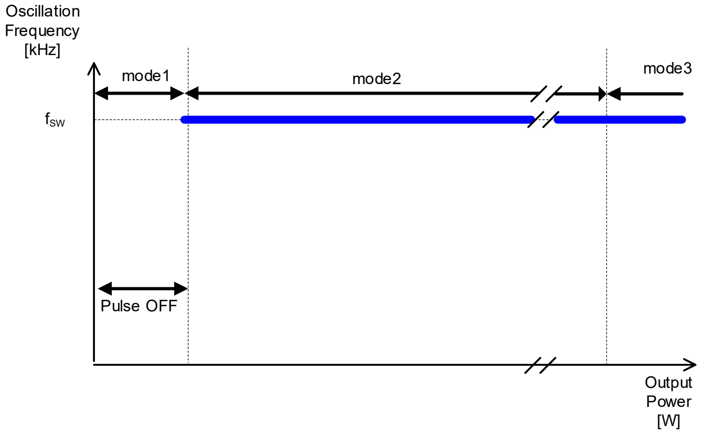


Figure 11. State Transition of Oscillation Frequency

6.3 Frequency Hopping Function

Frequency hopping function achieves low EMI by change the frequency at random. The wave width of frequency's upper limit is ±6 % for basic frequency.

6 DC/DC Driver – continued

6.4 PWM Error AMP and PWM Comparator

The internal Error AMP achieves the reduction of external parts. In addition, this IC adopts current mode method. It makes the design easy.

6.5 Over Current Limiter Function

This IC has an internal over current limiter function per switching cycle. This function monitors the coil current and if it exceeds a certain current, the IC stops switching. Additionally, an internal current detection resistor contributes to reduction of parts and improvement of efficiency. The peak current by which the IC switches to the over load mode is determined by the formula below.

$$Peak\ current = I_{PEAK} + \frac{(V_{DRAIN} - V_{OUT})}{L} \times t_{delay}$$

where:
I_{PEAK} is the over current limiter internal the IC.
V_{DRAIN} is the DRAIN voltage.
V_{OUT} is the output voltage.
L is the coil value.
t_{delay} is the delay time after detection of over current limiter.

6.6 Dynamic Over Current Limiter Function

This IC has a built-in dynamic over current limiter function. In case that coil current exceeds I_{DPEAK} two times consecutively, it stops pulse operation for t_{DPEAK}.

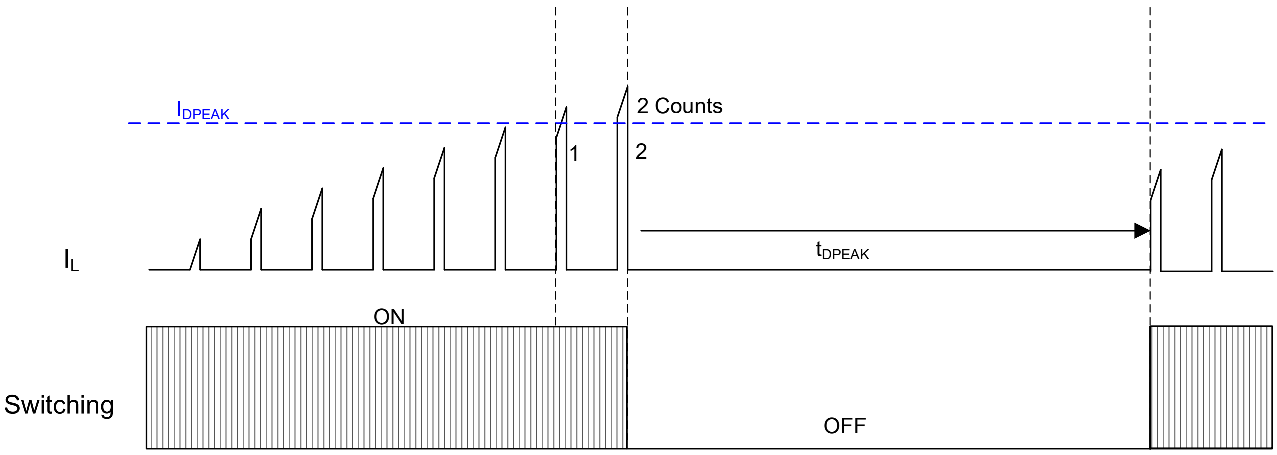


Figure 12. Dynamic Over Current Limiter

6 DC/DC Driver – continued

6.7 Soft Start Operation

At startup, this function controls the over current limiter value in order to prevent any excessive voltage or current rising. The details are shown in Figure 13. The IC enables the soft start operation by changing the over current limiter value with time.

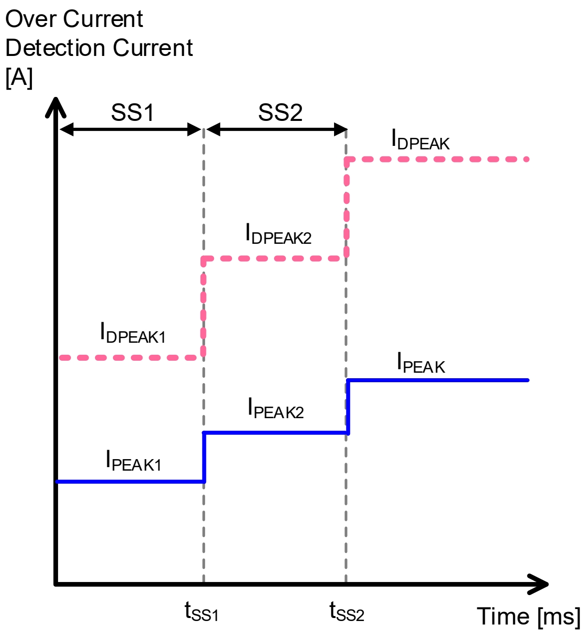


Figure 13. Soft Start Operation

7 Output Over Load Protection Function (OLP)

Output over load protection function monitors load status and stops switching at over load. In the over load condition, the output voltage lowers. If a state is electric power set in the IC or more continues for t_{FOLP1}, the IC stops switching by judging the status as over load. The recovery after detection of OLP is t_{FOLP2} later.

8 Temperature Protection Circuit

Temperature protection circuit stops the oscillation of DC/DC if the IC becomes T_{SD1} or more.

9 Leading Edge Blanking Times

Surge current is generated by capacitive components, drive current, etc. when MOSFET for driving turns on. At this time, the GND_IC pin voltage rises temporarily, which may cause the over current detection circuit to detect incorrectly. To prevent false positives, the leading edge blanking function is built-in. This function masks the GND_IC pin voltage for 250 ns after the DRAIN pin switches from H to L built-in.

Description of Blocks – continued

10 Operation Mode of Protection Circuits

The operation mode of protection functions is shown in Table 1.

Table 1. The Operation Mode of Protection Functions

Function	VCC Pin Under Voltage Lockout Protection	VCC Pin Over Voltage Protection	Over Temperature Protection	Output Over Load Protection	Dynamic Over Current Protection
Detection	V_{UVLO2} (at falling voltage)	V_{OVP1} (at rising voltage)	T_{SD1} (at rising temperature)	The current detected by over current sense current or more	The current detected by dynamic over current detection or more
Release	V_{UVLO1} (at rising voltage)	V_{OVP2} (at falling voltage)	T_{SD2} (at falling temperature)	Less than the current detected by over current sense current	After t_{DPEAK}
Detection Timer	-	100 µs	100 µs	128 ms	2 pulse when continuous detection
Release Timer	-	-	-	512 ms	128 µs
Type	Auto Recovery	Auto Recovery	Auto Recovery	Auto Recovery	Auto Recovery

Description of Blocks – continued

11 External Components

Each part should be designed considering input voltage condition and output load condition.
Figure 14 shows application circuit.

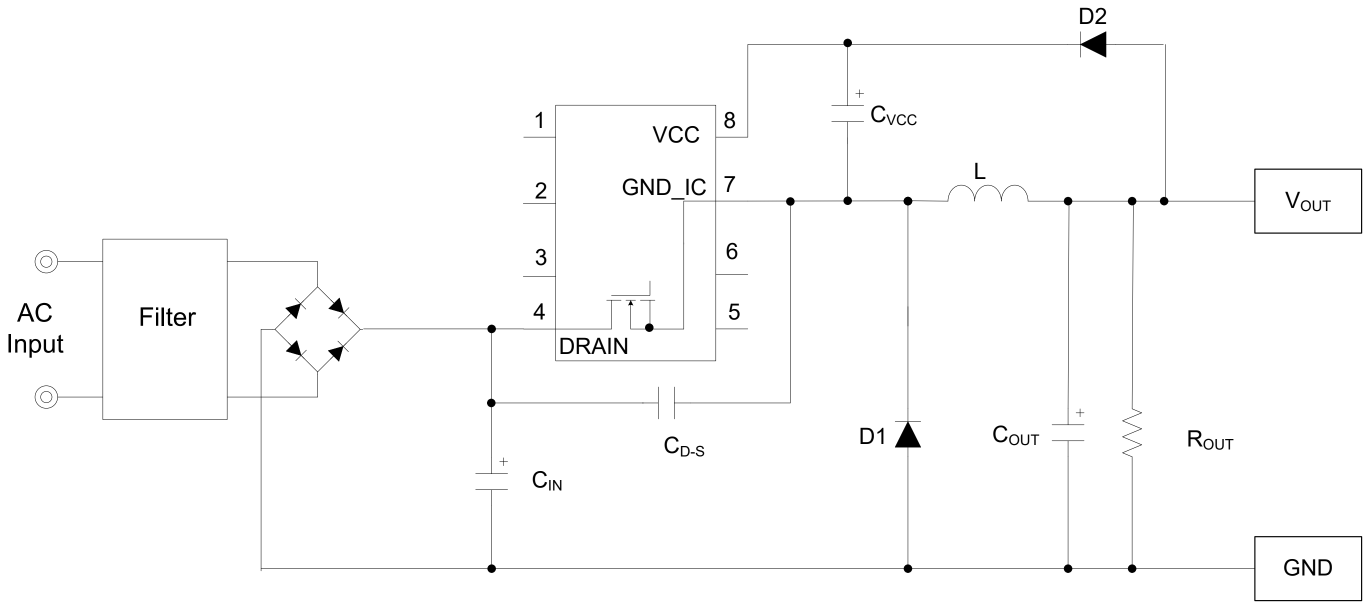


Figure 14. Application Circuit

11.1 Output Capacitor C_{OUT}

Output capacitor C_{OUT} should be designed considering the spec of output ripple voltage and start up time within t_{FOLP1}. It is recommended to be 100 µF or more.

11.2 Inductor L

The value of inductor should be designed considering the spec of output voltage and input voltage.
If inductor value is too large, the operation becomes continuous mode and increases heat. If inductor value is too small, it is impossible that the IC controls in the minimum ON width t_{MINON} or less, so there is a possibility of over current detection at normal operation load. It is recommended to be 270 µH to 680 µH.
At this time, maximum power is from 2.2 W to 5.0 W.

11.3 VCC Pin Capacitor C_{VCC}

The VCC pin capacitor C_{VCC} adjusts start up time and response of output voltage.
Set it to about 1/100 or less value of C_{OUT} as a guide.

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit	Conditions
Maximum Applied Voltage 1	V_{MAX1}	-0.3 to +650	V	DRAIN
Maximum Applied Voltage 2	V_{MAX2}	-0.3 to +32.0	V	VCC *(Note 3)*
DRAIN Pin Current (Pulse)	I_{DD}	1.30	A	Consecutive operation
Power Dissipation	Pd	0.56	W	*(Note 4)*
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 3) VCC voltage means the voltage between the VCC pin and the GND_IC pin

(Note 4) Derate by 4.563 mW/°C when operating Ta = 25 °C or more when mounted on (70 mm x 70 mm x 1.6 mm thick, glass epoxy on single-layer substrate).

Thermal Resistance

The thermal design should set operation for the following conditions.

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

The thermal abatement characteristics are as follows.
(PCB: 70 mm x 70 mm x 1.6 mm single layer board, the back side is copper foil)

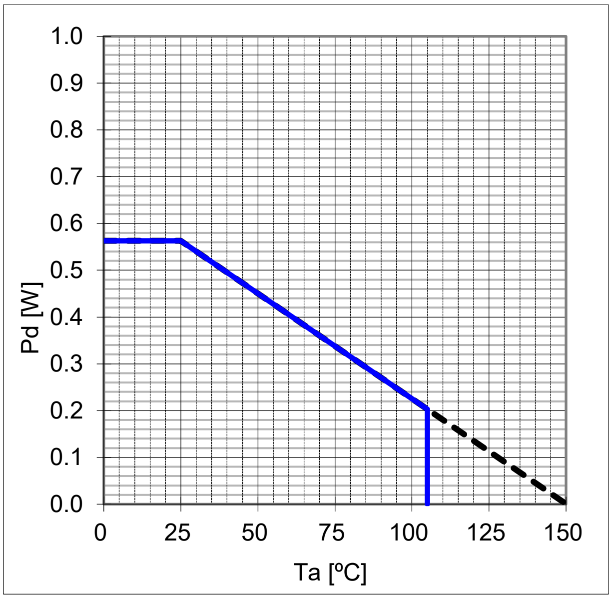


Figure 15. Thermal Abatement Characteristics

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Power Supply Voltage 1	V_{DRAIN}	-	-	650	V	DRAIN pin voltage
Power Supply Voltage 2	VCC	10.60	-	14.05	V	VCC voltage *(Note 3)*
Operating Temperature	Topr	-40	-	+105	°C	Surrounding temperature

(Note 3) VCC voltage means the voltage between the VCC pin and the GND_IC pin

Electrical Characteristics in MOSFET Part (Unless otherwise specified, Tj = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Voltage between DRAIN and SOURCE Pins	$V_{(BR)DDS}$	650	-	-	V	I_D = 1 mA, V_{GS} = 0 V
DRAIN Pin Leakage Current	I_{DSS}	-	0	100	µA	V_{DS} = 650 V, V_{GS} = 0 V
ON Resistor	$R_{DS(ON)}$	-	9.5	12.5	Ω	I_D = 0.25 A, V_{GS} = 10 V

Electrical Characteristics in Start Circuits Part (Unless otherwise specified, Tj = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Start Current 1	I_{START1}	0.15	0.30	0.60	mA	VCC = 0 V *(Note 3)*
Start Current 2	I_{START2}	1.2	3.0	6.0	mA	VCC = 7 V *(Note 3)*
OFF Current	I_{START3}	-	10	20	µA	After UVLO is released
Start Current Switching Voltage	V_{SC}	0.5	0.8	1.2	V	

(Note 3) VCC voltage means the voltage between the VCC pin and the GND_IC pin

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

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
[Circuit Current]						
Current at Switching Operation	I_{ON1}	-	500	900	μA	At pulse operation DRAIN = open(Note 6)
Current at Burst Operation	I_{ON2}	150	250	450	μA	At burst operation(Note 6)
[The VCC Pin Protection Function]						
VCC UVLO Voltage 1	V_{UVLO1}	10.2	11.1	12.0	V	VCC voltage rising
VCC UVLO Voltage 2	V_{UVLO2}	8.8	9.7	10.6	V	VCC voltage failing
VCC UVLO Hysteresis	V_{UVLO3}	-	1.4	-	V	$V_{UVLO3} = V_{UVLO1} - V_{UVLO2}$
VCC Recharge Start Voltage	V_{CHG1}	9.5	10.2	10.9	V	
VCC Recharge Stop Voltage	V_{CHG2}	9.9	10.6	11.3	V	
VCC Recharge Hysteresis	V_{CHG3}	-	0.4	-	V	
VCC Control Voltage	V_{CNT}	12.87	13.00	13.13	V	
VCC OVP Voltage 1	V_{OVP1}	14.05	14.95	15.85	V	VCC voltage rising
VCC OVP Voltage 2	V_{OVP2}	13.44	14.30	15.16	V	VCC voltage failing
VCC OVP Hysteresis	V_{OVP3}	-	0.65	-	V	
VCC OVP / TSD Timer	t_{COMP}	-	100	-	μs	
Over Temperature Protection 1	T_{SD1}	120	150	180	°C	Control IC part at temperature rising(Note 5)
Over Temperature Protection 2	T_{SD2}	-	85	-	°C	Control IC part at temperature failing(Note 5)
Over Temperature Protection Hysteresis	T_{SD3}	-	65	-	°C	(Note 5)
[PWM Type DC/DC Driver Block]						
Oscillation Frequency	f_{SW}	94	100	106	kHz	(Note 6)
Frequency Hopping Width	f_{DEL}	-	6.0	-	kHz	
Maximum DUTY	D_{MAX}	66	75	84	%	
FB OLP ON Detection Timer	t_{FOLP1}	80	128	176	ms	
FB OLP OFF Detection Timer	t_{FOLP2}	332	512	692	ms	
Soft Start Time 1	t_{SS1}	5.6	8.0	10.4	ms	
Soft Start Time 2	t_{SS2}	11.2	16.0	20.8	ms	
[Over Current Detection Block]						
Over Current Detection Current	I_{PEAK}	0.395	0.450	0.505	A	
Over Current Detection Current (SS1)	I_{PEAK1}	-	0.225	-	A	(Note 5)
Over Current Detection Current (SS2)	I_{PEAK2}	-	0.338	-	A	(Note 5)
Dynamic Over Current Detection Current	I_{DPEAK}	0.935	1.100	1.265	A	
Dynamic Over Current Detection Current (SS1)	I_{DPEAK1}	-	0.650	-	A	(Note 5)
Dynamic Over Current Detection Current (SS2)	I_{DPEAK2}	-	0.825	-	A	(Note 5)
Dynamic Over Current Enforced OFF Time	t_{DPEAK}	64	128	170	μs	
Leading Edge Blanking Time	t_{LEB}	-	150	-	ns	(Note 5)
Minimum ON Width	t_{MINON}	-	300	550	ns	(Note 5)

(Note 5) Not 100% tested.
(Note 6) Tj = 25 °C guaranteed.

Typical Performance Curves
(Reference Data)

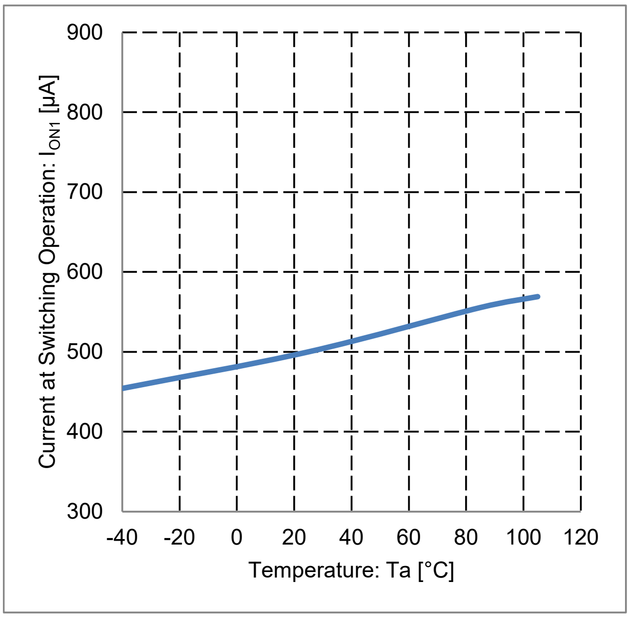


Figure 16. Current at Switching Operation vs Temperature

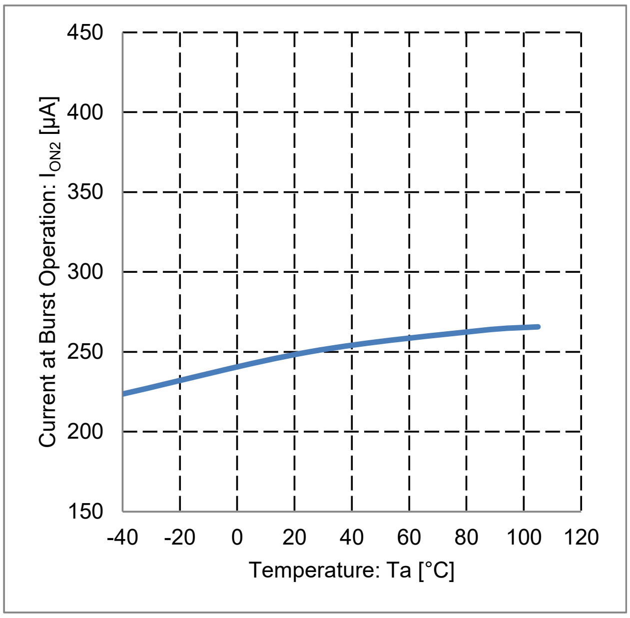


Figure 17. Current at Burst Operation vs Temperature

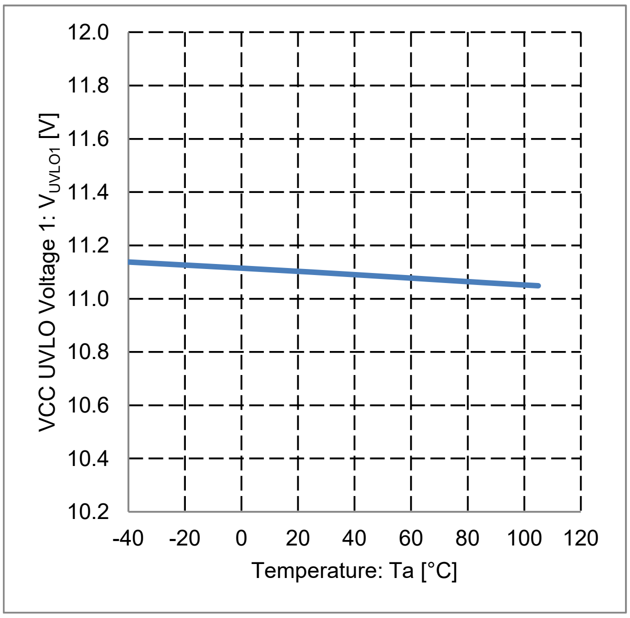


Figure 18. VCC UVLO Voltage 1 vs Temperature

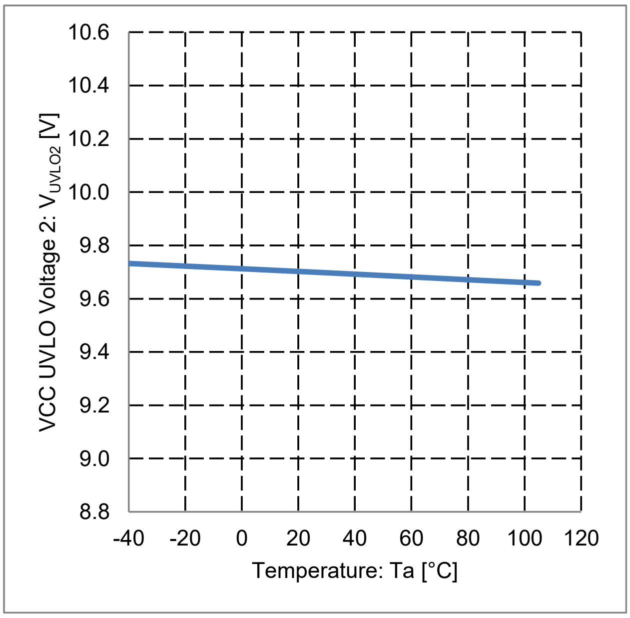


Figure 19. VCC UVLO Voltage 2 vs Temperature

Typical Performance Curves
(Reference Data) – continued

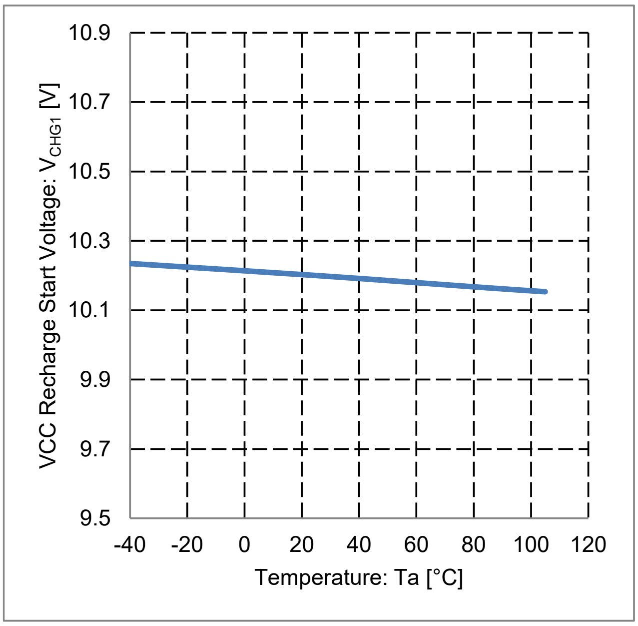


Figure 20. VCC Recharge Start Voltage vs Temperature

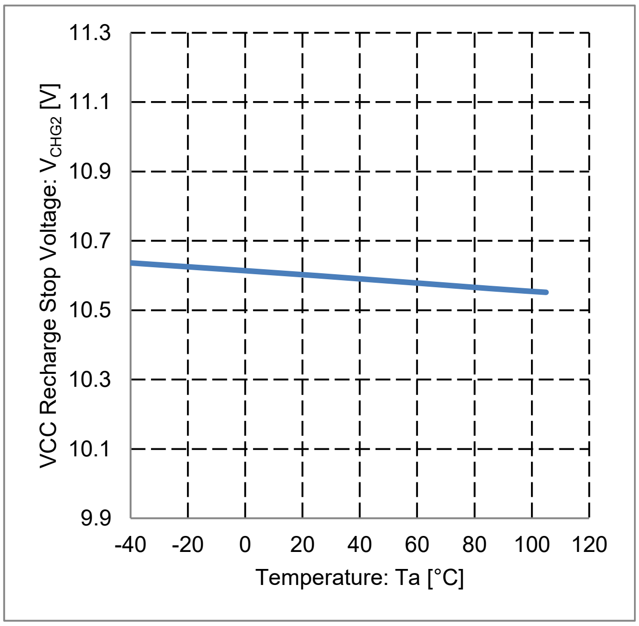


Figure 21. VCC Recharge Stop Voltage vs Temperature

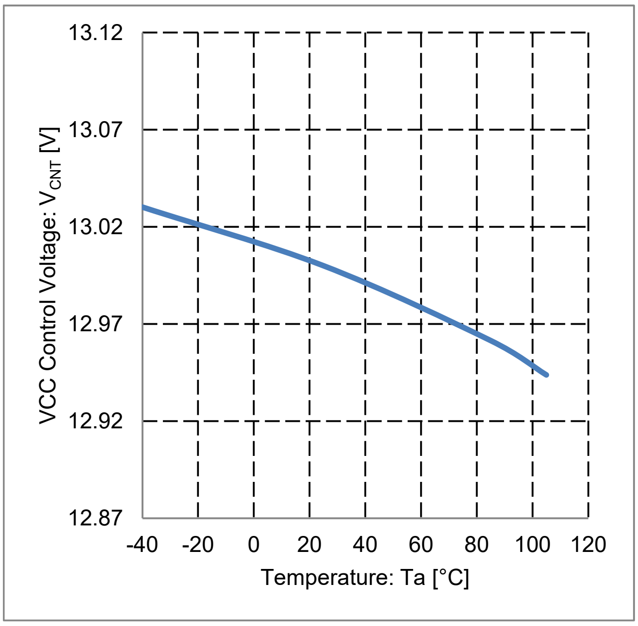


Figure 22. VCC Control Voltage vs Temperature

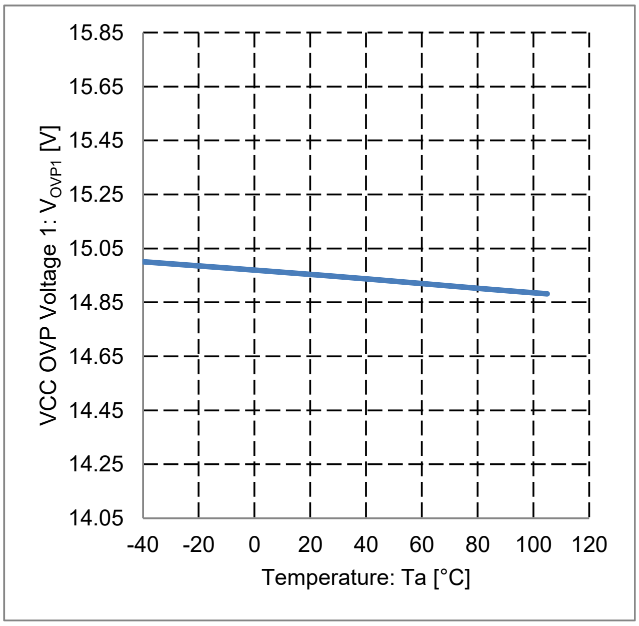


Figure 23. VCC OVP Voltage 1 vs Temperature

Typical Performance Curves
(Reference Data) – continued

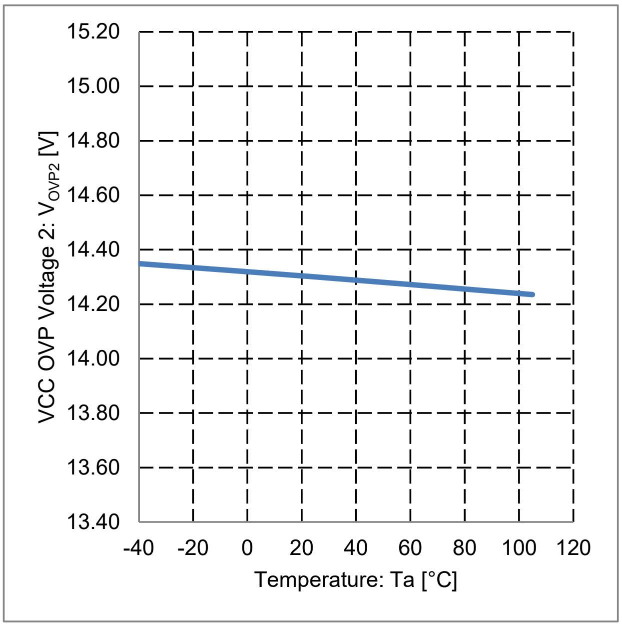


Figure 24. VCC OVP Voltage 2 vs Temperature

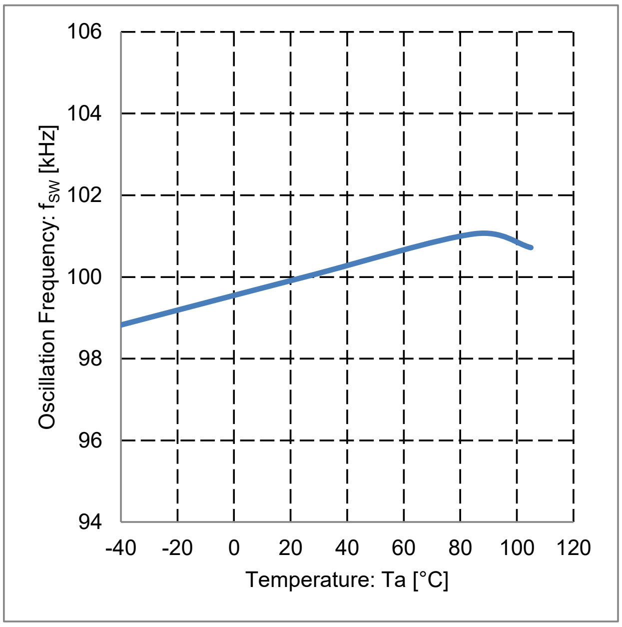


Figure 25. Oscillation Frequency vs Temperature

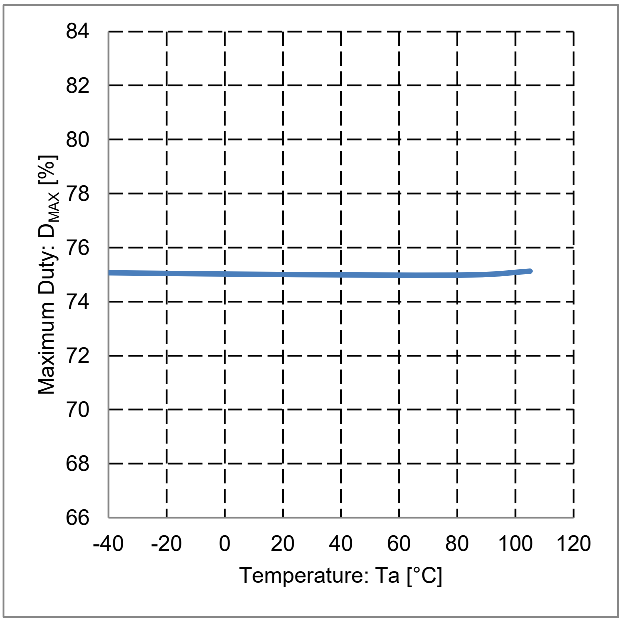


Figure 26. Maximum DUTY vs Temperature

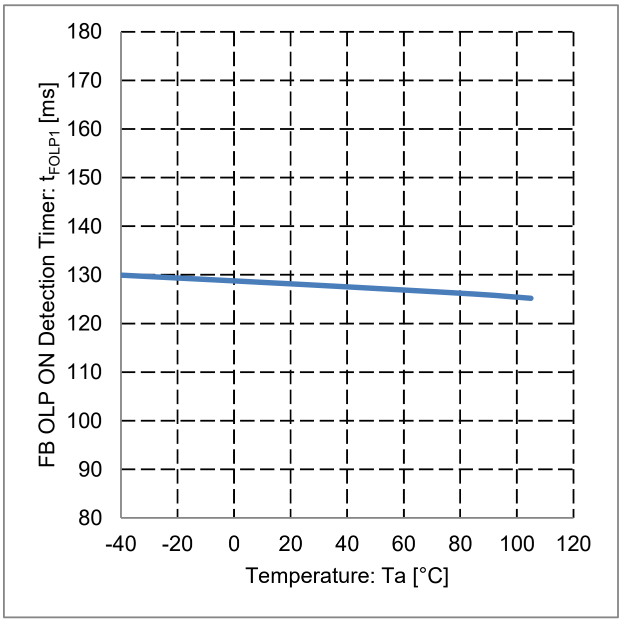


Figure 27. FB OLP ON Detection Timer vs Temperature

Typical Performance Curves
(Reference Data) – continued

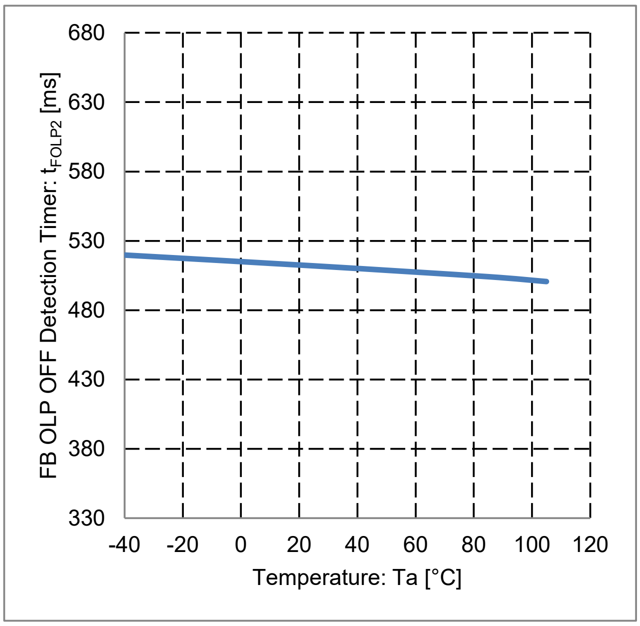


Figure 28. FB OLP OFF Detection Timer vs Temperature

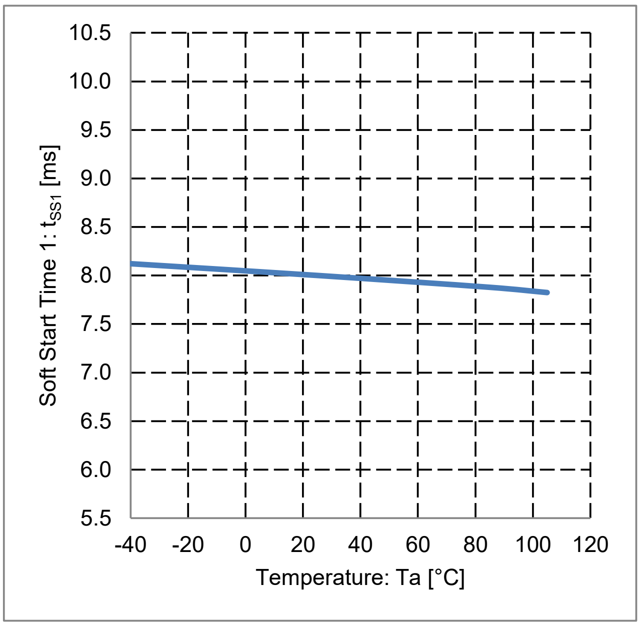


Figure 29. Soft Start Time 1 vs Temperature

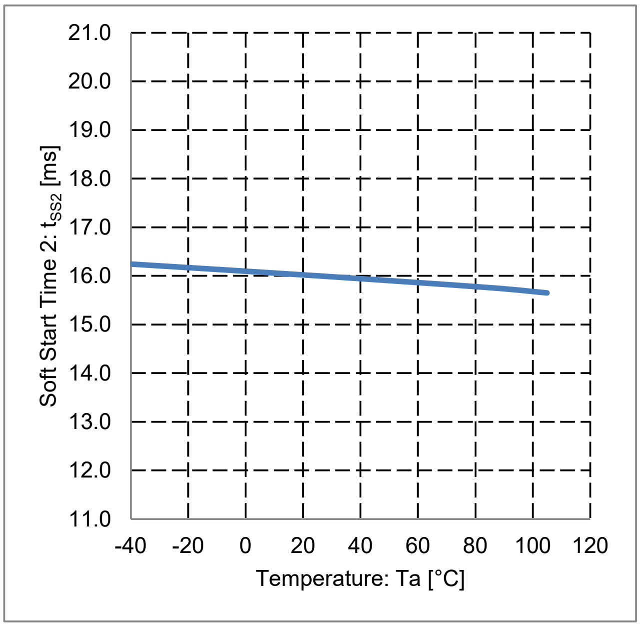


Figure 30. Soft Start Time 2 vs Temperature

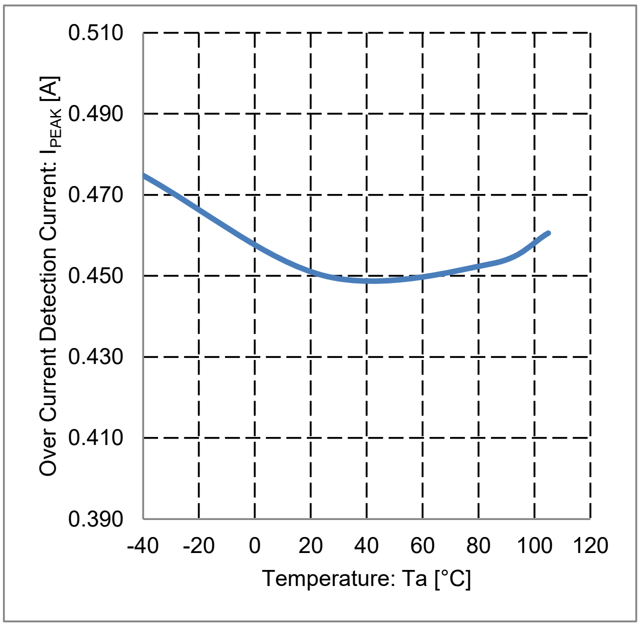


Figure 31. Over Current Detection Current vs Temperature

Typical Performance Curves
(Reference Data) – continued

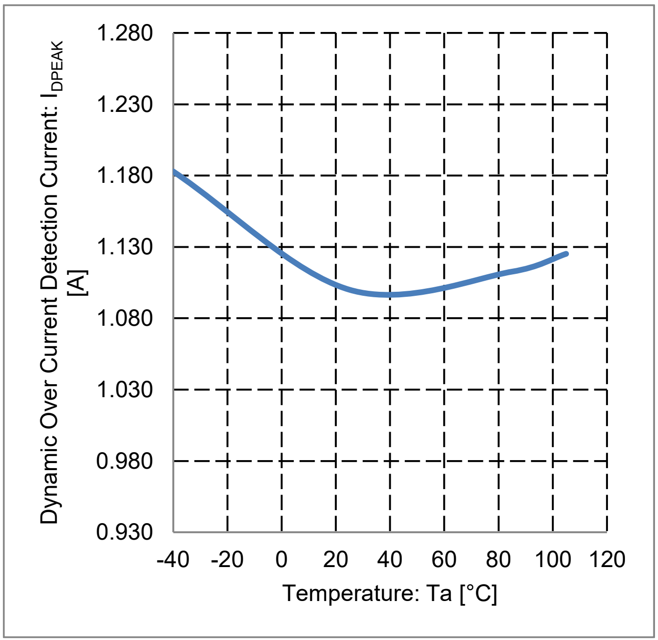
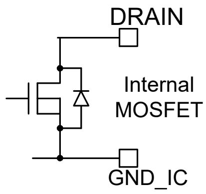
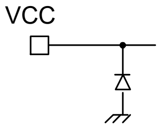
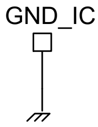


Figure 32. Dynamic Over Current Detection Current vs Temperature

I/O Equivalence Circuit

<table>
<tr><td>1</td><td>N.C.</td><td>2</td><td>N.C.</td><td>3</td><td>N.C.</td><td>4</td><td>DRAIN</td></tr>
<tr><td colspan="2">Non Connection</td><td colspan="2">Non Connection</td><td colspan="2">Non Connection</td><td colspan="2">
</td></tr>
<tr><td>8</td><td>VCC</td><td>7</td><td>GND_IC</td><td>6</td><td>N.C.</td><td>5</td><td>N.C.</td></tr>
<tr><td colspan="2">
</td><td colspan="2">
</td><td colspan="2">Non Connection</td><td colspan="2">Non Connection</td></tr>
</table>

Operational Notes

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

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

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

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

5. **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.

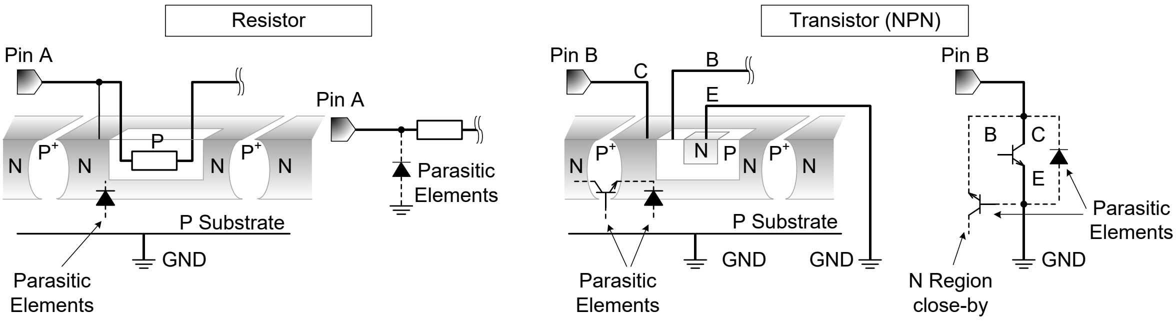


Figure 33. Example of IC Structure

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)

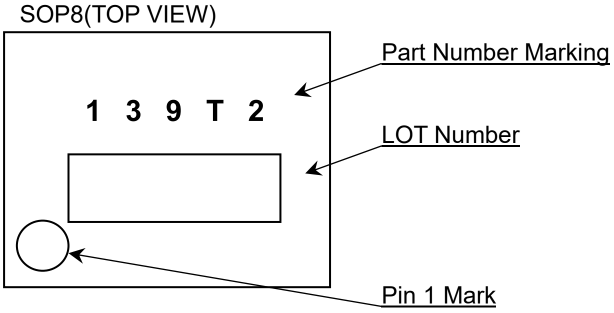
This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning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

Ordering Information

B	M	2	P	1	3	9	T	2	F	-	E2

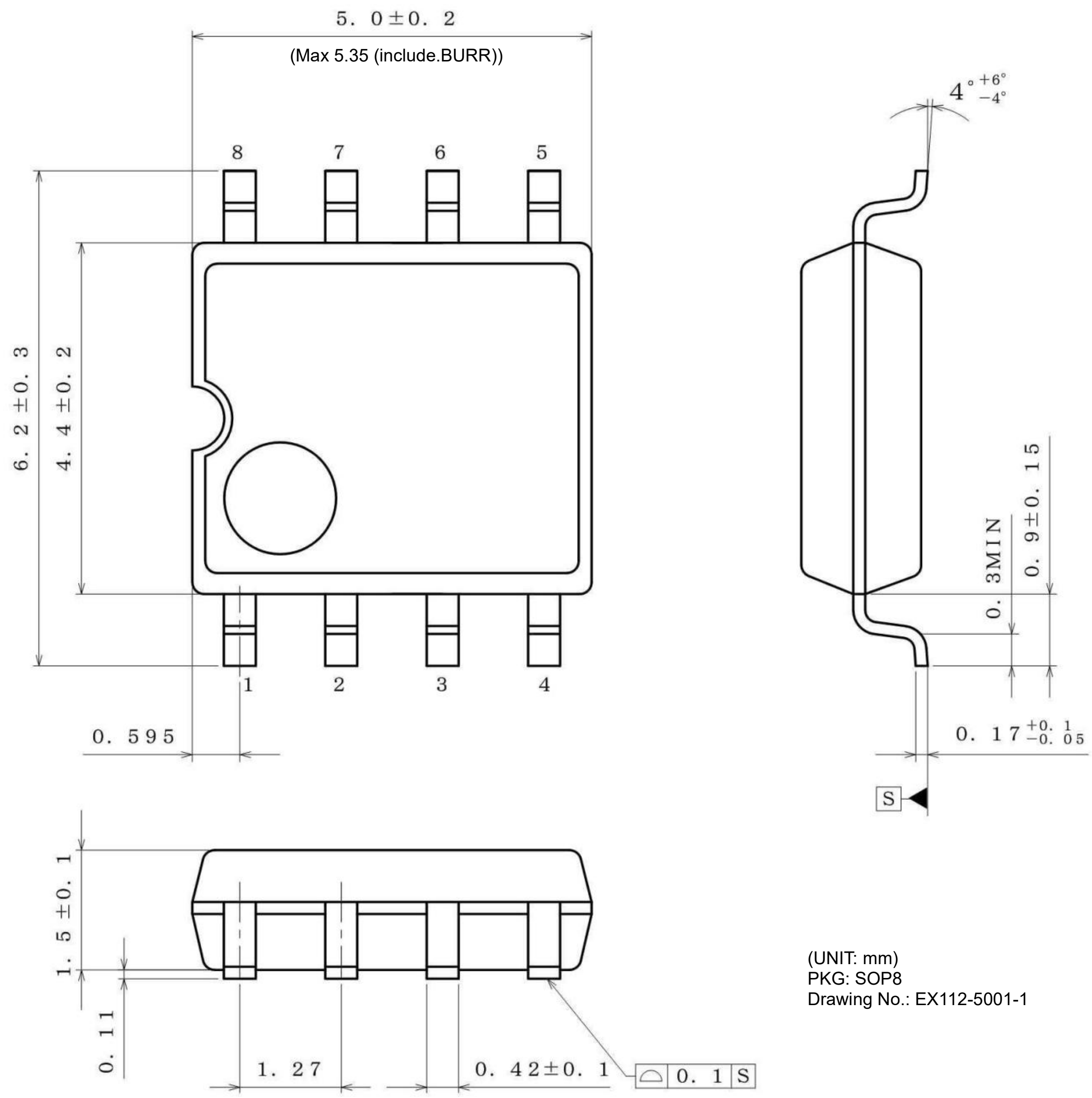
Packaging and forming specification
E2: Embossed tape and reel

Marking Diagram



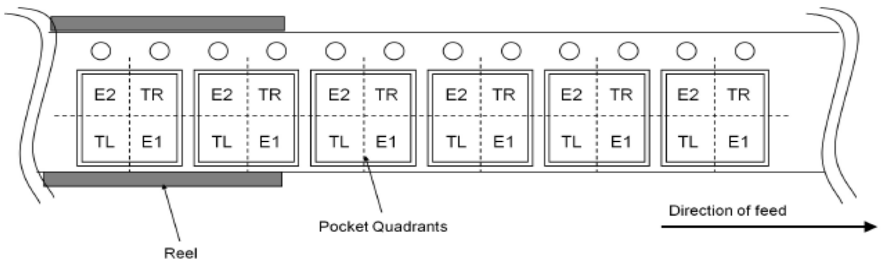
Physical Dimension and Packing Information

Package Name	SOP8



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



Revision History

Date	Revision	Changes
04.Sep.2025	001	New Release

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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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   [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

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.

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Precaution for Disposition

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