

## Constant Current LED Drivers

# 50V 500mA

# 1ch Source Driver for Automotive

**BD8374HFP-M BD8374EFJ-M**

### General Description

BD8374HFP-M and BD8374EFJ-M are 50V-withstanding LED source drivers. Most suitably for Automotive LED driving, it can control light through PWM of constant current output.

Having LED open/short detective circuit and overvoltage mute functions integrated, it can deliver high reliability.

Also by utilizing our patented PBUS function, it is possible to turn OFF all LEDs in case where a row of LEDs are short/open-circuited if multiple rows of LEDs are driven through multiple number of the ICs.

### Key Specifications

- Input Voltage Range: 4.5V to 42V
- Max Output Current: 500mA (Max)
- Output Current Accuracy:  $\pm 5\%$  (Max)
- Operating Temperature Range: -40°C to +125°C

### Packages

HRP7  
 HTSOP-J8

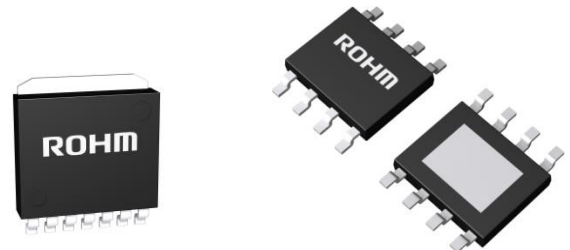
W(Typ) x D(Typ) x H(Max)  
 9.395mm x 10.540mm x 2.005mm  
 4.90mm x 6.00mm x 1.00mm

### Features

- AEC-Q100 Qualified
- Variable form Constant-Current Source Driver
- PWM Dimming Function
- CR Timer for PWM Dimming Function Integrated
- LED Open/Short detective Circuit Function Integrated
- Overvoltage Mute and Temperature Protection Functions Integrated
- Abnormal Output Detection and Output Functions (PBUS)

### Application

- On-board Exterior Lamp  
 (Rear Lamp, Turn Lamp, DRL/Position Lamp, Fog Lamp, etc.)
- On-board Interior Lamp  
 (Air Conditioner Lamp, Interior Lamp, Cluster Light, etc.)



HRP7

HTSOP-J8

### Basic Application Circuit

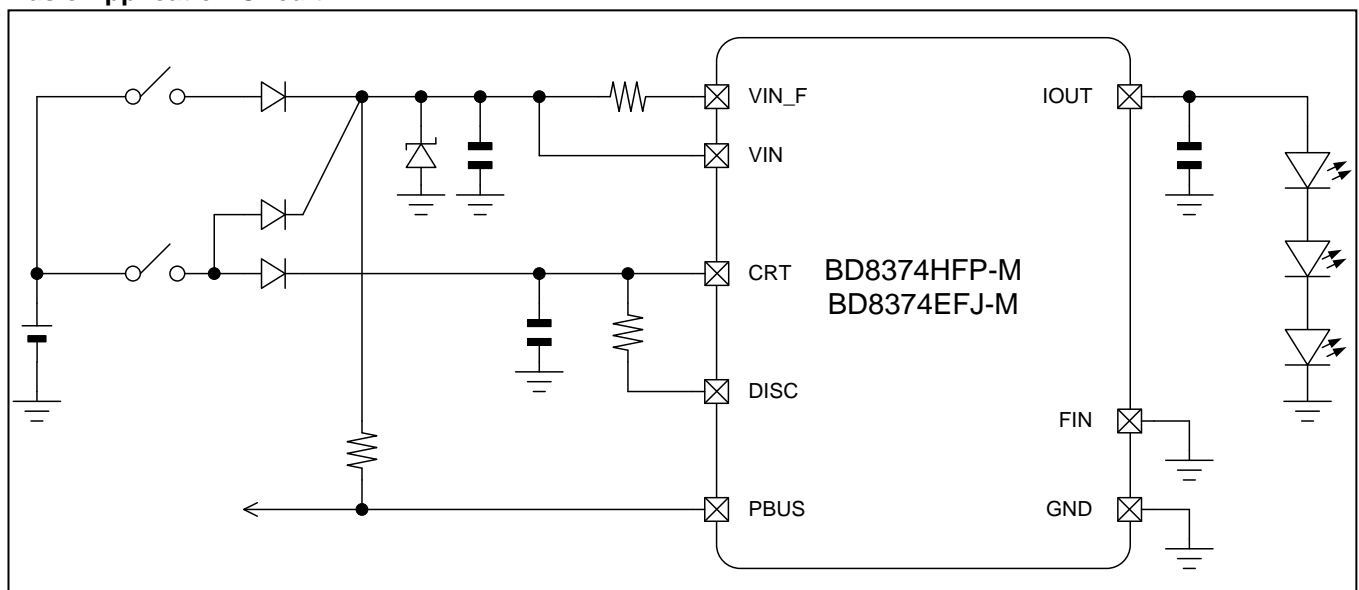


Figure 1. Typical Application Circuit

Pin Configurations

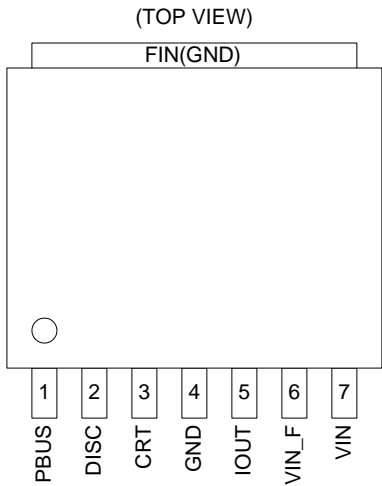


Figure 2. HRP7 Package Pin Configuration

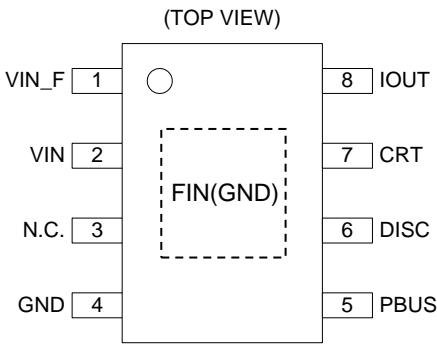


Figure 3. HTSOP-J8 Package Pin Configuration

Pin Descriptions

HRP7 Package

Pin No.	Pin Name	Function
1	PBUS	Error detection I/O
2	DISC	Discharge setting
3	CRT	PWM dimming timer setting
4	GND	GND
5	IOUT	Current output
6	VIN_F	Output current detection
7	VIN	Power supply input

HTSOP-J8 Package

Pin No.	Pin Name	Function
1	VIN_F	Output current detection
2	VIN	Power supply input
3	N.C.	N.C.
4	GND	GND
5	PBUS	Error detection I/O
6	DISC	Discharge setting
7	CRT	PWM dimming timer setting
8	IOUT	Current output

Block Diagram

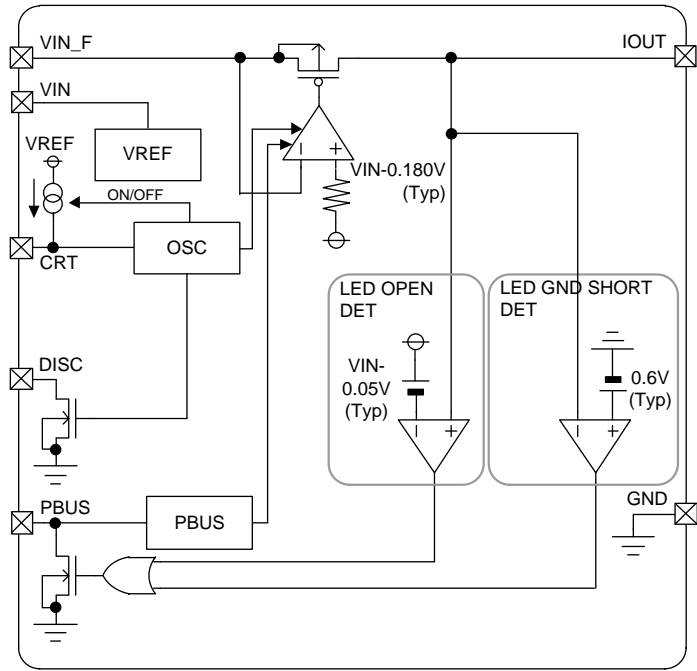


Figure 4. Block Diagram

## Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol		Rating	Unit
Supply Voltage	VIN		-0.3 ~ +50	V
VIN_F,CRT,DISC,IOUT,PBUS Terminal Voltage	VVIN_F,VCRT,VDISC,VIOUT,VPBUS		-0.3 ~ VIN+0.3	V
Power Dissipation	Pd	HRP7	2.3 <sup>(Note1)</sup>	W
		HTSOP-J8	1.1 <sup>(Note2)</sup>	
Operating Temperature Range	Topr		-40~125	°C
Storage Temperature Range	Tstg		-55~150	°C
Junction Temperature	Tjmax		150	°C
IOUT Output Maximum Current	IOUT		500	mA

(Note1) HRP7  
Derate by 18.4mW/°C when operating above Ta=25°C  
(when mounted in ROHM's standard board(70mm × 70mm × 1.6mm) 2 layer copper foil(15mm × 15mm)).

(Note2) HTSOP-J8  
Derate by 8.8mW/°C when operating above Ta=25°C  
(when mounted in ROHM's standard board(70mm × 70mm × 1.6mm) 2 layer copper foil(15mm × 15mm)).

**Caution:** 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.

## Recommended Operating Conditions

Parameter	Symbol	Rating	Unit
Supply Voltage <sup>(Note1)</sup>	VIN	4.5~42.0	V
Operating Temperature Range	Topr	-40~125	°C
Current Setting Resistor	RVIN_F	0.36~3.6	Ω
Minimum capacitor connecting IOUT terminal	CIOUT_MIN	0.1	μF
CRTIMER Frequency Range	FPWM	100~5000	Hz
PWM Minimum Pulse Width	TMIN	20	μs

(Note1) Pd, ASO should not be exceeded

**Electrical Characteristics**(Unless otherwise specified Ta=-40~125°C, VIN= 13V, RVIN\_F=0.47Ω, RPBUS=10kΩ)

Parameter	Symbol	Min	Typ	Max	UNIT	Condition
Circuit Current	IVIN	-	2.1	6.0	mA	
IOUT Terminal Output Current Accuracy	IOUT	373	383	393	mA	Ta=25°C
		364	383	402	mA	Ta=-40°C~125°C
VIN – IOUT Drop Voltage	VDR_IOUT	-	0.45	1.0	V	IOUT=383mA
IOUT Terminal OFF Current	IOUT_OFF	-	-	1	μA	VIOUT=2V, VCRT=0.7V Ta=25°C
IOUT Current at GND Short	IOUT_SHORT	-	-	40	μA	VIOUT=0V
VIN_F Terminal Voltage	VIN_F_REF	0.171	0.180	0.189	V	VIN_F_REF=VIN-VIN_F
IOUT Voltage at LED Open Detection	VIOUT_OPEN	VIN -0.15	VIN -0.050	VIN -0.020	V	
IOUT Voltage at LED Open Detection Release	VIOUT_OPEN_RELEASE	VIN -0.300	VIN -0.150	VIN -0.060	V	
IOUT Voltage at LED Short Detection	VIOUT_SHORT	0.2	0.6	1.0	V	
CRT Terminal Charge Current	ICRT_SO	29.75	35.00	40.25	μA	VCRT=0.9V
CRT Terminal Charge Voltage	VCRT_CHA	0.990	1.10	1.21	V	
CRT Terminal Discharge Voltage 1	VCRT_DIS1	2.7	3.0	3.3	V	
CRT Terminal Discharge Voltage 2	VCRT_DIS2	3.6	4.0	4.4	V	RD1<->RD2 <sup>(Note1)</sup>
CRT Terminal Charge Resistance	RCHA	51.6	54.3	57.0	kΩ	RCHA=(VCRT_DIS1 – VCRT_CHA) / ICRT_SO
DISC Terminal Discharge Resistance 1	RD1	-	50.0	100	Ω	VCRT=3.4V
DISC Terminal Discharge Resistance 2	RD2	2.5	5.0	10	kΩ	VCRT=5V
PBUS Terminal Input Voltage High	VIH_PBUS	4.0	-	VIN +0.20	V	
PBUS Terminal Input Voltage Low	VIL_PBUS	GND -0.20	-	2.0	V	
PBUS Terminal Low Voltage	VOL_PBUS	-	-	1.5	V	IPBUS=2mA
PBUS Terminal Input Current	IIN_PBUS	-	38.0	100	μA	VPBUS=13V
Overvoltage Mute	VIN_OVPMUTE	27	29	33	V	VIOUT=6V

(Note) This product is not designed for use in radioactive environments.

(Note1) Refer to Functional Description

**Typical Performance Curves (Reference Data)**

(Unless otherwise specified Ta=25°C, VIN=VIN\_F=13V)

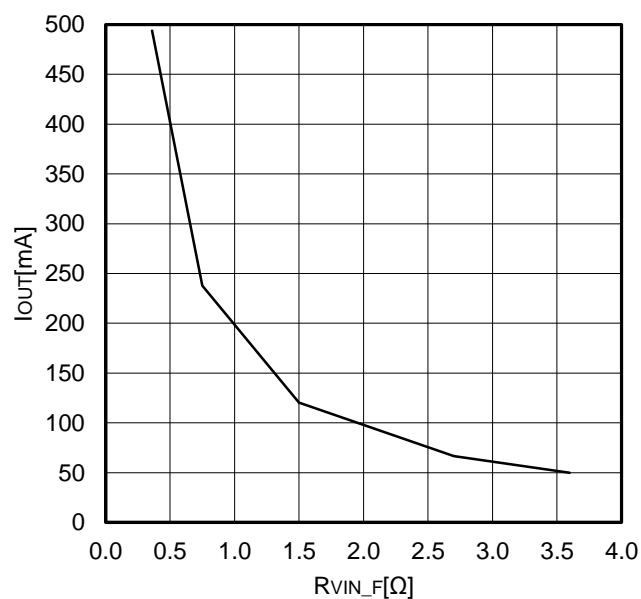


Figure 5. Rvin\_F vs Iout

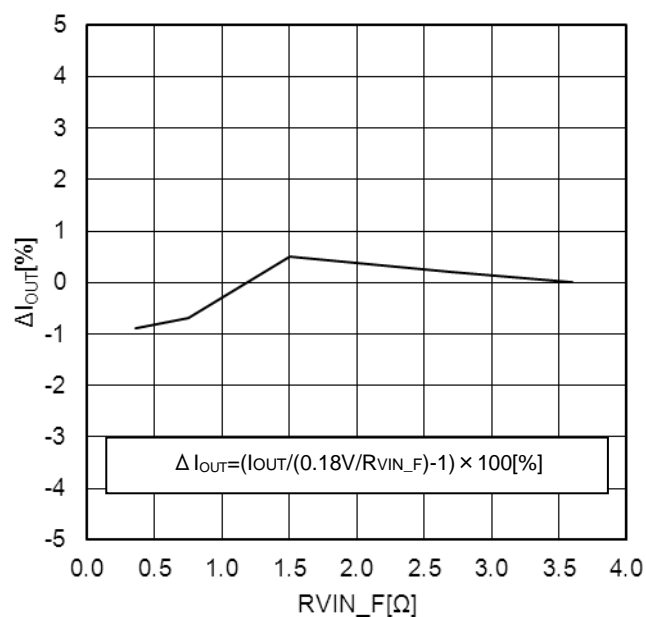


Figure 6. Rvin\_F vs ΔIout

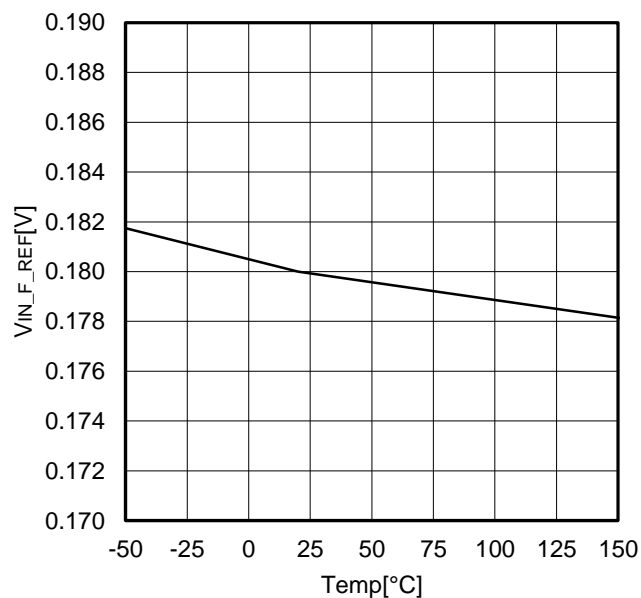


Figure 7. Temperature vs VIN\_F\_REF

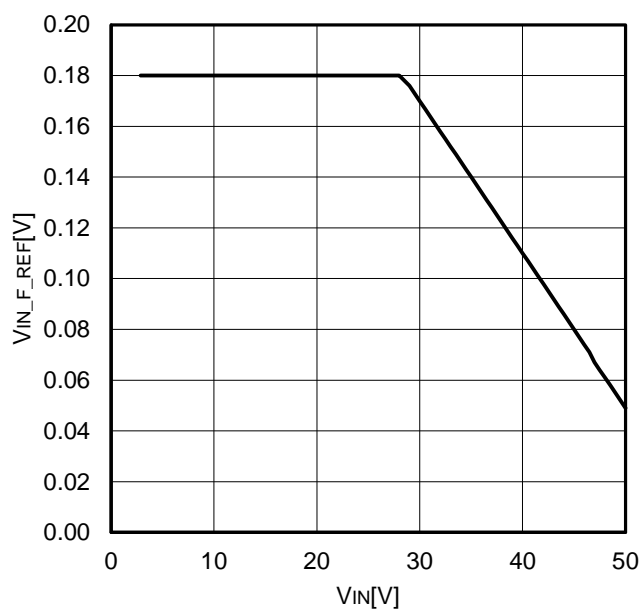


Figure 8. Vin vs VIN\_F\_REF

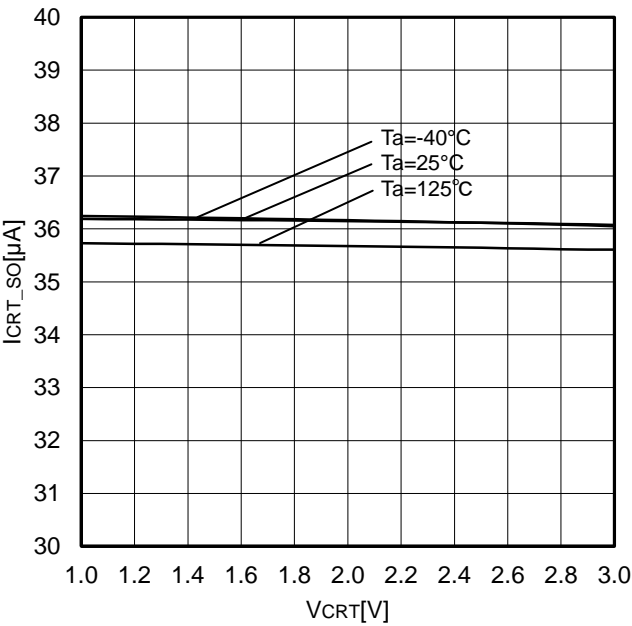


Figure 9.  $V_{CRT}$  vs  $I_{CRT\_SO}$   
( $V_{CRT}$ :CRT Terminal Voltage)

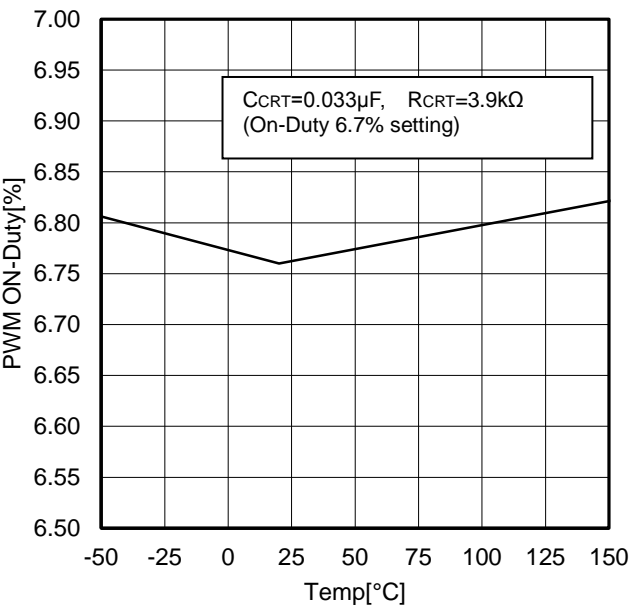


Figure 10. Temperature vs PWM ON Duty

## Functional Description

(Unless otherwise specified, Ta=25°C, VIN=13V, IOUT=6V and RVIN\_F=0.47Ω. Numbers are "Typical" values.)

### 1. Output Current Setting

LED Current IOUT can be set as below depending on values of current setting resistance RVIN\_F.

$$I_{OUT} = \frac{(V_{IN} - V_{IN\_F})}{R_{VIN\_F}} = \frac{V_{IN\_F\_REF}}{R_{VIN\_F}} [A]$$

where:

VIN\_F\_REF is 0.18V (Typ)

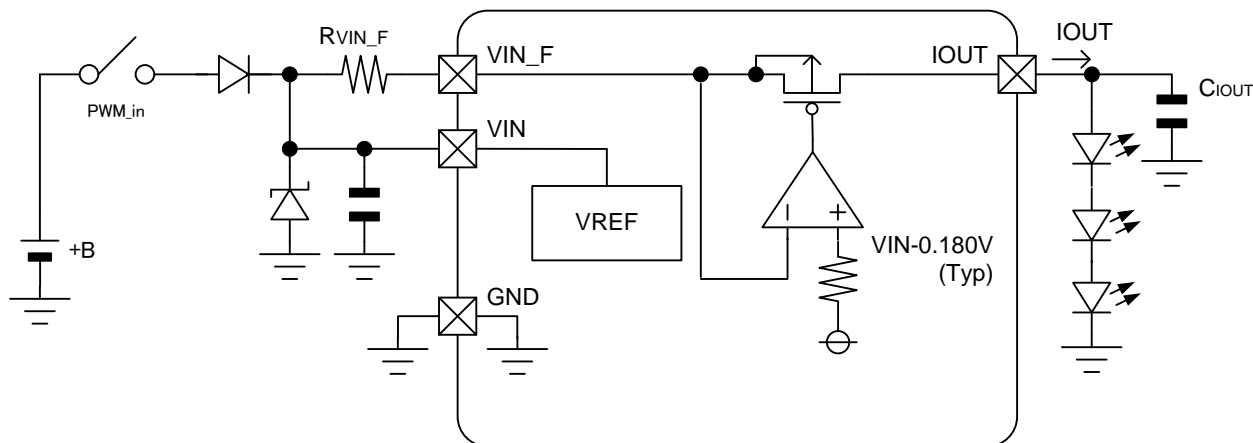


Figure 11. Output Current Setting

### 2. Table of Operations

PWM dimming mode switches to linear control depending on CRT terminal voltage.

When CRT terminal voltage surpasses VCRT\_DIS2(4.0V(Typ)), Dimming mode turns to Linear Control, and discharge resistance of DISC terminal changes from RD1(50Ω(Typ)) to RD2(5kΩ(Typ)).

LED open/short-circuit protection is activated depending on IOUT terminal voltage status, and output current is turned OFF. Output current is also turned OFF when Low signal is input to PBUS terminal.

Operation Mode	CRT Terminal	IOUT Terminal Voltage (VIOUT)	Output Current (IOUT)	PBUS Terminal
Linear Control	4.0V(Typ) ≤ VCRT	-	50mA ~ 500mA	Hi-Z
PWM dimming	See Features Description, 3. PWM Dimming Operation	-	See Features Description, 3. PWM Dimming Operation	Hi-Z
LED Open	-	VIOUT ≥ VIN - 0.050V(Typ)	1μA(Max)	Low Output
LED Short	-	VIOUT ≤ 0.6V(Typ)	40μA(Max)	Low Output
PBUS Control OFF	-	-	1μA(Max)	Low Input

### 3. PWM Dimming Operation

PWM Dimming is performed if CRT terminal is the following circuit.

Dimming cycle and Duty width can be set through external resistance value and capacity.

CR timer function in IC is activated if DC\_in OPEN. In order to perform PWM light control of LED current, triangular waveform is generated at CRT terminal. Output is controlled so that **LED current is turned OFF** while CRT voltage is ramping up, and **LED current is turned ON** while CRT voltage is ramping down.

Ramp up/down time of CRT voltage can be set by values of external components (**CCRT**, **RCRT**).

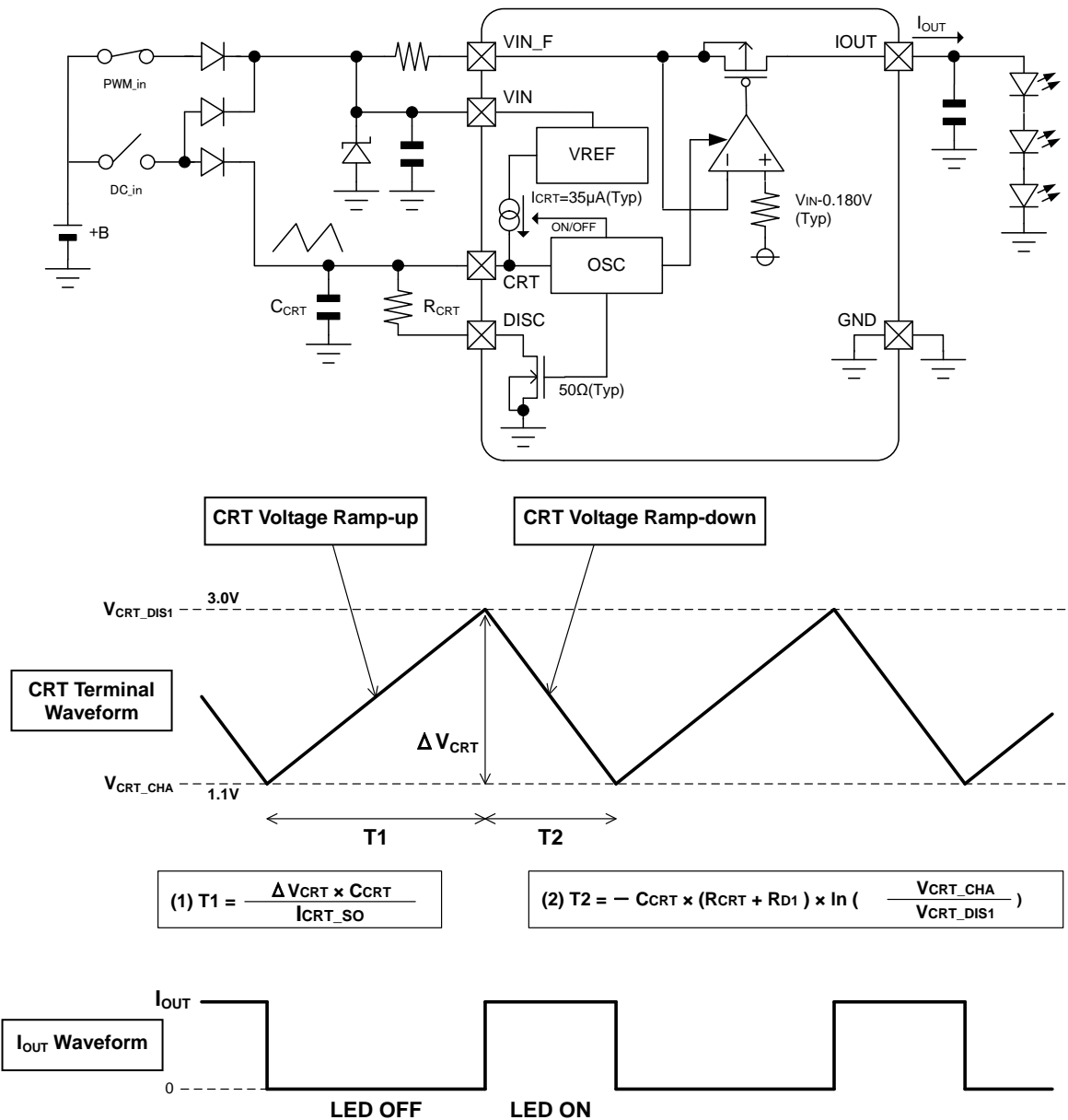


Figure 12. PWM Fimming Operation

#### (1) CRT Ramp up Time T1

CRT ramp up time can be obtained from the following equations:

$$T1 = \frac{\Delta V_{CRT} \times C_{CRT}}{I_{CRT\_SO}} = R_{CHA} \times C_{CRT} [s]$$

where:

I\_CRT\_SO is the CRT Terminal Charge Current 35μA (Typ)

R\_CHA is the CRT Terminal Charge Resistance 54.3kΩ(Typ)



## (2) CRT Ramp down Time T2

CRT ramp down time is defined by discharge period due to external capacity  $C_{CRT}$  and resistance ( $R_{CRT} + R_{D1}$ ).  
(CRT Terminal Charge Current is OFF at CRT ramp down)

Make sure that T2 is set at not smaller than Min. pulse width 20 $\mu$ s(Min).

$$T2 = -C_{CRT} \times (R_{CRT} + R_{D1}) \times \ln \left( \frac{V_{CRT\_CHA}}{V_{CRT\_DIS1}} \right) \quad [s]$$

where:

$R_{D1}$  is the CRT Terminal Discharge Resistance 1      50 $\Omega$  (Typ)

$V_{CRT\_CHA}$  is the CRT Terminal Discharge ON Voltage 1.1V (Typ)

$V_{CRT\_DIS1}$  is the CRT Terminal Discharge ON Voltage 3.0V (Typ)

(3) Dimming Frequency  $f_{PWM}$ 

PWM frequency is defined by T1 and T2.

$$f_{PWM} = \frac{1}{T1 + T2} \quad [Hz]$$

## (4) ON Duty (DON)

Like the above, PWM ON duty is defined by T1 and T2.

$$DON = \frac{T2}{T1 + T2}$$

(Ex) In case of  $f_{PWM} = 518Hz$  and 6.7% Duty (Typ),

From  $f_{PWM} = 518Hz$ ;  $T1 + T2 = 1 / f_{PWM} = 1 / 518Hz = 1931\mu s$

From ON Duty = 6.7%; CRT ramp up time T1 is  $T1 = (T1 + T2) \times 0.933 = 1801.6\mu s$

External capacity  $C_{CRT}$  is;

$$C_{CRT} = T1 \times (I_{CRT} / \Delta V_{CRT}) = 1801.6\mu s \times 35\mu A / 1.9V \approx \underline{\underline{0.033\mu F}}$$

CRT ramp down time T2 is;  $T2 = (T1 + T2) \times 0.067 = 129\mu s$

External resistance  $R_{CRT}$  is;

$$R_{CRT} = -T2 / (C_{CRT} \times \ln(V_{CRT\_CHA} / V_{CRT\_DIS1})) - R_{D1} = -129\mu sec / (0.033\mu F \times \ln(1.1 / 3.0)) - 50\Omega \approx \underline{\underline{3.9k\Omega}}$$

In case where PWM signal is applied from external;

It is possible to directly input PWM signal from external microcomputer for Dimming.

Input PWM signal to CRT terminal. In that case, 'High' level voltage of PWM signal should be equal to or higher than  $V_{CRT\_DIS2}(4.4V(Max))$  and 'Low' level voltage of PWM signal should be equal to or less than  $V_{CRT\_CHA}(0.99V(Min))$ .

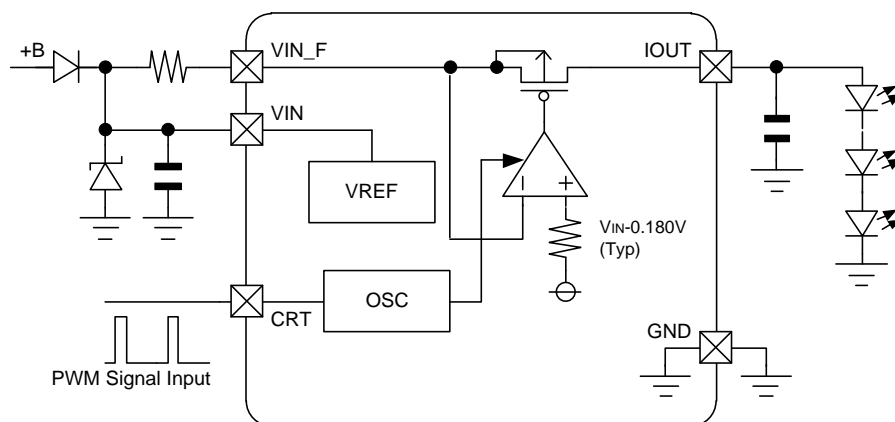


Figure 13. External Input of PWM Signal

## 4. LED Setting Range

Number of LED connections N should meet the following conditions:

$$V_{f\_led} \times N \leq +B - V_{f\_diode} - V_{IN\_F\_REF} - V_{DR\_IOUT}$$

where:

+B is the Battery Voltage

$V_{f\_diode}$  is the Reverse Connection Preventing Diode  $V_f$

$V_{IN\_F\_REF}$  is the  $V_{IN\_F}$  Terminal Voltage ( $V_{IN} - V_{IN\_F}$ )

$V_{DR\_IOUT}$  is the IOUT Terminal Drop Voltage

$V_{f\_led}$  is the LED  $V_f$

N is the Number of LED Levels

Ex) If you want to supply constant current to LED at 9V or higher Battery Voltage (+B) (Supposing that  $V_{f\_diode}$  is 0.5V),

$$V_{f\_led} \times N \leq +B - V_{f\_diode} - V_{IN\_F\_REF} - V_{DR\_IOUT} = 9V - 0.5V - 0.189V(\text{Max}) - 1.0V(\text{Max}) = 7.311V$$

(Sum of  $V_f$  of LED connected to IOUT terminal is set to be 7.311V Max.)

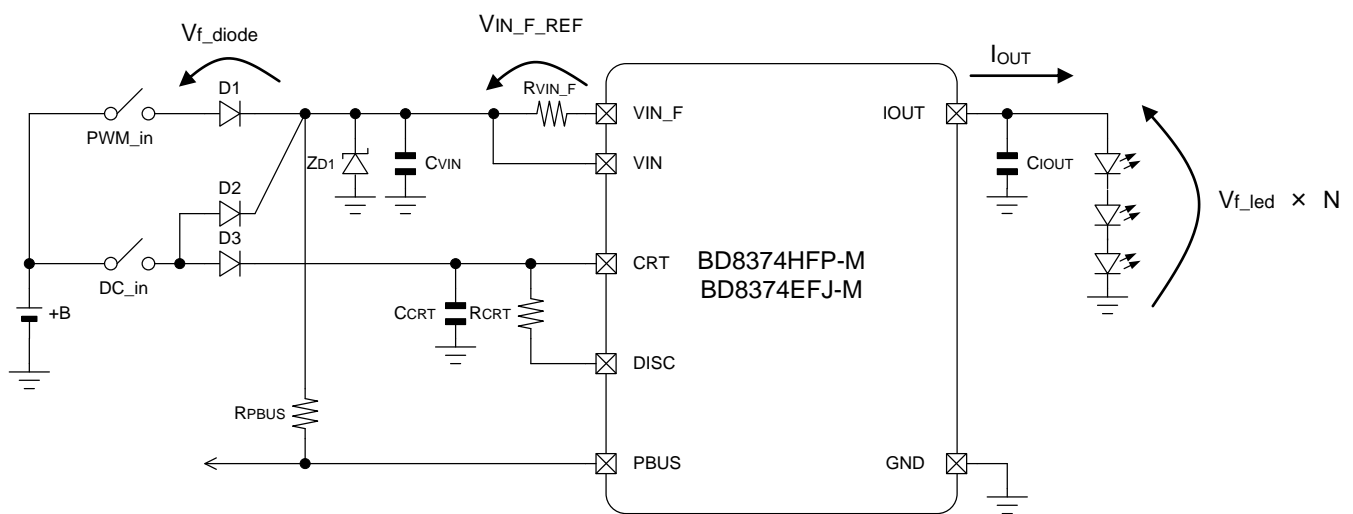


Figure 14. LED Setting Range Schematic

## 5. Overvoltage Mute

If  $29V (\text{Typ}) \leq V_{IN}$ , Overvoltage Mute is activated to restrict output current in order to suppress heat generated from IC.  $I_{OUT}$  attenuates by  $3.2\%/V(\text{Typ})$ .

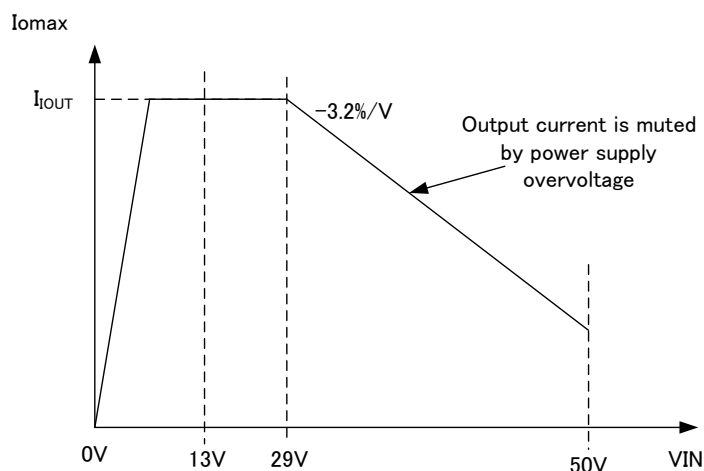


Figure 15. Overvoltage Mute Performance

## 6. Protective Function

In this IC integrated is a function for protection from short/open-circuit of external component, and it is possible to detect abnormal condition at PBUS terminal.

### (1) LED Open Detective Function

In case where LED connected to IOOUT terminal is open-circuited, it is detected due to overvoltage of IOOUT terminal. During the detection, PBUS terminal is switched to Low to notify the trouble.

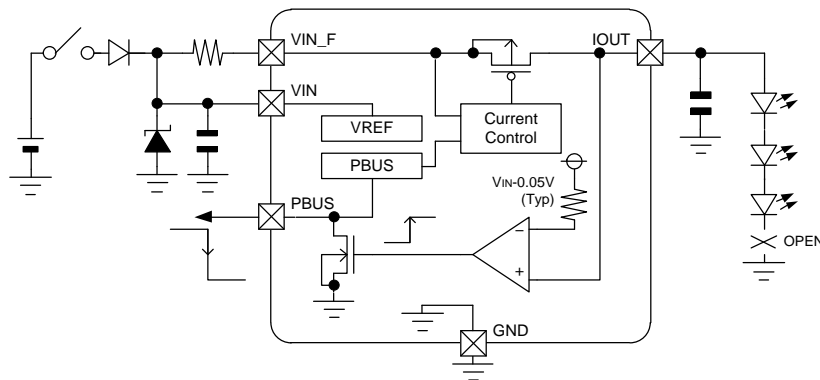


Figure 16. LED Open Detection

## (2) LED Short-circuit Detective Function

In case where LED connected to IOUT terminal is short-circuited, it is detected due to low voltage of IOUT terminal. During the detection, output current is turned OFF to prevent thermal destruction of IC, and PBUS terminal is switched to Low to notify the trouble.

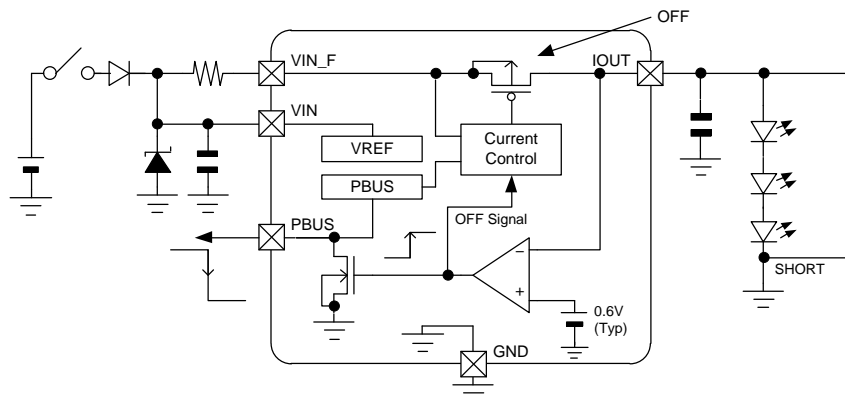


Figure 17. LED Short-circuit Detection

### (3) IOOUT Current at GND Short (I<sub>IOOUT\_SHORT</sub>)

When VIOUT is less than 1.4V(Typ), IOUT Current at GND Short(IOUT\_SHORT) flows from IOUT terminal. It is varied due to IOUT terminal Voltage.

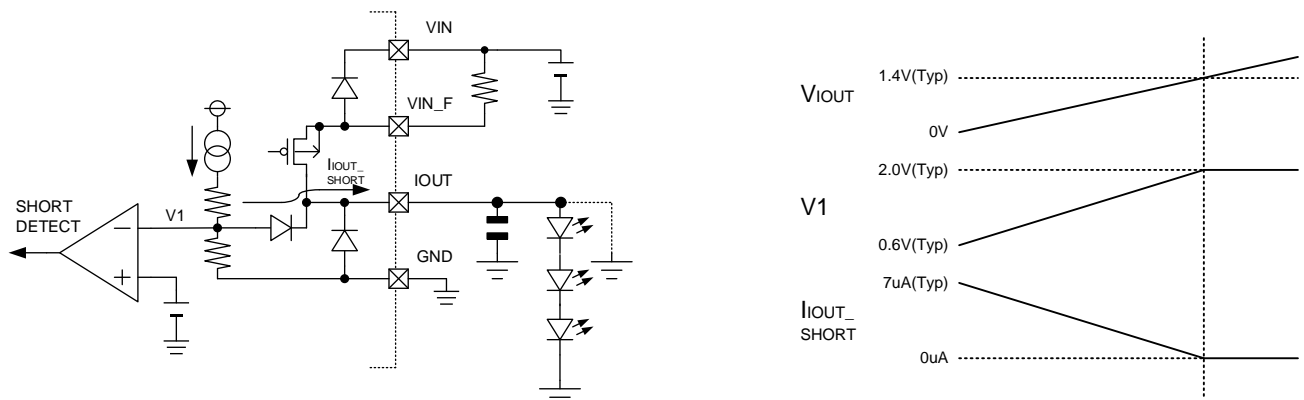


Figure 18. About IO<sub>UT</sub> Current at GND Short

## (4) About Active zone of LED Open Detective &amp; LED Short Detective Function and IOUT Terminal Hi-Z zone

Active zone of LED Open Detective & LED Short Circuit Detective Function is different from Linear Control Mode and PWM dimming Mode.(Refer to Figure19.)

Linear Control Mode : Each function is active at All zone.

PWM dimming Mode : LED Open Detective Function is active only Fall time of VCRT.  
LED Short Circuit Detective Function is active at All zone.

There is **IOUT Terminal Hi-Z zone at PWM dimming Mode.**

To prevent Malfunction of LED Short Detective Function by noise<sup>(Note1)</sup>,

**It is necessary to connect Capacitor(more than 0.1 $\mu$ F<sup>(Note2)</sup>)**

**between IOUT terminal and GND terminal nearby terminal**

**(ROHM Recommended Value : C<sub>IOUT</sub>=0.1 $\mu$ F GCM188R11H104KA42 murata)**

(Note1) Conducted noise, Radiated noise, Interference of connector and PCB pattern etc...

(Note2) If connect more than 0.1 $\mu$ F, please evaluate the time of V<sub>IN</sub> on to I<sub>OUT</sub> on.

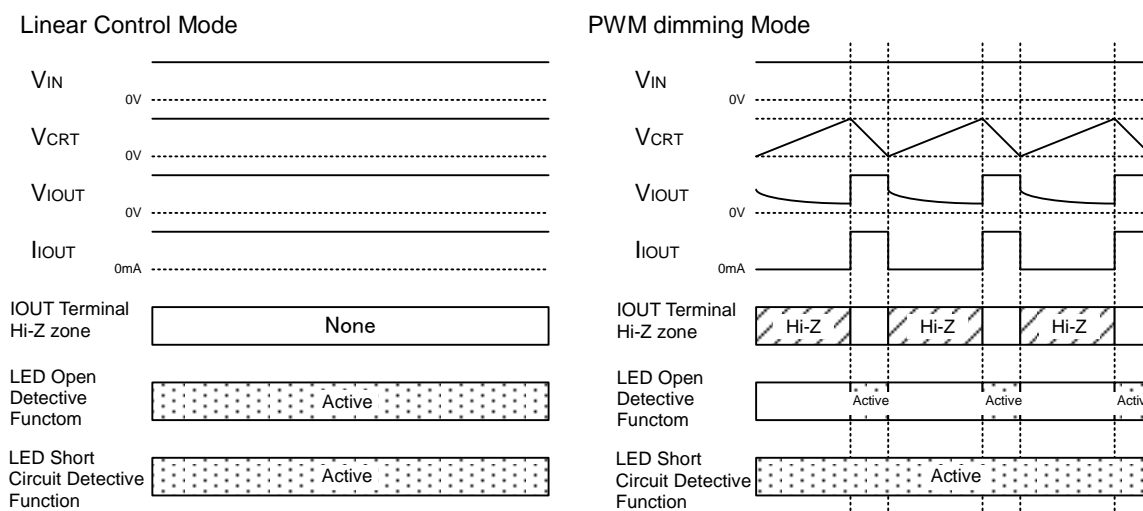


Figure 19. About Active zone of LED Open Detective & LED Short Detective Function and IOUT Terminal Hi-Z zone

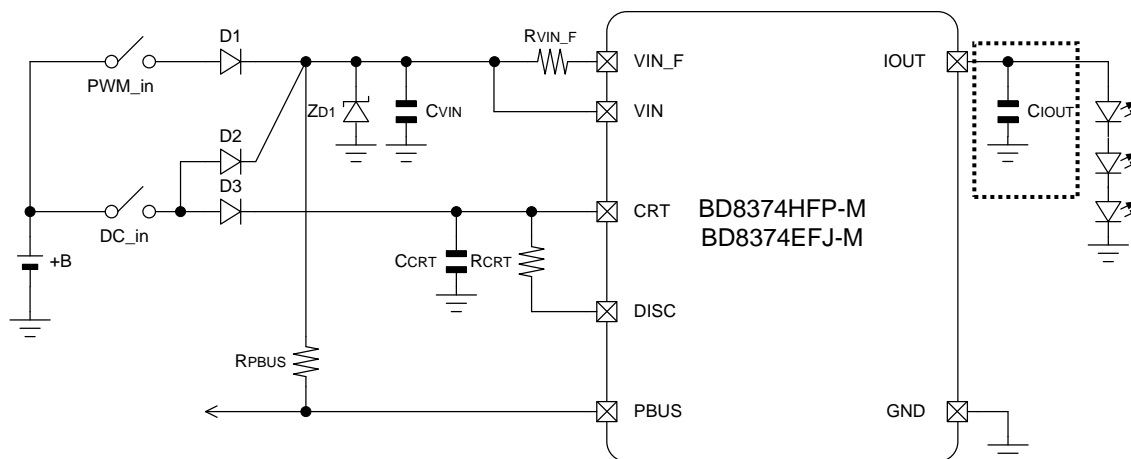
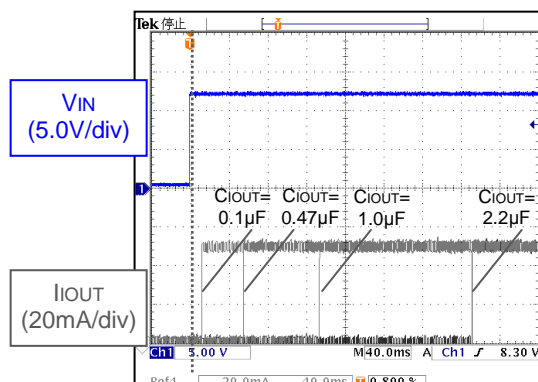


Figure 20. About the capacitor of connecting IOUT terminal

## Evaluation example(The time of VIN on to IOUT on)

Condition : +B=13V  
 Ta=25°C  
 LED 3Strings  
 VCRT=VIN  
 DC Mode

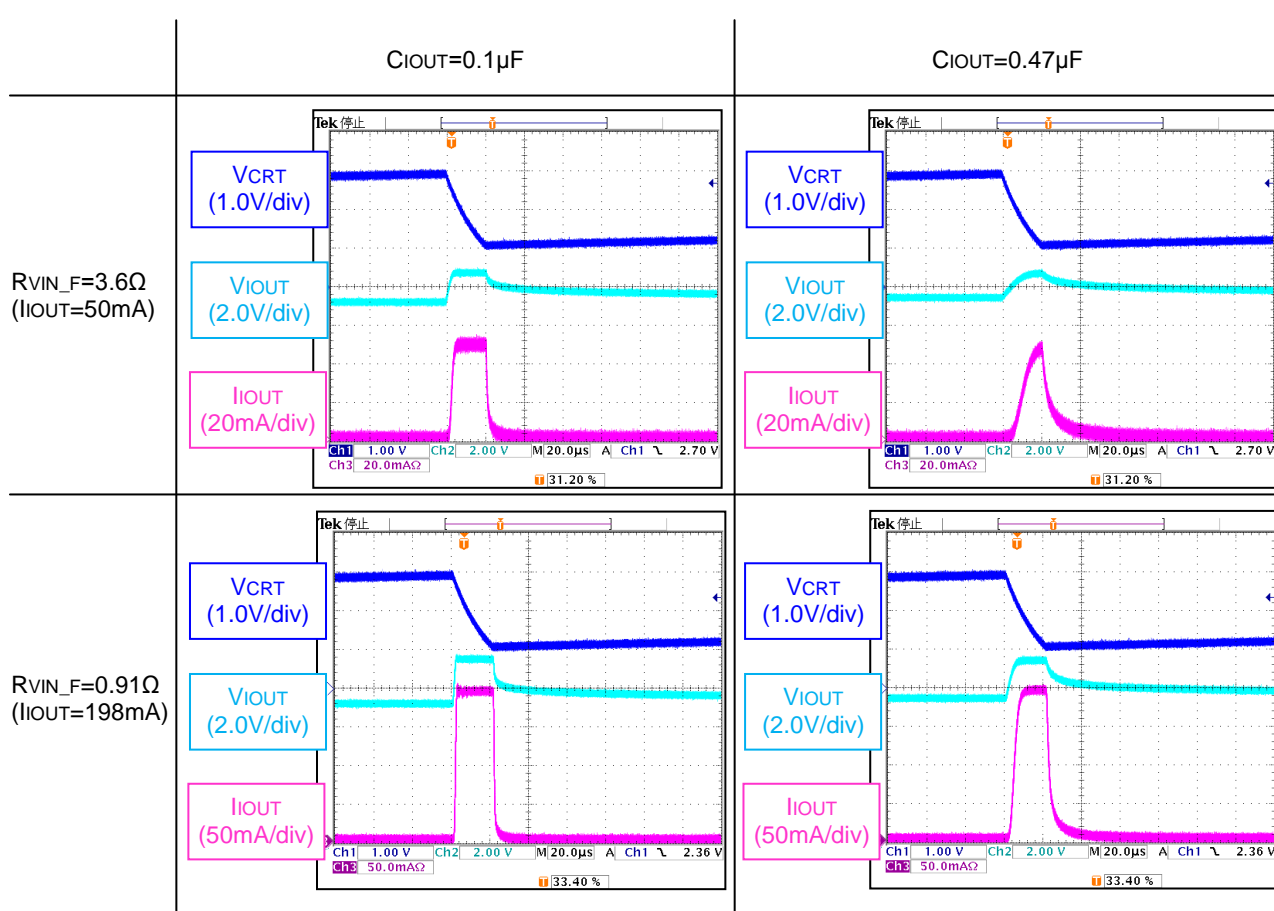


The time of VIN on to IOUT on

CIOUT=0.1μF : 11ms  
 CIOUT=0.47μF : 51ms  
 CIOUT=1.0μF : 130ms  
 CIOUT=2.2μF : 290ms

## Evaluation example(IOUT pulse width at PWM Dimming operation)

Condition : +B=13V  
 Ta=25°C  
 LED 3Strings  
 RCRT=560Ω  
 CCRT=0.033μF  
 PWM Dimming Mode



## 7. PBUS Function

PBUS terminal is an input/output terminal for outputting trouble and inputting trouble detection.

In case where a trouble occurred due to open/short-circuit of external component, it is possible to notify the trouble outside by switching PBUS terminal output from High<sup>(Note1)</sup> to Low.

It is possible to turn OFF output current by externally controlling PBUS from High→Low.

(Note1) PBUS terminal is an open drain terminal. Even when used separately, please be pulled up(10kΩ) to power supply voltage.

In case where you use multiple number of this LSI to drive multiple LEDs, as shown in the drawing below, it is possible to turn off all rows of LEDs even if some LEDs are short/open-circuited by connecting PBUS terminal of each CH.

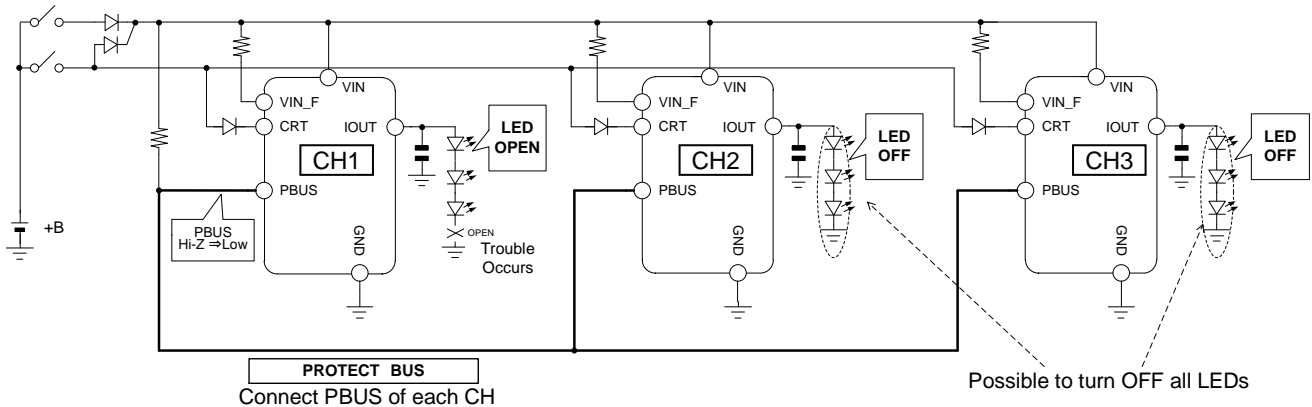


Figure 21. PBUS Function

▼Example of Protective Operation by LED Open

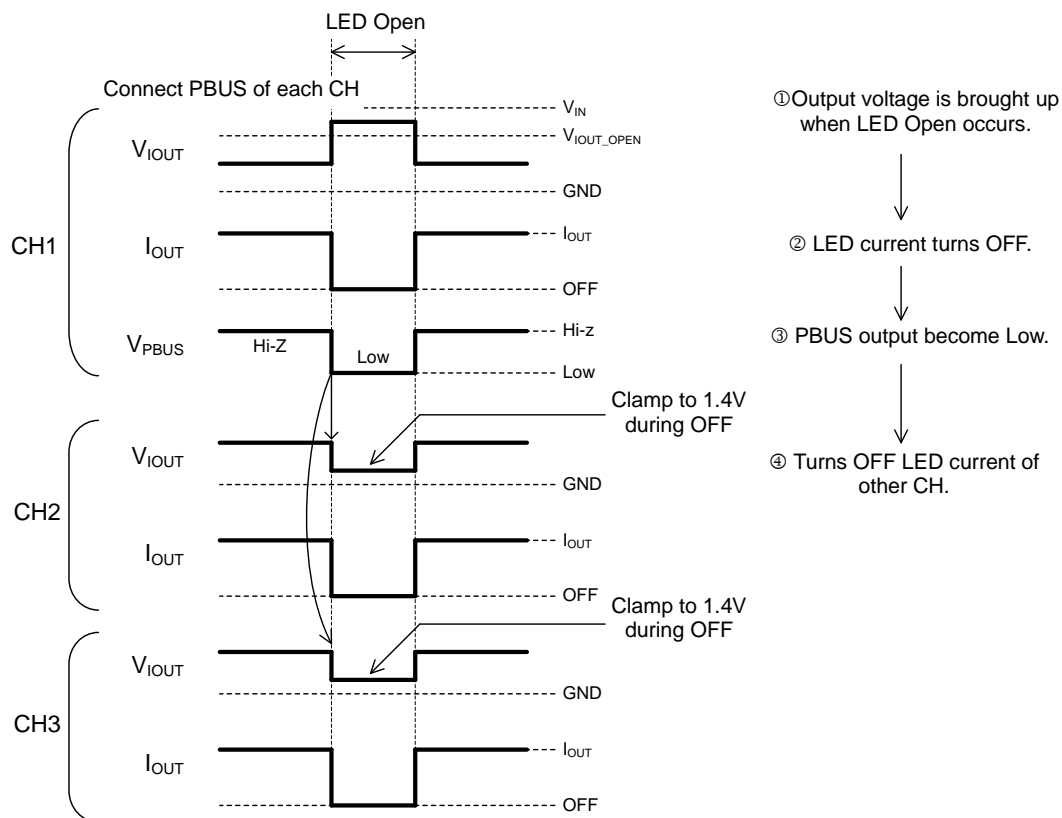


Figure 22. Example of Protective Operation

If LED OPEN occurs, PBUS of CH1 is switched from Hi-z to Low output. As PBUS becomes Low, LED drivers of other CH detect the trouble and turns OFF their own LEDs. V<sub>IOUT</sub> clamps to 1.4V (Typ) during the OFF period, in order to prohibit ground fault detection.

## 8. Caution of driving IC used multi-power supply

Each Input terminal is built-in ESD protection diodes. (Refer to I/O equivalence circuits)

**If VIN terminal is not supplied voltage and Input terminal (without VIN) is supplied voltage, IC may occur malfunction(abnormal operation mode, abnormal LED lighting) due to arise VIN terminal voltage .**

The Application Example of accidental operation is below.

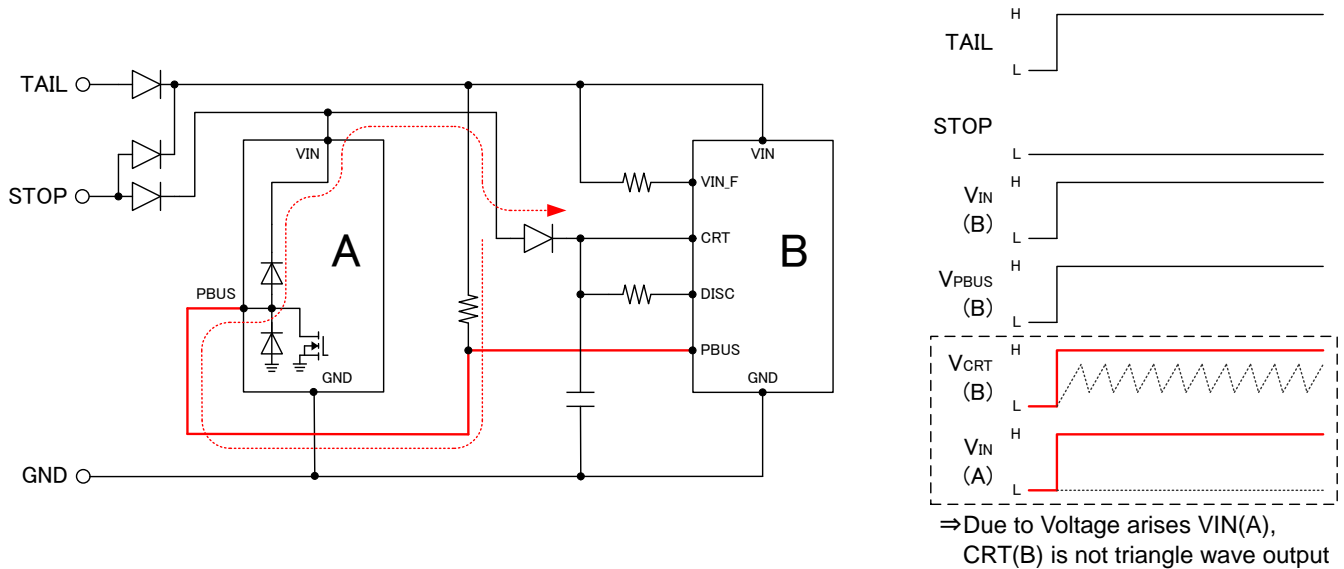


Figure 23. Application Example

(Operational Explanation)

Only input Tail : Arise VIN terminal voltage of IC A from ESD protection Diode between VIN terminal and PBUS terminal of IC A.  
Due to connect VIN terminal of IC A and CRT terminal of IC B across Diode, DC voltage inputs CRT terminal of IC B, so it is possible to operate ICB DC mode.

## Timing Chart

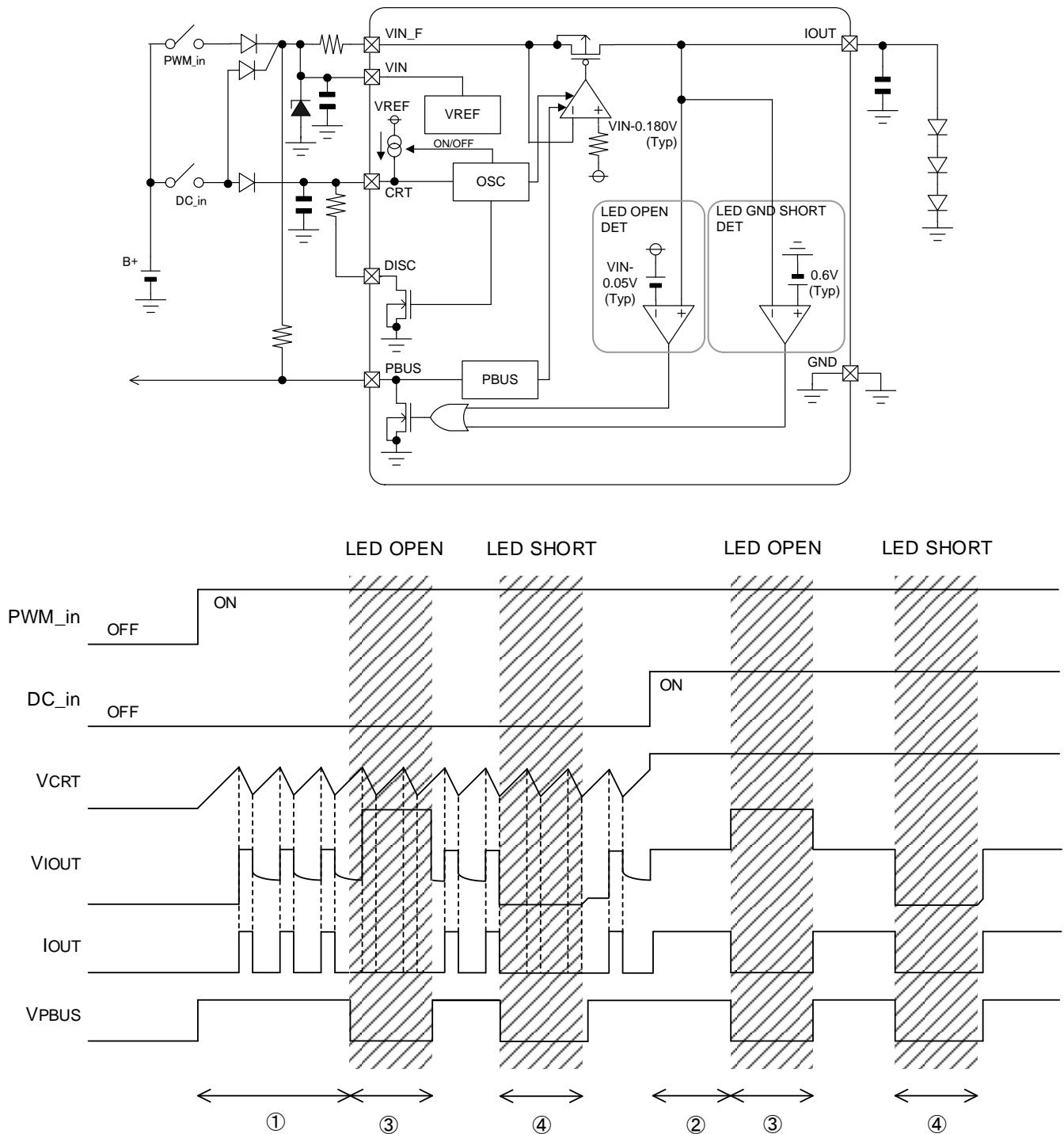


Figure 24. Timing Chart

- ① If PWM\_in is switched ON, VCRT will start oscillation, and according to its waveform LED current IOUT is output. (PWM light control mode)
- ② If DC\_in is switched ON, VCRT will be fixed at High ( $V_{IN}-V_f$ ). LED current IOUT will be continuously output. (Linear control mode)
- ③ If LED becomes OPEN, LED current IOUT will stop. At the same time, VPBUS falls to Low.
- ④ If LED is short-circuited to GND, LED current IOUT will stop. At the same time, VPBUS falls to Low.



## Guaranteed Range of Current Accuracy and LED Open Detection Range

Guaranteed range of current accuracy and LED open detection range can be obtained from the following equation:

PBUS output becomes Low if IOUT terminal output ( $V_{IOUT}$ ) is higher than the LED open detection range at the time of reduced  $V_{IN}$  terminal voltage.

Therefore, pay attention to respective setting range during power ON/OFF, and consider operating voltage range of the set.

Guaranteed Range of Current Accuracy

$$V_{IN} \geq V_{f\_led} \times N + V_{IN\_F\_REF} + V_{DR\_IOUT} [V]$$

Where:

$V_{IN}$  is the  $V_{IN}$  Terminal Voltage

$V_{f\_led}$  is the LED  $V_f$

$N$  is the: Number of LED Levels

$V_{IN\_F\_REF}$  is the  $V_{IN\_F}$  Terminal Voltage ( $V_{IN} - V_{IN\_F}$ )

$V_{DR\_IOUT}$  is the IOUT Terminal Drop Voltage

LED Open Detection Voltage

$$V_{IOUT} = V_{IN} - 50mV(Typ)$$

LED Open Detection Release Voltage

$$V_{IOUT} = V_{IN} - 150mV(Typ)$$

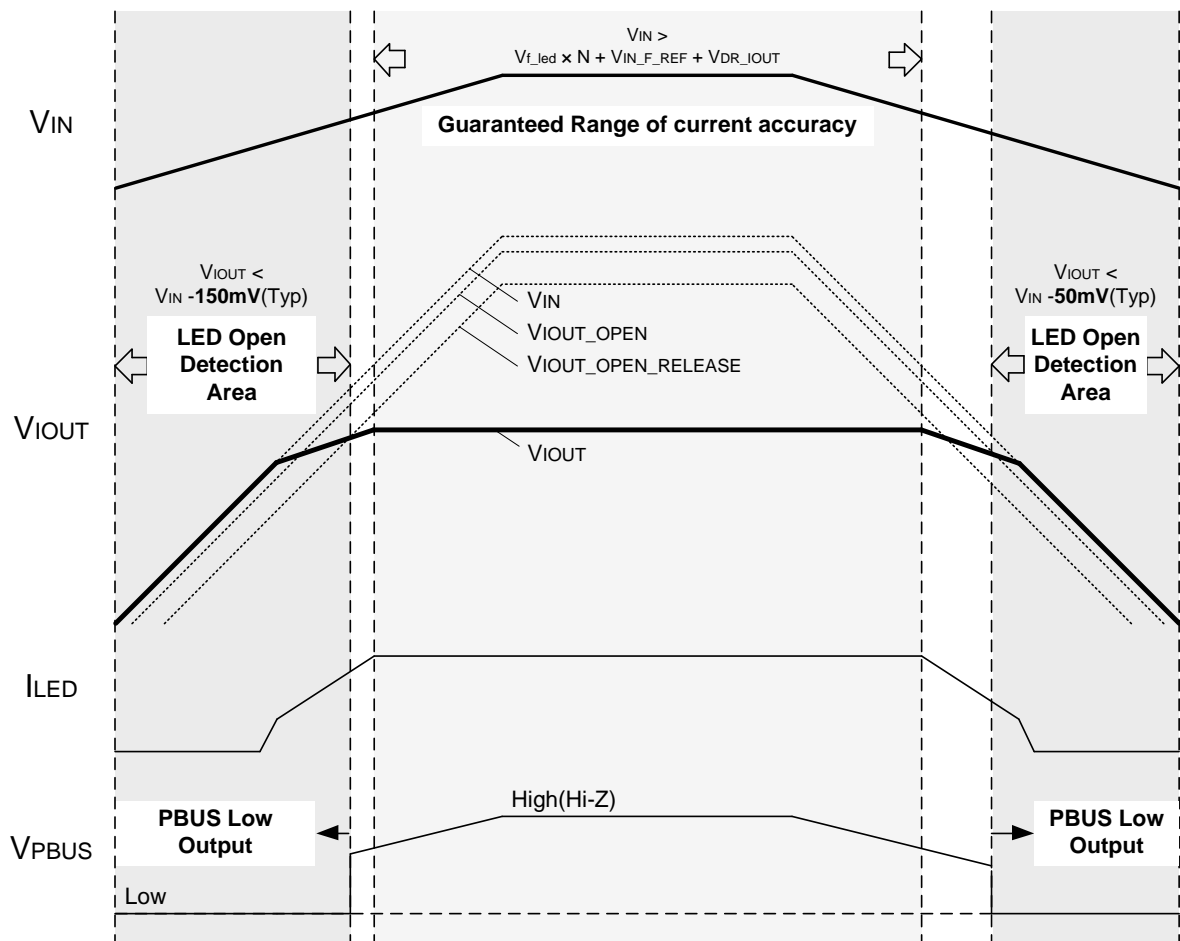


Figure 25. Guaranteed Range of Current Accuracy and LED Open Detection Range

How to Connect LED

In case of connected LED to IOOUT terminal as shown in the following, note that protective detection becomes possible/impossible depending on connection patterns.

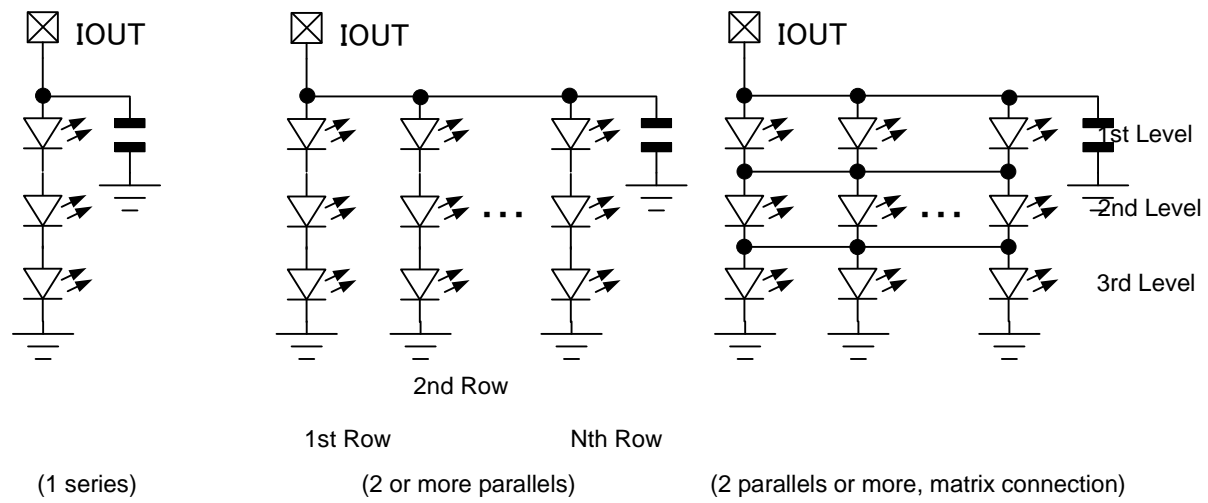


Figure 26. LED Connection Patterns

Connection Pattern	LED Short-circuit Detection (GND short of IOOUT terminal)	LED OPEN detection
1 Series	Detectable	Detectable-
2 parallels or more	Detectable	Non-detectable <sup>(Note 1)</sup>
2 parallels or more (Matrix Connection)	Detectable	Non-detectable <sup>(Note 2)</sup>

(Note1) : Detectable only when one or more LEDs become open in all rows.

(Note2) : Detectable only when all LEDs on the same level become open.

Recommended Application Circuit

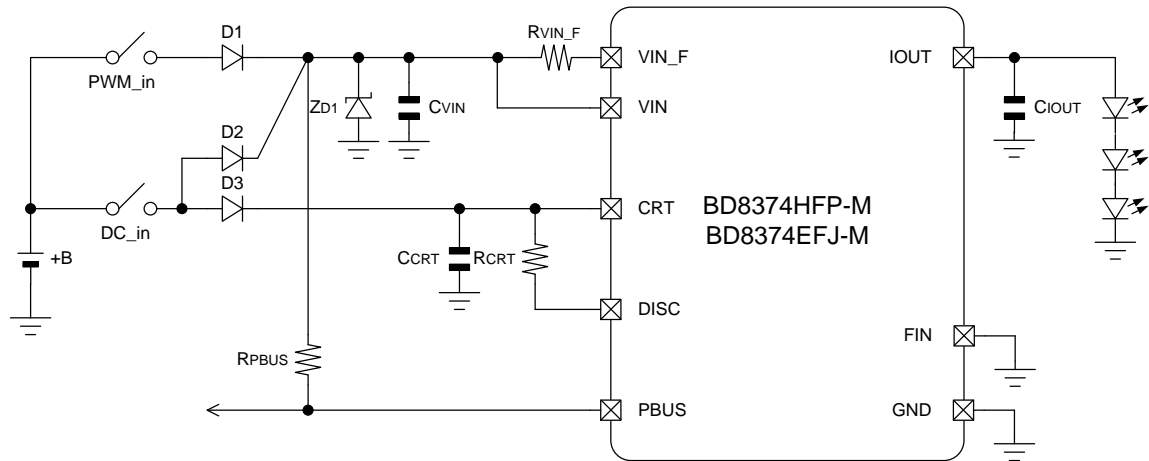


Figure 27. Recommended Application Circuit

▼ Corresponding EMC Test Items

- ISO11425-2
- ISO11452-4
- ISO7637-2  
(pulse1, pulse 2a,2b, pulse 3a,3b)

No.	Component Name	Component Value	Product Name	Company
1	D1	-	RFN1L6S	ROHM
2	D2	-	RFN1L6S	ROHM
3	D3	-	RFN1L6S	ROHM
4	Z <sub>D1</sub>	-	TNR12H-220K	NIPPON CHEMICON
5	C <sub>VIN</sub>	4.7μF	GCM32ER71H475KA40	murata
6	R <sub>VIN_F</sub>	0.91Ω	MCR10 Series	ROHM
7	R <sub>PBUS</sub>	10kΩ	MCR03 Series	ROHM
8	C <sub>CRT</sub>	0.033μF	GCM188R11H333KA40	murata
9	R <sub>CRT</sub>	3.9kΩ	MCR03 Series	ROHM
10	C <sub>IOUT</sub>	0.1μF	GCM188R11H104KA42	murata

Table 1. BOM List

PWM_in	DC_in	Mode
Low	Low	OFF
High	Low	PWM Dimming Mode <sup>(Note1,Note2)</sup> (13.25mA 6.7% ON duty@518Hz)
Low	High	Linear Control Mode <sup>(Note2)</sup> (197.8mA 100% ON duty)
High	High	Linear Control Mode <sup>(Note2)</sup> (197.8mA 100% ON duty)

(Note1) See Functional Description "3. PWM Dimming Operation."  
(Note2) See Functional Description "2. Table of Operations."

Table 2. Table of Operations

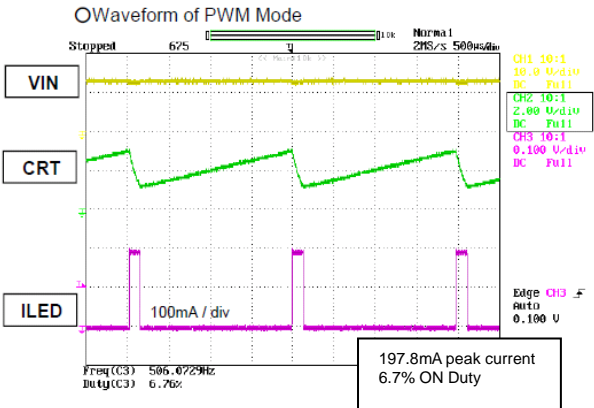


Figure 28. Example of Waveform Measurement

## Thermal Loss

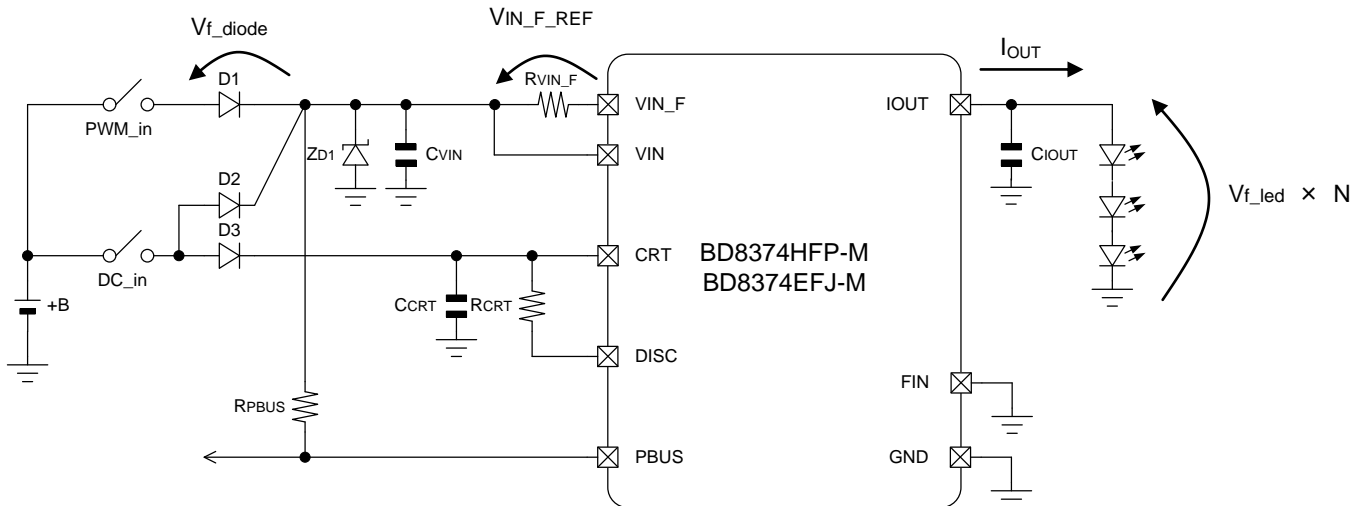


Figure 29. Application Circuit Diagram for Thermal Description

Thermal design should meet the following equation:

$$P_d > P_c = (+B - V_{f\_diode} - V_{IN\_F\_REF} - V_{f\_led} \times N) \times I_{OUT} + I_{VIN} \times V_{IN}$$

$$P_d = (1/\theta_{ja}) \times (T_{jmax} - T_a) \text{ or } (1/\theta_{jc}) \times (T_{jmax} - T_c)$$

where:

Pd is the Power Dissipation

Pc is the Power Consumption

+B is the Battery Voltage

$V_{f\_diode}$  is the Reverse Connection Preventing Diode  $V_f$

VIN\_F\_REF is the VIN\_F Terminal Voltage ( $V_{IN}-V_{IN\_F}$ )

$V_{f\_led}$  is the LED  $V_f$

N is the Number of LED Levels

$I_{OUT}$  is the Output Current

IVIN is the Circuit Current

$V_{IN}$  is the Power Supply Voltage

$\theta_{ja}$  is the Thermal Resistance between  $T_j$  and  $T_a$

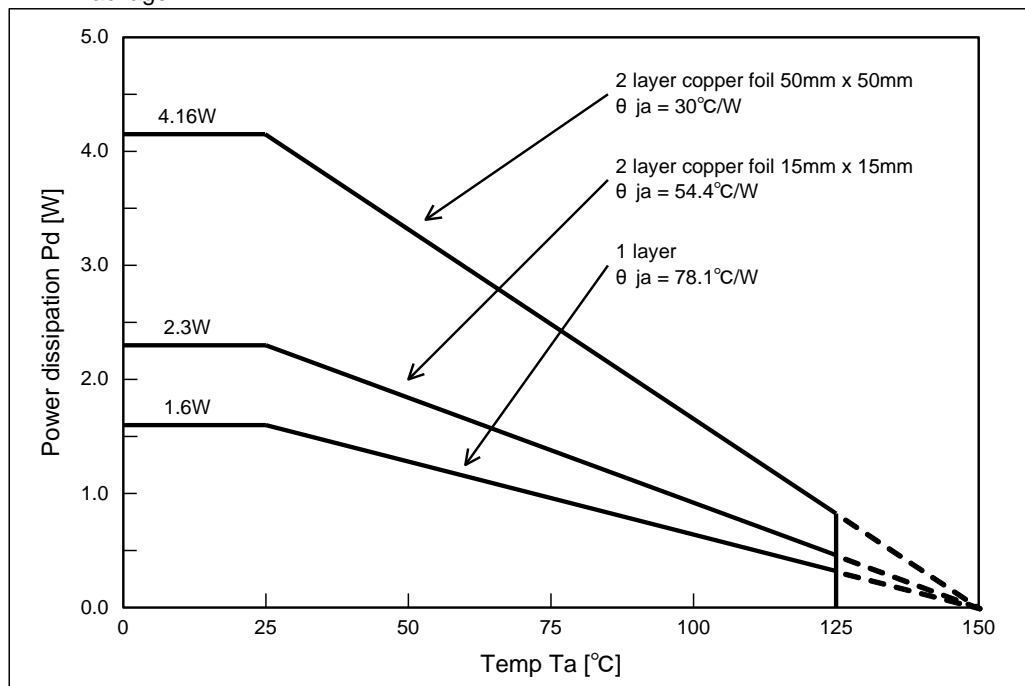
$\theta_{jc}$  is the Thermal Resistance between  $T_j$  and  $T_c$

Tjmax is the Max Joint Temperature (150°C)

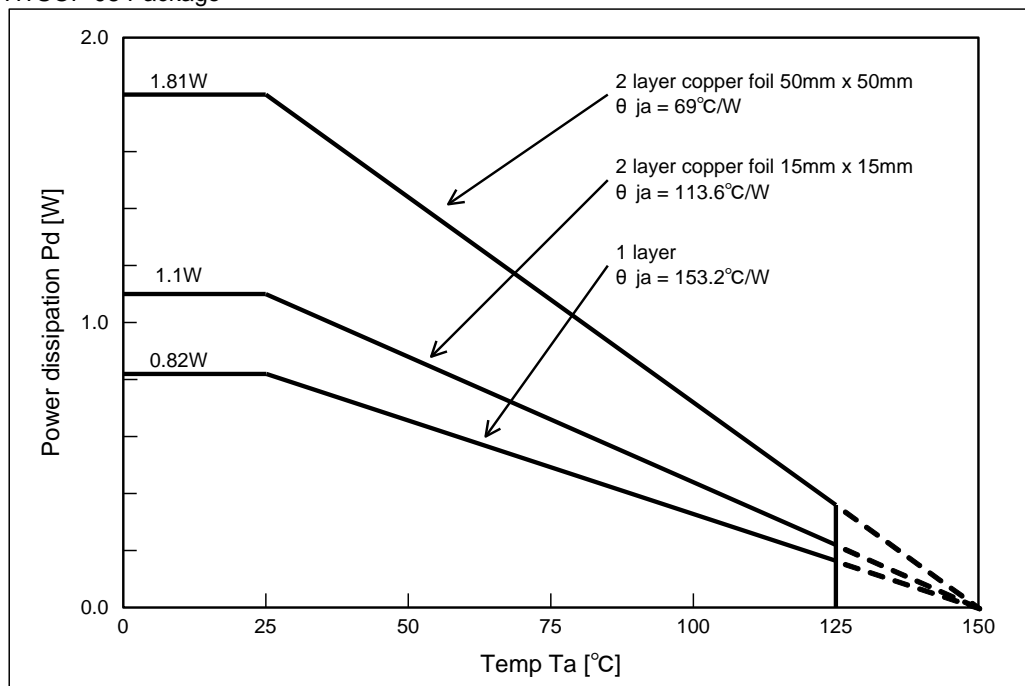
Ta is the Ambient Temperature

Tc is the Case Surface Temperature

## HRP7 Package



## HTSOP-J8 Package



(Caution1) When mounted with 70.0mm X 70.0mm X 1.6mm glass epoxy substrate.

(Caution2) Above copper foil area indicates backside copper foil area.

(Caution3) Value changes according to number of substrate layers and copper foil area. Note that this value is a measured value, not a guaranteed value.

Figure 30. Thermal Dissipation Curve

## Thermal Design for Few Number of LED Lamps

If there are few LED lamps, insert resistance between IOUT terminal and LED to reduce heat generation from IC and dissipate heat.

(This does not apply where amperage is low.)

In that case, note that guaranteed range of current accuracy will be as shown in the following equation:

$$+B \geq V_{f\_diode} + V_{f\_led} \times N + V_{IN\_F\_REF} + V_{DR\_IOUT} + I_{OUT} \times R1$$

$V_{f\_diode}$  is the Reverse Connection Preventing Diode  $V_f$

$V_{f\_led}$  is the LED  $V_f$

$N$  is the Number of LED Levels

$V_{IN\_F\_REF}$  is the  $V_{IN\_F}$  Terminal Voltage ( $V_{IN} - V_{IN\_F}$ )

$V_{DR\_IOUT}$  is the IOUT Terminal Drop Voltage

$I_{OUT}$  is the Output Current

$R1$  is the Thermal Dissipation Resistance

Thermal design should meet the following equation when inserting thermal dissipation resistance:

$$P_d > P_c = (+B - V_{f\_diode} - V_{IN\_F\_REF} - V_{f\_led} \times N) \times I_{OUT} + I_{VIN} \times V_{IN}$$

$$P_d = (1/\theta_{ja}) \times (T_{jmax} - T_a) \text{ or } (1/\theta_{jc}) \times (T_{jmax} - T_c)$$

$P_d$  is the Power Dissipation

$P_c$  is the Power Consumption

$+B$  is the Battery Voltage

$V_{f\_diode}$  is the Reverse Connection Preventing Diode  $V_f$

$V_{IN\_F\_REF}$  is the  $V_{IN\_F}$  Terminal Voltage ( $V_{IN} - V_{IN\_F}$ )

$V_{f\_led}$  is the LED  $V_f$

$N$  is the Number of LED Levels

$I_{OUT}$  is the Output Current

$R1$  is the Thermal Dissipation Resistance

$I_{VIN}$  is the Circuit Current

$V_{IN}$  is the Power Supply Voltage

$\theta_{ja}$  is the Thermal Resistance between  $T_j$  and  $T_a$

$\theta_{jc}$  is the Thermal Resistance between  $T_j$  and  $T_c$

$T_{jmax}$  is the Max Joint Temperature (150°C)

$T_a$  is the Ambient Temperature

$T_c$  is the Case Surface Temperature

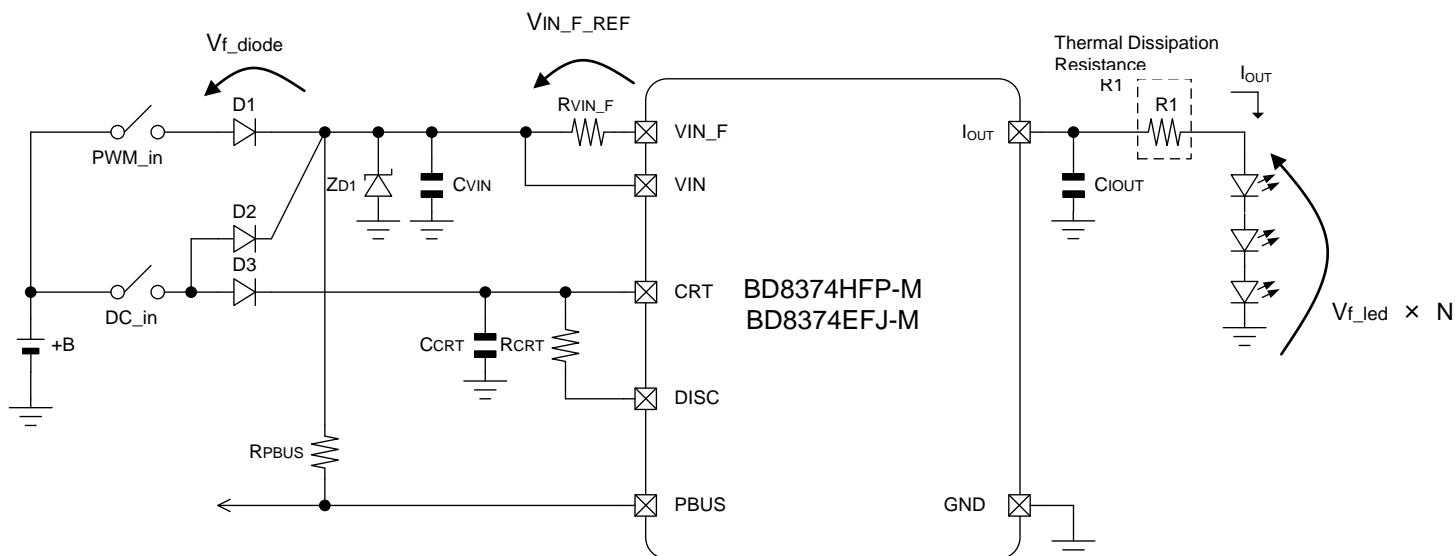


Figure 31. Example of How to Connect Thermal Dissipation Resistance

## I/O equivalence circuits (HRP7 Package)

Number	Terminal Name	Equivalence Circuit
1	PBUS	
2	DISC	
3	CRT	
4	GND	-
5	IOUT	
6	VIN_F	
7	VIN	-

## 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 terminals.

### 2. Power Supply Lines

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

### 3. Ground Voltage

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

### 4. Ground Wiring Pattern

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

### 5. Thermal Consideration

Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the Pd stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

### 6. Recommended Operating Conditions

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

### 7. Rush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 9. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

### 10. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.



## Operational Notes – continued

**11. Unused Input Terminals**

Input terminals 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 terminals should be connected to the power supply or ground line.

**12. Regarding the Input Pin of the IC**

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

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

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

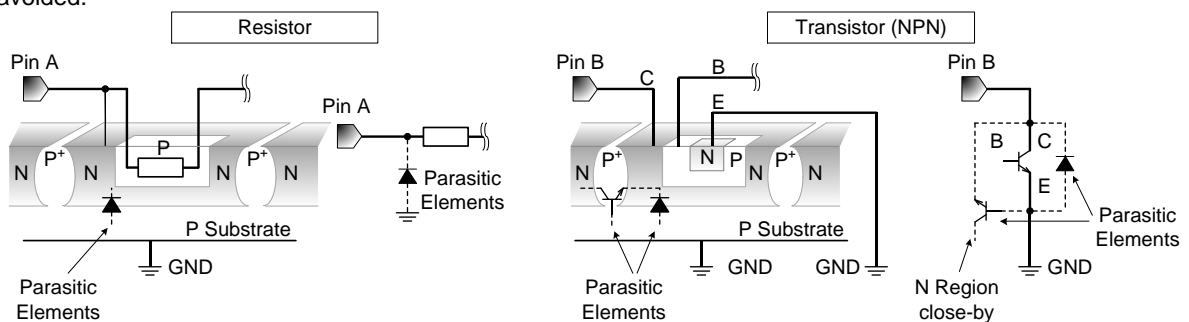


Figure 32. Example of monolithic IC structure

**13. Ceramic Capacitor**

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

**14. Area of Safe Operation (ASO)**

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

**15. Thermal Shutdown Circuit(TSD)**

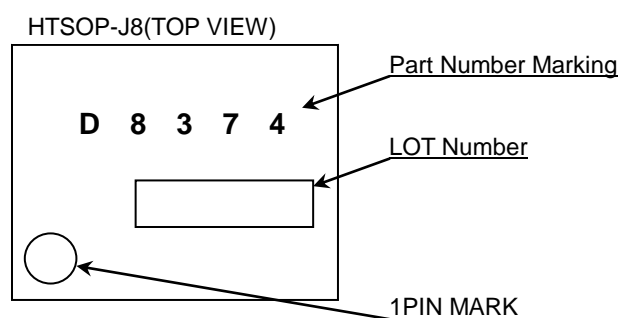
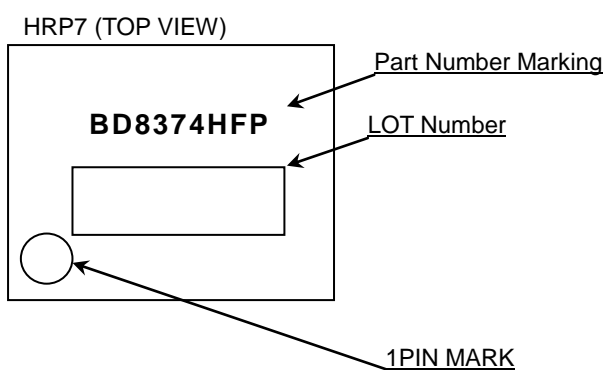
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that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

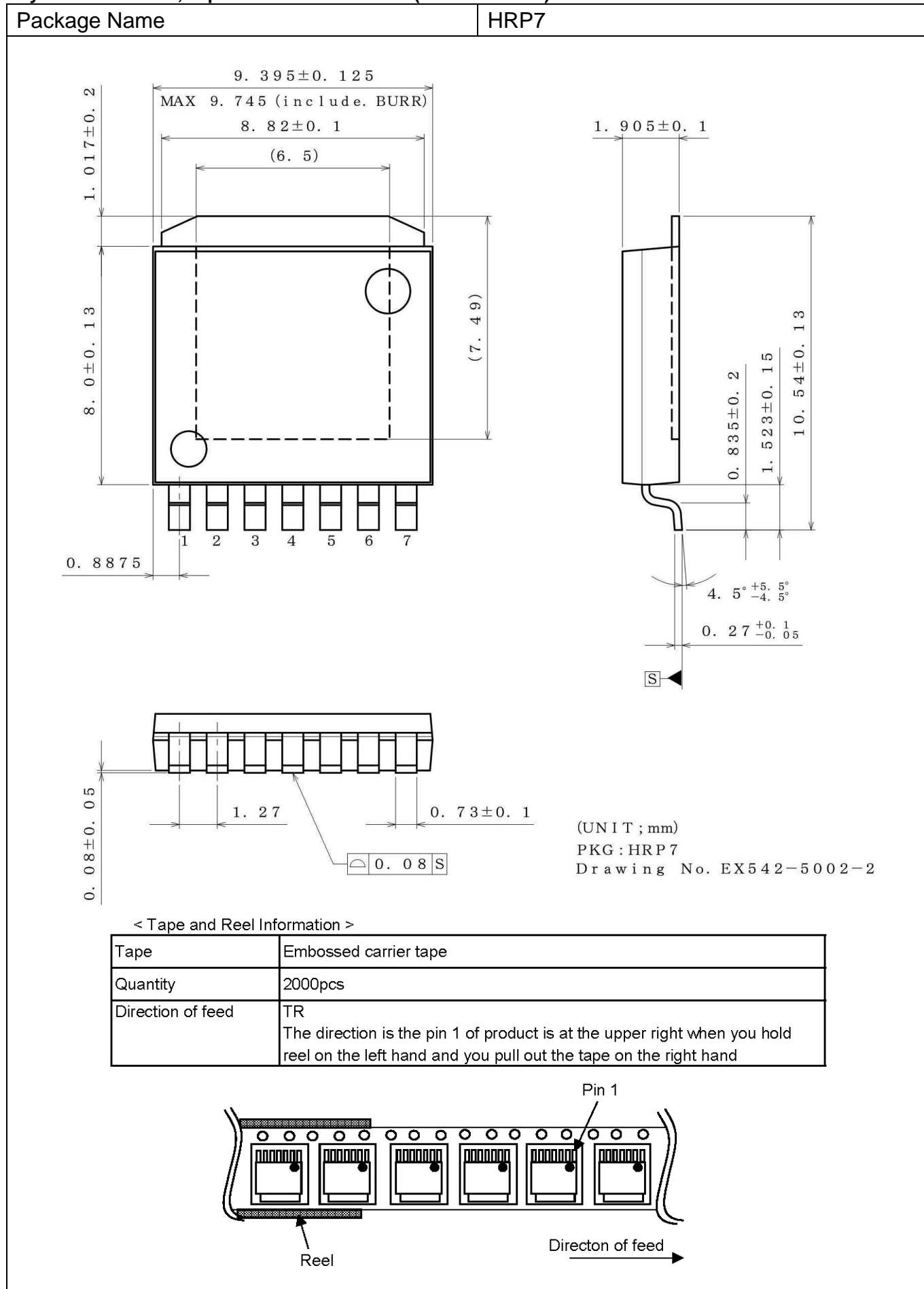
## Ordering Information

<b>B D 8 3 7 4 H F P</b>	<b>MTR</b>
Package HFP:HRP7	Packaging and forming specification M: High Reliability Design TR: Embossed tape and reel (HRP7)
<b>B D 8 3 7 4 E F J</b>	<b>ME2</b>
Package EFJ:HTSOP-J8	Packaging and forming specification M: High Reliability Design E2: Embossed tape and reel (HTSOP-J8)

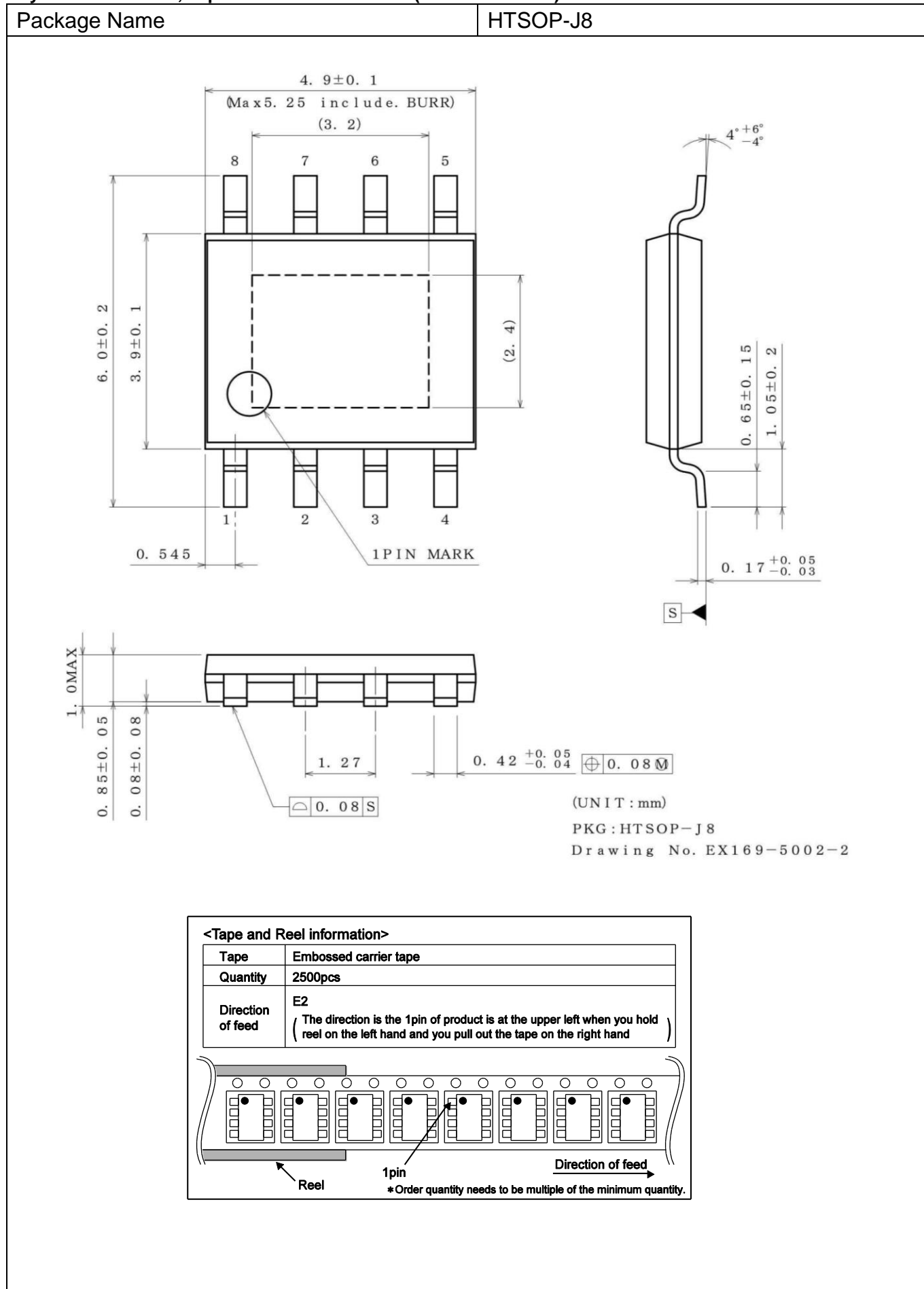
## Marking Diagrams



## Physical Dimension, Tape and Reel Information(BD8374HFP-M)



## Physical Dimension, Tape and Reel Information(BD8374VEFV-M)



## Revision History

Date	Revision	Changes
6.Aug.2013	001	New Release
14.May.2014	002	<p>General Added the capacitor to all Block Diagram</p> <p>Page.3 Absolute Maximum Ratings Revised</p> <p><b>Recommended Operating Conditions</b>  Minimum Pulse Width 100μs → 20μs  Minimum capacitor connecting IOUT terminal CIOUT_MIN added  CRTIMER Frequency Range added</p> <p>Page.4 <b>Electrical Characteristics</b>  IOUT Open detection Release Voltage added</p> <p>Page.5 Figure 7.(VIN vs VIN_F_REF) revised</p> <p>Page.7 Table of Operations revised</p> <p>Page.8 Figure 11. (PWM Dimming Operation) revised</p> <p>Page.11 the explanation of IOUT Current at GND Short added</p> <p>Page.12 the explanation about Active zone of LED Open Detective  &amp; LED Short Detective Function and IOUT Terminal Hi-Z zone added</p> <p>Page.15 Caution of driving IC used multi-power supply added</p> <p>Page.17 Guaranteed Range of Current Accuracy and LED Open Detection Range  Tenor Revised</p> <p>Page.18 How to Connect LED LED Tenor Revised</p> <p>Page.23 I/O equivalence circuits Number1,2 Revised</p>
06.Sep.2016	003	<p>Page 8 PWM Dimming operation Figure11  Line4 CRT → DC_in</p> <p>Page 9 Line19 1800.7μs → 1801.6μs  Line23 <math>-129\mu\text{sec} / (0.033\mu\text{F} \times \ln(1.1 / 3.0)) - 50\Omega</math>  ↓  <math>-129\mu\text{sec} / (0.033\mu\text{F} \times \ln(1.1 / 3.0)) - 50\Omega</math></p> <p>Page 16 Figure24 revise</p> <p>Page 19 D1,D2,D3 Product Name RF201L2S → RFN1L6S</p> <p>Page 22 Line16  <math>P_d &gt; P_c = (+B - V_{f\_diode} - V_{IN\_F\_REF} - V_{f\_led} \times N - I_{OUT} \times R_1) \times I_{OUT} + I_{VIN} \times V_{IN}</math> Add</p> <p>Page 23 I/O equivalence circuits CRT revise</p>

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CLASS IV		CLASS III	

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  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
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