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Datasheet

Buck LED Driver

Buck LED Driver for Automotive Suitable for Matrix LED Control

BD18395EFV-M

General Description

BD18395EFV-M is a Buck LED driver suitable for matrix LED control. It has a wide input voltage range from 4.5 V to 70 V with a possible average output current of 2.0 A max. A shutdown function reduces power consumption. The LED current can be set by an external current setting resistor, and it operates by peak current detection OFF TIME control. The device includes self-protection features such as UVLO, overcurrent protection, LED open detection, low output voltage detection, status good output and a thermal shutdown function.
The device is suitable for matrix control of LEDs.

Key Specifications

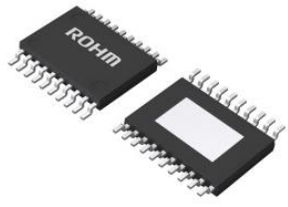
- Input Voltage Range: 4.5 V to 70 V
- Output Voltage Range: 0 V to 60 V
- Average Output Current: 0.1 A to 2.0 A
- High side FET ON Resistance: 170 mΩ (Typ)
- Standby Current: 0 μA (Typ)
- Operating Temperature Range: -40 °C to +125 °C

Package

	W (Typ) x D (Typ) x H (Max)
HTSSOP-B20	6.5 mm x 6.4 mm x 1.0 mm

Features

- AEC-Q100 Qualified *(Note 1)*
- Functional Safety Supportive Automotive Products
- Peak Current Detection OFF TIME Control System
- For Use with Matrix LED Control
  (High-speed Response Current Control)
- High-side LED Current Detection
- LED Voltage Maximum 60 V
- Shutdown for Low Power Consumption
- Control Loop Compensating Circuit is not needed
- Normal State Flag Output (Status Good Signal)
- Various Protection Functions
  (Note 1) Grade 1

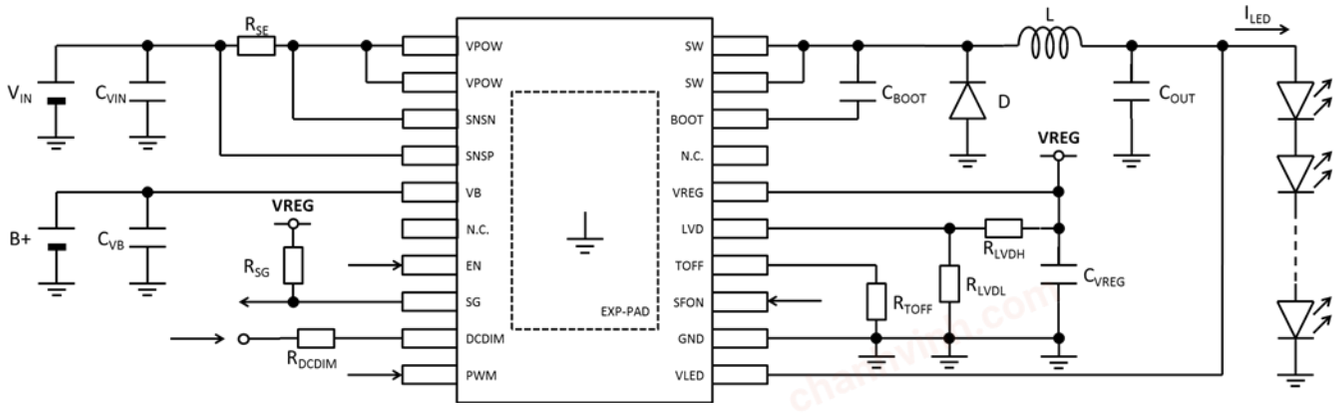


HTSSOP-B20

Applications

- Automotive Exterior Lamps
  (Rear, Turn, DRL/Position, Fog, Dynamic Indicator, High/Low Beam, AFS Head Lamp, ADB Head Lamp etc.)

Typical Application Circuit



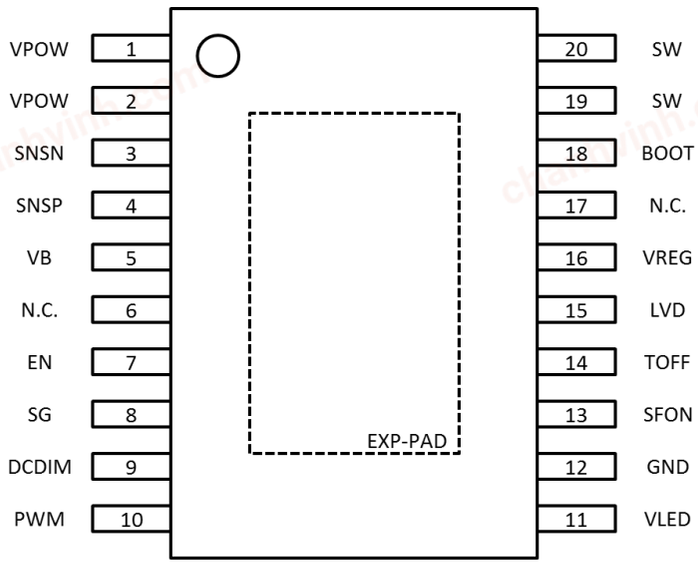
○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays

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Pin Configuration

HTSSOP-B20
(TOP VIEW)



Pin Description

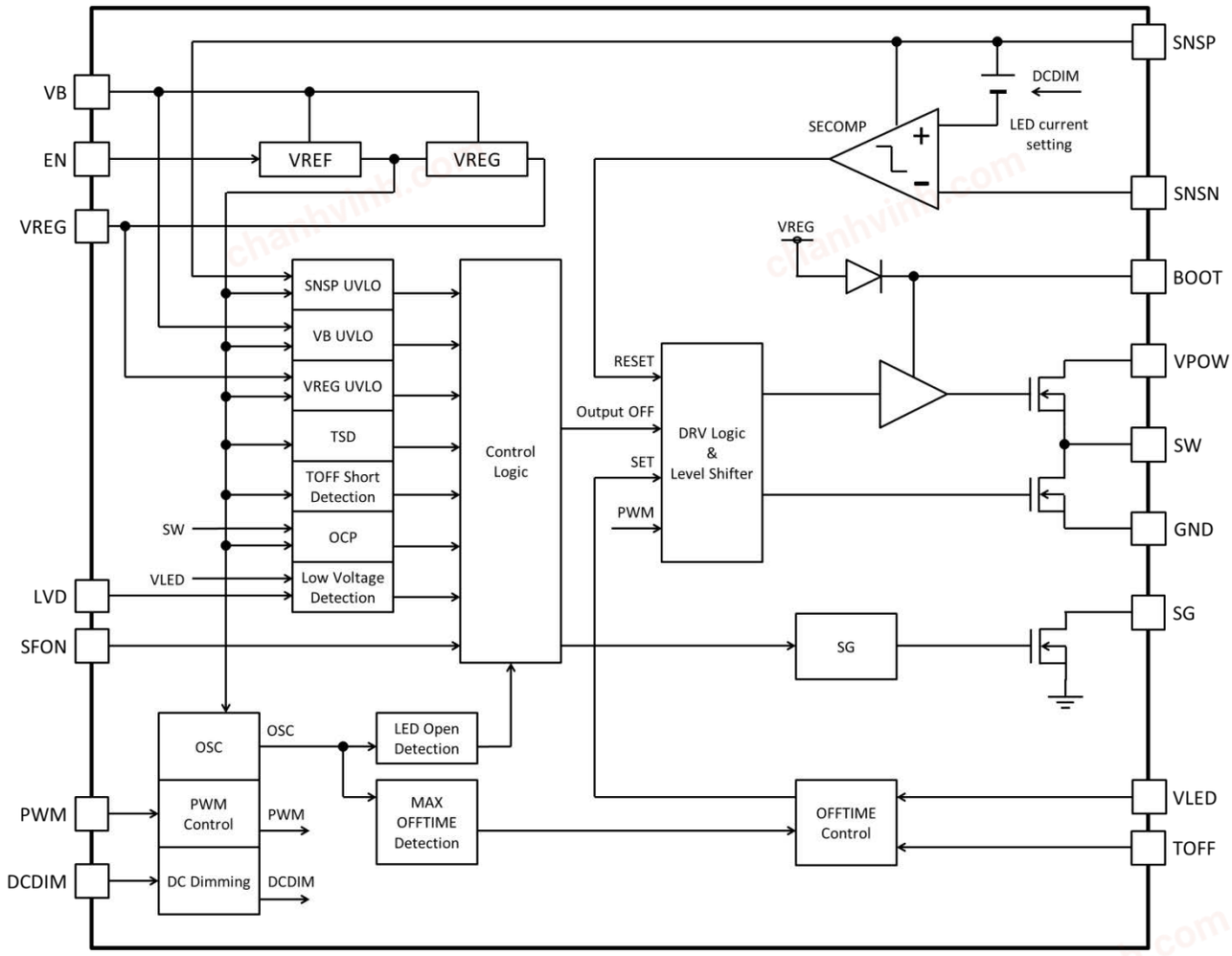
Pin No.	Pin Name	Function
1	VPOW	Power supply input for high side FET
2	VPOW	Power supply input for high side FET
3	SNSN	Inductor current sense input (-)
4	SNSP	Inductor current sense input (+)
5	VB	Power supply input
6	N.C.	Non connected *(Note 1)*
7	EN	Enable input
8	SG	Status good output
9	DCDIM	Analog dimming input
10	PWM	PWM dimming input
11	VLED	LED voltage detection input
12	GND	GND
13	SFON	Short detection flag enable input
14	TOFF	Resistor connection for OFF TIME setting
15	LVD	Low voltage detection setting input
16	VREG	Connecting capacitor for 5 V gate drive
17	N.C.	Non connected *(Note 1)*
18	BOOT	Connecting boot strap capacitor for high side gate drive
19	SW	Connecting to high side FET source
20	SW	Connecting to high side FET source
-	EXP-PAD	Heat radiation pad. The EXP-PAD is connected to GND.

(Note 1) Leave this pin unconnected.

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Block Diagram



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Description of Blocks

1 Control Method (OFF TIME Control)

This product uses the OFF TIME control method for LED current control.
OFF TIME control consists of a comparator that detects the peak current of the LED and an OFF TIME generation circuit that generates a set signal in a time according to the output voltage.

First turn on the high side FET and let the current flow through the inductor. Current flowing through the inductor flows directly to the LED. The current flowing through the inductor is monitored by the voltage generated between the peak current detection resistors R_{SE}, and when the set peak current is detected, the high side FET is turned off. After that, when the OFF TIME set inside the circuit elapses according to the Vf voltage of the generated LED, the high side FET is turned on again. By repeating this, LED current is controlled.
One characteristic of the OFF TIME control method is that it can reduce the output capacitor C_{OUT}. If the output capacitor is increased, the charge of the output capacitor flows to the LED as the rush current when reducing the number of LED lamps by matrix control, so it may cause flickering of the LED and breakdown beyond the rating. Also, when switching the number of LED lights, delay in output responsiveness due to LC filter made up of inductor and capacitor occurs. For this reason, it is necessary to minimize the output capacitor during matrix control.

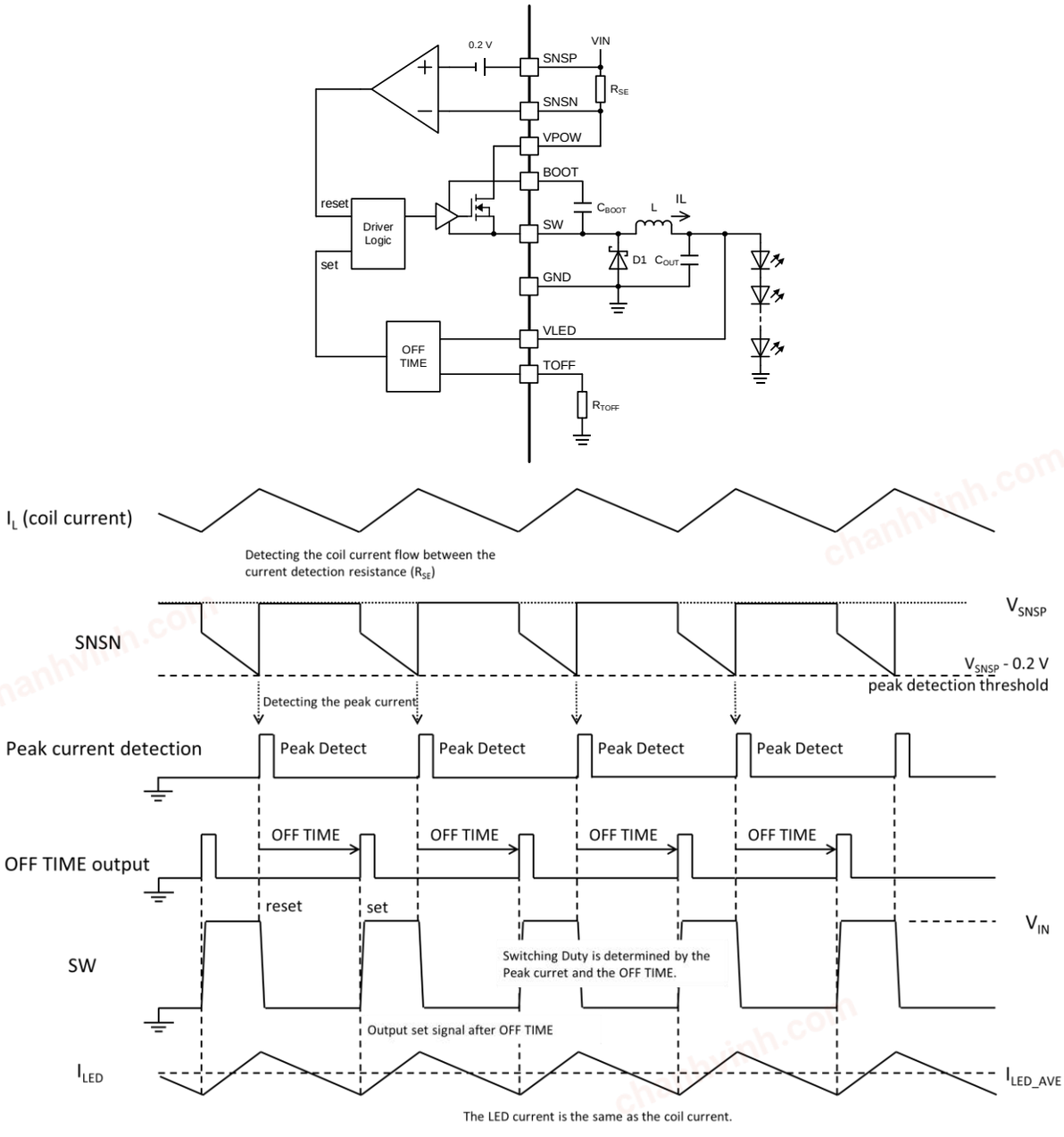


Figure 1. OFF TIME Control Method

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Description of Blocks – continued

2 Reference Voltage VREG (5 V Output)

The VREG voltage 5.0 V (Typ) is generated from the VB pin voltage and VREF block. This voltage is used as the internal power supply of the IC and the FET drive. It also supplies current to the SG pin and the LVD pin connected resistor. The total current supplied to the resistor must be 10 mA or less. Connect C_{VREG} = 2.2 µF as feedback compensation capacitor to the VREG pin. Place ceramic capacitor close to the IC to minimize trace length to the VREG pin also to the IC ground. Do not use the VREG as a power supply other than this IC.
When the EN pin voltage exceeds the threshold voltage V_{ENH}, the reference voltage generation circuit starts operating. When the EN pin voltage falls below the threshold voltage V_{ENL}, all internal circuits including the reference voltage generation circuit stop operating and the circuit current becomes 0 µA (Typ).

3 SG (Status Good Signal)

The SG pin has an open drain output and requires an external pull-up to the power supply for use. When the LED driver is activated and the current control circuit detects the peak current three times, the SG pin is Hiz controlled. In addition, when a failure is detected (UVLO, TSD, OCP, LED OPEN), the SG pin is controlled low. (See 7. Fault Detection / Protection Functions.) This SG signal can be used as an enable signal for the Matrix SW driver. (For applications using Matrix SW, refer to the application circuit example.)

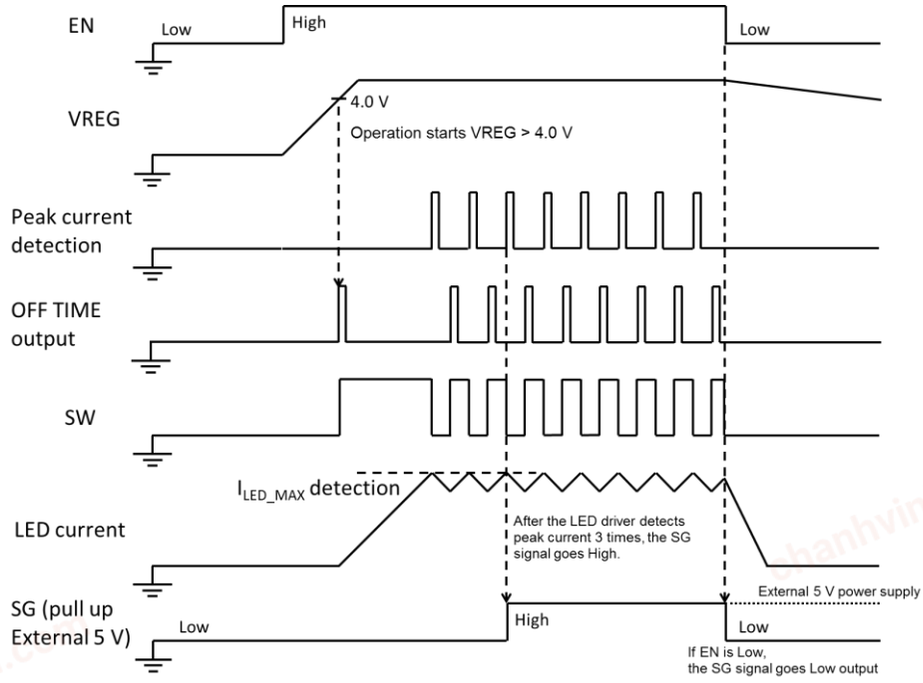


Figure 2. Explanation of SG Signal Operation (When Switching the EN Pin Low/High)

4 Average LED Current Control

4.1 SECOMP (Peak current detection)

The voltage between the SNSP and SNSN pins is used to detect the peak current flowing through the inductor. The detection resistor R_{SE} is connected between the SNSP pin and the SNSN pin, and the voltage between the pins is adjusted to V_{SNS} = 200 mV (Typ). Therefore, the LED peak current I_{LED_MAX} can be set by the following formula.

$$I_{LED_MAX} = \frac{0.2}{R_{SE}} \quad [A]$$

R_{SE} : Peak current detection resistance

4.2 OFF TIME Control (OFF TIME Generation Circuit)

OFF TIME block generates the set signal of the time to depend on the VLED pin voltage V_{VLED}. When peak current is detected, the high side FET is off, and the OFF TIME count starts. When OFF TIME passes, the set signal is output, and the high side FET is turned on. Since the OFF TIME is generated according to the VLED pin voltage, it varies under the control of the Matrix SW controller, but the ripple of the LED current is controlled to be constant. The OFF TIME can be changed by the external resistor R_{TOFF} connected to the TOFF pin, and the switching frequency can be adjusted. The maximum time is set in OFF TIME (MAX OFF TIME Detection), and the set signal is automatically output when counting 80 µs or more (same time as t_{OPEN}).

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4.2 OFF TIME Control (OFF TIME Generation Circuit) – continued
The OFF TIME (t_{OFF}) is set using the formula shown below.

$$t_{OFF} = 1.05 \times 10^{-9} \times \frac{R_{TOFF}}{V_{VLED}} \quad [s]$$

R_{TOFF} : External resistance value connected to the TOFF pin
V_{VLED} : LED Vf voltage (= VLED pin voltage)

t_{OFF} affects the switching frequency f_{SW}. f_{SW} can be determined according to the formula below.

$$f_{SW} = \frac{V_{SNSP} - V_{VLED}}{V_{SNSP} + V_{SBD}} \times \frac{1}{t_{OFF}} \quad [Hz]$$

R_{TOFF} : External resistance value connected to the TOFF pin
V_{VLED} : LED Vf voltage (= VLED pin voltage)
V_{SNSP} : SNSP pin voltage
V_{SBD} : Schottky barrier diode forward voltage

This formula shows parabolic characteristics and the switching frequency becomes maximum when $V_{VLED} = V_{SNSP} / 2$.
The maximum value of the switching frequency f_{SW_MAX} is calculated by the formula below.

$$f_{SW_MAX} = \frac{{V_{SNSP}}^2}{2 \times (V_{SNSP} + V_{SBD}) \times 2.10 \times 10^{-9} \times R_{TOFF}} \quad [Hz]$$

R_{TOFF} : External resistance value connected to the TOFF pin
V_{SNSP} : SNSP pin voltage
V_{SBD} : Schottky barrier diode forward voltage

Due to the circuit delay, f_{SW_MAX} will be lower than this calculation suggests.

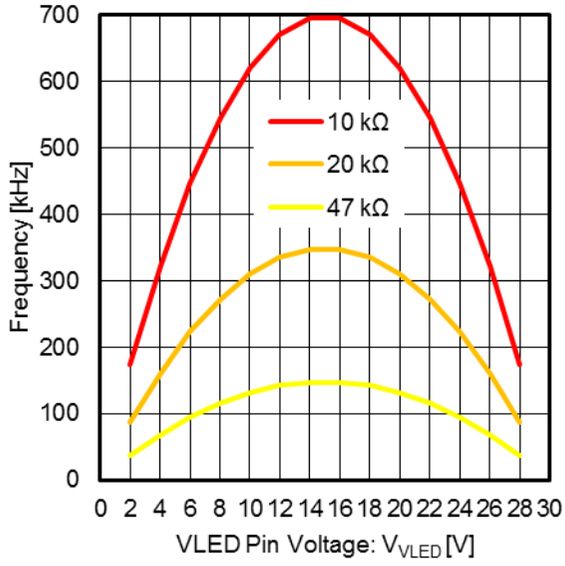


Figure 3. Switching Frequency vs V_{VLED}
(V_{SNSP} = 30 V, V_{SBD} = 0.7 V, R_{TOFF} = 10 kΩ, 20 kΩ, 47 kΩ)

Using the above graph, determine the maximum switching frequency f_{SW_MAX} and R_{TOFF} for a given V_{SNSP}.

$$R_{TOFF} = \frac{{V_{SNSP}}^2}{2 \times (V_{SNSP} + V_{SBD}) \times 2.10 \times 10^{-9} \times f_{SW_MAX}} \quad [\Omega]$$

V_{SNSP} : SNSP pin voltage
V_{SBD} : Schottky barrier diode forward voltage

4.3 DRV Logic (Output control logic)
The high side FET is controlled according to the output signal (reset) of the SECOMP circuit and the output signal (set) of the OFF TIME circuit. The switching frequency can be adjusted.

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Description of Blocks – continued

5 Dimming Function

To adjust the LED current, the PWM dimming function and analog dimming function is integrated in this IC.

5.1 PWM Control (PWM Dimming)

The LED current ON/OFF is controlled by inputting a PWM signal to the PWM pin. It is ON control when PWM = High and OFF control when PWM = Low. No additional FET are required for PWM control.

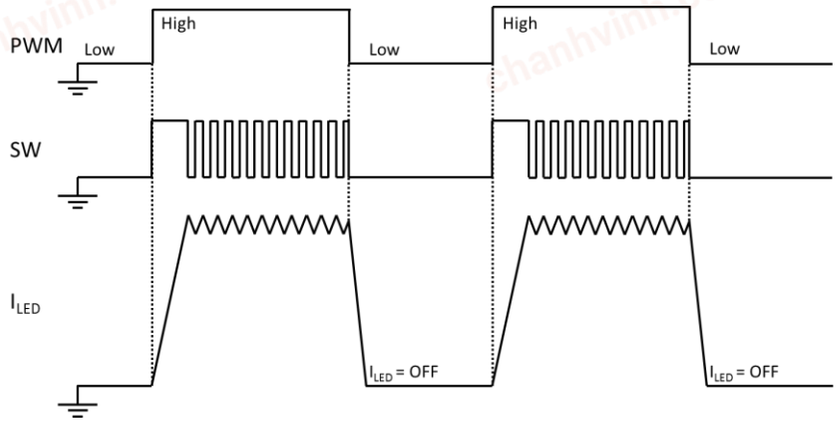


Figure 4. PWM Dimming Operation

5.2 DC Dimming (Analog Dimming)

If a derating in the current is desired, due to LED temperature, the analog dimming function can be used. The LED peak current is adjusted according to the voltage applied to the DCDIM pin. If the DCDIM voltage V_{DCDIM} is above 1.0 V (Typ), the peak detection voltage V_{SNS} is 200 mV (Typ). If a lower voltage is applied, the peak detection voltage will be reduced, as shown in the diagram below. If the analog dimming function is not used, connect the DCDIM pin to the VREG pin with 10 kΩ or more.

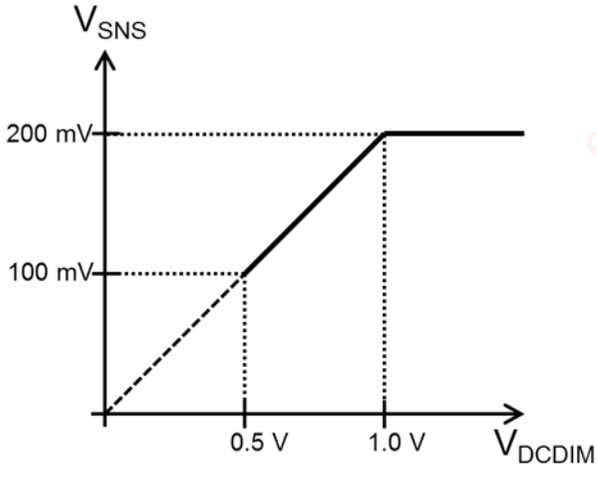


Figure 5. Analog Dimming

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Description of Blocks – continued

6 Zero LED Operation

When driving Matrix SW such as dynamic indicator, all Matrix SW may be turned on and LED may be 0. At this time, the current supplied from the LED driver does not flow to the LED but flows to the Matrix SW, and the switching operation continues.

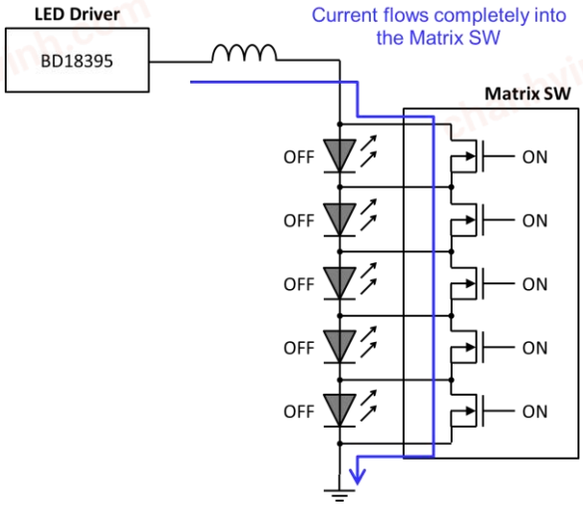


Figure 6. Current Path at Zero LED

6.1 Low Voltage Detection (LED Anode Low Voltage Detection Function)

BD18395EFV-M has the LVD (Low Voltage Detection) function in order to detect if the voltage of the VLED pin which connects to the LED anode side goes down. When the voltage of the VLED pin becomes lower than the set voltage when the SFON pin voltage V_{SFON} > 2.4 V, it acts as ground fault detection (SCP) on the LED anode side and outputs the SG pin Low to notify abnormality. When the SFON pin voltage V_{SFON} < 0.6 V, the current drive operation is continued while keeping the SG pin Hiz output. The detection voltage of LVD is set by the voltage value externally input to the LVD pin. Connect external resistors R_{LVDH}, R_{LVDL} between the VREG pin and the GND pin, and set arbitrarily according to Vf of LED.

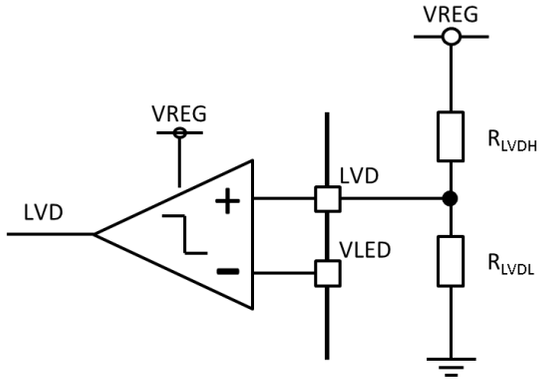


Figure 7. How to Set the LVD Voltage

The low voltage detection voltage V_{LVD} is calculated by the following formula. The minimum VLED pin voltage depends upon the number of LEDs and their Vf. The LVD detection voltage must be between 1.5 V and 2.75 V.

$$V_{LVD} = V_{REG} \times \frac{R_{LVDL}}{R_{LVDH}+R_{LVDL}} \quad [V]$$

V_{REG} : VREG output voltage
R_{LVDH}, R_{LVDL} : LVD pin connection resistance

The low voltage detection voltage V_{LVD} should be set lower than a single LED Vf. Therefore, consider the variation of LED Vf when setting the low voltage detection voltage. An example is shown below.

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6.1. Low Voltage Detection (LED Anode Low Voltage Detection Function) – continued

6.1.1 The Low Voltage Detection Voltage Setting Example (When Using the Matrix SW)

Conditions.
LED Forward Voltage (Vf) : Min 1.6 V, Max 2.4 V
(Including current range of used LED and temperature characteristics)
Number of LEDs (N) : 8
Average LED Current (I_{LED_AVE}) : 1.0 A
LED Current Ripple (ΔI_{LED}) : 0.1 A
Matrix SW ON Resistance (R_{ON_MIN}) : 0.12 Ω/ch

Min voltage value of the LED anode side, in case of a single LED

$$V_{LED} = V_f + (I_{LED_AVE} - \Delta I_{LED}) \times R_{ON_MIN} \times (N - 1) \quad [V]$$

= 1.6 V + (1.0 A - 0.1 A) x 0.12 Ω x (8−1) = 2.356 V

Taking the dispersion (±5 %) of V_{REG} into consideration, the low voltage detection voltage is set to 2.0 V. Therefore, determine the resistance to be connected the LVD pin: R_{LVDH} = 30 kΩ, R_{LVDL} = 20 kΩ.

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Description of Blocks – continued

7 Malfunction Detection / Protective Functions

Detection/Protection function	Detection conditions (Typ)		Operation during detection	SG output during detection
	Detection	Release		
UVLO	V_{SNSP} < 4.1 V or V_B < 4.1 V or V_{REG} < 3.8 V	V_{SNSP} ≥ 4.5 V and V_B ≥ 4.5 V and V_{REG} ≥ 4.0 V	High side FET OFF	SG = Low
TSD	Tj > 175 °C	Tj ≤ 150 °C	High side FET OFF	SG = Low
Overcurrent protection OCP	I_{VPOW} > 3.5 A	I_{VPOW} ≤ 3.5 A	OFF TIME operation starts after High side FET OFF	SG = Low
The TOFF pin short protection	I_{TOFF} > 0.5 mA	I_{TOFF} ≤ 0.5 mA	High side FET OFF	SG = Low
LED open detection timer	High side FET ON time > 80 µs	High side FET ON time ≤ 80 µs	OFF TIME operation starts after High side FET OFF	SG = Low
LED anode short detection	V_{LVD} < Setting voltage (1.50 V to 2.75 V)	V_{LVD} ≥ Setting voltage (1.50 V to 2.75 V)	-	SG = Low (effective only when SFON = High)

7.1 Under Voltage Locked Out (UVLO)

UVLO is a protection circuit that prevents IC malfunction at power-on or power-off. This IC is equipped with 3 UVLO circuits: UVLO VB for the VB voltage, UVLO VREG for the VREG voltage and UVLO SNSP for the SNSP voltage. When UVLO is detected, the switching operation stop, and the high side FET is turned off. Also, during UVLO detection, the SG pin is set to Low output to notify the outside of an abnormality.

7.2 Thermal Protection Circuit (TSD Thermal Shutdown)

TSD is a protection circuit to prevent IC destruction due to abnormal heat generation.
The TSD stops switching at 175 ° C (Typ), recovers at 150 ° C (Typ), and starts switching operation again. Also, during TSD detection, the SG pin is set to Low output to notify the outside of the abnormality.

7.3 Overcurrent Protection Circuit (OCP)

By detecting the current flowing between the VPOW pin and the SW pin and prevents destruction due to an excess current higher than the tolerance of the high side FET, inductor or LED. When the OCP operates, it stops the step-down switching operation and the high side FET turned off. Hence the output of the SW pin will be Low. The step-down switching operation starts again when the OFF TIME, which depends on the VLED pin voltage, has passed, after the output of the SW pin has become Low.

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7.3 Overcurrent Protection Circuit (OCP) – continued

If OCP is detected even once, the SG pin is set to Low output to notify the outside of the abnormality. If OCP is detected twice when the SG pin is low output, it will be in a hiccup operation, and after 10 ms (Typ) of OCP detection has elapsed, the step-down switching operation will start again. If the peak current detection comparator operates three times in succession without detecting OCP, the SG pin returns from the Low state to the Hiz state.

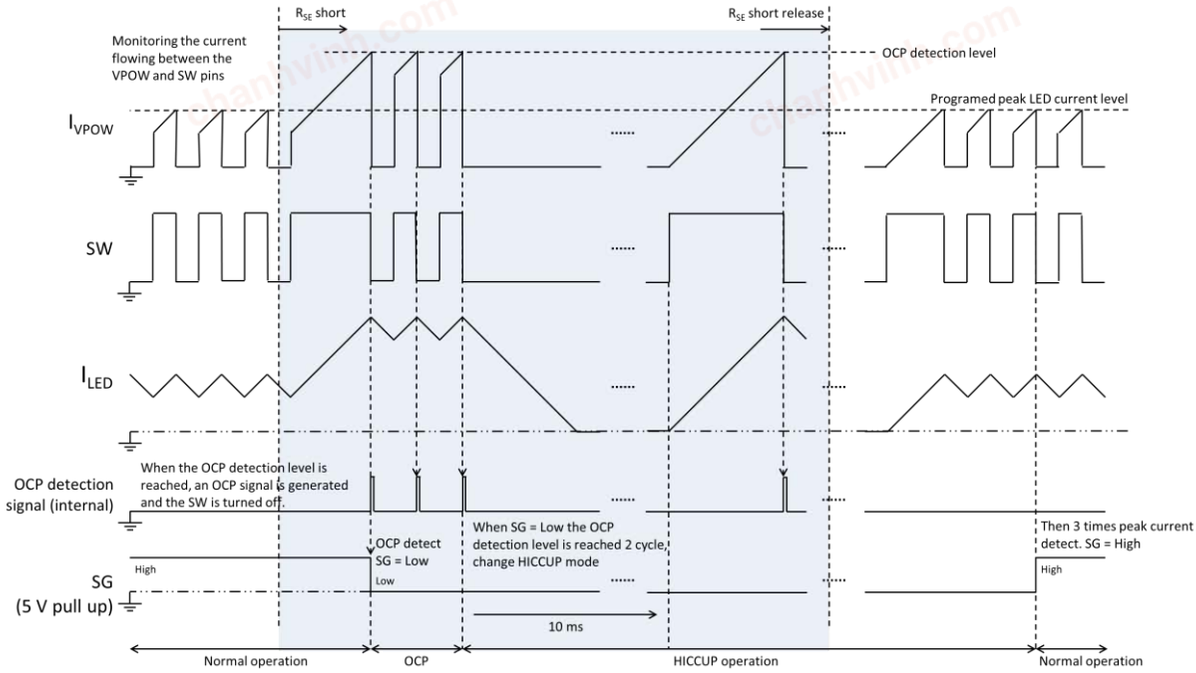


Figure 8. OCP Detection Operation

7.4 LED Open Detection (LED OPEN)

An abnormality is detected when an open failure occurs in the LED or a connector opening to the LED board occurs. Since no current flows through the current detection resistor when the LED is open, no peak current detection signal is generated, and the high side FET is kept on. When 80 µs or more of the high side FET is turned on, it recognizes the LED open state and outputs the reset signal to turn off the high side FET. Also, output the SG pin Low to notify abnormality to the outside.

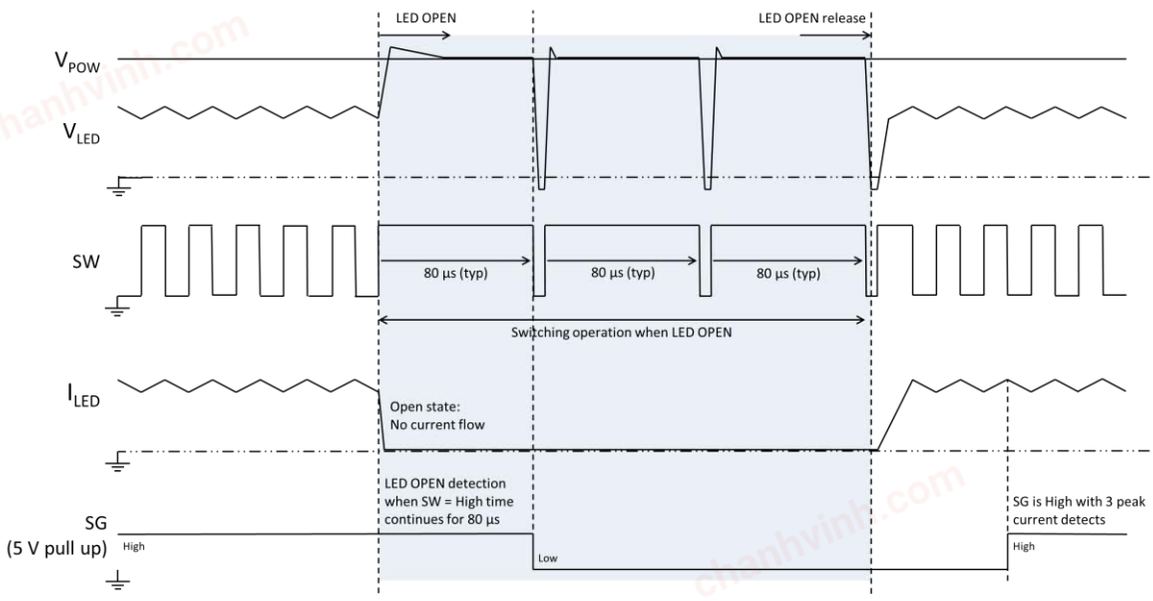


Figure 9. LED OPEN Detection Operation

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7 Malfunction Detection / Protective Functions – continued

7.5 TOFF Pin Short Detection Function

When the TOFF pin short-circuited with GND or when external resistor R_{TOFF} short-circuited, the TOFF pin short detection function detects abnormality. When the TOFF pin short detection function detects abnormality, the high side FET is turned off, and the SG pin outputs Low.

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Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Power Supply Voltage (VB)	V_B	-0.3 to +72	V
Power Supply Voltage (SNSP)	V_{SNSP}	-0.3 to +72	V
VREG Pin Voltage	V_{REG}	-0.3 to +7 ≤ V_B + 0.3	V
EN Pin Voltage	V_{EN}	-0.3 to +72 ≤ V_B + 0.3	V
VPOW, SNSN, SW, VLED Pin Voltage	V_{POW}, V_{SNSN}, V_{SW}, V_{VLED}	-0.3 to +72 ≤ V_{SNSP} + 0.3	V
SNSP to SNSN Pin Voltage	V_{SNSP_SNSN}	-0.3 to +2	V
SNSP to VPOW Pin Voltage	V_{SNSP_VPOW}	-0.3 to +2	V
BOOT Pin Voltage	V_{BOOT}	-0.3 to +72 ≤ V_{SNSP} + 7	V
BOOT to SW Pin Voltage	V_{BOOT_SW}	-0.3 to +7	V
DCDIM, TOFF, LVD Pin Voltage	V_{DCDIM}, V_{TOFF}, V_{LVD}	-0.3 to +7 ≤ V_{REG} + 0.3	V
PWM, SFON, SG Pin Voltage	V_{PWM}, V_{SFON}, V_{SG}	-0.3 to +7 ≤ V_{REG} + 0.3	V
DCDIM Pin Input Current	I_{DCDIM}	-0.01 to +10	mA
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.*

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Thermal Resistance *(Note 1)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s *(Note 3)*	2s2p *(Note 4)*	
HTSSOP-B20				
Junction to Ambient	θ_{JA}	143.0	26.8	°C/W
Junction to Top Characterization Parameter *(Note 2)*	Ψ_{JT}	8	4	°C/W

(Note 1) Based on JESD51-2A (Still-Air).
(Note 2) 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 3) Using a PCB board based on JESD51-3.
(Note 4) Using a PCB board based on JESD51-5, 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	Thermal Via *(Note 5)*	
			Pitch	Diameter
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt	1.20 mm	Φ0.30 mm

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

(Note 5) This thermal via connects with the copper pattern of all layers.

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Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating Voltage (VB)*(Note 1)(Note 2)*	V_B	4.5	13.0	70.0	V
Operating Voltage (SNSP)*(Note 1)((Note 2)*	V_{SNSP}	4.5	13.0	70.0	V
Operating Temperature	Topr	-40	-	+125	°C
VLED Voltage	V_{VLED}	0	-	60	V
LED Average Current Setting	I_{SW}	0.1	-	2.0	A
VREG Output Current	I_{VREG}	-	-	10	mA
TOFF Output Current	I_{TOFF}	2	-	250	μA
PWM Frequency Input	f_{PWM}	100	-	2000	Hz
Low Voltage Detection Voltage	V_{LVD}	1.50	-	2.75	V

(Note 1) ASO should not be exceeded.
(Note 2) At start-up time, apply the voltage 5 V or more once. The value is the voltage range after the temporary rise to 5 V or more.

Recommended Setting Parts Range

Parameter	Symbol	Min	Typ	Max	Unit
Capacitor Connecting to VREG Pin*(Note 3)*	C_{VREG}	1.0	2.2	4.7	μF
Capacitor Connecting to VLED Pin*(Note 3)*	C_{VLED}	10	100	1000	nF
Capacitor for BOOST *(Note 3)*	C_{BOOT_SW}	0.10	0.22	0.33	μF
Inductor Set Range	L	22	220	470	μH
Resistor for SG Pin	R_{SG}	10	47	200	kΩ

(Note 3) Capacitor capacitance should be set considering temperature characteristics, DC bias characteristics, etc.

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Electrical Characteristics
(Unless otherwise specified V_B = 13 V, V_{SNSP} = 13 V, V_{EN} = 5 V, Tj = 25 °C)

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
[Total]						
VB Circuit Current	I_{CCVB}	-	2.5	6.0	mA	V_{PWM} = 5 V, V_{DCDIM} = 5 V
SNSP Circuit Current	I_{CCSNSP}	-	0.4	2.0	mA	V_{PWM} = 5 V, V_{DCDIM} = 5 V
VB Standby Current	I_{STVB}	-	0	10	µA	V_{EN} = 0 V
SNSP Standby Current	I_{STSNSP}	-	0	10	µA	V_{EN} = 0 V
VB UVLO Detection Voltage	V_{BUVD}	3.75	4.10	4.45	V	V_B falling
VB UVLO Release Voltage	V_{BUVR}	4.15	4.50	4.85	V	V_B rising
VB UVLO Hysteresis Voltage	V_{BUVHYS}	-	0.4	-	V	-
SNSP UVLO Detection Voltage	$V_{SNSPUVD}$	3.75	4.10	4.45	V	V_{SNSP} falling
SNSP UVLO Release Voltage	$V_{SNSPUVR}$	4.15	4.50	4.85	V	V_{SNSP} rising
SNSP UVLO Hysteresis Voltage	$V_{SNSPUVHYS}$	-	0.4	-	V	-
[Reference Voltage]						
VREG Voltage	V_{REG}	4.75	5.00	5.25	V	C_{VREG} = 2.2 µF
VREG Line Regulation	$V_{LINEREG}$	-	10	-	mV	C_{VREG} = 2.2 µF, V_B = 13 V to 70 V
VREG Load Regulation	$V_{LOADREG}$	4.75	5.00	5.25	V	C_{VREG} = 2.2 µF I_{VREG} = -10 mA
[EN]						
EN Pin Input Current	I_{EN}	-	7	15	µA	V_{EN} = 5 V
EN Threshold Voltage H (Rising)	V_{ENH}	2.4	-	-	V	V_{EN} rising
EN Threshold Voltage L (Falling)	V_{ENL}	-	-	0.6	V	V_{EN} falling
EN Hysteresis Voltage	V_{ENHYS}	-	50	-	mV	-
[PWM]						
PWM Pin Input Current	I_{PWM}	-	50	100	µA	V_{PWM} = 5 V
PWM Threshold Voltage H (Rising)	V_{PWMH}	2.0	-	-	V	V_{PWM} rising
PWM Threshold Voltage L (Falling)	V_{PWML}	-	-	0.8	V	V_{PWM} falling
PWM Hysteresis Voltage	V_{PWMHYS}	-	0.25	-	V	-
[DCDIM]						
DCDIM Gain	GA_{DCDIM}	-	0.2	-	V/V	V_{SNS} / V_{DCDIM}
DCDIM Voltage	V_{DCDIM}	-	1.00	-	V	-
DCDIM Pin Output Current	I_{DCDIM}	1.0	3.5	7.0	µA	V_{DCDIM} = GND

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Electrical Characteristics - continued
(Unless otherwise specified V_B = 13 V, V_{SNSP} = 13 V, V_{EN} = 5 V, Tj = 25 °C)

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
[Status Good]						
SG Output Leak Current	I_{SGLK}	-	0	10	µA	V_{SG} = 5 V
SG Pin Low Output Voltage	V_{SGL}	-	0.1	0.4	V	I_{SG} = 0.5 mA input
[SFON (Short Flag ON)]						
SFON Threshold Voltage H(Rising)	V_{SFONH}	2.4	-	-	V	V_{SFON} rising
SFON Threshold Voltage L(Falling)	V_{SFONL}	-	-	0.6	V	V_{SFON} falling
SFON Hysteresis Voltage	$V_{SFONHYS}$	-	50	-	mV	-
[Low Voltage Detection]						
LVD Threshold Voltage	V_{LVDTH}	1.9	2.0	2.1	V	V_{VLED} = 2 V
LVD Pin Input Current	I_{LVD}	-	0	10	µA	V_{LVD} = 2 V
[Buck Converter]						
MOS FET ON Resistance between the VPOW and SW Pins	R_{ONH}	-	170	500	mΩ	I_{SW} = -100 mA
MOS FET ON Resistance between the SW and GND Pins	R_{ONL}	-	6	15	Ω	I_{SW} = 10 mA
LED Peak Current Detection Voltage	V_{SNS}	196	200	205	mV	Ta = 25 °C, V_{VLED} = 5 V, V_{SNS} = V_{SNSP} - V_{SNSN}
		194	200	206	mV	Ta = -40 °C to +125 °C, V_{VLED} = 5 V, V_{SNS} = V_{SNSP} - V_{SNSN}
V_{VLED} x t_{OFF}	V_{VLED} x t_{OFF}	44.40	49.35	54.20	Vµs	R_{TOFF} = 47 kΩ
VLED Pin Input Current	I_{VLED}	0	15	30	µA	V_{PWM} = 5 V, V_{VLED} = 5 V
SW Pin Minimum ON Time	t_{ONMIN}	-	200	-	ns	-
LED Open Detection Time	t_{OPEN}	60	80	100	µs	-
Overcurrent Detection	I_{OCP}	3.0	3.5	-	A	-
HICCUP Time	t_{HICCUP}	-	10	-	ms	-

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Typical Performance Curves (Reference Data)

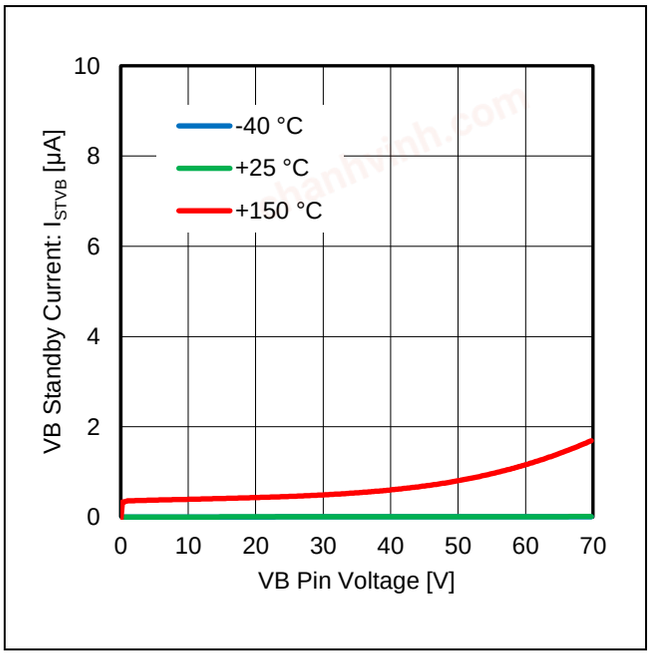


Figure 10. VB Standby Current vs VB Pin Voltage

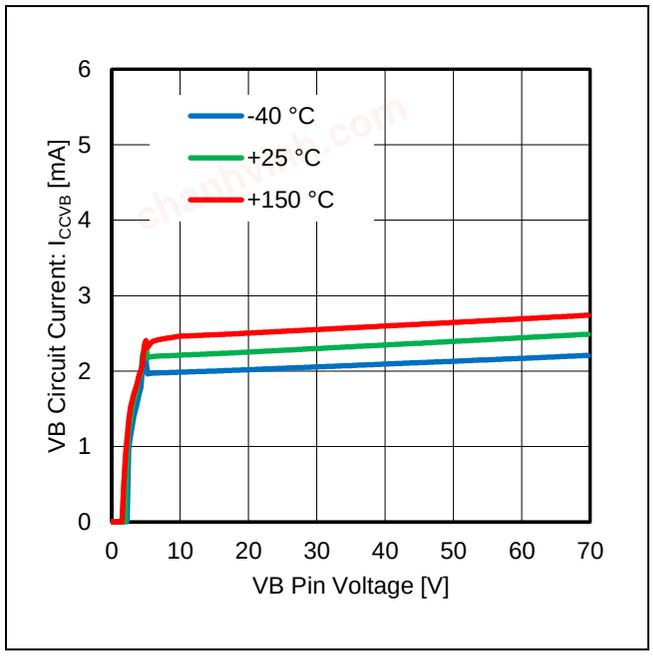


Figure 11. VB Circuit Current vs VB Pin Voltage

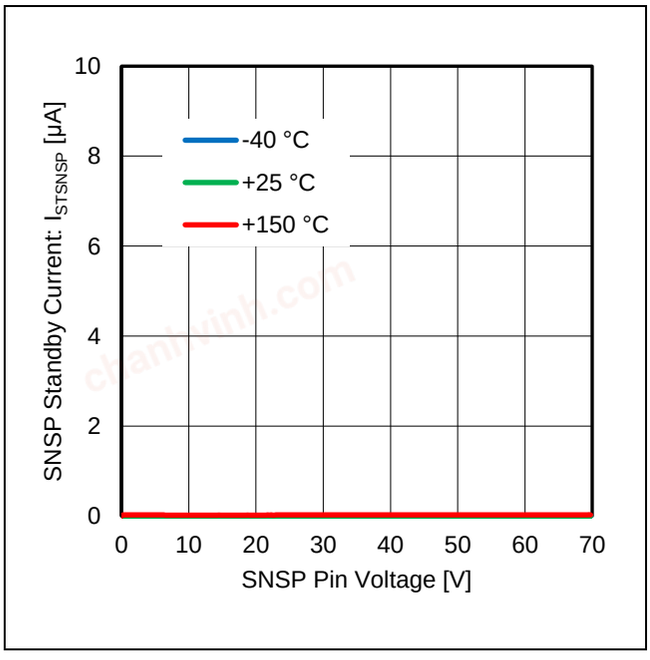


Figure 12. SNSP Standby Current vs SNSP Pin Voltage

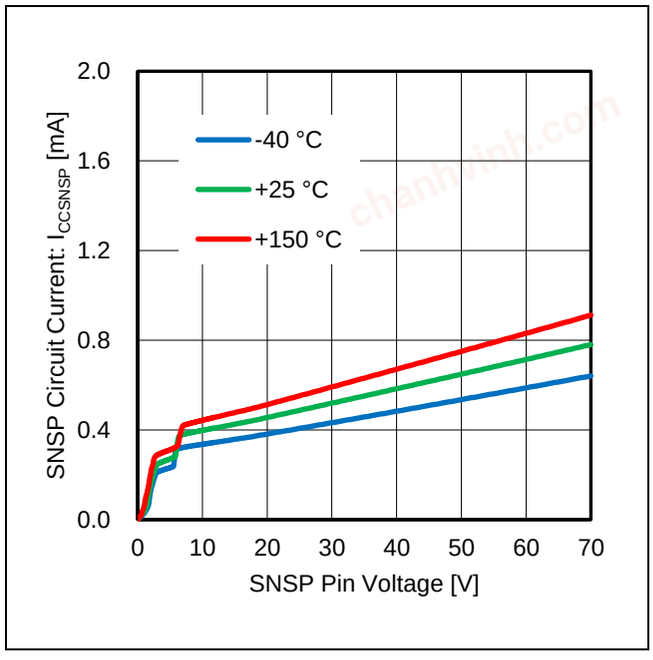


Figure 13. SNSP Circuit Current vs SNSP Pin Voltage

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Typical Performance Curves (Reference Data) - continued

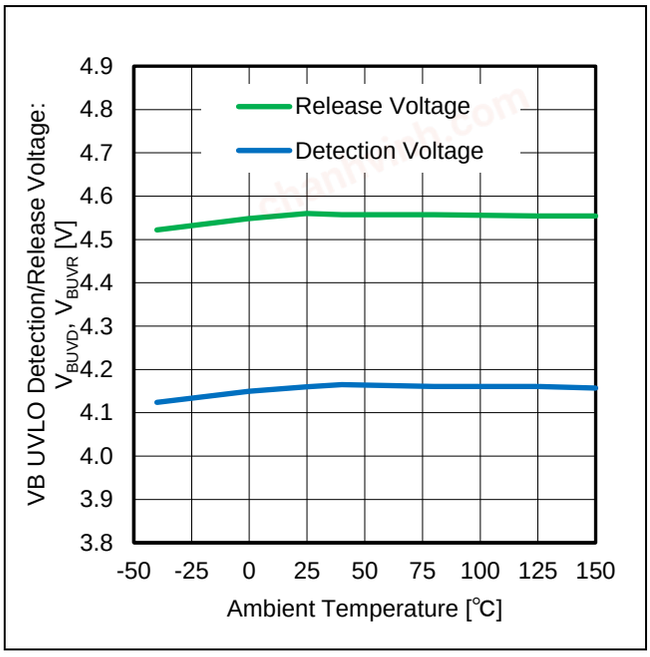


Figure 14. VB UVLO Detection/Release Voltage vs Ambient Temperature

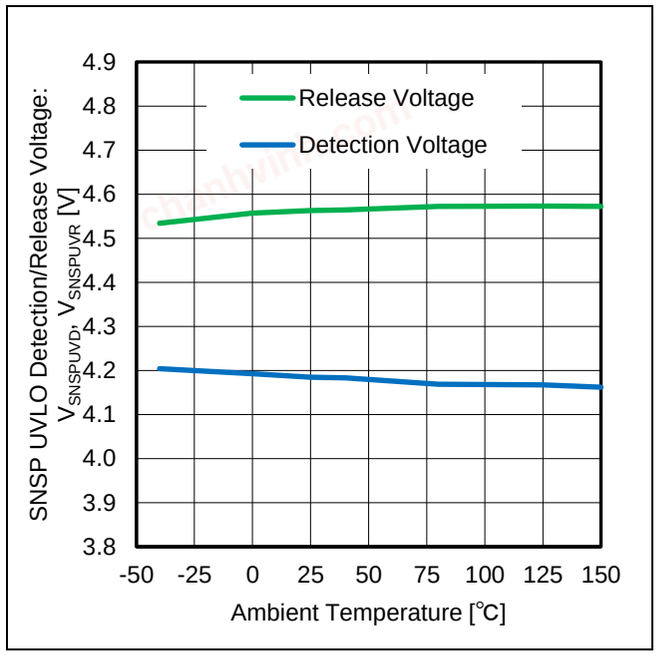


Figure 15. SNSP UVLO Detection/Release Voltage vs Ambient Temperature

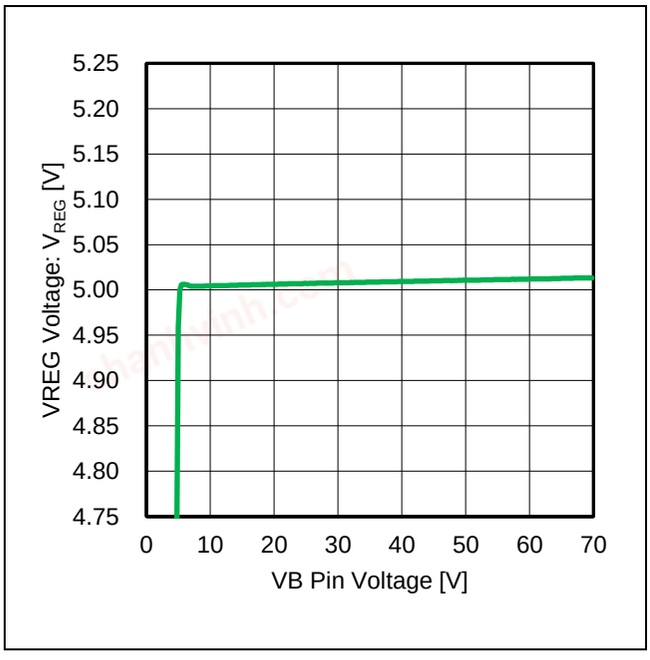


Figure 16. VREG Voltage vs VB Pin Voltage

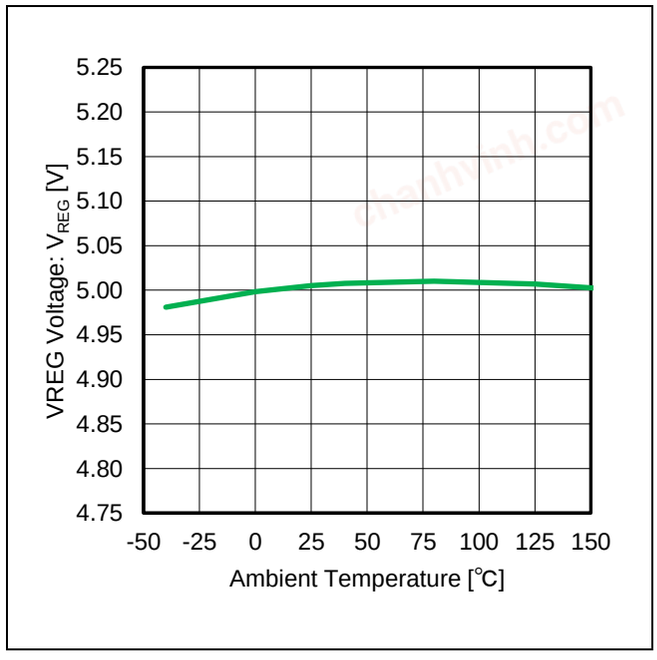


Figure 17. VREG Voltage vs Ambient Temperature

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Typical Performance Curves (Reference Data) - continued

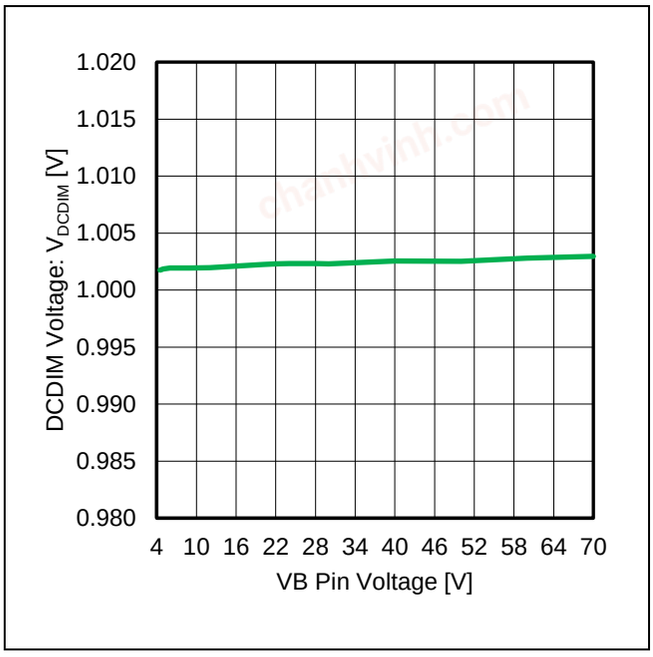


Figure 18. DCDIM Voltage vs VB Pin Voltage

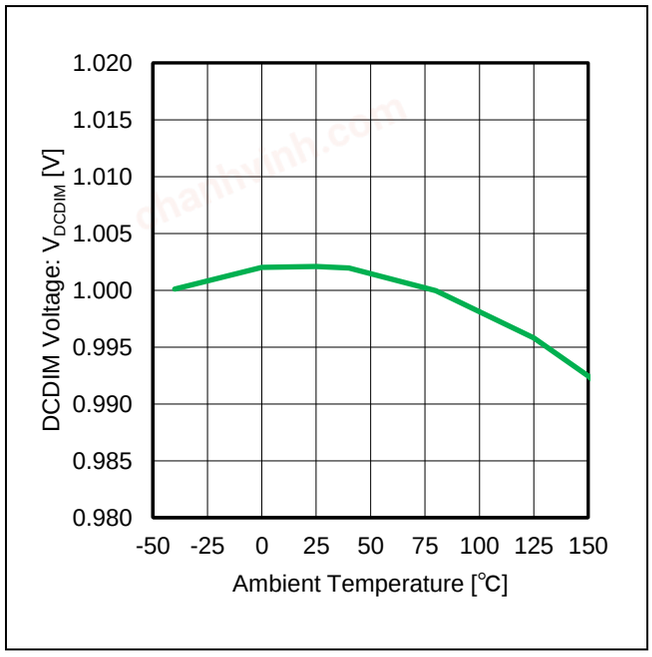


Figure 19. DCDIM Voltage vs Ambient Temperature

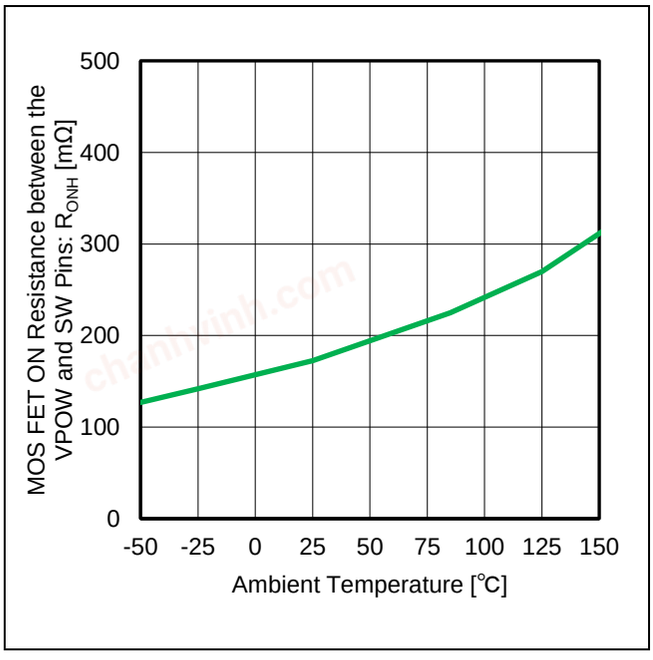


Figure 20. MOS FET ON Resistance between the VPOW and SW Pins vs Ambient Temperature (I_{SW} = -100 mA)

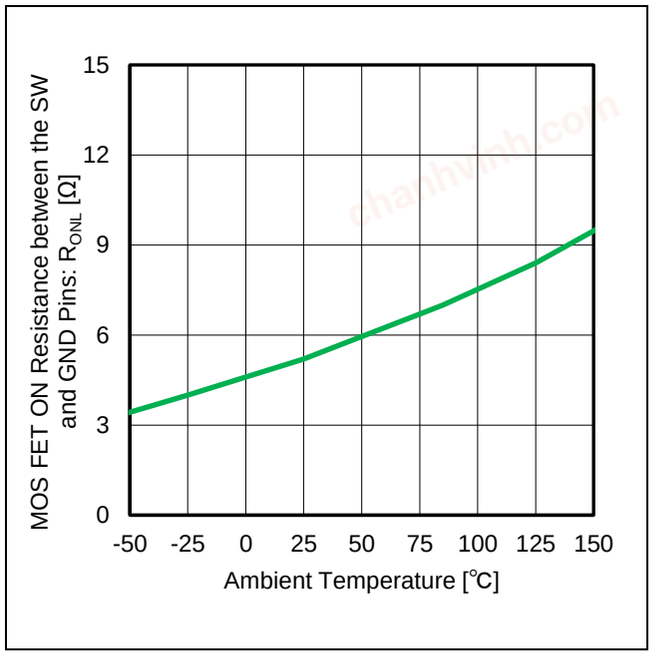


Figure 21. MOS FET ON Resistance between the SW and GND Pins vs Ambient Temperature (I_{SW} = 10 mA)

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Typical Performance Curves (Reference Data) - continued

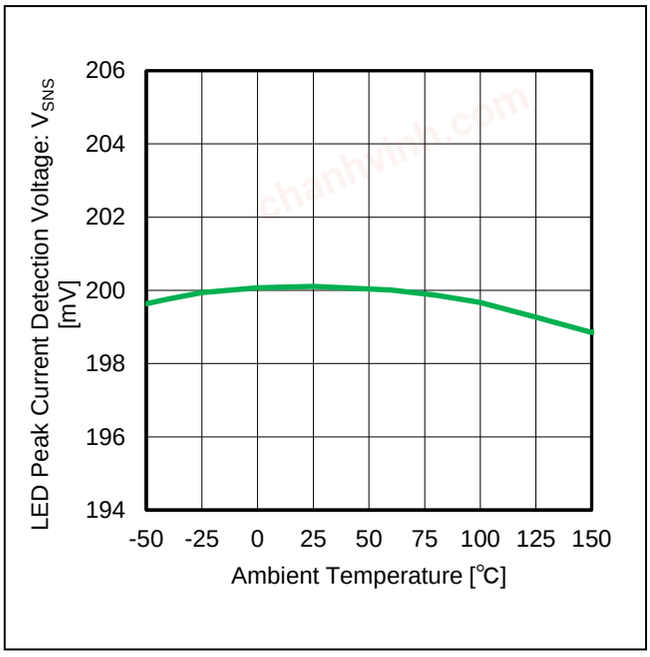


Figure 22. LED Peak Detection Voltage vs Ambient Temperature

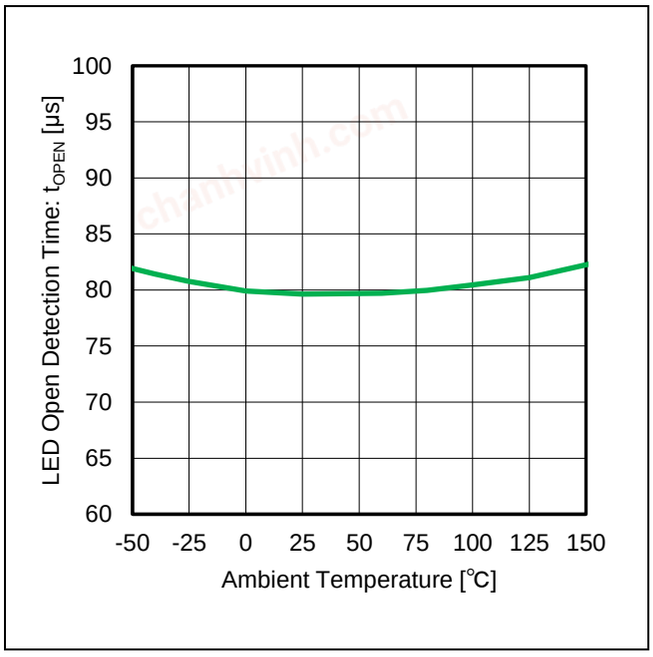


Figure 23. LED Open Detection Time vs Ambient Temperature

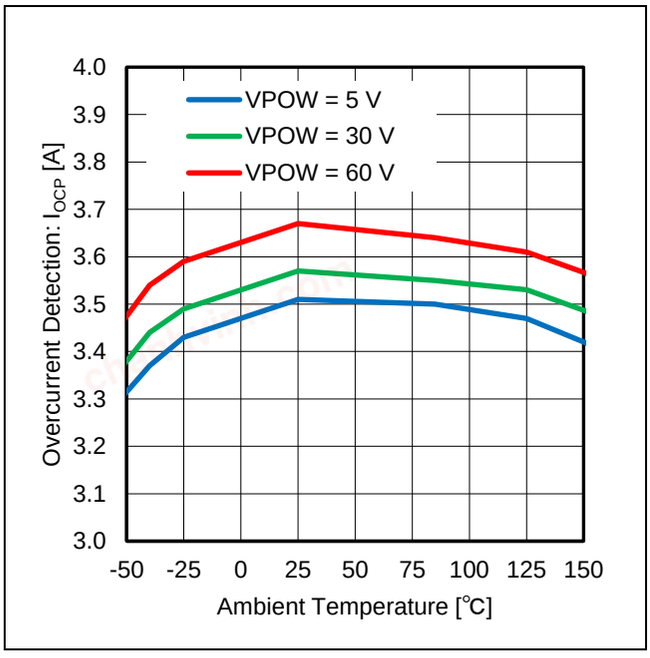


Figure 24. Overcurrent Detection vs Ambient Temperature

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Typical Performance Curves (Reference Data) - continued

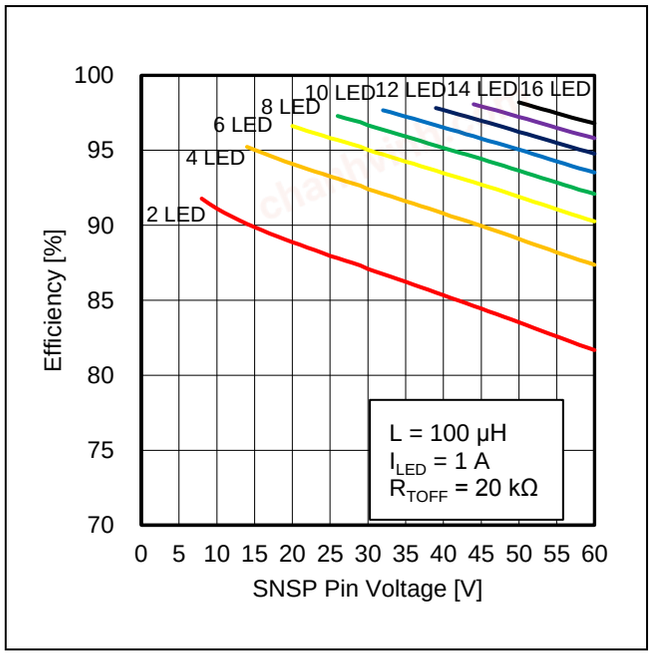


Figure 25. Efficiency vs SNSP Pin Voltage
(V_B = 13 V, I_{LED} = 1 A, R_{TOFF} = 20 kΩ, L = 100 µH)

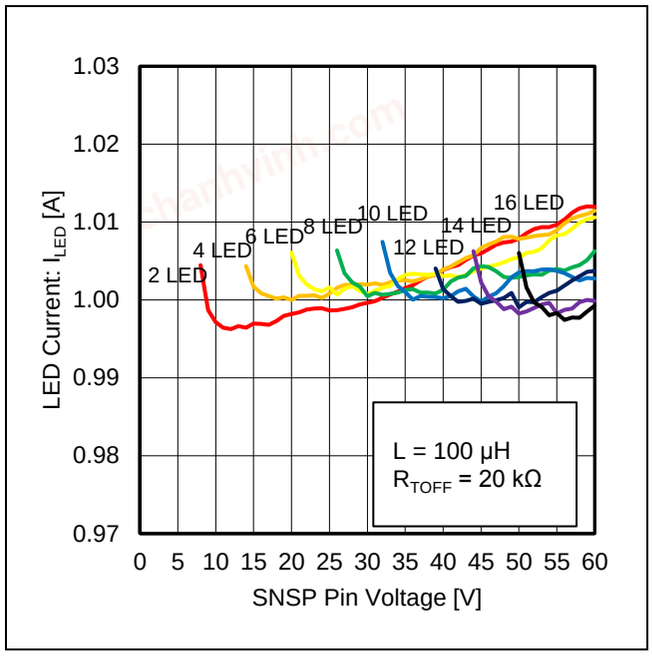


Figure 26. LED Current vs SNSP Pin Voltage
(V_B = 13 V, R_{TOFF} = 20 kΩ, L = 100 µH)

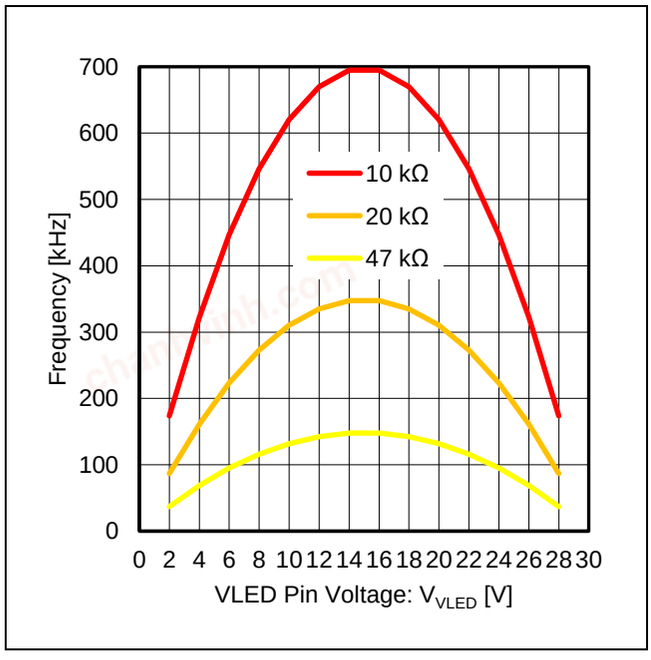


Figure 27. Frequency vs VLED Pin Voltage
(V_{SNSP} = 30 V, R_{TOFF} = 10 kΩ, 20 kΩ, 47 kΩ)

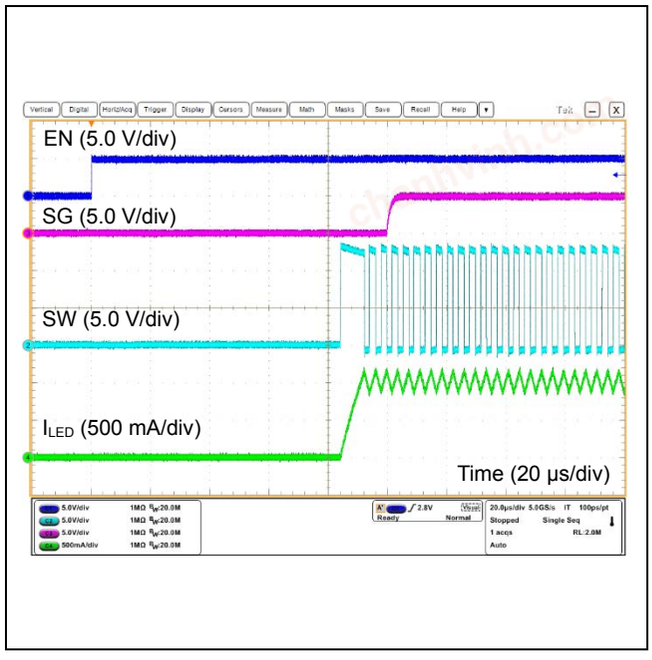


Figure 28. EN Start-up
(V_B = 13 V, V_{SNSP} = 13 V, L = 47 µH, I_{LED} = 1 A)

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Typical Performance Curves (Reference Data) - continued

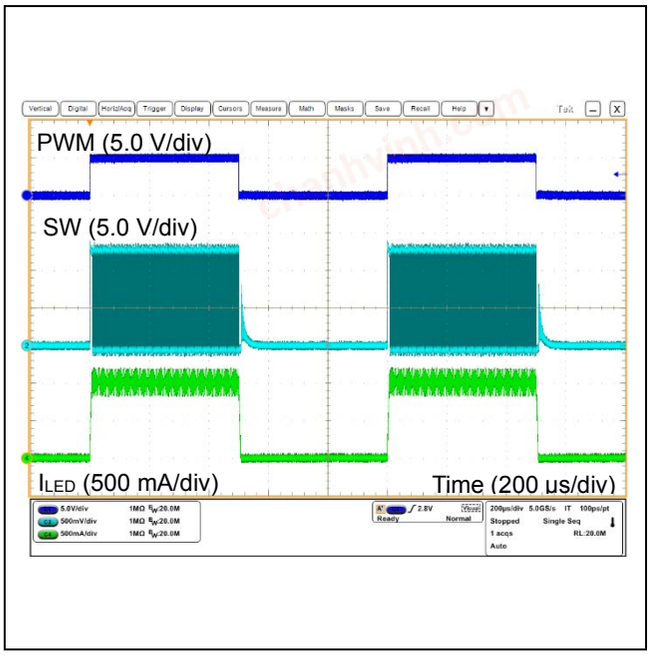


Figure 29. PWM Dimming
(V_B = 13 V, V_{SNSP} = 13 V, L = 47 µH, I_{LED} = 1 A,
PWM = 1 kHz, Duty = 50 %)

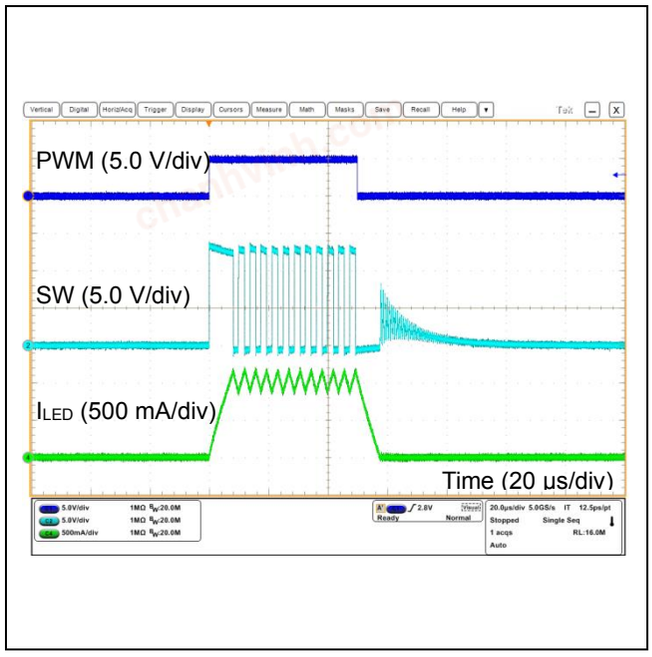


Figure 30. PWM Dimming
(V_B = 13 V, V_{SNSP} = 13 V, L = 47 µH, I_{LED} = 1 A,
PWM = 1 kHz, Duty = 0.5 %)

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Timing Chart

1. Start-up Sequence Controlled EN

(Start-up sequence of VB/SNSP is arbitrary)

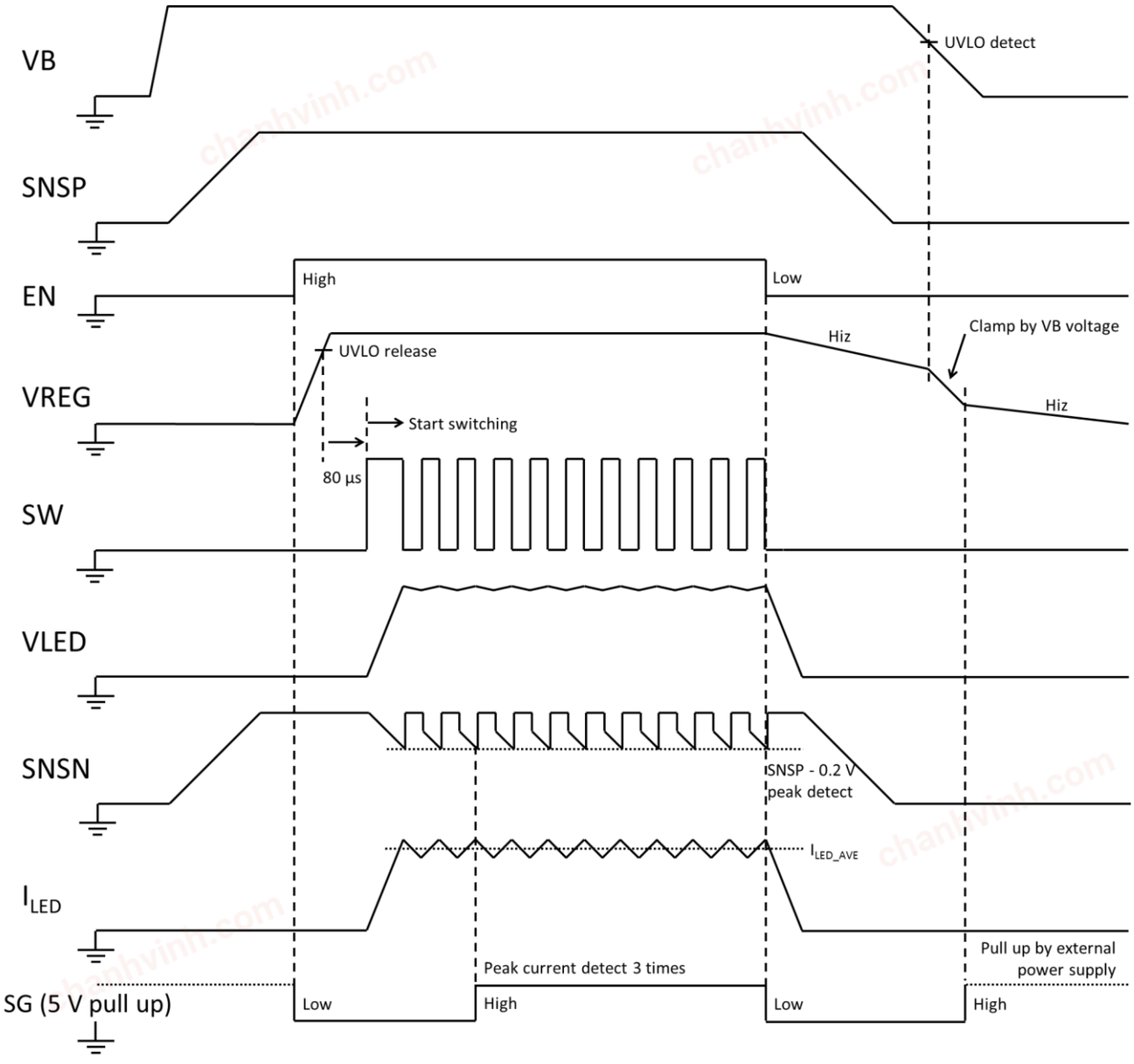


Figure 31. Timing Chart (ON/OFF Control with the EN Pin)

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Timing Chart – continued

2. Start-up Sequence for SNSP Rising 1 [EN Tied to VB]

(VB Start-up → SNSP Start-up / SNSP Shutdown → VB Shutdown)

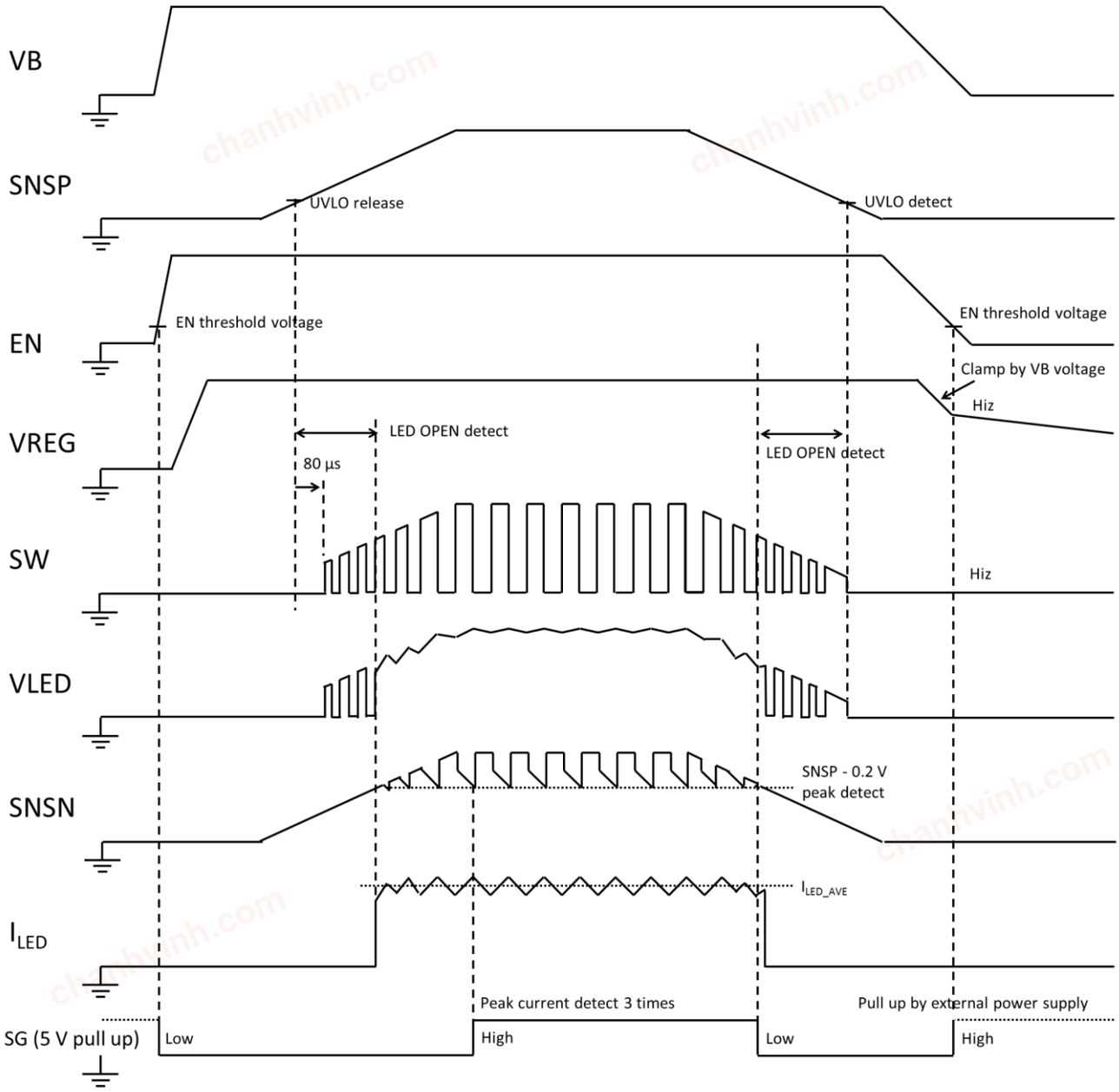


Figure 32. Timing Chart (VB Start-up → SNSP Start-up)

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Timing Chart – continued

3. Start-up Sequence for SNSP Rising 2 [EN Tied to VB]

(SNSP Start-up → VB Start-up / VB Shutdown → SNSP Shutdown)

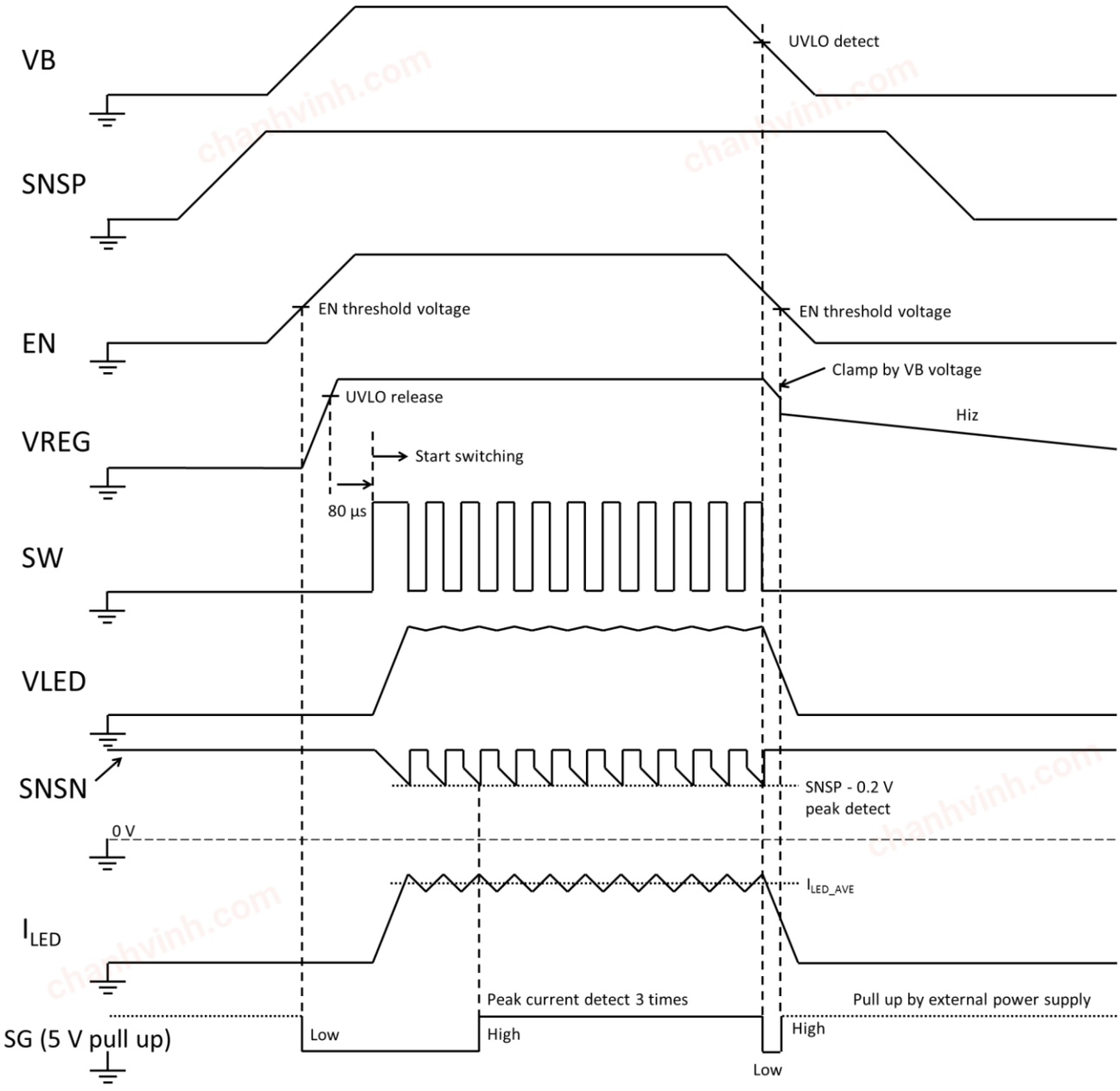


Figure 33. Timing Chart (SNSP Start-up → VB Start-up)

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Application Examples

1 3 LEDs (White), I_{LED} = 2 A Setting

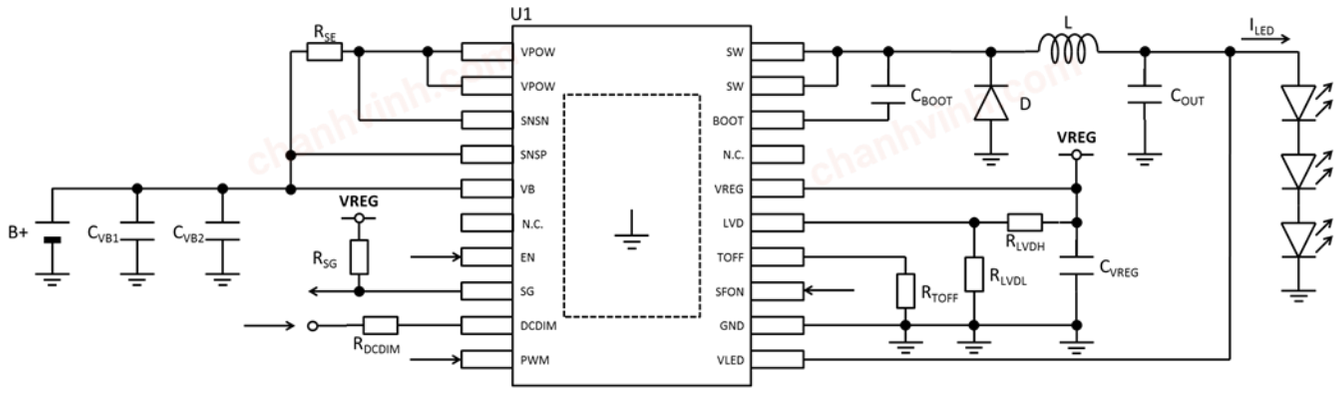


Figure 34. V_B = 13 V, I_{LED} = 2 A, LED = 3 Series, Frequency = 210 kHz

Recommended Parts List

Parts	Symbol	Parts Name	Value	Unit	Product Maker
IC	U1	BD18395EFV-M	-	-	ROHM
Resistor	R_{SE}	LTR18	91	mΩ	ROHM
	R_{SG}	MCR01	47	kΩ	ROHM
	R_{DCDIM}	MCR01	10	kΩ	ROHM
	R_{TOFF}	MCR01	11	kΩ	ROHM
	R_{LVDH}	MCR01	30	kΩ	ROHM
	R_{LVDL}	MCR01	20	kΩ	ROHM
Capacitor	C_{VB1}	GCM32EC71H106KA	10	μF	murata
	C_{VB2}	GCM155R71H104KE	0.1	μF	murata
	C_{BOOT}	GCM155R71C224KE	0.22	μF	murata
	C_{VREG}	GCM21BR71E225KA	2.2	μF	murata
	C_{OUT}	GCM155R71H103KA	0.01	μF	murata
Diode	D	RBR5LAM60ATF	-	-	ROHM
Inductor	L	CLF12577NIT-330M-D	33	μH	TDK

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Application Examples - continued

2 8 LEDs (White), I_{LED} = 1 A Setting

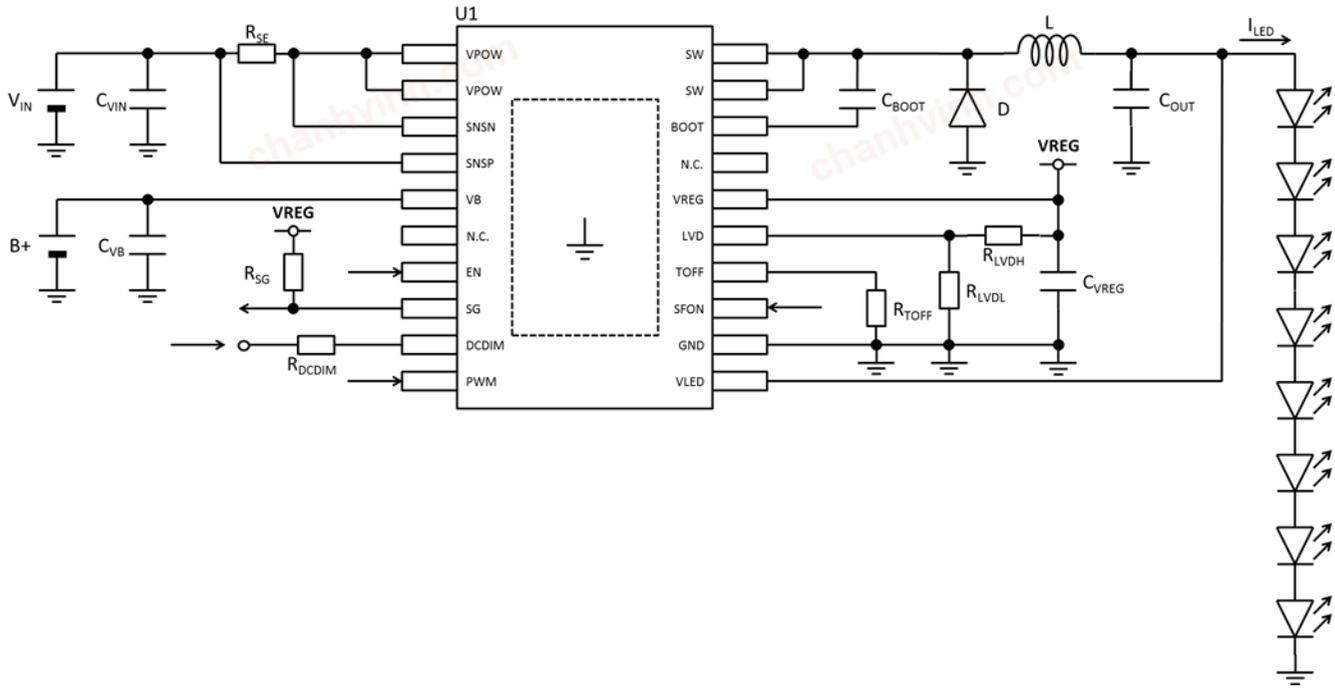


Figure 35. V_{IN} = 48 V, V_B = 13 V, I_{LED} = 1 A, LED = 8 Series, Frequency = 250 kHz

Recommended Parts List

Parts	Symbol	Parts Name	Value	Unit	Product Maker
IC	U1	BD18395EFV-M	-	-	ROHM
Resistor	R_{SE}	LTR18	182	mΩ	ROHM
	R_{SG}	MCR01	47	kΩ	ROHM
	R_{DCDIM}	MCR01	10	kΩ	ROHM
	R_{TOFF}	MCR01	40	kΩ	ROHM
	R_{LVDH}	MCR01	30	kΩ	ROHM
	R_{LVDL}	MCR01	20	kΩ	ROHM
Capacitor	C_{VIN}	GCM32EC71H106KA	10	μF	Murata
	C_{VB}	GCM21BR71C225KA	2.2	μF	Murata
	C_{BOOT}	GCM155R71C224KE	0.22	μF	Murata
	C_{VREG}	GCM21BR71E225KA	2.2	μF	Murata
	C_{OUT}	GCM155R71H103KA	0.01	μF	Murata
Diode	D	RB058LAM100TF	-	-	ROHM
Inductor	L	CLF12577NIT-221M-D	220	μH	TDK

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Application Examples - continued

3 16 LEDs (Yellow), I_{LED} = 350 mA Setting

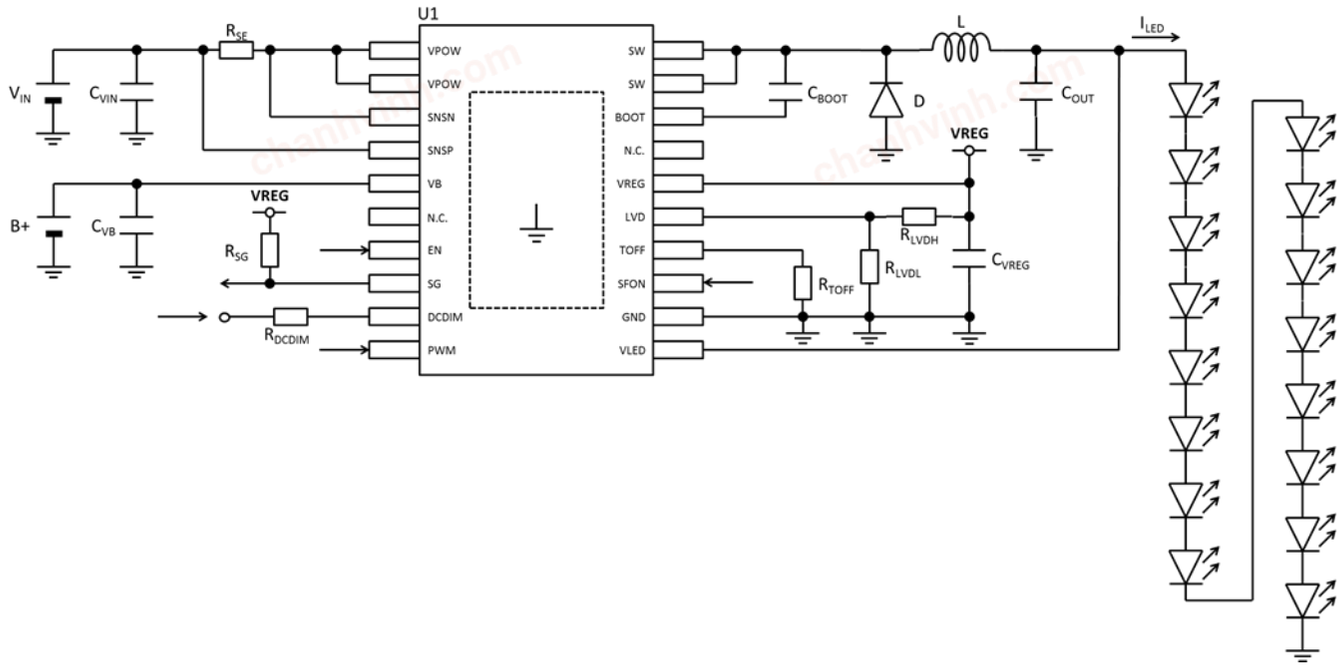


Figure 36. V_{IN} = 60 V, V_B = 13 V, I_{LED} = 350 mA, LED = Yellow 16 Series, Frequency = 350 kHz

Recommended Parts List

Parts	Symbol	Parts Name	Value	Unit	Product Maker
IC	U1	BD18395EFV-M	-	-	ROHM
Resistor	R_{SE}	LTR18	510	mΩ	ROHM
	R_{SG}	MCR01	47	kΩ	ROHM
	R_{DCDIM}	MCR01	10	kΩ	ROHM
	R_{TOFF}	MCR01	36	kΩ	ROHM
	R_{LVDH}	MCR01	39	kΩ	ROHM
	R_{LVDL}	MCR01	22	kΩ	ROHM
Capacitor	C_{VIN}	GCM32DC72A475KE	4.7	μF	Murata
	C_{VB}	GCM21BR71C225KA	2.2	μF	Murata
	C_{BOOT}	GCM155R71C224KE	0.22	μF	Murata
	C_{VREG}	GCM21BR71E225KA	2.2	μF	Murata
	C_{OUT}	GCM155R71H103KA	0.01	μF	Murata
Diode	D	RB058LAM100TF	-	-	ROHM
Inductor	L	CLF12577NIT-471M-D	470	μH	TDK

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Application Examples - continued

4 8 LEDs (Yellow), I_{LED} = 300 mA, with the Matrix SW Setting

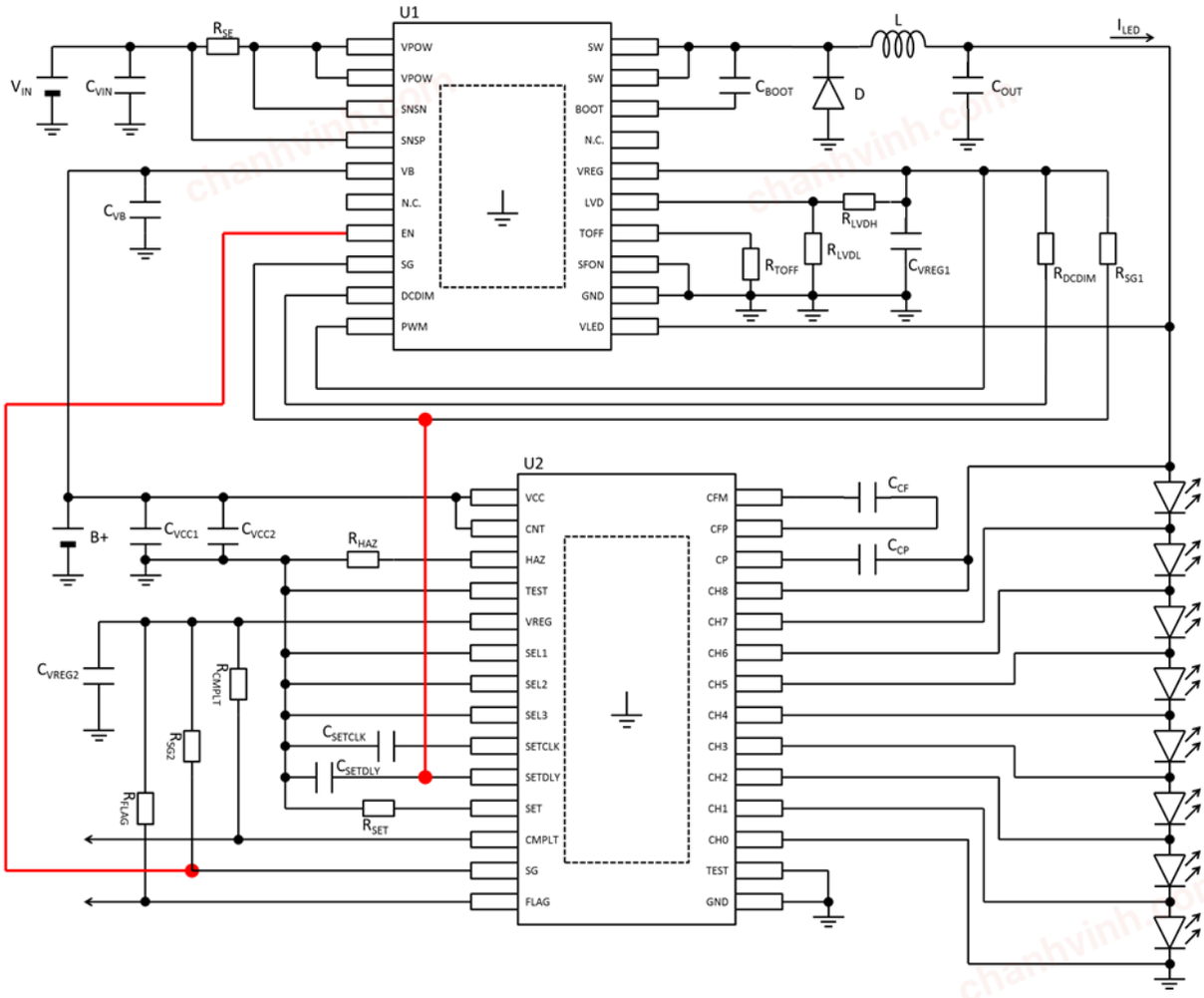


Figure 37. Use BD18395EFV-M and BD18362EFV-M *(Note 1)* 8 ch Dynamic Indicator
{BD18395EFV-M: V_{IN} = 24 V, V_B = 13 V, I_{LED} = 300 mA, LED = Yellow 8 Series (18.4 V), Frequency = 310 kHz}
{BD18362EFV-M: 8 ch Setting, The Sequential Lighting Phase Time t_{PS1} = 15 ms, The Sequential Lighting Start-up Delay Time t_{DLY} = 1.25 ms}

- Application of Dynamic Indicator (Use BD18395EFV-M and BD18362EFV-M *(Note 1)*)

The BD18395EFV-M has SG function (status good), and by using this function, it is easy to design the dynamic indicator application using BD18362EFV-M (8 ch Matrix SW).

· Connect the SG signal of BD18362EFV-M to the EN pin of BD18395EFV-M
· Connect the SG signal of BD18395EFV-M to the SETDLY pin of BD18362EFV-M

By starting the operation by connecting the above two points

Start operation

→ All the SW of BD18362EFV-M are ON (the SG pin of BD18362EFV-M = High).
→ The EN pin of BD18395EFV-M becomes High, so the driver operation starts.
→ Driver operation is normal, the SG pin of BD18395EFV-M = High.
→ The SETDLY pin of BD18362EFV-M becomes High, so sequential operation is started.

This prevents chattering at LED startup due to variation in startup time setting.

(Note 1) Please refer to datasheet for usage of BD18362EFV-M.

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4 8 LEDs (Yellow), I_{LED} = 300 mA, with the Matrix SW Setting - continued

Recommended Parts List

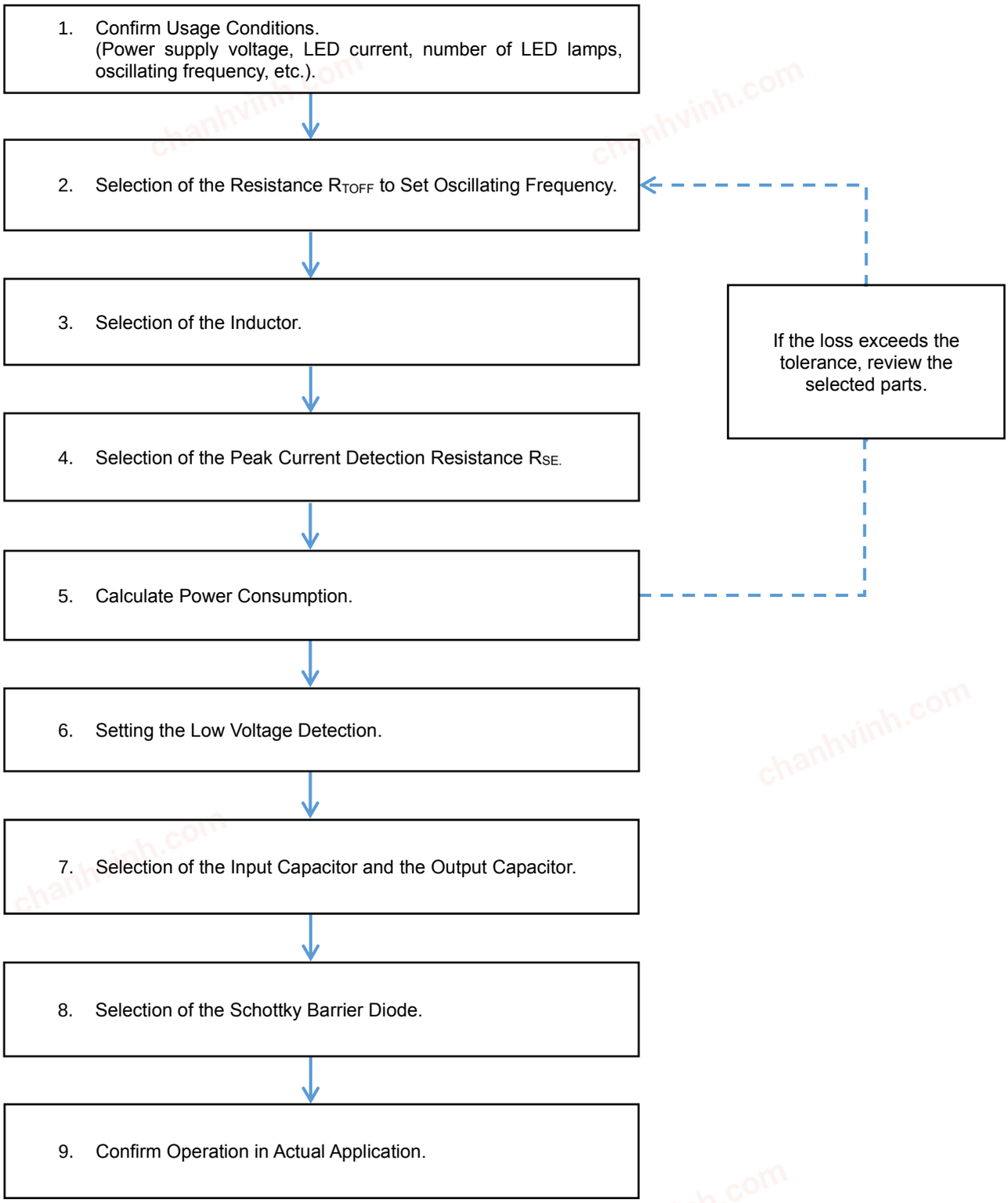
Parts	Symbol	Parts Name	Value	Unit	Product Maker
IC	U1	BD18395EFV-M	-	-	ROHM
Resistor	R_{SE}	LTR18	510	mΩ	ROHM
	R_{SG1}	MCR01	47	kΩ	ROHM
	R_{DCDIM}	MCR01	10	kΩ	ROHM
	R_{TOFF}	MCR01	13	kΩ	ROHM
	R_{LVDH}	MCR01	39	kΩ	ROHM
	R_{LVDL}	MCR01	22	kΩ	ROHM
Capacitor	C_{VIN}	GCM32EC71H106KA	4.7	μF	Murata
	C_{VB}	GCM21BR71C225KA	2.2	μF	Murata
	C_{BOOT}	GCM155R71C224KE	0.22	μF	Murata
	C_{VREG}	GCM21BR71E225KA	2.2	μF	Murata
	C_{OUT}	GCM155R71H103KA	0.01	μF	Murata
Diode	D	RBR5LAM60ATF	-	-	ROHM
Inductor	L	CLF12577NIT-221M-D	220	μH	TDK
IC	U2	BD18362EFV-M	-	-	ROHM
Resistor	R_{HAZ}	MCR01	10	kΩ	ROHM
	R_{SET}	MCR01	10	kΩ	ROHM
	R_{CMPLT}	MCR01	22	kΩ	ROHM
	R_{FLAG}	MCR01	22	kΩ	ROHM
	R_{SG2}	MCR01	22	kΩ	ROHM
Capacitor	C_{VCC1}	GCM32EC71H106KA	10	μF	Murata
	C_{VCC2}	GCM155R71H104KE	0.1	μF	Murata
	C_{VREG2}	GCM21BR71C225KA49	2.2	μF	Murata
	C_{SETDLY}	GCM155R71H473KE01	0.047	μF	Murata
	C_{SETCLK}	GCM2162C1K472JA01	0.0047	μF	Murata
	C_{CF}	GCJ188R71H473KA12	0.047	μF	Murata
	C_{CP}	GCJ188R71H473KA12	0.047	μF	Murata

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Selection of Parts Externally Connected

Please follow the below procedure for selecting application parts.



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Selection of Parts Externally Connected - continued

1. **Confirm Usage Conditions**
Confirm the following usage conditions before proceeding with calculations.

1.1	LED current (Average)	: I_{LED_AVE}
1.2	Power supply voltage	: V_{SNSP}
1.3	VLED voltage	: V_{VLED}
1.4	Oscillating frequency	: f_{SW}
1.5	Schottky barrier diode forward direction voltage	: V_{SBD}

2. **Selection of the Resistance R_{TOFF} to Set Oscillating Frequency**
Calculate oscillating frequency from power supply voltage V_{SNSP} and the VLED pin voltage V_{VLED}. Oscillating frequency can be adjusted by the external resistance R_{TOFF}. Oscillating frequency, f_{SW} can be calculated by the following formula:

$$f_{SW} = \frac{V_{SNSP}-V_{VLED}}{V_{SNSP}+V_{SBD}} \times \frac{1}{t_{OFF}} = \frac{V_{SNSP}-V_{VLED}}{V_{SNSP}+V_{SBD}} \times \frac{V_{VLED}}{1.05\times10^{-9}\times R_{TOFF}} \quad [Hz]$$

R_{TOFF} : External resistance value to connect at the TOFF pin
V_{VLED} : LED Vf voltage (= VLED pin voltage)
V_{SNSP} : SNSP pin voltage
V_{SBD} : External Schottky barrier diode forward direction voltage

When used in combination with Matrix SW controller, while switching LEDs, the frequency becomes minimum with either the minimum number of LED lights (other than zero) or the maximum number of LED lights. Also, when V_{VLED} = V_{SNSP} / 2, the oscillation frequency becomes maximum.

3. **Selection of the Inductor**
Calculate the desired LED current ripple I_{LED_RIPPLE} by selecting an optimal inductor value.
Recommended output ripple current is within 5 % to 20 % of desired LED current.
Value of inductor can be calculated by substituting the values of R_{TOFF} from step 2 above and desired LED current ripple, in the following formula:

$$I_{LED_RIPPLE} = \frac{V_{VLED}+V_{SBD}}{L} \times t_{OFF} = \frac{V_{VLED}+V_{SBD}}{L} \times 1.05 \times 10^{-9} \times \frac{R_{TOFF}}{V_{VLED}} \quad [A]$$

R_{TOFF} : External resistance value to connect at the TOFF pin
V_{VLED} : LED Vf voltage (= VLED pin voltage)
V_{SBD} : External Schottky barrier diode forward direction voltage
L : Inductor value

4. **Selection of the Peak Current Detection Resistance R_{SE}**
Calculate the average LED current I_{LED_AVE} and select the value of the peak current detection resistor R_{SE}.
Calculate the LED average current based on the R_{TOFF} and L values obtained in 2 and 3 above and calculate the peak current detection resistance value.
The average LED current I_{LED_AVE} is calculated by the following formula:

$$I_{LED_AVE} = \frac{0.2}{R_{SE}} - \frac{I_{LED_RIPPLE}}{2} \quad [A]$$

R_{SE} : Peak current detection resistance
I_{LED_RIPPLE} : LED ripple current

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Selection of Parts Externally Connected - continued

5. Calculate Power Consumption

Calculate power consumption from input voltage, number of LEDs, LED average current and oscillating frequency. Use the following formulae to calculate IC power consumption:

$$P_{TOTAL} = P_{FET} + P_{preDRV} + P_{ICC} \text{ [W]}$$

$$P_{FET} = P_{tr} + P_{tf} + P_{ton} + P_{toff} \text{ [W]} \qquad P_{preDRV} = Q_g \times V_{REG} \times f_{SW} \text{ [W]}$$

$$P_{ICC} = V_B \times I_{CCVB} + V_{SNSP} \times I_{CCSNSP} \text{ [W]} \qquad P_{tr} = V_{SNSP} \times I_{L_AVE} \times 0.5 \times t_r \times f_{SW} \text{ [W]}$$

$$P_{tf} = V_{SNSP} \times I_{L_AVE} \times 0.5 \times t_f \times f_{SW} \text{ [W]} \qquad P_{ton} = I_{L_AVE} \times I_{L_AVE} \times R_{ONH} \times \frac{V_{VLED}+V_{SBD}}{V_{SNSP}+V_{SBD}} \text{ [W]}$$

$$P_{toff} = \frac{{V_{SBD}}^2}{R_{ONL}} \times \frac{V_{SNSP}-V_{VLED}}{V_{SNSP}+V_{SBD}} \text{ [W]}$$

P_{TOTAL}	: Total power consumption
V_{SNSP}	: SNSP voltage
V_B	: VB voltage
V_{VLED}	: VLED voltage
V_{REG}	: VREG voltage
V_{SBD}	: External schottky barrier diode forward direction voltage
I_{L_AVE}	: Average inductor current
I_{CCSNSP}	: SNSP current
I_{CCVB}	: VB supply current
Q_g	: Internal gate charge (1.4 nC)
f_{SW}	: Oscillating frequency
R_{ONH}	: MOS FET ON resistance between the VPOW and SW pins
R_{ONL}	: MOS FET ON resistance between the SW and GND pins
t_r	: SW pin rising time
t_f	: SW pin falling time

6. Setting the Low Voltage Detection

If you have a situation where you are using the Matrix SW controller and all the switches are on and the LEDs are 0, you need to set the low voltage detection voltage V_{LVD} to detect that the LEDs are 0. The low voltage detection voltage is set by the voltage value input from the outside to the LVD pin. Connect external resistors R_{LVDH} and R_{LVDL} between the VREG pin and the GND pin. Also, set the low voltage detection voltage to be in the range of 1.5 V to 2.75 V. It must be set lower than the Vf voltage when one LED is lit.

The low voltage detection voltage V_{LVD} is calculated by the following formula.

$$V_{LVD} = V_{REG} \times \frac{R_{LVDL}}{R_{LVDH}+R_{LVDL}} \text{ [V]}$$

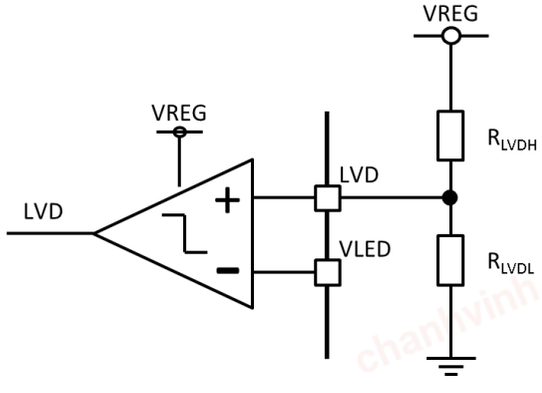


Figure 38. How to Set the Low Voltage Detection

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Selection of Parts Externally Connected - continued

7. **Selection of the Input Capacitor and the Output Capacitor**
   A capacitor is required on the input side of switching type LED driver as peak current flows between input and output. Capacitor value of 4.7 µF or more with ESR of 100 mΩ or less, is recommended at the input. Capacitor beyond this range may cause excessive ripple on the input, causing malfunction of the IC.

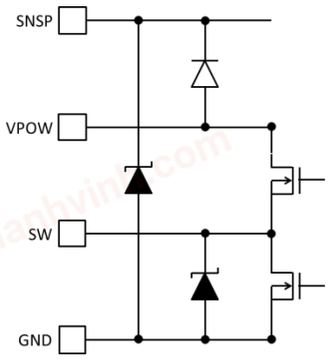
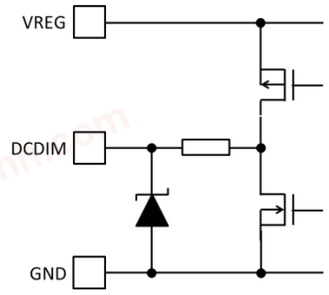
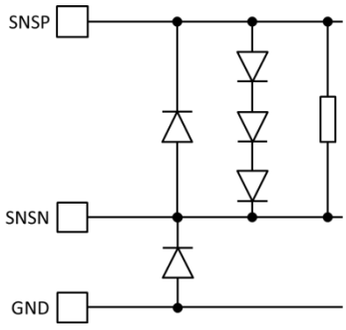
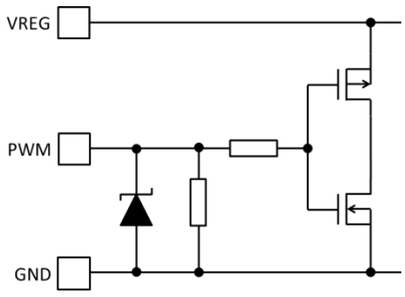
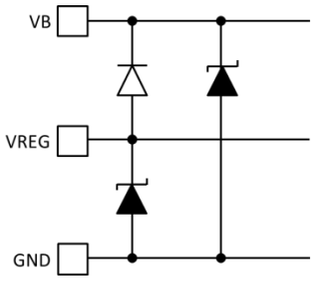
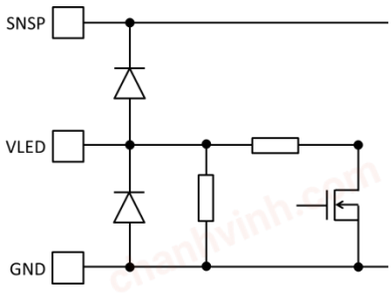
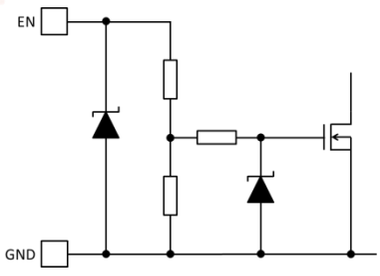
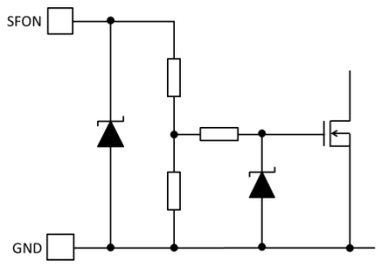
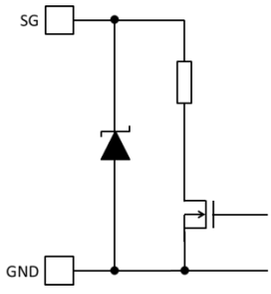
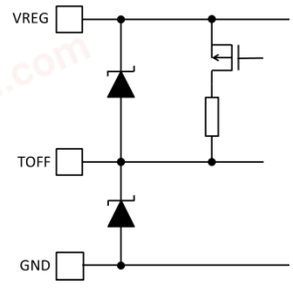
8. **Selection of the Schottky Barrier Diode**
   In the switching type Buck LED driver, when the High side FET is turned off, the current is supplied from the external Schottky barrier diode. Therefore, select a schottky barrier diode whose current capacity is sufficiently higher than the LED current. Also, if the Vf voltage of the diode is high, not only the power loss will increase, but also the SW pin voltage will become a negative voltage, which may cause the circuit inside the LSI to malfunction. Therefore, a diode with as low a Vf voltage as possible is recommended.

9. **Confirm Operation in Actual Application**
   The characteristics will change depending on the LED current, input voltage, output voltage, inductor value, load capacity, switching frequency, mounting pattern, etc., so be sure to check with the actual application.

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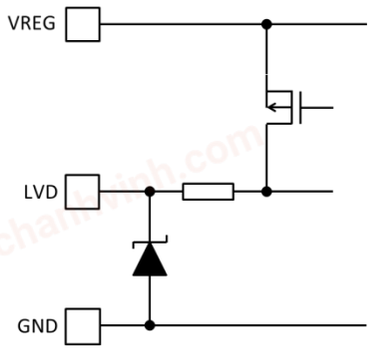
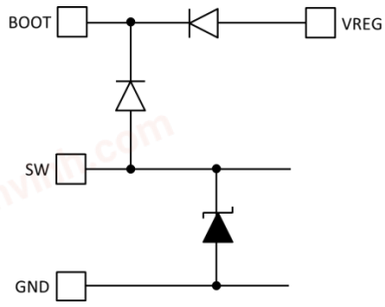
I/O Equivalence Circuit

1 2 4 19 20	VPOW VPOW SNSP SW SW		9	DCDIM	
3	SNSN		10	PWM	
5 16	VB VREG		11	VLED	
7	EN		13	SFON	
8	SG		14	TOFF	

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I/O Equivalence Circuit - continued

15	LVD		18	BOOT	

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Operational Notes

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

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

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition. However, pins that drive inductive loads (e.g. motor driver outputs, DC-DC converter outputs) may inevitably go below ground due to back EMF or electromotive force. In such cases, the user should make sure that such voltages going below ground will not cause the IC and the system to malfunction by examining carefully all relevant factors and conditions such as motor characteristics, supply voltage, operating frequency and PCB wiring to name a few.

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

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

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

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

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

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

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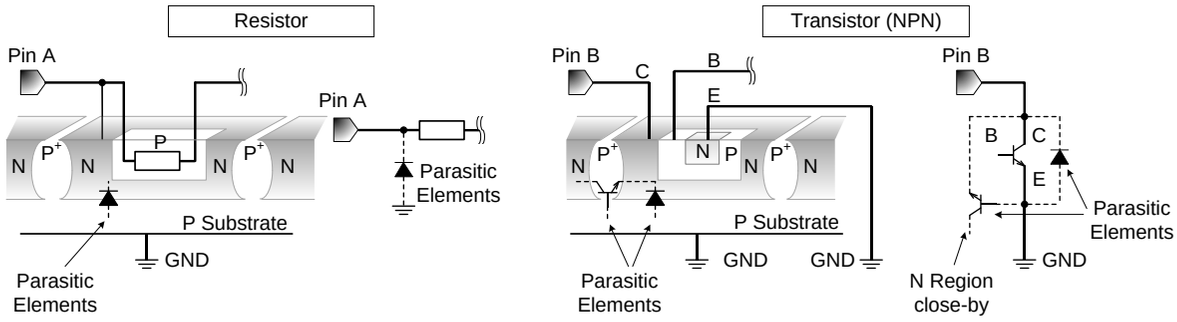
Operational Notes – continued

10. Regarding the Input Pin of the IC

This 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.



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.

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.

14. Functional Safety

"ISO 26262 Process Compliant to Support ASIL-*"
A product that has been developed based on an ISO 26262 design process compliant to the ASIL level described in the datasheet.
"Safety Mechanism is Implemented to Support Functional Safety (ASIL-*)"
A product that has implemented safety mechanism to meet ASIL level requirements described in the datasheet.
"Functional Safety Supportive Automotive Products"
A product that has been developed for automotive use and is capable of supporting safety analysis with regard to the functional safety.
Note: "ASIL-*" is stands for the ratings of "ASIL-A", "-B", "-C" or "-D" specified by each product's datasheet.

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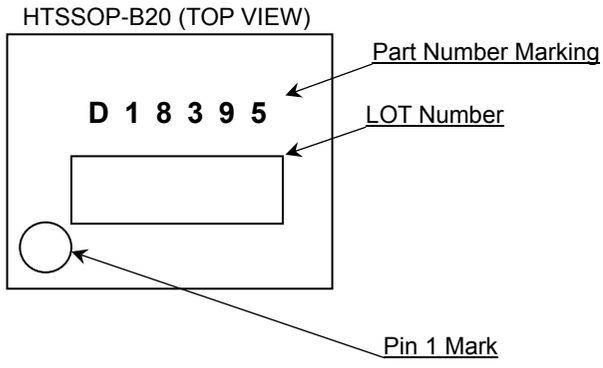
Ordering Information

B D 1 8 3 9 5 E F V - M E 2

Package
EFV: HTSSOP-B20

Packaging and forming specification
M: for Automotive
Packaging and forming specification
E2: Embossed tape and reel

Marking Diagram

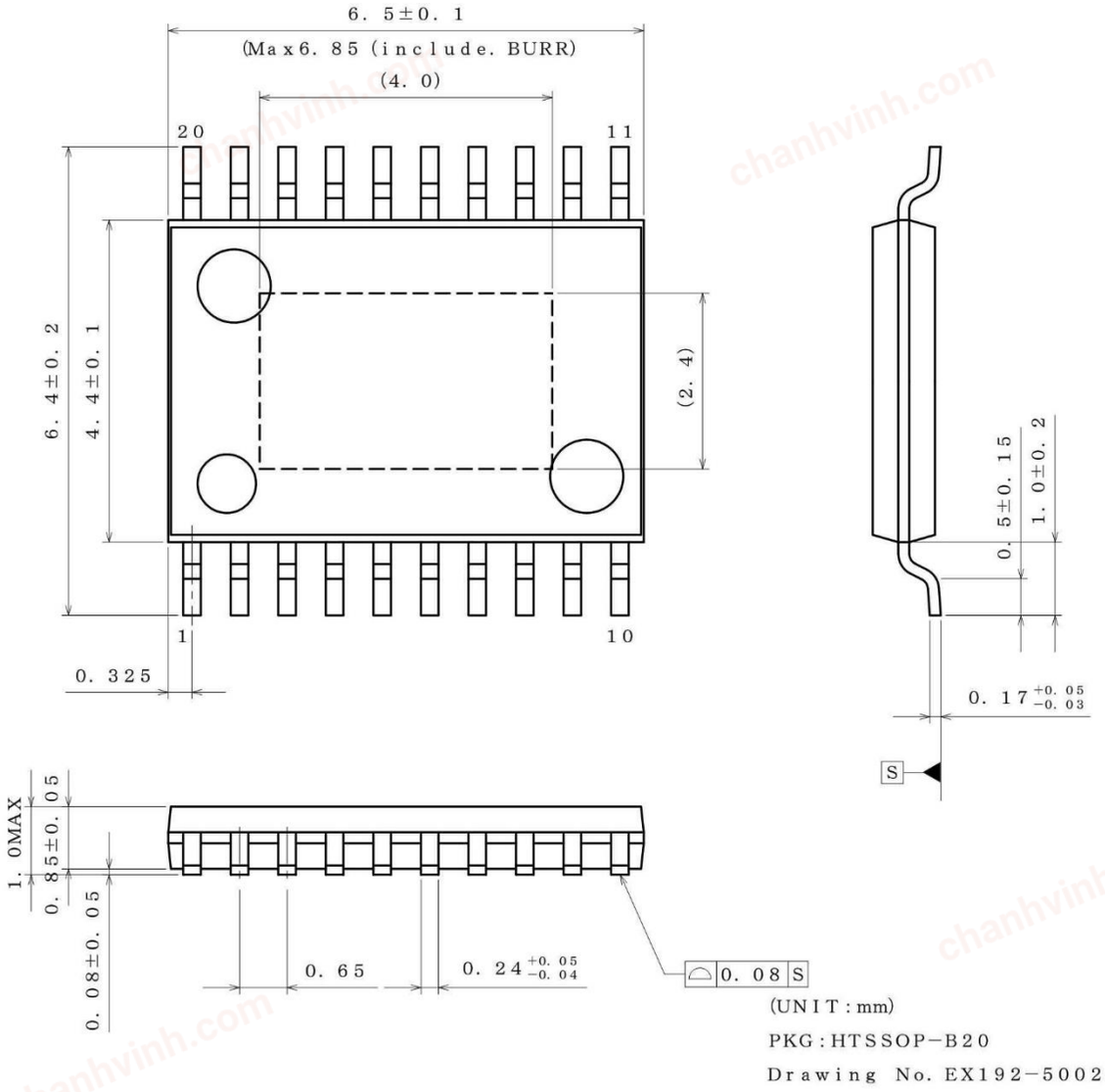


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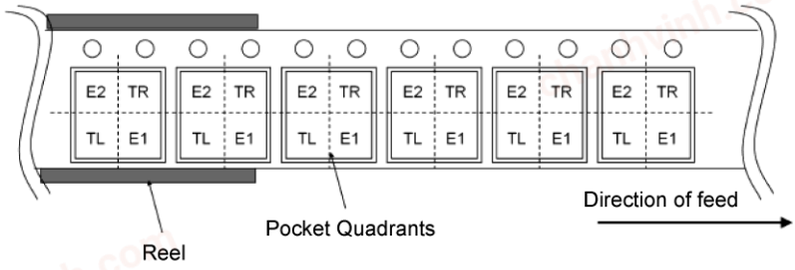
Physical Dimension and Packing Information

Package Name	HTSSOP-B20



< 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



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Revision History

Date	Revision	Changes
15.Dec.2020	001	New Release

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Notice

Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), aircraft/spacecraft, nuclear power controllers, 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:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are not designed under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

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

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

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

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

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

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

Precaution for Mounting / Circuit board design

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

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

For details, please refer to ROHM Mounting specification

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Precautions Regarding Application Examples and External Circuits

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

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

Precaution for Electrostatic

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

Precaution for Storage / Transportation

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

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

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

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

Precaution for Product Label

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

Precaution for Disposition

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

Precaution for Foreign Exchange and Foreign Trade act

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

Precaution Regarding Intellectual Property Rights

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General Precaution

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