Datasheet

Built-in Low Consumption and High Accuracy Shunt Regulator

High Efficiency, Low Standby Power and CCM Corresponding Secondary Side Synchronous Rectification Controller IC

BD87007FJ

General Description

BD87007FJ is synchronous rectification controller to be used in the secondary side output. It has a built-in low consumption and high accuracy shunt regulator, which reduces standby power. At continuous conduction mode (CCM) operation, further space saving can be realized when operating without the input switching synchronizing signal of the primary side.

BD87007FJ also features a wide operating supply voltage of 2.7 V to 32.0 V for various output applications. In addition, by adopting the high voltage 120 V (Max) process, it is possible to monitor the drain voltage directly.

Key Specifications

- Supply Voltage: 2.7 V to 32.0 V
- Circuit Current (No Switching): 800 µA (Typ)
- DRAIN Monitor Pin Absolute Voltage: 120 V (Max)
- Operating Temperature Range: -40 °C to +105 °C

Package

Package	W(Typ) x D(Typ) x H(Max)
SOP-J8	4.90 mm x 6.00 mm x 1.65 mm

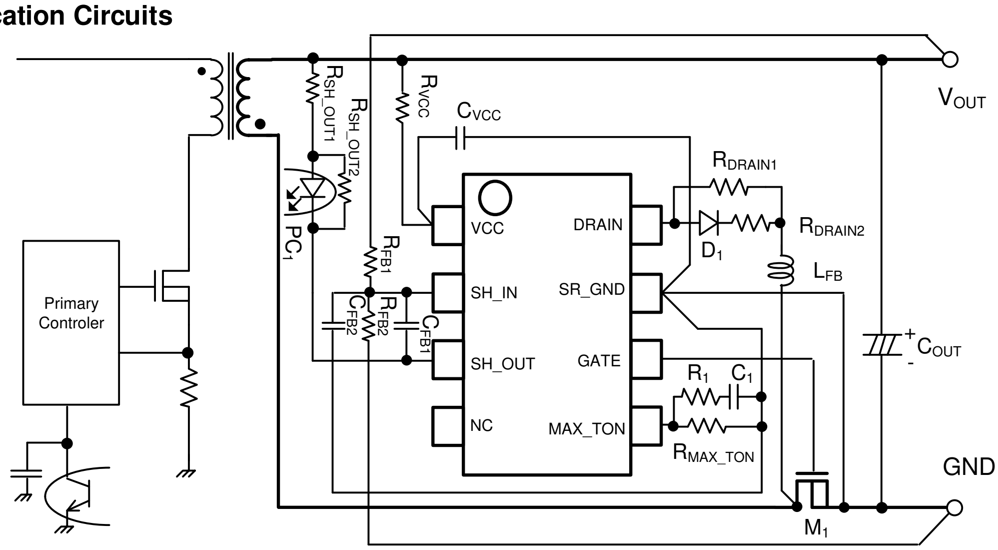
Features

- Built-in Low Consumption and High Accuracy Shunt Regulator, which Reduces Standby Power
- 120 V (Max) High Voltage Process DRAIN Monitor Pin
- Wide Supply Voltage Range of 2.7 V to 32.0 V
- Supports Drive Type: PWM, QR Controller etc.
- No Input Required on the Primary-Side at CCM
- Built-in Over Voltage Protection for SH_IN and VCC Pin
- Built-in Thermal Shutdown Function

Applications

- AC/DC Output Power Conversion Applications: Charger, Adapter, Household Appliance, etc.

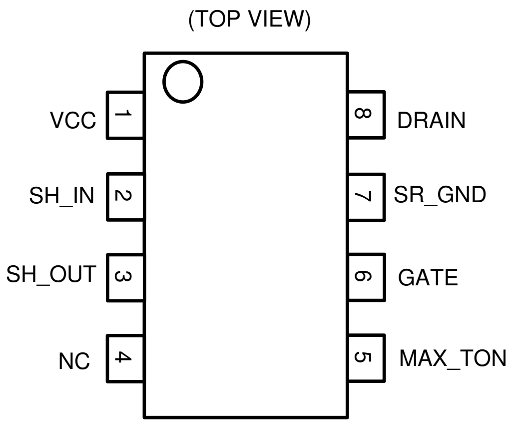
Typical Application Circuits



Flyback Application Circuit (Low side FET)

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

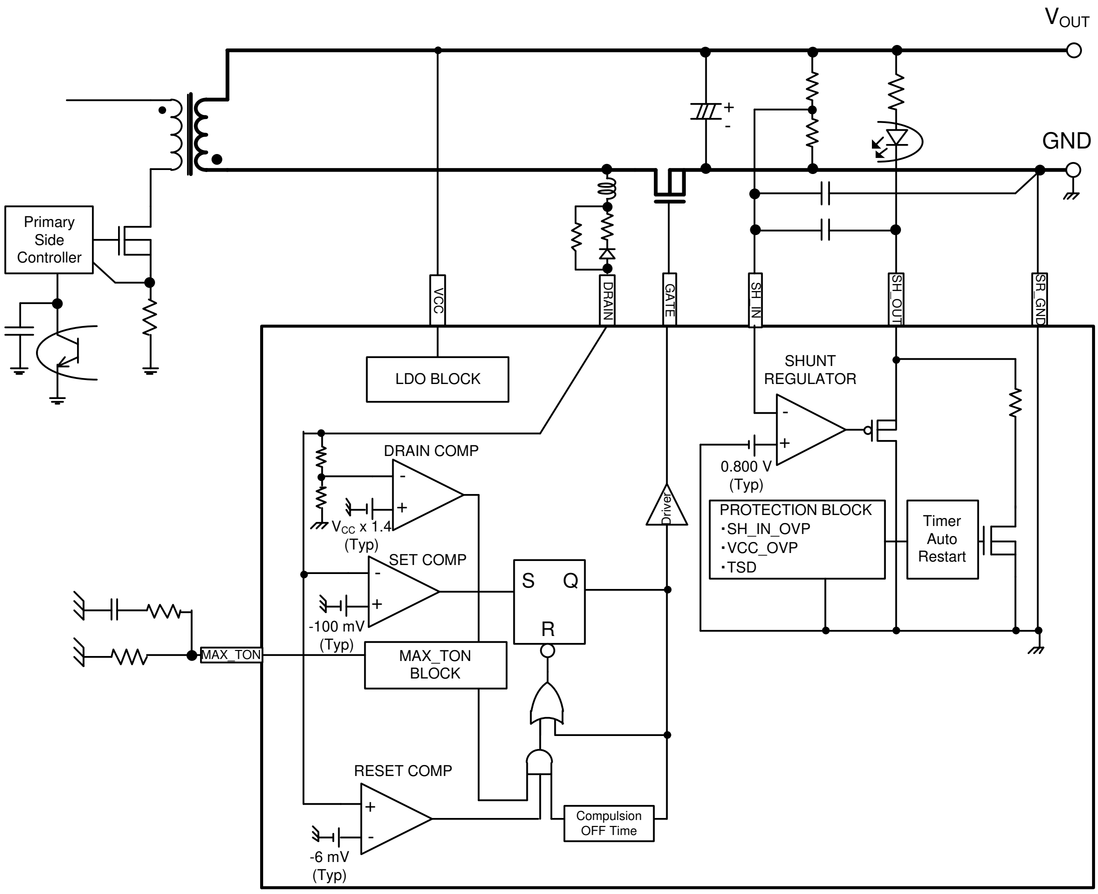
Pin Configuration



Pin Description

Pin No.	Pin Name	Function
1	VCC	Power supply input pin
2	SH_IN	Shunt regulator reference input pin
3	SH_OUT	Shunt regulator power supply input / output pin
4	NC	Non connection (Do not connect this pin to any potential and keep it open.)
5	MAX_TON	Set maximum on time pin
6	GATE	Secondary side FET GATE drive pin
7	SR_GND	GND pin
8	DRAIN	Secondary side FET DRAIN monitor pin

Block Diagram



Description of Block

1. **SET COMP Block**
   Monitors the DRAIN pin voltage, and outputs a signal to turn on the FET if the DRAIN pin voltage is -100 mV (Typ) or less.

2. **RESET COMP Block**
   Monitors the DRAIN pin voltage, and outputs a signal to turn off the FET if the DRAIN pin voltage is -6 mV (Typ) or more.

3. **Compulsion OFF Time Block**
   When the FET is turned OFF due to RESET COMP detection, resonance waveforms appear on the DRAIN pin. To prevent the resonance waveforms from turning on the FET, an OFF state should be forced for a certain time.

   Operation sequence of each block is shown on the figure below.

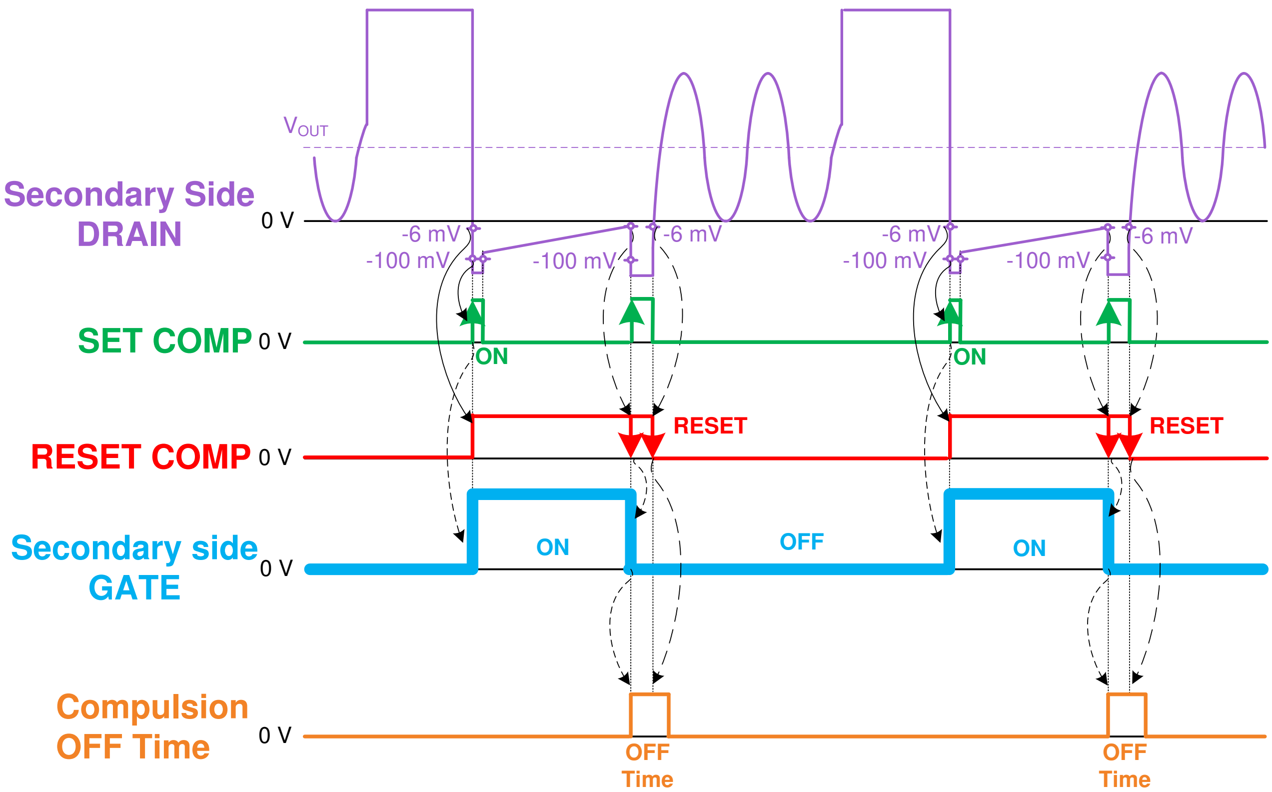


Figure 1. Operation Sequence

About Maximum Input Frequency
The Maximum Operating Frequency of the IC depends on the Compulsion OFF Time. For example, BD87007FJ Compulsion OFF Time is equal to 3.850 µs. Considering a variation of 9.09 %, the maximum input frequency is given by the following:

$$f_{MAX} = \frac{1}{3.850(\mu s)\times 1.0909} \approx 238 \quad \text{[kHz]}$$

However, because the frequency largely fluctuates depending on the input voltage, load conditions, etc., it will be different for each application.

Description of Block – continued

4. MAX_TON Block

MAX_TON block sets the maximum ON time. It starts the counting when the DRAIN pin voltage is on the rising edge of the output voltage V_{CC} x 1.4 V (Typ) or more. In addition, the FET will be forced OFF after the set time has elapsed.
The relationship between the resistance value (R_{MAX_TON}) and set time (t_{MAX_ON}) is described as follows:

$$t_{MAX\_TON}\ [\mu s] \times 10\ [k\Omega/\mu s] = R_{MAX\_TON}\quad [k\Omega]$$

Calculation Example:
If you want to set the maximum ON time to 10 µs, the value of R_{MAX_TON} is as follows:

$$10\ [\mu s] \times 10\ [k\Omega/\mu s] = 100\quad [k\Omega]$$

However, the formula above is for an ideal approximation only. It is strongly advised that the operation of the actual application should be verified.
By setting this time, it becomes possible to prevent the simultaneous ON operation of the primary side and the secondary side in CCM.
The drive sequence in CCM operation is shown in the figure below:

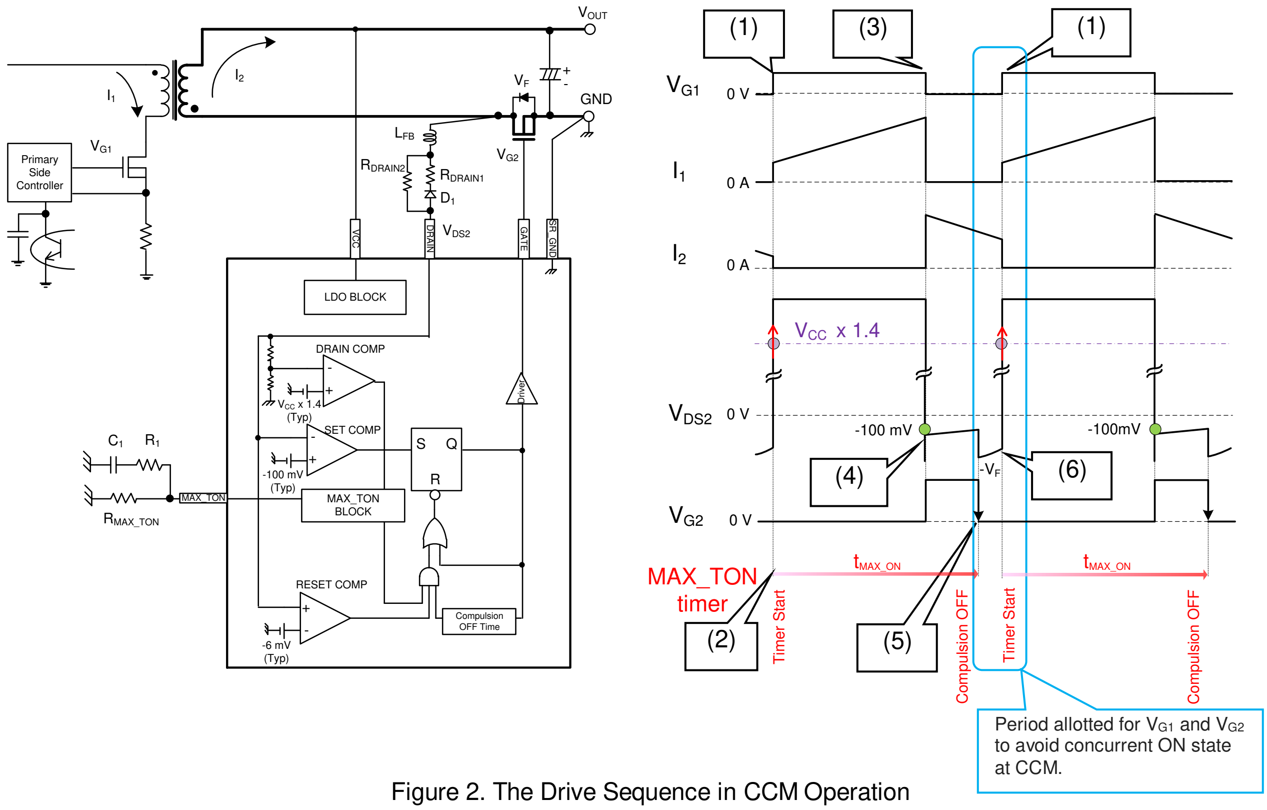


Figure 2. The Drive Sequence in CCM Operation

(1) Primary side FET = ON. Current I_1 flows to the primary side FET. Secondary side drain voltage V_{DS2} rises.
(2) The V_{DS2} = V_{CC} x 1.4 detects the rise edge of the threshold, MAX_TON timer start.
(3) Primary side FET = OFF. Current I_2 flows through the Body Diode of the secondary side FET (OFF state).
(4) Secondary side drain voltage $V_{DS2} \leq$ -100 mV by current I_2, Secondary side FET = ON.
(5) Elapsed the set time in the MAX_TON pin, the secondary side FET = compulsion OFF.
(6) Since the I_2 current flows through the Body Diode, V_F voltage occurs.

In order to reduce the influence of the switching noise as much as possible, capacitor C_1 and resistor R_1 in series should be connected to the MAX_TON pin. It is recommended that the capacitance be about 1000 pF and the resistance value be about 1 kΩ. This also serves as phase compensation of the MAX_TON pin and therefore should be connected.
For quasi-resonance (QR) application, this function is unnecessary because it basically does not operate in CCM. At this time, the setting method of the MAX_TON pin is invalidated by setting R_{MAX_TON} which is sufficiently large (300 kΩ or less) so that the minimum time of one period on the primary side including variation etc. << MAX_TON timer setting time.

Description of Block – continued

5. **SHUNT REGULATOR Block**
   It is a low consumption, high accuracy shunt regulator that controls the AC/DC output voltage.

6. **PROTECTION Block**
   When protection is detected, the timer starts counting. After completion, drive the photo coupler from the SH_OUT pin to stop the primary side drive operation.

Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
VCC Input Pin	V_{MAX_VCC}	-0.3 to +40	V
MAX_TON Output Pin	$V_{MAX\_MAX\_TON}$	-0.3 to +V_{MAX_VCC}	V
SH_IN Input Pin	$V_{MAX\_SH\_IN}$	-0.3 to +40	V
SH_OUT Input / Output Pin	$V_{MAX\_SH\_OUT}$	-0.3 to +40	V
Gate Output Pin	V_{MAX_GATE}	-0.3 to +15.5	V
Drain Input Pin	V_{MAX_DRAIN}	+120 *(Note 1)*	V
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 thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

(Note 1) When a negative voltage is applied, current flows through the ESD protection device. This current value is about 6 mA or less and will require a current limiting resistor to the DRAIN pin.

Thermal Resistance *(Note 2)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s *(Note 4)*	2s2p *(Note 5)*	
SOP-J8				
Junction to Ambient	θ_{JA}	149.3	76.9	°C/W
Junction to Top Characterization Parameter *(Note 3)*	Ψ_{JT}	18	11	°C/W

(Note 2) Based on JESD51-2A(Still-Air)
(Note 3) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 4) Using a PCB board based on JESD51-3.
(Note 5) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 µm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 µm	74.2 mm x 74.2 mm	35 µm	74.2 mm x 74.2 mm	70 µm

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{CC}	2.7	20.0	32.0	V
Operating Temperature	Topr	-40	+25	+105	°C
MAX_TON R_{MAX_TON} Resistor Range	R_{MAX_TON}	56	-	300	kΩ
MAX_TON R_1	R_1	0.5	1.0	2.0	kΩ
MAX_TON C_1	C_1	680	1000	2200	pF

Electrical Characteristics (Unless otherwise specified V_{CC} =20 V, V_{SH_OUT} = 20 V, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Circuit Current						
Circuit Current1	I_{ON}	0.5	1.0	2.0	mA	f_{SW} = 50 kHz at Switching Mode (GATE = OPEN)
Circuit Current2	I_{ACT}	350	800	1400	µA	Switching Stop Mode
Circuit Current3	I_{OFF}	18	35	60	µA	V_{CC} = 1.9 V, UVLO Mode
VCC Item						
VCC UVLO Threshold Voltage1	V_{UVLO1}	2.00	2.30	2.65	V	V_{CC} Sweep Up
VCC UVLO Threshold Voltage2	V_{UVLO2}	1.95	2.25	2.60	V	V_{CC} Sweep Down
VCC OVP Detection Voltage1	V_{OVP1}	32.5	35.0	37.5	V	V_{CC} Sweep Up
VCC OVP Detection Voltage2	V_{OVP2}	31.5	34.0	36.5	V	V_{CC} Sweep Down
SR Controller BLOCK						
GATE Turn ON Threshold Voltage	V_{GON}	-150	-100	-50	mV	V_{DRAIN} = +300 mV to -300 mV
GATE Turn OFF Threshold Voltage	V_{GOFF}	-10	-6	-1	mV	V_{DRAIN} = -300 mV to +300 mV
Compulsion OFF Time	t_{COFF}	3.50	3.85	4.20	µs	
MAX_TON BLOCK						
MAX_TON Timer Start Threshold Voltage	$V_{MAX\_ON\_START}$	24	28	32	V	V_{CC} = 20 V Pulse Input to DRAIN Pin
MAX_TON Timer	t_{MAX_ON}	9.4	10.0	10.6	µs	R_{MAX_TON} = 100 kΩ V_{CC} = 3 V V_{DRAIN} = -0.3 V↔+7 V
MAX_TON Output Voltage	V_{MAX_ON}	0.24	0.40	0.56	V	
Drain Monitor BLOCK						
Drain Pin Sink Current	I_{D_SINK}	130	270	550	µA	V_{DRAIN} = 120 V
Drain Pin Source Current1	I_{DRAIN_SO1}	-23	-11	-5	µA	V_{DRAIN} = 0.1 V
Drain Pin Source Current2	I_{DRAIN_SO2}	-3.0	-1.0	-0.3	µA	V_{DRAIN} = -0.2 V
Driver BLOCK						
GATE Pin High Voltage	V_{GATE_H1}	11	12	14	V	V_{CC} = 20 V
High Side FET ON-Resistance1	R_{HIONR1}	12.0	23.0	50.0	Ω	V_{CC} = 2.7 V, I_{OUT} = -10 mA
High Side FET ON-Resistance2	R_{HIONR2}	6.0	12.0	24.0	Ω	V_{CC} = 5.0 V, I_{OUT} = -10 mA
High Side FET ON-Resistance3	R_{HIONR3}	4.0	9.0	18.0	Ω	V_{CC} = 10 V, I_{OUT} = -10 mA
Low Side FET ON-Resistance1	$R_{LOWONR1}$	1.1	2.2	4.4	Ω	V_{CC} = 2.7 V, I_{OUT} = +10 mA
Low Side FET ON-Resistance2	$R_{LOWONR2}$	0.9	1.8	3.6	Ω	V_{CC} = 5.0 V, I_{OUT} = +10 mA
Delay Time GATE Pin Turn ON	t_{DELAY_ON}	-	50	-	ns	V_{DRAIN} = +300 mV to -300 mV
Delay Time GATE Pin Turn OFF	t_{DELAY_OFF}	-	100	-	ns	V_{DRAIN} = -300 mV to +300 mV

Electrical Characteristics - continued

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Shunt Regulator BLOCK						
Reference Voltage	V_{SHREF}	0.792	0.800	0.808	V	V_{SH_OUT} = 5 V SH_OUT Sink Current = 100 µA
Reference Voltage Changing Ratio by Temperature	ΔV_{SHEMP}	-	-8	-	mV	V_{SH_OUT} = 5 V SH_OUT Sink Current = 100 µA Ta = +25 °C to +105 °C
SH_OUT Coefficient of the Reference Voltage1	ΔV_{SHREF1}	-	1	-	mV	V_{SH_OUT} = 2.7 V to 5 V SH_OUT Sink Current = 100 µA
SH_OUT Coefficient of the Reference Voltage2	ΔV_{SHREF2}	-	2	-	mV	V_{SH_OUT} = 5 V to 20 V SH_OUT Sink Current = 100 µA
Reference Input Current	I_{SH_IN}	-0.2	0.0	+0.2	µA	V_{SH_IN} = 2 V
Dynamic Impedance1	R_{SH_OUT1}	-	0.3	-	Ω	SH_OUT Sink Current = 100 µA to 300 µA (V_{SH_OUT} = 2.7 V)
Dynamic Impedance2	R_{SH_OUT2}	-	0.2	-	Ω	SH_OUT Sink Current = 100 µA to 300 µA (V_{SH_OUT} = 20 V)
SH_OUT Current at SH_IN = Low	I_{SH_OUT}	5	10	18	µA	V_{SH_IN} = 0 V, V_{SH_OUT} = 5 V
SH_OUT Regulation Current	$I_{SH\_OUT\_REG}$	1	-	-	mA	V_{SH_IN} = 0.85 V, V_{SH_OUT} = 5 V
SH_IN OVP Detection Voltage1	V_{SHI_OVP1}	0.90	1.00	1.10	V	V_{SH_IN} Sweep Up
SH_IN OVP Detection Voltage2	V_{SHI_OVP2}	0.85	0.95	1.05	V	V_{SH_IN} Sweep Down
Protection Detect Timer	$t_{PROTECTION}$	500	900	1500	µs	
SH_OUT Pull Down Current at Protection Detect Mode	$I_{PROTECTION}$	1.3	2.5	5.0	mA	V_{SH_IN} = 0 V, V_{SH_OUT} = 5 V

Typical Performance Curves
(Reference Data)

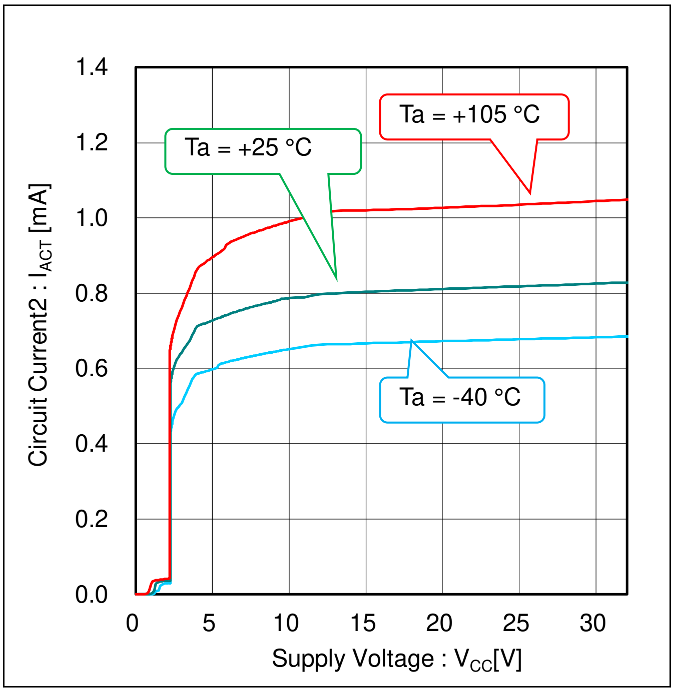


Figure 3. Circuit Current2 vs Supply Voltage
(Switching Stop Mode)

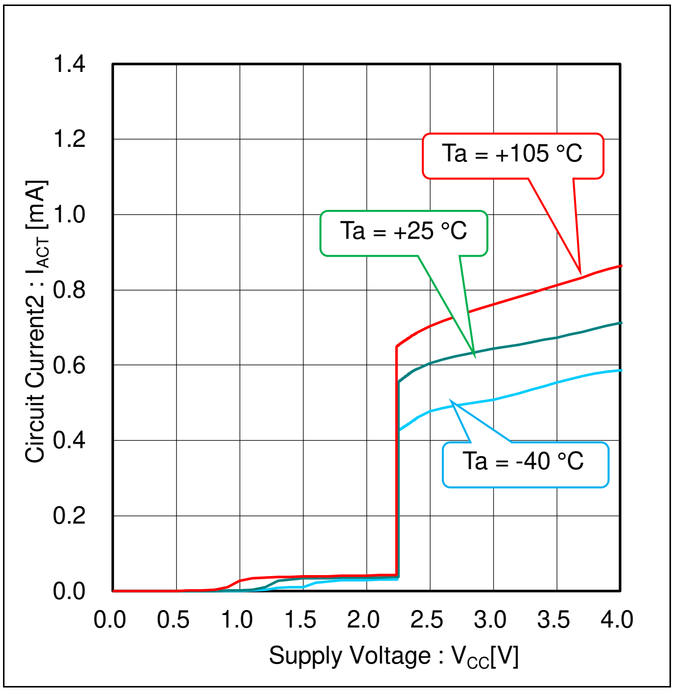


Figure 4. Circuit Current2 vs Supply Voltage
(Switching Stop Mode V_{CC} Zoom)

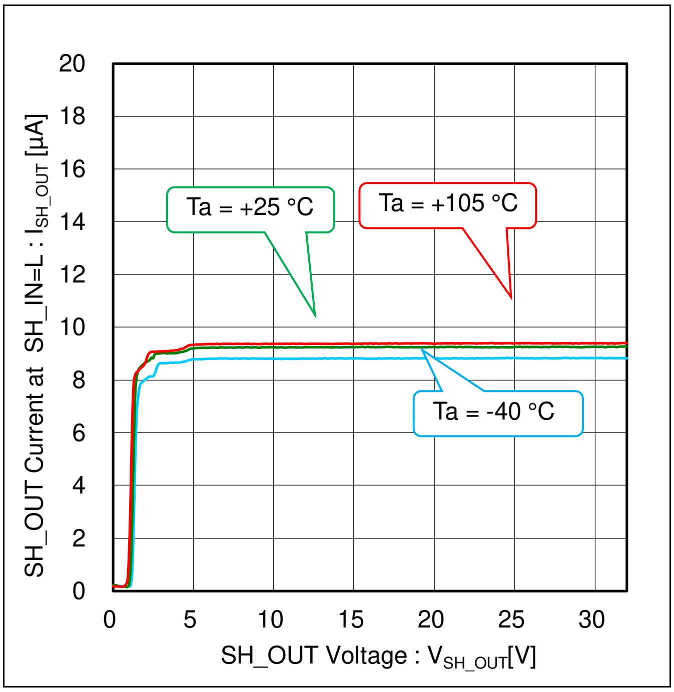


Figure 5. SH_OUT Current at SH_IN = L vs SH_OUT Voltage
(V_{SH_IN} = 0 V)

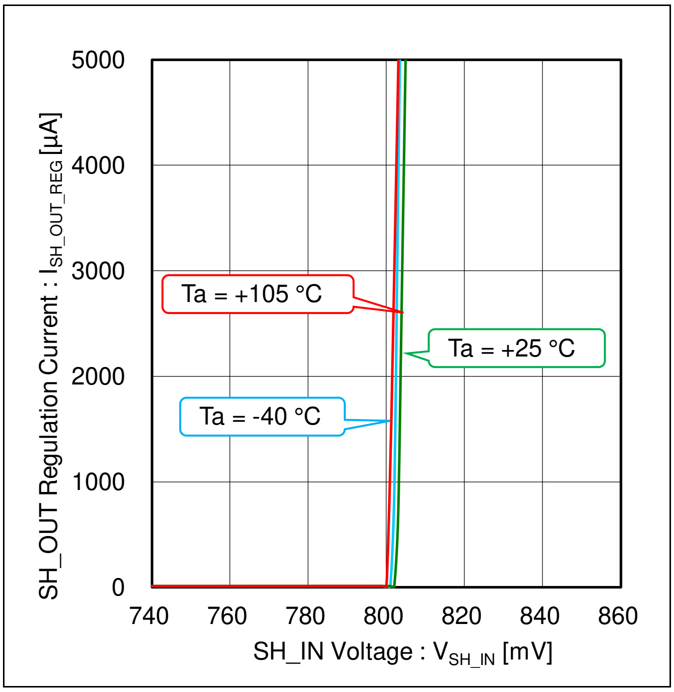


Figure 6. SH_OUT Regulation Current vs SH_IN Voltage
(V_{SH_OUT} = 5 V)

Typical Performance Curves - continued

(Reference Data)

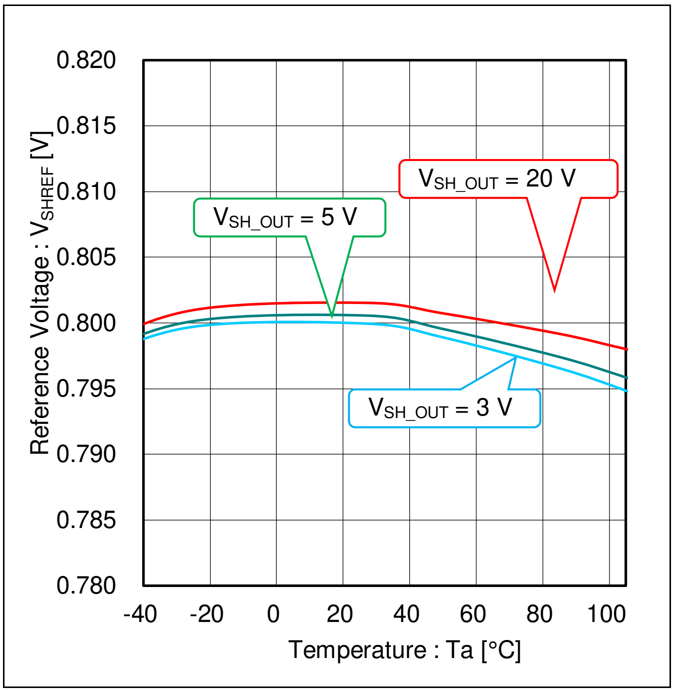


Figure 7. Reference Voltage vs Temperature (SH_OUT Sink Current = 100 µA)

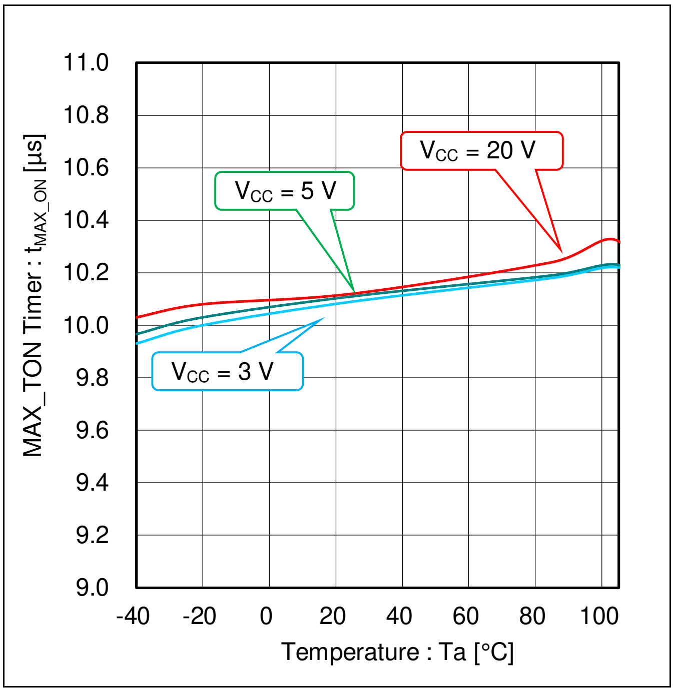


Figure 8. MAX_TON Timer vs Temperature (R_{MAX_TON} = 100 kΩ, V_{DRAIN} = -0.3 V↔+7 V)

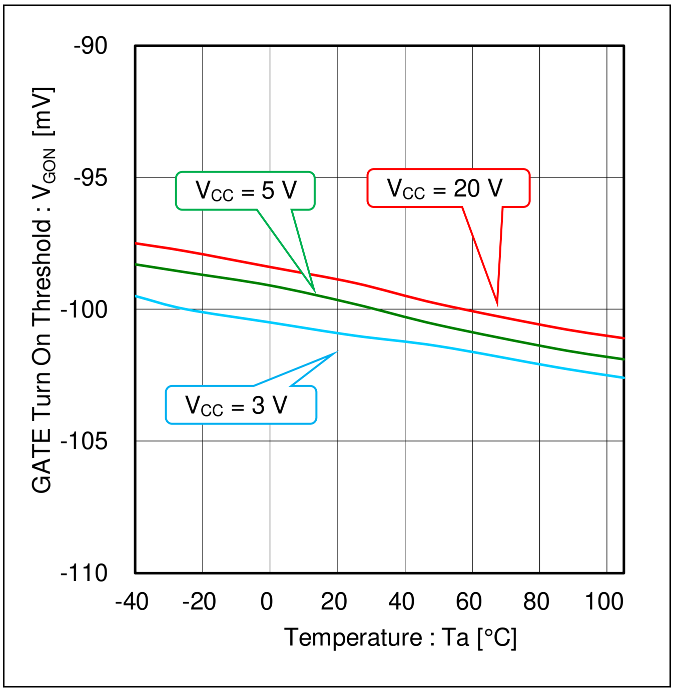


Figure 9. GATE Turn On Threshold vs Temperature (DRAIN Sweep Down)

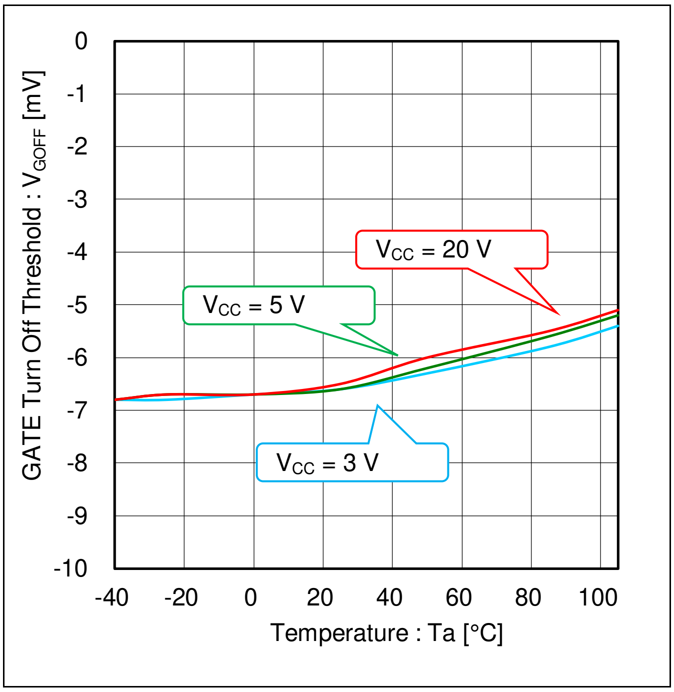


Figure 10. GATE Turn Off Threshold vs Temperature (DRAIN Sweep Up)

Timing Chart

The startup sequence is shown below.

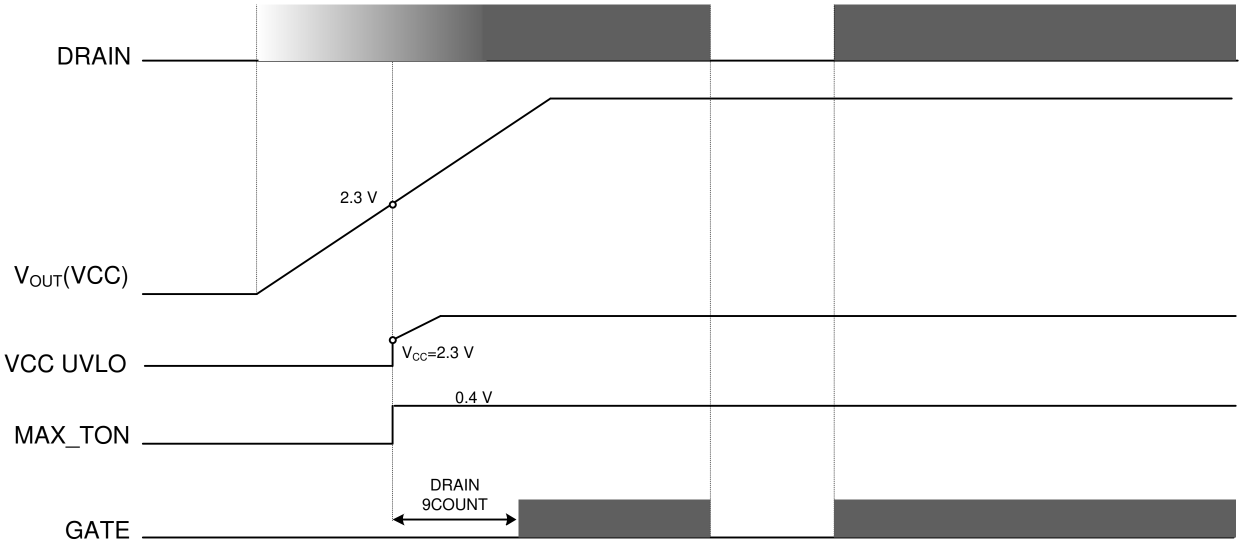


Figure 11. Startup Sequence

Application Examples

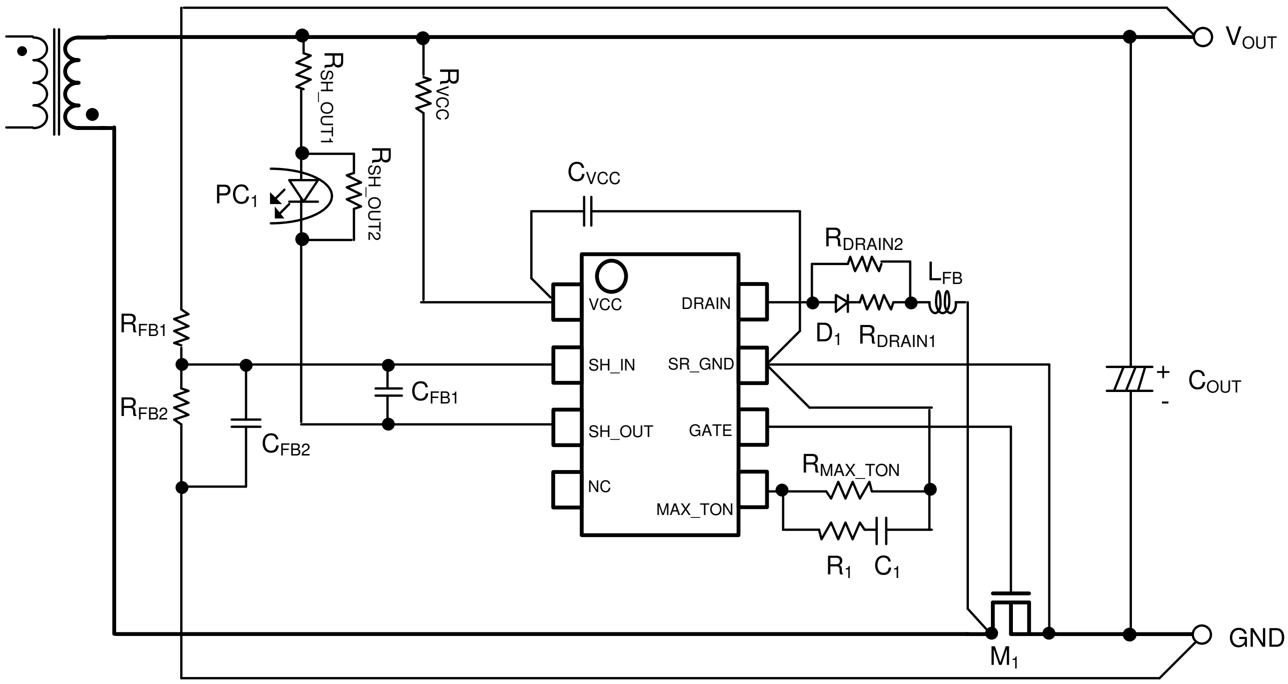


Figure 12. Flyback Application Circuit
(Low Side FET)

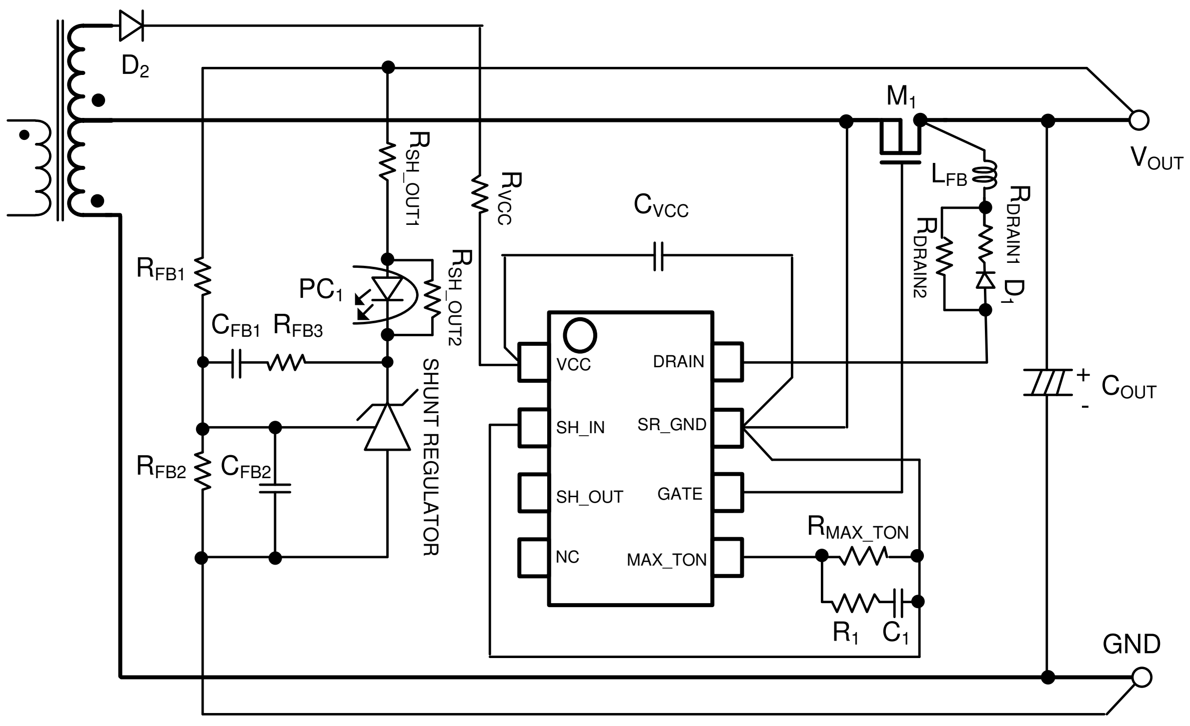


Figure 13. Flyback Application Circuit
(High Side FET)

The built-in shunt regulator block is connected in the IC with SR_GND of the synchronous rectification controller. Therefore, do not use the shunt regulator for high side FET type flyback application. Connect the SH_IN pin to the SR_GND pin. Set the SH_OUT pin open.

Selection of Components Externally Connected

1. MAX_TON Pin Setting
A resistance value which is connected to the MAX_TON pin is used to set the timer to force the GATE output OFF. (For detailed operation, please see "Description of Block Operation / MAX_TON Block")
Set timer is proportional to the resistance value which can be set in the range of 56 kΩ to 300 kΩ. This IC is capable of an accuracy of 10 µs ±6 % at 100 kΩ. However, accuracy deteriorates as the resistance value gets further away from 100 kΩ. For example, 5.6 µs ±0.9 µs at 56 kΩ, 30 µs ±4.5 µs at 300 kΩ. (See graph below)

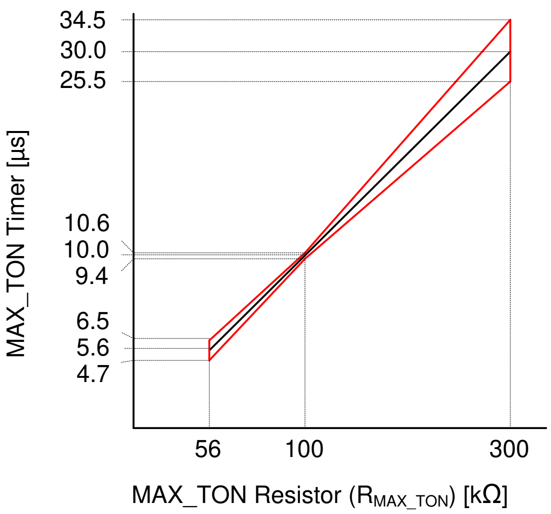


Figure 14. MAX_TON Timer vs MAX_TON Resistor

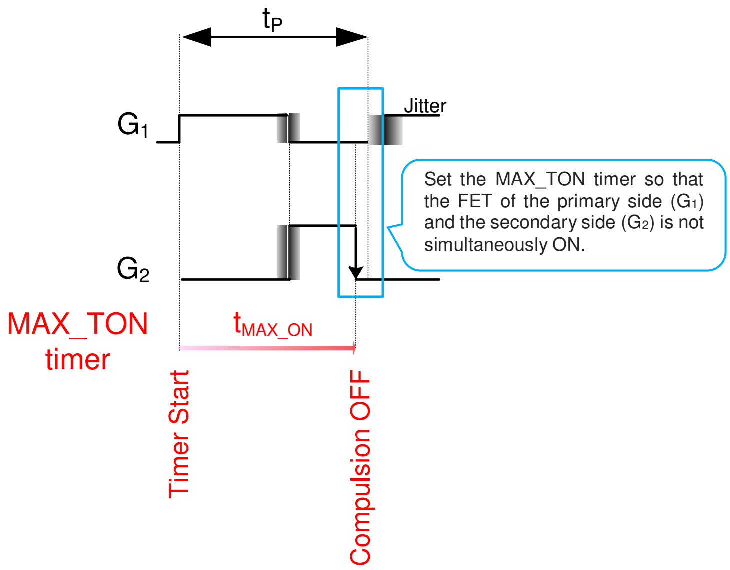


Figure 15. Primary FET and Secondary FET Sequence at CCM

To prevent destruction due to surge current in CCM, set the MAX_TON timer before turning on the primary side FET (G_1) to forcibly OFF the secondary side FET (G_2). Including such variations, select a resistance value of the MAX_TON pin (R_{MAX_TON}) so that the MAX_ON timer setting time is less than one cycle in the primary side ($t_P > t_{MAX\_ON}$).

$$R_{MAX\_TON} < \frac{10\times10^3}{(1+\Delta t_{MAX\_ON}+\Delta R+\Delta f_{MAX})\times(f_{MAX}+f_{JITTER})} \quad [\text{k}\Omega]$$

Frequency Variation Ratio: $(1+\Delta t_{MAX\_ON}+\Delta R+\Delta f_{MAX})$
Maximum Frequency Value: $(f_{MAX}+f_{JITTER})$

where:
f_{MAX} is the primary side of the maximum frequency [kHz]
Δf_{MAX} is the primary side of the maximum frequency accuracy [%]
f_{JITTER} is the primary side of the jitter frequency [kHz]
Δt_{MAX_ON} is Secondary side MAX_TON timer time accuracy [%]
ΔR is Secondary side MAX_TON When the connection resistance accuracy [%]

2. Calculation Example

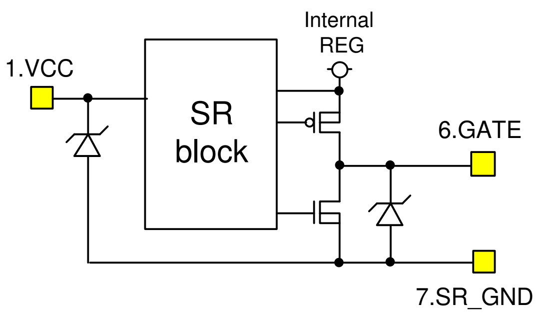
$$R_{MAX\_TON} < \frac{10\times10^3}{(1+0.06+0.01+0.05)\times(100+8)} = 82.67 \quad [\text{k}\Omega]$$

f_{MAX} is the primary side of the maximum frequency 100[kHz]
Δf_{MAX} is the primary side of the maximum frequency accuracy 5[%]
f_{JITTER} is the primary side of the jitter frequency 8[kHz]
Δt_{MAX_ON} is Secondary side MAX_TON timer time accuracy 6[%]
ΔR is Secondary side MAX_TON When the connection resistance accuracy 1[%]

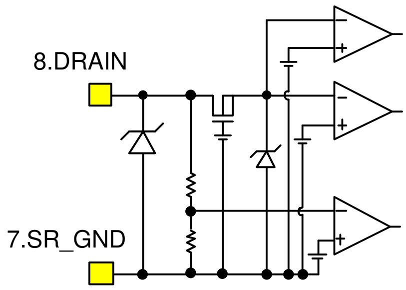
With these conditions, MAX_TON Resistor (R_{MAX_TON}) should be set to 82 kΩ or less. In addition, it is recommended that the temperature characteristics of each component should also be taken into account.

I/O Equivalence Circuits

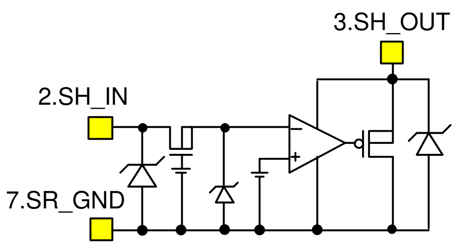
Pin 1: VCC / Pin 6: GATE / Pin 7: SR_GND



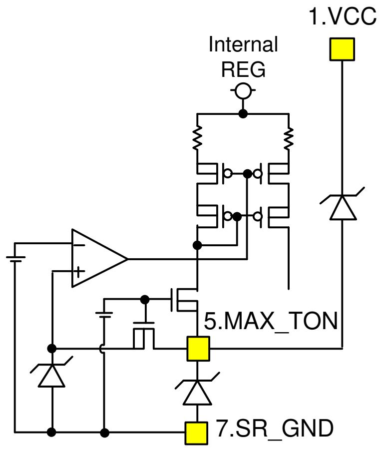
Pin 8: DRAIN



Pin 2: SH_IN / Pin 3: SH_OUT



Pin 5: MAX_TON



Notes on the Layout

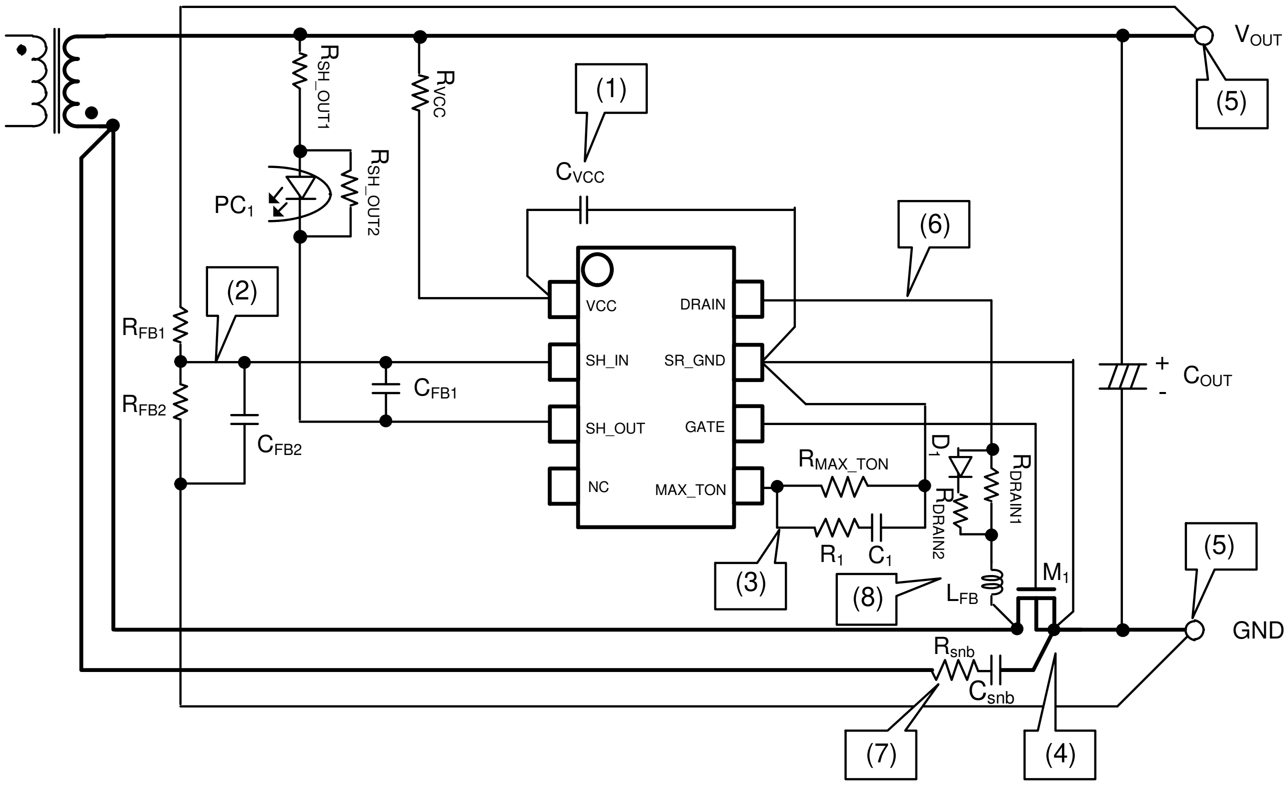


Figure 16. Flyback Application Circuit
(Low Side FET)

(1) VCC line may malfunction under the influence of switching noise. Therefore, it is recommended to insert a capacitor C_{VCC} between the VCC and SR_GND pin.
(2) The SH_IN pin is a high impedance line. To avoid crosstalk, electrical wiring should be as short as possible and not in parallel with the switching line.
(3) The MAX_TON pin has a 0.4 V output. Therefore, there is a possibility that compulsion OFF time is affected by the switching operation. We recommend connecting R_{MAX_TON}, R_1, C_1 just before the MAX_TON pin output as much as possible and connecting to the SR_GND pin with independent wiring. It is also recommended to use an independent electrical wiring in connection with the SR_GND pin.
(4) The synchronous rectification controller IC must accurately monitor the V_{DS} generated in the FET. Accordingly, the electrical wiring between the DRAIN to DRAIN and SR_GND to SOURCE of the IC and FET respectively **should be connected independently.**
(5) The feedback resistors of V_{OUT} are recommended to be connected to the GND of the output with an independent electrical wiring.
(6) The DRAIN pin is a switching line. Use a narrow wiring and connect as short as possible.
(7) Use an independent wiring if connecting a snubber circuit between the DS of the FET. The connection of the transformer output and the SOURCE of the FET should be thick and short as possible.
(8) Due to the DRAIN pin detects the small voltage, a malfunction which the switch turns ON/OFF caused by the surge voltage may occur. So that, the filters such as the ferrite bead are recommended for alleviating the surge voltage. Select L_{FB} with high impedance type in the frequency range (1 MHz to 10 MHz). If the ferrite bead is unnecessary, short the wiring.

Configuration example*(Note 6)*:
D_1 (a schottky barrier diode): RB751VM-40 (ROHM)
R_{DRAIN1} (a filter resistor for the FET turn off): 0.3 kΩ to 2 kΩ
R_{DRAIN2} (a current limiting resistor to the DRAIN pin): 150 Ω

(Note 6) The value is not a guaranteed value, but for reference. Please choose the optimum values of the components after sufficient evaluations based on the actual application.

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**
   Except for pins the output and the input of which were designed to go below ground, 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 monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

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

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

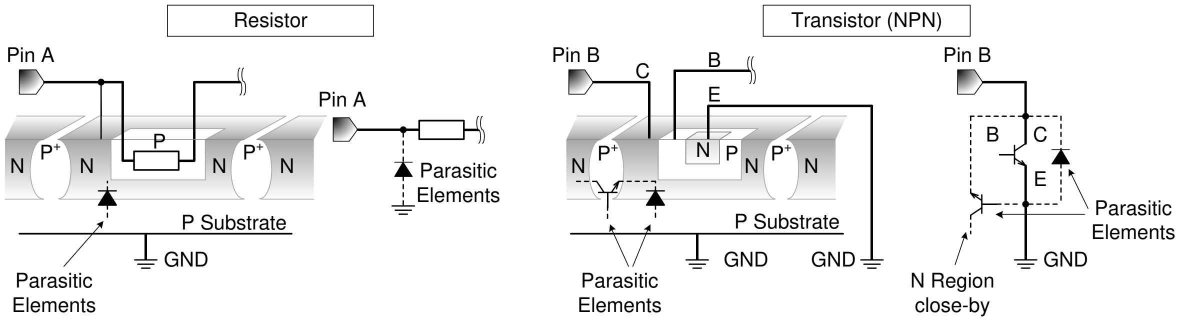


Figure 17. Example of Monolithic IC Structure

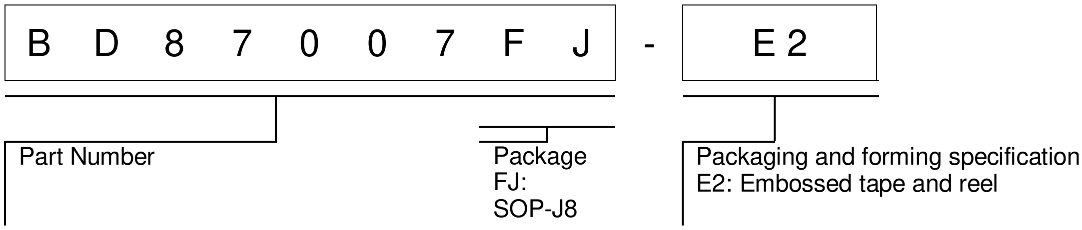
11. Ceramic Capacitor

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.

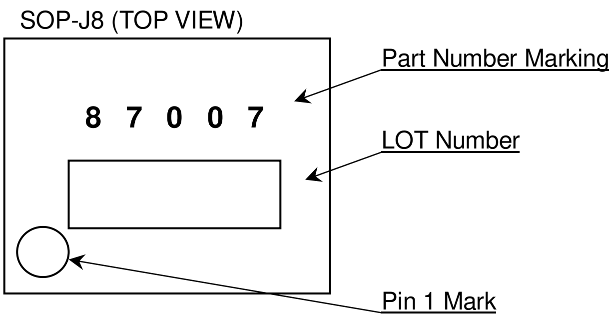
12. Thermal Shutdown Circuit (TSD)

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.

Ordering Information

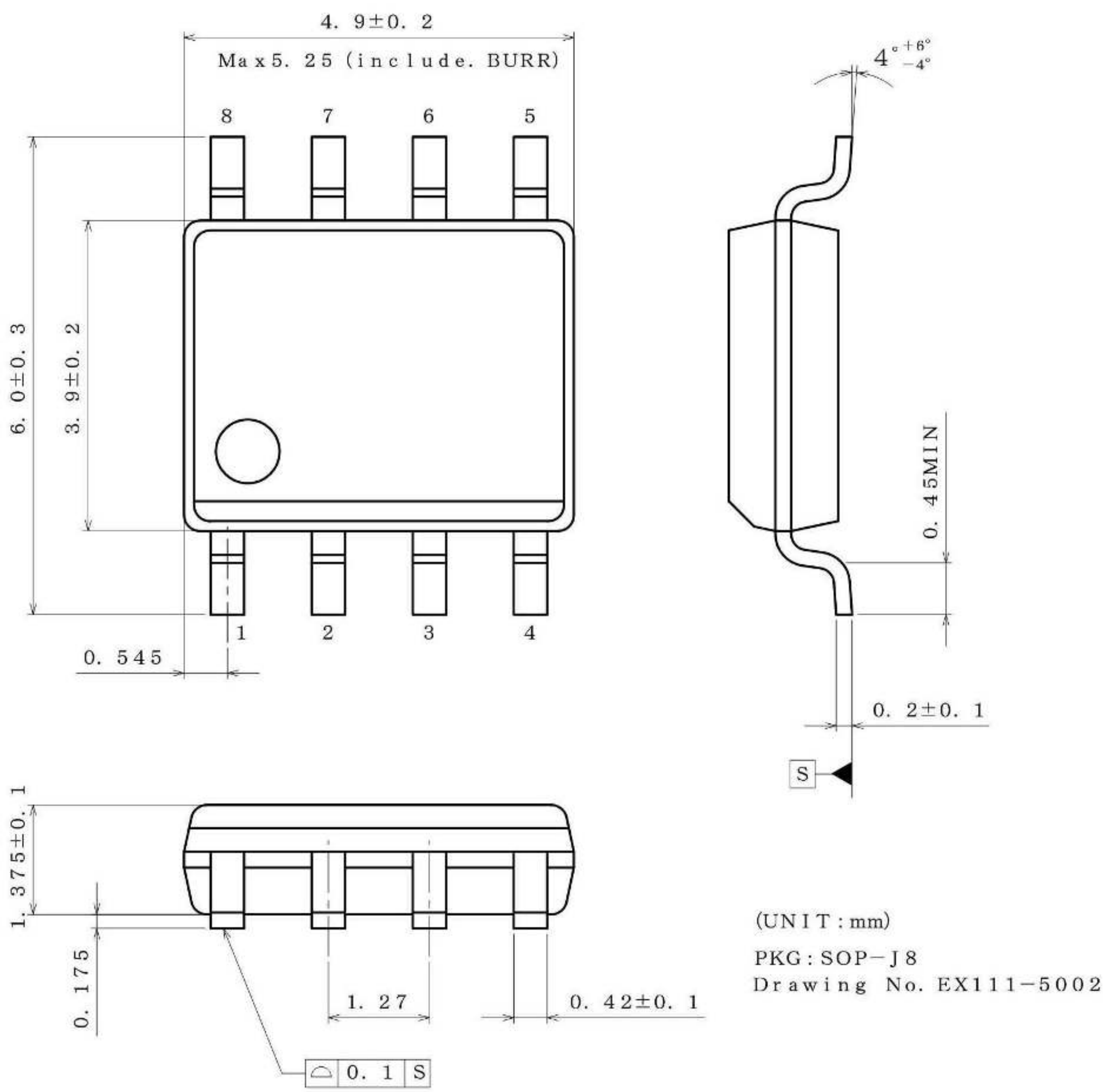


Marking Diagram



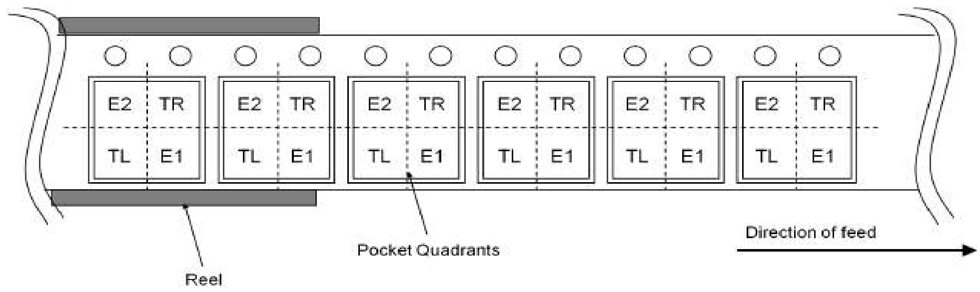
Physical Dimension and Packing Information

Package Name	SOP-J8



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin 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
11.Jul.2019	001	New Release

Notice

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1. 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
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. 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:
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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

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

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

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

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   - [b] the temperature or humidity exceeds those recommended by ROHM
   - [c] the Products are exposed to direct sunshine or condensation
   - [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

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

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

Precaution for Product Label

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

Precaution for Disposition

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

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.

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