Power Management IC Series for Automotive Body Control

White Backlight LED Driver for Medium to Large LCD Panels (Switching Regulator Type)

BD8119FM-M

No.11039EBT07

●Description

BD8119FM-M is a white LED driver with the capability of withstanding high input voltage (36V MAX).
This driver has 4ch constant-current drivers integrated in 1-chip, which each channel can draw up to 150mA max, so that high brightness LED driving can be realized.
Furthermore, a current-mode buck-boost DC/DC controller is also integrated to achieve stable operation against unstable car-battery voltage input and also to remove the constraint of the number of LEDs in series connection.
The brightness can be controlled by either PWM or VDAC techniques.

●Features

1) Input voltage range is 5.0 to 30 V
2) Integrated buck-boost current-mode DC/DC controller
3) Four integrated LED current driver channels (150mA max. each channel)
4) PWM Light Modulation (Minimum Pulse Width 25µs)
5) Built-in protection functions (UVLO, OVP, TSD, OCP, SCP)
6) Abnormal status detection function (OPEN/ SHORT)
7) HSOP-M28 package

●Applications

Backlight for car navigation, dashboard panels, etc.
(※ Recommended Component of Toshiba Matsushita Display Technology Co.,Ltd.)

●Absolute maximum ratings (Ta=25℃)

Parameter	Symbol	Ratings	Unit
Power supply voltage	V_{CC}	36	V
BOOT ,OUTH Voltage	V_{BOOT}, V_{OUTH}	41	V
SW,CS Voltage	V_{SW}, V_{CS}, V_{OUTH}	36	V
BOOT-SW Voltage	$V_{BOOT\text{-}SW}$	7	V
LED output voltage	$V_{LED1\sim4}$	36	V
VREG, OVP, OUTL, FAIL1, FAIL2, LEDEN1, LEDEN2, ISET, VDAC, PWM, SS, COMP, RT, SYNC, EN Voltage	V_{VREG}, V_{OVP}, V_{OUTL}, V_{FAIL1}, V_{FAIL2}, V_{LEDEN1}, V_{LEDEN2}, V_{ISET}, V_{VDAC}, V_{PWM}, V_{SS}, V_{COMP}, V_{RT}, V_{SYNC}, V_{EN}	-0.3～7 < V_{CC}	V
Power Consumption	Pd	2.20 ※1	W
Operating temperature range	Topr	-40～+95	℃
Storage temperature range	Tstg	-55～+150	℃
LED maximum output current	I_{LED}	150 ※2 ※3	mA

※1 IC mounted on glass epoxy board measuring 70mm×70mm×1.6mm, power dissipated at a rate of 17.6mw/℃ at temperatures above 25℃.
※2 Dispersion figures for LED maximum output current and V_F are correlated. Please refer to data on separate sheet.
※3 Amount of current per channel.

●Operating conditions (Ta=25℃)

Parameter	Symbol	Ratings	Unit
Power supply voltage	V_{CC}	5.0～30	V
Oscillating frequency range	F_{OSC}	250～550	kHz
External synchronization frequency range ※4 ※5	F_{SYNC}	fosc～550	kHz
External synchronization pulse duty range	F_{SDUTY}	40～60	%

※4 Connect SYNC to GND or OPEN when not using external frequency synchronization.
※5 Do not switch between internal and external synchronization when an external synchronization signal is input to the device.

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●Electrical Characteristics (unless otherwise specified, V_{CC}=12V Ta=25℃)

Parameter	Symbol	Limits			Unit	Conditions
		Min	Typ	Max.		
Circuit current	I_{CC}	-	7	14	mA	EN=Hi, SYNC=Hi, RT=OPEN PWM=Low, ISET=OPEN, C_{IN}=10µF
Standby current	I_{ST}	-	4	8	µA	EN=Low
[VREG Block (VREG)]						
Reference voltage	V_{REG}	4.5	5	5.5	V	I_{REG}=-5mA, C_{REG}=2.2µF
[OUTH Block]						
OUTH high-side ON resistance	R_{ONHH}	1.0	3	4.5	Ω	I_{ON}=-10mA
OUTH low-side ON resistance	R_{ONHL}	0.5	2	3.0	Ω	I_{ON}=10mA
Over-current protection operating voltage	V_{OLIMIT}	V_{CC} -0.66	V_{CC} -0.6	V_{CC} -0.54	V	
[OUTL Block]						
OUTH high-side ON resistance	R_{ONLH}	1.0	3	4.5	Ω	I_{ON}=-10mA
OUTH low -side ON resistance	R_{ONLL}	0.5	2	3.0	Ω	I_{ON}=10mA
[SW Block]						
SW low -side ON resistance	R_{ON_SW}	1.0	2.0	4.0	Ω	I_{ON_SW}=10mA
[Error Amplifie Block]						
LED voltage	V_{LED}	0.9	1.0	1.1	V	
COMP sink current	$I_{COMPSINK}$	15	25	35	µA	V_{LED}=2V, Vcomp=1V
COMP source current	$I_{COMPSOURCE}$	-35	-25	-15	µA	V_{LED}=0V, Vcomp=1V
[Oscillator Block]						
Oscillating frequency	f_{OSC}	250	300	350	KHz	R_T=100kΩ
[OVP Block]						
Over-voltage detection reference voltage	V_{OVP}	1.9	2.0	2.1	V	V_{OVP}=Sweep up
OVP hysteresis width	V_{OHYS}	0.45	0.55	0.65	V	V_{OVP}=Sweep down
SCP Latch OFF Delay Time	T_{SCP}	70	100	130	ms	R_T=100kΩ
[UVLO Block]						
UVLO voltage	V_{UVLO}	4.0	4.3	4.6	V	V_{CC} : Sweep down
UVLO hysteresis width	V_{UHYS}	50	150	150	mV	V_{CC} : Sweep up

◎ This product is not designed for use in radioactive environments.

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●**Electrical Characteristics – Continued** (unless otherwise specified, VCC=12V Ta=25℃)

Parameter	Symbol	Limits			Unit	Conditions
		Min	Typ	Max.		
[LED Output Block]						
LED current relative dispersion width	ΔI_{LED1}	-3	-	+3	%	I_{LED}=50mA, $\Delta I_{LED1}=(I_{LED} I_{LED\_AVG}-1)\times 100$
LED current absolute dispersion width	ΔI_{LED2}	-5	-	+5	%	I_{LED}=50mA, $\Delta I_{LED2}=(I_{LED}50mA-1)\times 100$
ISET voltage	V_{ISET}	1.96	2.0	2.04	V	RISET 1=120kΩ
PWM minimum pulse width	Tmin	25	-	-	µs	F_{PWM}=150Hz, I_{LED}=50mA
PWM maximum duty	Dmax	-	-	100	%	F_{PWM}=150Hz, I_{LED}=50mA
PWM frequency	f_{PWM}	-	-	20	KHz	Duty=50%, I_{LED}=50mA
VDAC gain	G_{VDAC}	-	25	-	mA/V	V_{DAC}=0～2V, R_{ISET}=120kΩ I_{LED}=VDAC÷R_{ISET}×Gain
Open detection voltage	V_{OPEN}	0.2	0.3	0.4	V	V_{LED}= Sweep down
LED Short detection Voltage	V_{SHORT}	4.4	4.7	5.0	V	V_{OVP}= Sweep up
LED Short Latch OFF Delay Time	T_{SHORT}	70	100	130	ms	RT=100kΩ
PWM Latch OFF Delay Time	T_{PWM}	70	100	130	ms	RT=100kΩ
[Logic Inputs (EN, SYNC, PWM, LEDEN1, LEDEN2)]						
Input HIGH voltage	V_{INH}	2.1	-	5.5	V	
Input LOW voltage	V_{INL}	GND	-	0.8	V	
Input current 1	I_{IN}	20	35	50	µA	V_{IN}=5V (SYNC, PWM, LEDEN1, LEDEN2)
Input current 2	I_{EN}	15	25	35	µA	V_{EN}=5V (EN)
[FAIL Output (open drain)]						
FAIL LOW voltage	V_{OL}	-	0.1	0.2	V	I_{OL}=0.1mA

◎ This product is not designed for use in radioactive environments.

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●Reference data (unless otherwise specified, Ta=25℃)

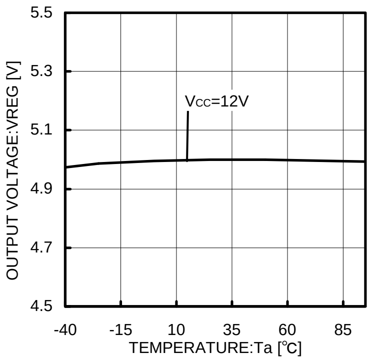

Fig.1 VREG
temperature characteristic

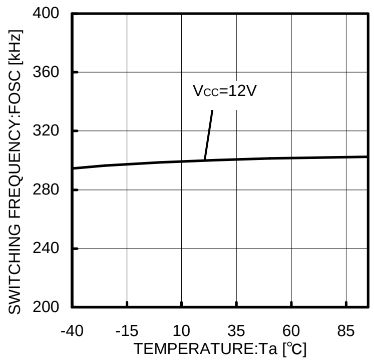

Fig.2 OSC
temperature characteristic

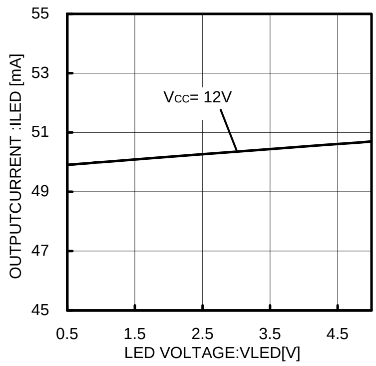

Fig.3 ILED depend on VLED

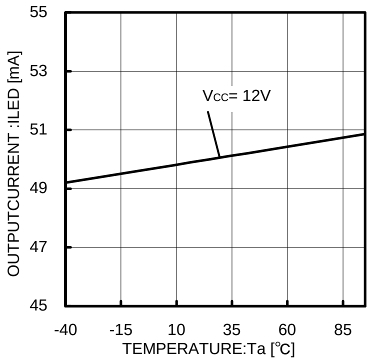

Fig.4 ILED
temperature characteristic

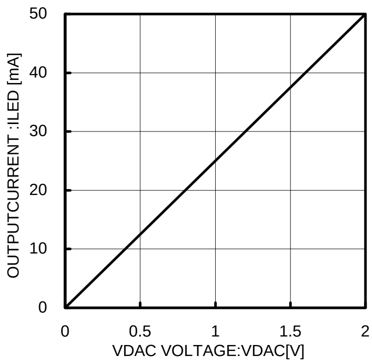

Fig.5 VDAC Gain①

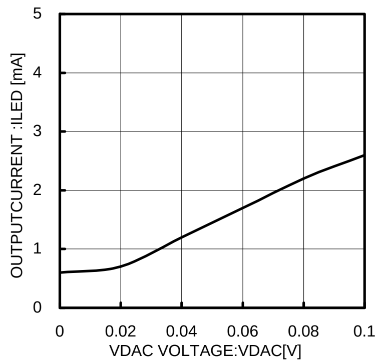

Fig.6 VDAC Gain②

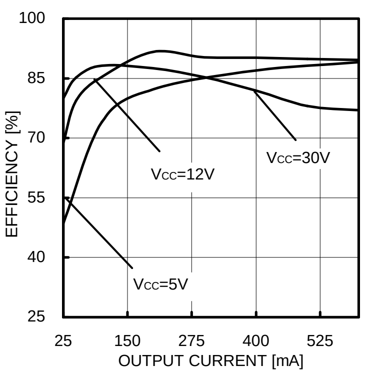

Fig.7 Efficiency
(Depend on input voltage)

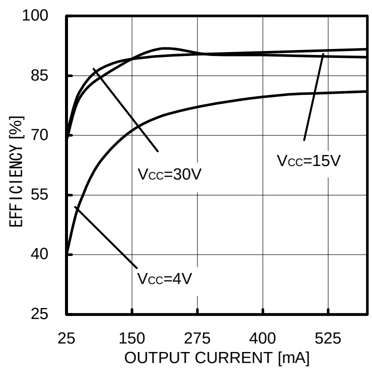

Fig.8 Efficiency
(Depend on output voltage)

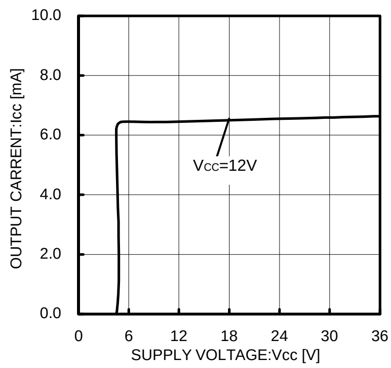

Fig.9 Circuit Current
(Switching OFF)

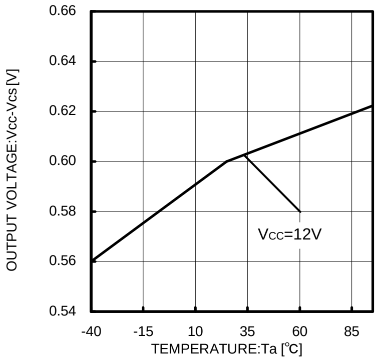

Fig.10 Overcurrent detecting
voltage temperature characteristic

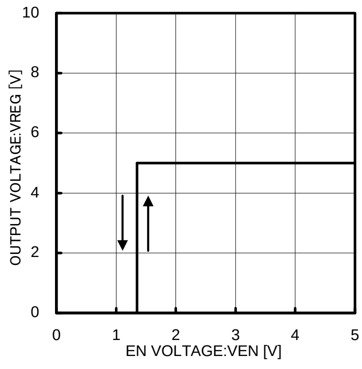

Fig.11 EN threshold voltage

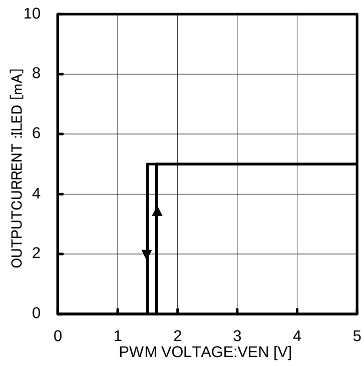

Fig.12 PWM threshold voltage

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● Block diagram

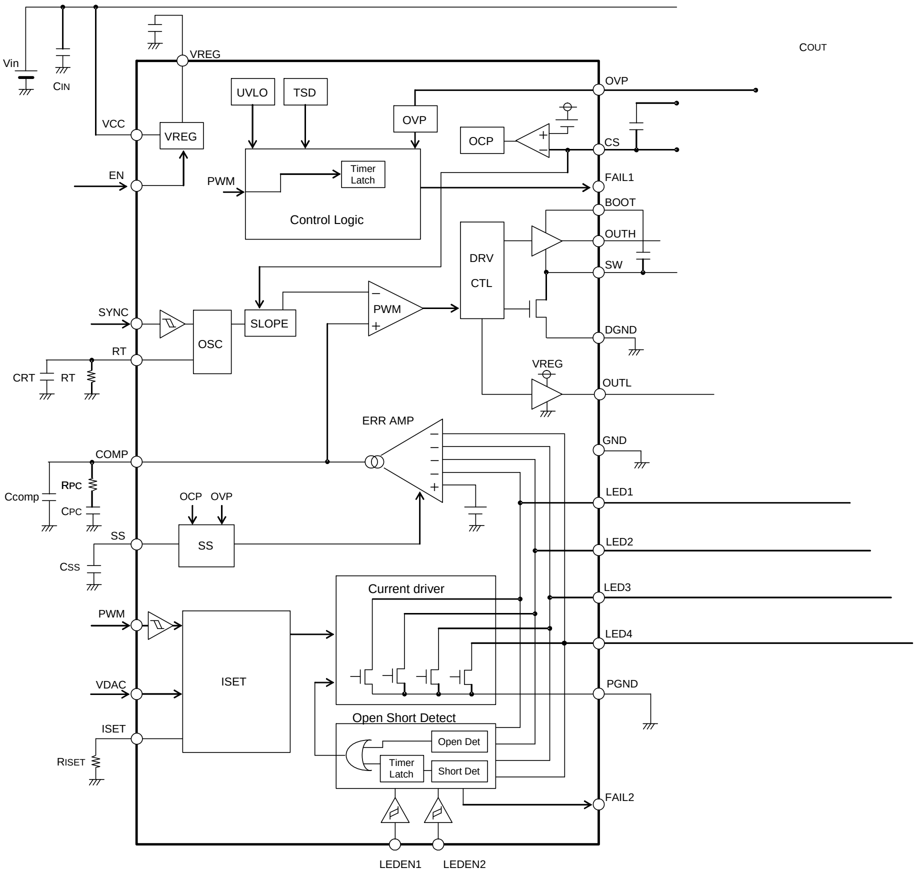

Fig.13

● Pin layout

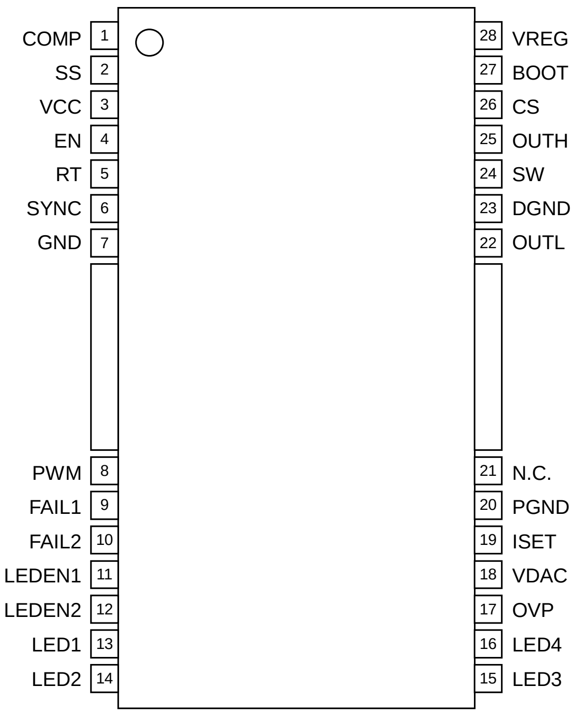

Fig.14

● Pin function table

Pin	Symbol	Function
1	COMP	Error amplifier output
2	SS	Soft start time-setting capacitance input
3	VCC	Input power supply
4	EN	Enable input
5	RT	Oscillation frequency-setting resistance input
6	SYNC	External synchronization signal input
7	GND	Small-signal GND
8	PWM	PWM light modulation input
9	FAIL1	Failure signal output
10	FAIL2	LED open/short detection signal output
11	LEDEN1	LED output enable pin 1
12	LEDEN2	LED output enable pin 2
13	LED1	LED output 1
14	LED2	LED output 2
15	LED3	LED output 3
16	LED4	LED output 4
17	OVP	Over-voltage detection input
18	VDAC	DC variable light modulation input
19	ISET	LED output current-setting resistance input
20	PGND	LED output GND
21	-	N.C.
22	OUTL	Low-side external MOSFET Gate Drive out put
23	DGND	Low-side internal MOSFET Source out put
24	SW	High-side external MOSFET Source pin
25	OUTH	High-side external MOSFET Gate Drive out pin
26	CS	DC/DC Current Sense Pin
27	BOOT	High-side MOSFET Power Supply pin
28	VREG	Internal reference voltage output

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●5V voltage reference (VREG)

5V (Typ.) is generated from the V_{CC} input voltage when the enable pin is set high. This voltage is used to power internal circuitry, as well as the voltage source for device pins that need to be fixed to a logical HIGH.
UVLO protection is integrated into the VREG pin. The voltage regulation circuitry operates uninterrupted for output voltages higher than 4.5 V (Typ.), but if output voltage drops to 4.3 V (Typ.) or lower, UVLO engages and turns the IC off.
Connect a capacitor (Creg = 2.2µF Typ.) to the VREG terminal for phase compensation. Operation may become unstable if Creg is not connected.

●Constant-current LED drivers

If less than four constant-current drivers are used, unused channels should be switched off via the LEDEN pin configuration. The truth table for these pins is shown below. If a driver output is enabled but not used (i.e. left open), the IC's open circuit-detection circuitry will operate. Please keep the unused pins open. The LEDEN terminals are pulled down internally in the IC, so if left open, the IC will recognize them as logic LO. However, they should be connected directly to VREG or fixed to a logic HI when in use.

LED EN		LED			
〈1〉	〈2〉	1	2	3	4
L	L	ON	ON	ON	ON
H	L	ON	ON	ON	OFF
L	H	ON	ON	OFF	OFF
H	H	ON	OFF	OFF	OFF

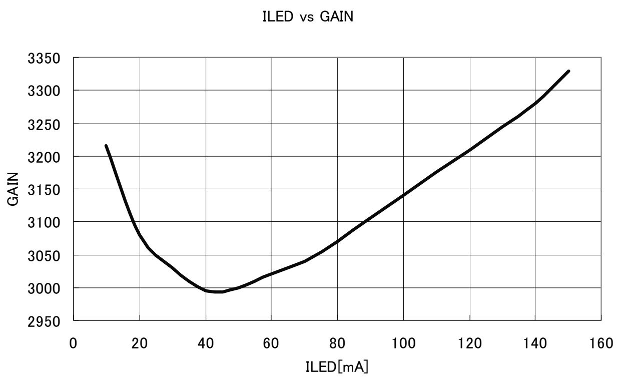
・Output current setting

LED current is computed via the following equation:

$$I_{LED} = \min[VDAC , VISET(=2.0V)] / RSET \times GAIN \ [A]$$

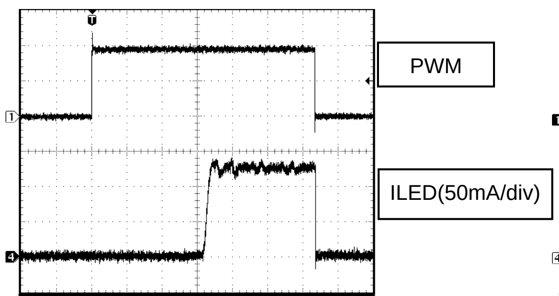
(min[VDAC , 2.0V] = the smaller value of either VDAC or VISET; GAIN = set by internal circuitry.)
In applications where an external signal is used for output current control, a control voltage in the range of 0.1 to 2.0 V can be connected on the VDAC pin to control according to the above equation. If an external control signal is not used, connect the VDAC pin to VREG (do not leave the pin open as this may cause the IC to malfunction). Also, do not switch individual channels on or off via the LEDEN pin while operating in PWM mode.

The following diagram illustrates the relation between ILED and GAIN.

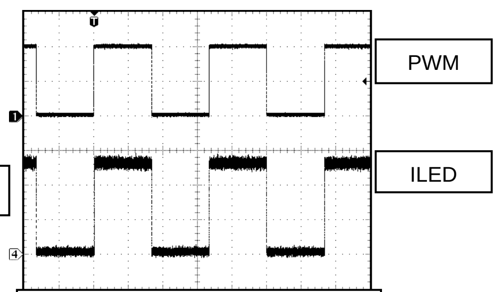


ILED[mA]	GAIN
10	3215
20	3080
30	3030
40	2995
50	3000
60	3020
70	3040
80	3070
90	3105
100	3140
110	3175
120	3210
130	3245
140	3280
150	3330

In PWM intensity control mode, the ON/OFF state of each current driver is controlled directly by the input signal on the PWM pin; thus, the duty ratio of the input signal on the PWM pin equals the duty ratio of the LED current. When not controlling intensity via PWM, fix the PWM terminal to a high voltage (100%). Output light intensity is greatest at 100% input.



PWM=150Hz Duty=0.38%



PWM=150Hz Duty=50%

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●Buck-Boost DC/DC controller

・Number of LEDs in series connection

Output voltage of the DCDC converter is controlled such that the forward voltage over each of the LEDs on the output is set to 1.0V (Typ.). DCDC operation is performed only when the LED output is operating. When two or more LED outputs are operating simultaneously, the LED voltage output is held at 1.0V (Typ.) per LED over the column of LEDs with the highest VF value. The voltages of other LED outputs are increased only in relation to the fluctuation of voltage over this column. Consideration should be given to the change in power dissipation due to variations in VF of the LEDs. Please determine the allowable maximum VF variance of the total LEDs in series by using the description as shown below:
VF variation allowable voltage 3.7V(Typ.) = short detecting voltage 4.7V(Typ.) - LED control voltage 1.0V(Typ.)
The number of LEDs that can be connected in series is limited due to the open-circuit protection circuit, which engages at 85% of the set OVP voltage. Therefore, the maximum output voltage of the under normal operation becomes 30.6 V (= 36 V x 0.85, where (30.6 V – 1.0 V) / VF > N [maximum number of LEDs in series]).

・Over-voltage protection circuit (OVP)

The output of the DCDC converter should be connected to the OVP pin via a voltage divider. In determining an appropriate trigger voltage of for OVP function, consider the total number of LEDs in series and the maximum variation in VF. Also, bear in mind that over-current protection (OCP) is triggered at 0.85 x OVP trigger voltage. If the OVP function engages, it will not release unless the DCDC voltage drops to 72.5% of the OVP trigger voltage. For example, if ROVP1 (output voltage side), ROVP2 (GND side), and DCDC voltage VOUT are conditions for OVP, then:
VOUT ≥ (ROVP1 + ROVP2) / ROVP2 x 2.0 V.
OVP will engage when VOUT > 32 V if ROVP1 = 330 kΩ and ROVP2 = 22 kΩ.

・Buck-boost DC/DC converter oscillation frequency (FOSC)

The regulator’s internal triangular wave oscillation frequency can be set via a resistor connected to the RT pin (pin 26). This resistor determines the charge/discharge current to the internal capacitor, thereby changing the oscillating frequency. Refer to the following theoretical formula when setting RT:

$$fosc = \frac{30 \times 10^{6}}{RT\,[\Omega]} \times \alpha \;\;[kHz]$$

30×10^{6} (V/A/S) is a constant (±16.6%) determined by the internal circuitry, and α is a correction factor that varies in relation to RT: { RT: α = 50kΩ: 0.98, 60kΩ: 0.985, 70kΩ: 0.99, 80kΩ: 0.994, 90kΩ: 0.996, 100kΩ: 1.0, 50kΩ: 1.01, 200kΩ: 1.02, 300kΩ: 1.03, 400kΩ: 1.04, 500kΩ: 1.045 }
A resistor in the range of 62.6kΩ～523kΩ is recommended. Settings that deviate from the frequency range shown below may cause switching to stop, and proper operation cannot be guaranteed.

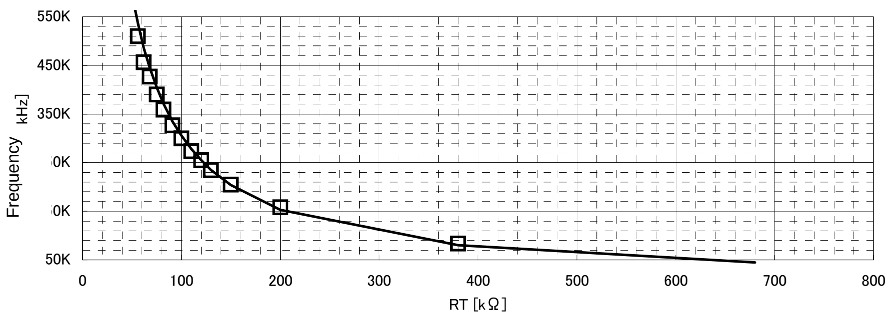

Fig.15 RT versus switching frequency

・External DC/DC converter oscillating frequency synchronization (FSYNC)

Do not switch from external to internal oscillation of the DC/DC converter if an external synchronization signal is present on the SYNC pin. When the signal on the SYNC terminal is switched from high to low, a delay of about 30 µS (typ.) occurs before the internal oscillation circuitry starts to operate (only the rising edge of the input clock signal on the SYNC terminal is recognized). Moreover, if external input frequency is less than the internal oscillation frequency, the internal oscillator will engage after the above-mentioned 30 µS (typ.) delay; thus, do not input a synchronization signal with a frequency less than the internal oscillation frequency.

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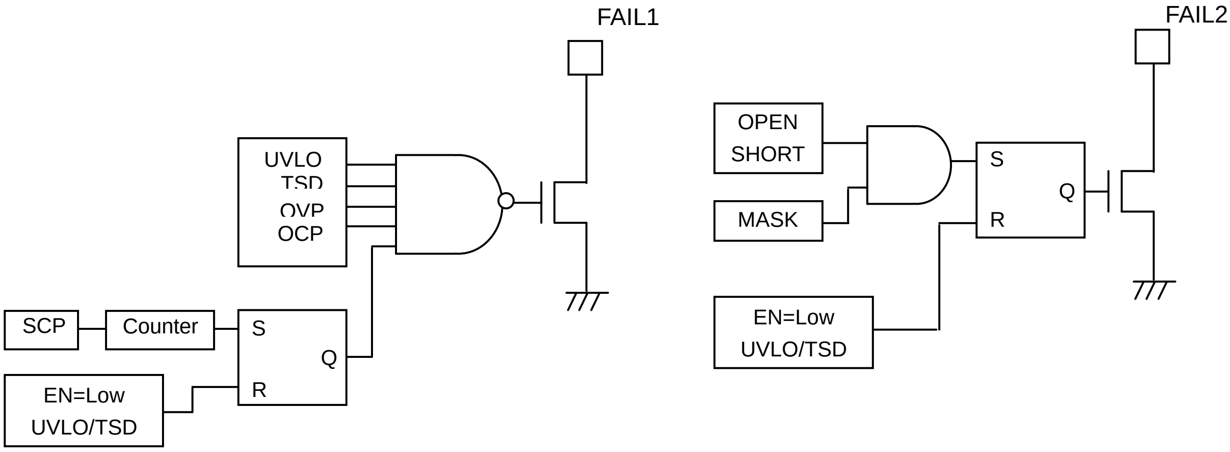
・Soft Start Function

The soft-start (SS) limits the current and slows the rise-time of the output voltage during the start-up, and hence leads to prevention of the overshoot of the output voltage and the inrush current.

・Self-diagnostic functions

The operating status of the built-in protection circuitry is propagated to FAIL1 and FAIL2 pins (open-drain outputs). FAIL1 becomes low when UVLO, TSD, OVP, or SCP protection is engaged, whereas FAIL2 becomes low when open or short LED is detected.



・Operation of the Protection Circuitry

・Under-Voltage Lock Out (UVLO)

The UVLO shuts down all the circuits other than REG when VCC ≤ 4.3V (TYP).

・Thermal Shut Down (TSD)

The TSD shuts down all the circuits other than REG when the Tj reaches 175℃ (TYP), and releases when the Tj becomes below 150℃ (TYP).

・Over Current Protection (OCP)

The OCP detects the current through the power-FET by monitoring the voltage of the high-side resistor, and activates when the CS voltage becomes less than VCC-0.6V (TYP).
When the OCP is activated, the external capacitor of the SS pin becomes discharged and the switching operation of the DCDC turns off.

・Over Voltage Protection (OVP)

The output voltage of the DCDC is detected with the OVP-pin voltage, and the protection activates when the OVP-pin voltage becomes greater than 2.0V (TYP).
When the OVP is activated, the external capacitor of the SS pin becomes discharged and the switching operation of the DCDC turns off.

・Short Circuit Protection (SCP)

When the LED-pin voltage becomes less than 0.3V (TYP), the internal counter starts operating and latches off the circuit approximately after 100ms (when FOSC = 300kHz). If the LED-pin voltage becomes over 0.3V before 100ms, then the counter resets.
When the LED anode (i.e. DCDC output voltage) is shorted to ground, then the LED current becomes off and the LED-pin voltage becomes low. Furthermore, the LED current also becomes off when the LED cathode is shorted to ground. Hence in summary, the SCP works with both cases of the LED anode and the cathode being shorted.

・LED Open Detection

When the LED-pin voltage ≤ 0.3V (TYP) as well as OVP-pin voltage ≥ 1.7V (TYP) simultaneously, the device detects as LED open and latches off that particular channel.

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・LED Short Detection

When the LED-pin voltage ≥ 4.7V (TYP) as well as OVP-pin voltage ≤ 1.6V (TYP) simultaneously the internal counter starts operating, and approximately after 100ms (when FOSC = 300kHz) the only detected channel (as LED short) latches off. With the PWM brightness control, the detecting operation is processed only when PWM-pin = High. If the condition of the detection operation is released before 100ms (when FOSC = 300kHz), then the internal counter resets.

※ The counter frequency is the DCDC switching frequency determined by the RT. The latch proceeds at the count of 32770.

Protection	Detecting Condition		Operation after detect
	[Detect]	[Release]	
UVLO	VREG<4.3V	VREG>4.5V	All blocks shut down
TSD	Tj>175℃	Tj<150℃	All blocks (but except REG) shut down
OVP	VOVP>2.0V	VOVP<1.45V	SS discharged
OCP	VCS≦VCC-0.6V	VCS>VCC-0.6V	SS discharged
SCP	VLED<0.3V (100ms delay when FOSC=300kHz)	EN or UVLO	Counter starts and then latches off all blocks (but except REG)
LED open	VLED<0.3V & VOVP>1.7V	EN or UVLO	The only detected channel latches off
LED short	VLED>4.7V & VOVP<1.6V (100ms delay when FOSC=300kHz)	EN or UVLO	The only detected channel latches off (after the counter sets)

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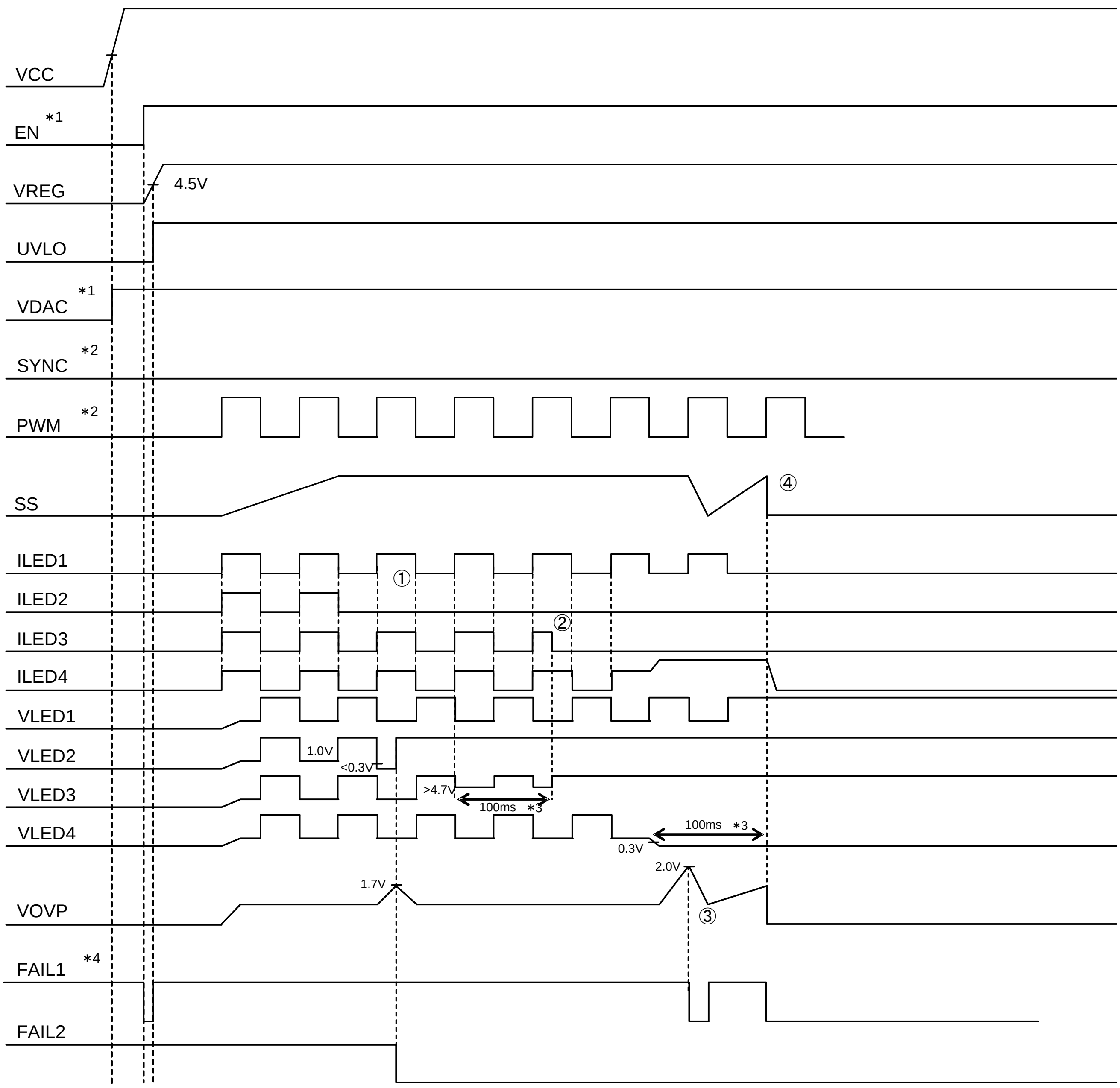
●Protection Sequence



∗1 Turn on the EN after the VCC is on
∗2 SYNC and PWM inputs are allowed to be on beforethe VCC is on
∗3 Aprox 100ms of delay when Fosc = 300kHz

① Case for LED2 in open-mode
When VLED2＜0.3V and VOVP＞1.7V simultaneously, then LED2 becomes off and FAIL2 becomes low

② Case for LED3 in short-mode
When VLED3＞4.7V and VOVP＜1.6V simultaneously, then LED3 becomes off after 100ms approx

③ Case for LED4 in short to GND
③-1 DCDC output voltage increases, and then SS dichages and FAIL1 becomes low
③-2 Detects VLED4<0.3V and shuts down after 100ms approx

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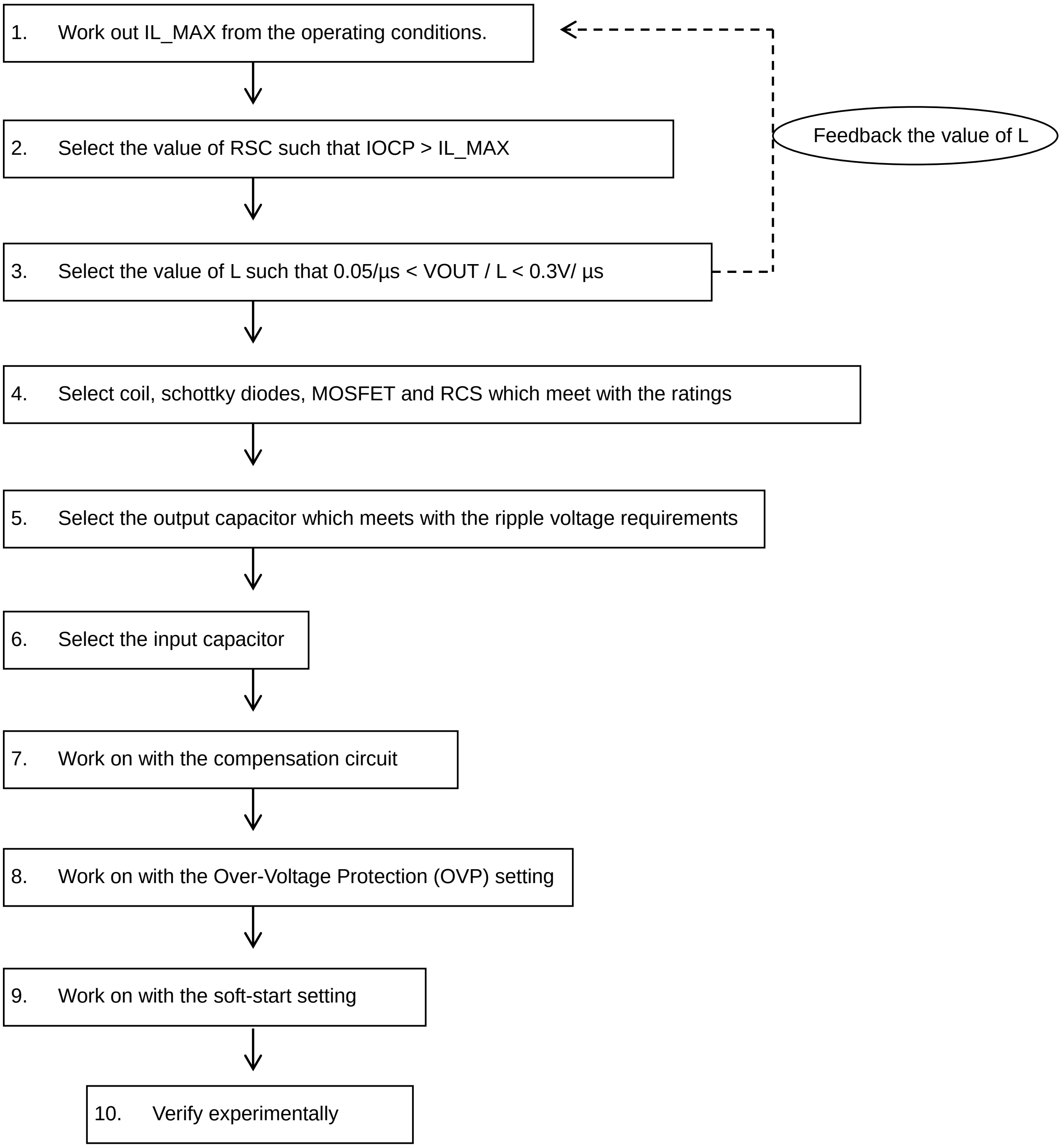
●Procedure for external components selection

Follow the steps as shown below for selecting the external components



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1. Computation of the Input Peak Current and IL_MAX

①Calculation of the maximum output voltage (Vout_max)

To calculate the Vout_max, it is necessary to take into account of the VF variation and the number of LED connection in series.

Vout_max = (VF + ΔVF) × N + 1.0V ΔVF: VF Variation N: Number of LED connection in series

②Calculation of the output current Iout

Iout = ILED × 1.05 × M Number of LED connection in parallel

③Calculation of the input peak current IL_MAX

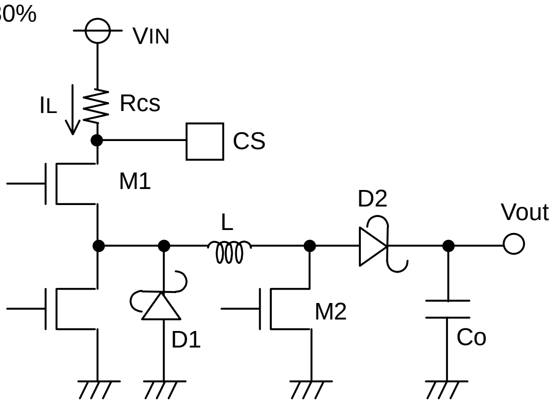
IL_MAX = IL_AVG + 1/2ΔIL

IL_AVG = (VIN + Vout) × Iout / (n × VIN)

$$\Delta IL = \frac{V_{IN}}{L} \times \frac{1}{Fosc} \times \frac{Vout}{V_{IN}+Vout}$$

n: efficiency Fosc: switching frequency

- The worst case scenario for VIN is when it is at the minimum, and thus the minimum value should be applied in the equation.
- The L value of 10µF ~ 47µF is recommended. The current-mode type of DC/DC conversion is adopted for BD8119FM-M, which is optimized with the use of the recommended L value in the design stage. This recommendation is based upon the efficiency as well as the stability. The L values outside this recommended range may cause irregular switching waveform and hence deteriorate stable operation.
- n (efficiency) is approximately 80%



External Application Circuit

2. The setting of over-current protection

Choose Rcs with the use of the equation Vocp_min (=0.54V) / Rcs > IL_MAX

When investigating the margin, it is worth noting that the L value may vary by approximately ±30%.

3. The selection of the L

In order to achieve stable operation of the current-mode DC/DC converter, we recommend selecting the L value in the range indicated below:

$$0.05\ [V/\mu S] < \frac{Vout \times Rcs}{L} < 0.3\ [V/\mu S]$$

The smaller $\frac{Vout \times Rcs}{L}$ allows stability improvement but slows down the response time.

4. Selection of coil L, diode D1 and D2, MOSFET M1 and M2, and Rcs

	Current rating	Voltage rating	Heat loss
Coil L	> IL_MAX	—	
Diode D1	> Iocp	> VIN_MAX	
Diode D2	> Iocp	> Vout	
MOSFET M1	> Iocp	> VIN_MAX	
MOSFET M2	> Iocp	> Vout	
Rcs	—	—	> $Iocp^2$ × Rcs

※ Allow some margin, such as the tolerance of the external components, when selecting.

※ In order to achieve fast switching, choose the MOSFETs with the smaller gate-capacitance.

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5. Selection of the output capacitor
Select the output capacitor Cout based on the requirement of the ripple voltage Vpp.

$$Vpp = \frac{Iout}{Cout} \times \frac{Vout}{Vout+V_{IN}} \times \frac{1}{Fosc} + IL\_MIN \times RESR$$

Choose Cout that allows the Vpp to settle within the requirement. Allow some margin also, such as the tolerance of the external components.

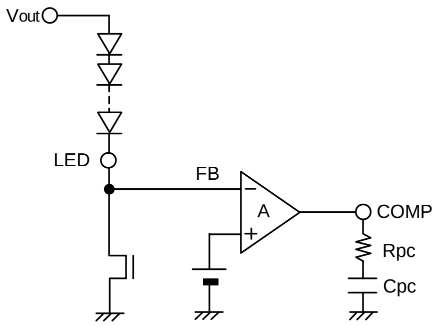
6. Selection of the input capacitor
A capacitor at the input is also required as the peak current flows between the input and the output in DC/DC conversion. We recommend an input capacitor greater than 10µF with the ESR smaller than 100mΩ. The input capacitor outside of our recommendation may cause large ripple voltage at the input and hence lead to malfunction.

7. Phase Compensation Guidelines
In general, the negative feedback loop is stable when the following condition is met:
・Overall gain of 1 (0dB) with a phase lag of less than 150º (i.e., a phase margin of 30º or more)
However, as the DC/DC converter constantly samples the switching frequency, the gain-bandwidth (GBW) product of the entire series should be set to 1/10 the switching frequency of the system. Therefore, the overall stability characteristics of the application are as follows:
・Overall gain of 1 (0dB) with a phase lag of less than 150º (i.e., a phase margin of 30º or more)
・GBW (frequency at gain 0dB) of 1/10 the switching frequency
Thus, to improve response within the GBW product limits, the switching frequency must be increased.

The key for achieving stability is to place fz near to the GBW.

Phase-lead $fz = \frac{1}{2\pi CpcRpc}$ [Hz]

Phase-lag $fp1 = \frac{1}{2\pi RLCout}$ [Hz]



Good stability would be obtained when the fz is set between 1kHz～10kHz.

In buck-boost applications, Right-Hand-Plane (RHP) Zero exists. This Zero has no gain but a pole characteristic in terms of phase. As this Zero would cause instability when it is in the control loop, so it is necessary to bring this zero before the GBW.

$$fRHP = \frac{Vout+VIN/(Vout+VIN)}{2\pi I_{LOAD}L} \text{ [Hz]}$$

I_{LOAD}: Maximum Load Current

It is important to keep in mind that these are very loose guidelines, and adjustments may have to be made to ensure stability in the actual circuitry. It is also important to note that stability characteristics can change greatly depending on factors such as substrate layout and load conditions. Therefore, when designing for mass-production, stability should be thoroughly investigated and confirmed in the actual physical design.

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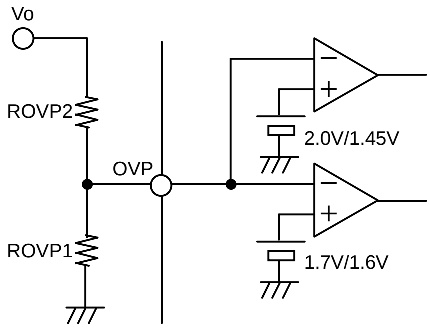
8. Setting of the over-voltage protection

We recommend setting the over-voltage protection Vovp 1.2V to 1.5V greater than Vout which is adjusted by the number of LEDs in series connection. Less than 1.2V may cause unexpected detection of the LED open and short during the PWM brightness control. For the Vovp greater than 1.5V, the LED short detection may become invalid.



9. Setting of the soft-start

The soft-start allows minimization of the coil current as well as the overshoot of the output voltage at the start-up.

For the capacitance we recommend in the range of 0.001 ~ 0.1µF. For the capacitance less than 0.001µF may cause overshoot of the output voltage. For the capacitance greater than 0.1µF may cause massive reverse current through the parasitic elements of the IC and damage the whole device. In case it is necessary to use the capacitance greater than 0.1µF, ensure to have a reverse current protection diode at the Vcc or a bypass diode placed between the SS-pin and the Vcc.

Soft-start time TSS

TSS = CSSX0.7V / 5µA [s]   CSS: The capacitance at the SS-pin

10 Verification of the operation by taking measurements

The overall characteristic may change by load current, input voltage, output voltage, inductance, load capacitance, switching frequency, and the PCB layout. We strongly recommend verifying your design by taking the actual measurements.

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●Power Dissipation Calculation

Power dissipation can be calculated as follows:

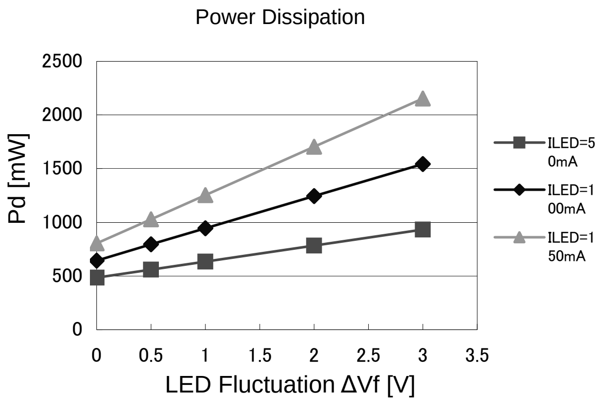
Pc(N) = ICC*VCC + 2*Ciss*VREG*Fsw*Vcc+[VLED*N+△Vf*(N-1)]*ILED

I_{CC} Maximum circuit current
V_{CC} Supply power voltage
C_{iss} External FET capacitance
V_{sw} SW gate voltage
F_{sw} SE frequency
V_{LED} LED control voltage
N LED parallel numeral
ΔV_f LED V_f fluctuation
I_{LED} LED output current

Sample Calculation:

Pc(4) = 10mA × 30V + 500pF × 5V × 300kHz × 30V + [1.0V × 4 + △Vf × 3] × 100mA

△Vf = 3.0V, Pc (4) = 322.5mW + 1.3W = 1622.5mW



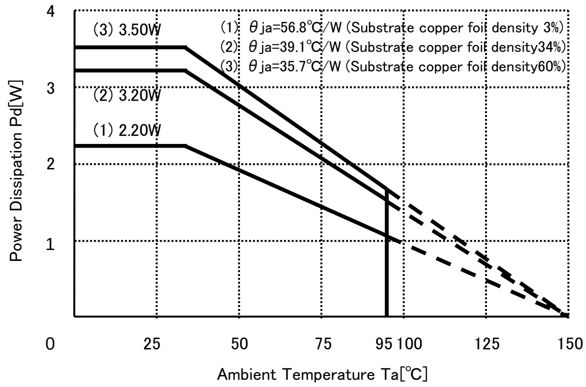


Fig.16

Note 1: Power dissipation calculated when mounted on 70mm X 70mm X 1.6mm glass epoxy substrate (1-layer platform/copper thickness 18µm)

Note 2: Power dissipation changes with the copper foil density of the board.
The area of the copper foil becomes the total area of the heat radiation fin and the foot pattern (connected directly with IC) of this IC.
This value represents only observed values, not guaranteed values.

Pd=2200mW (968mW): Substrate copper foil density 3%
Pd=3200mW (1408mW): Substrate copper foil density 34%
Pd=3500mW (1540mW): Substrate copper foil density 60% (Value within parentheses represents power dissipation when Ta=95°C)

Note 3: Please design so that ambient temperature + self-generation of heat may become 150℃ or less because this IC is Tj=150℃.

Note 4: Please note the heat design because there is a possibility that thermal resistance rises from the examination result of the temperature cycle by 20% or less.

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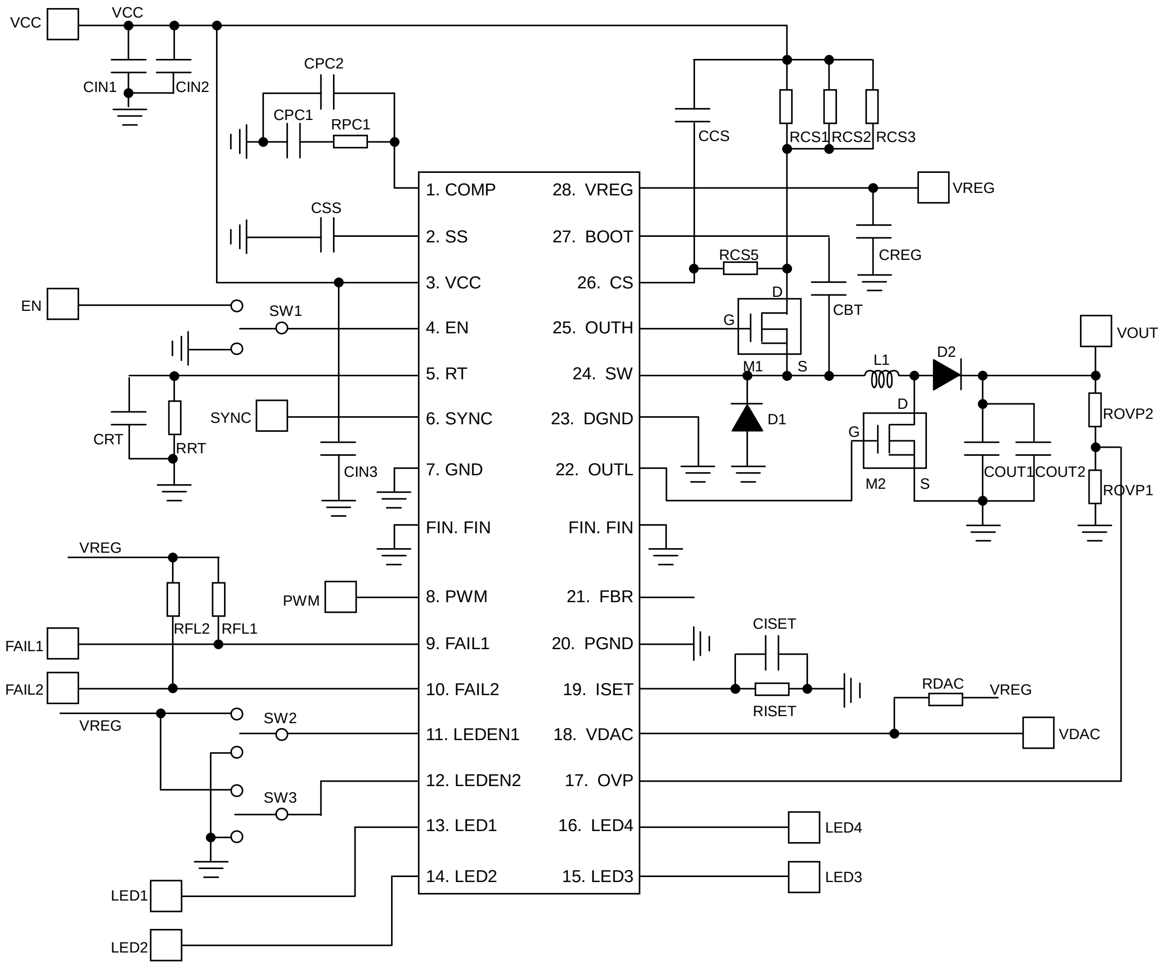

- The coupling capacitors CVCC and CREG should be mounted as close as possible to the IC's pins.
- Large currents may pass through DGND and PGND, so each should have its own low-impedance routing to the system ground.
- Noise should be minimized as much as possible on pins VDAC, ISET,RT and COMP.
- PWM, SYNC and LED1-4 carry switching signals, so ensure during layout that surrounding traces are not affected by crosstalk.

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●Application Board Part List

serial No.	component name	component value	product name	Manufacturer
1	CIN1	10µF	GRM31CB31E106KA75B	murata
2	CIN2	–		
3	CIN3	–		
4	CPC1	0.1µF		
5	CPC2	–		murata
6	RPC1	510Ω		
7	CSS	0.1µF	GRM188B31H104KA92	murata
8	RRT	100kΩ	MCR03 Series	Rohm
9	CRT	–		
10	RFL1	100kΩ	MCR03 Series	Rohm
11	RFL2	100kΩ	MCR03 Series	Rohm
12	CCS	–		
13	RCS1	620mΩ	MCR100JZHFLR620	Rohm
14	RCS2	620mΩ	MCR100JZHFLR620	Rohm
15	RCS3	–		
16	RCS5	0Ω		
17	CREG	2.2µF	GRM188B31A225KE33	murata
18	CBT	0.1µF	GRM188B31H104KA92	murata
19	M1	–	RSS070N05	Rohm
20	M2	–	RSS070N05	Rohm
21	D1	–	RB050L-40	Rohm
22	D2	–	RF201L2S	Rohm
23	L1	33µH	CDRH105R330	Sumida
24	COUT1	10µF	GRM31CB31E106KA75B	murata
25	COUT2	10µF	GRM31CB31E106KA75B	murata
26	ROVP1	30kΩ	MCR03 Series	Rohm
27	ROVP2	360kΩ	MCR03 Series	Rohm
28	RISET	120kΩ	MCR03 Series	Rohm
29	CISET	–		
30	RDAC	0Ω		

・The above values are fixed numbers for confirmed operation with the following conditions: V_{CC} = 12V, four parallel channels of five series-connected LEDs, and ILED=50mA.
・Optimal values of external components depend on the actual application; these values should only be used as guidelines and should be adjusted to fit the operating conditions of the actual application.

When performing open/short tests of the external components, the open condition of D1 or D2 may cause permanent damage to the driver and/or the external components. In order to prevent this, we recommend having parallel connections for D1 and D2.

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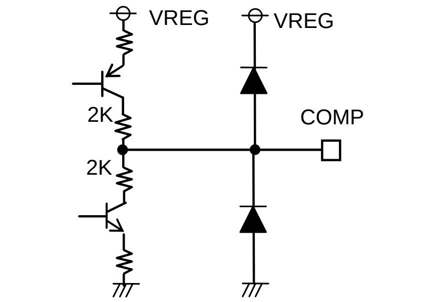
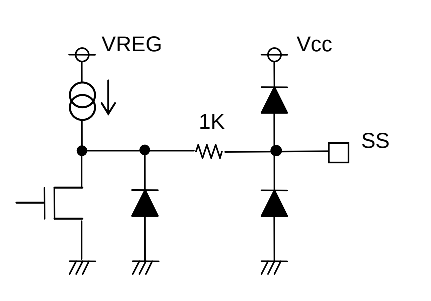
●Input/output Equivalent Circuits (terminal name follows pin number)

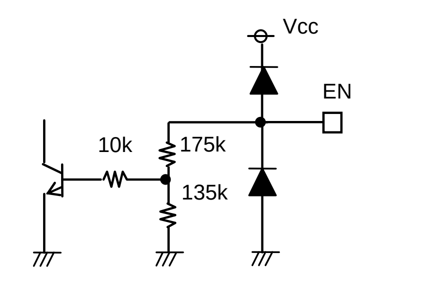
1. COMP



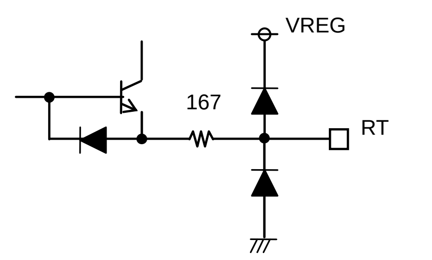
2. SS



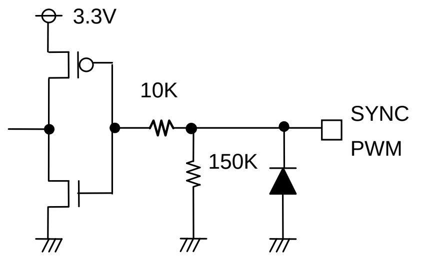
4. EN



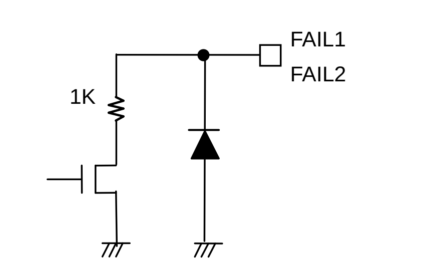
5. RT



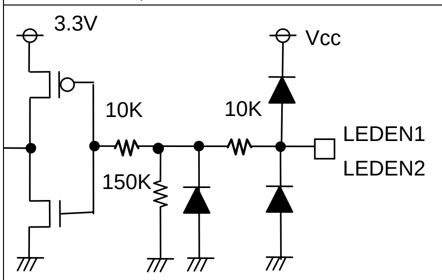
6. SYNC, 8. PWM



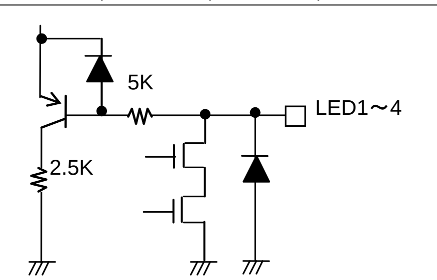
9. FAIL1, 10. FAIL2



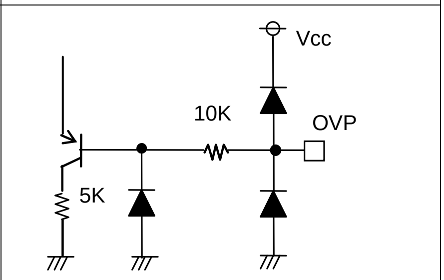
11. LEDEN1, 12. LEDEN2



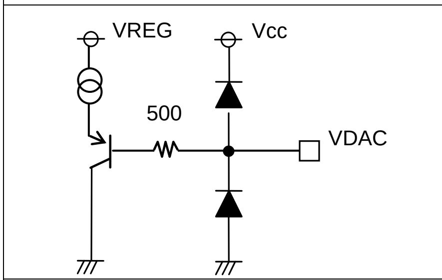
13. LED1, 14. LED2, 15. LED3, 16. LED4



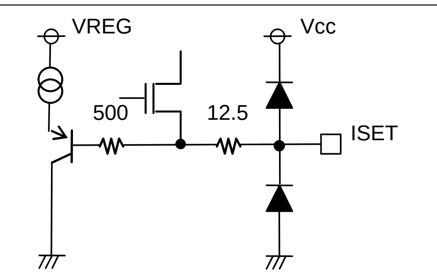
17. OVP



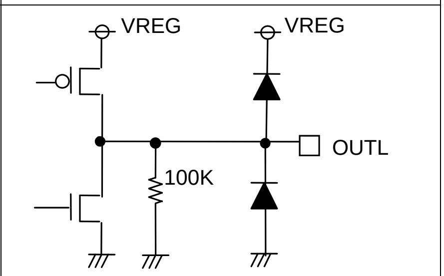
18. VDAC



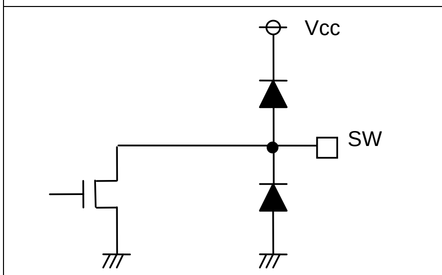
19. ISET



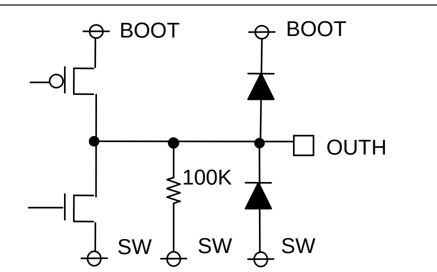
22. OUTL



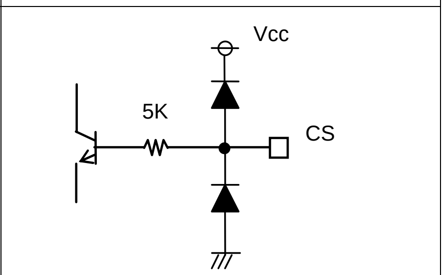
24. SW



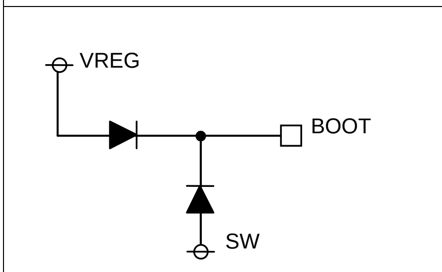
25. OUTH



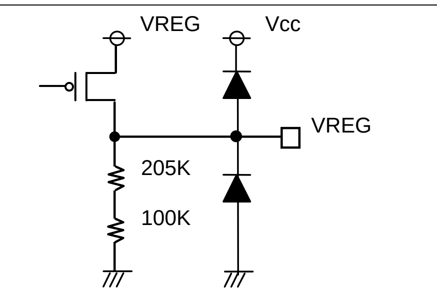
26. CS



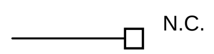
27. BOOT



28. VREG



21.



N.C. = no connection (open)

※All values typical.

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●Notes for use

1) Absolute maximum ratings
Use of the IC in excess of absolute maximum ratings (such as the input voltage or operating temperature range) may result in damage to the IC. Assumptions should not be made regarding the state of the IC (e.g., short mode or open mode) when such damage is suffered. If operational values are expected to exceed the maximum ratings for the device, consider adding protective circuitry (such as fuses) to eliminate the risk of damaging the IC.

2) GND potential
Ensure that the GND pin is held at the minimum potential in all operating conditions.

3) Thermal Design
Use a thermal design that allows for a sufficient margin for power dissipation (Pd) under actual operating conditions.

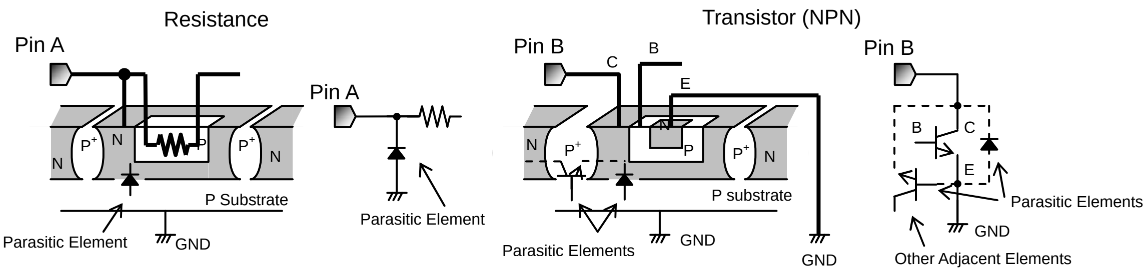
4) Inter-pin shorts and mounting errors
Use caution when orienting and positioning the IC for mounting on printed circuit boards. Improper mounting may result in damage to the IC. Shorts between output pins or between output pins and the power supply and GND pins caused by poor soldering or foreign objects may result in damage to the IC.

5) Operation in strong electromagnetic fields
Exercise caution when using the IC in the presence of strong electromagnetic fields as doing so may cause the IC to malfunction.

6) Testing on application boards
When testing the IC on an application board, connecting a capacitor directly to a low-impedance 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 a jig or fixture during the evaluation process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

7) Ground wiring patterns
When using both small-signal and large-current GND traces, the two ground traces should be routed separately but connected to a single ground potential within the application in order to avoid variations in the small-signal ground caused by large currents. Also ensure that the GND traces of external components do not cause variations on GND voltage.

8) IC input pins and parasitic elements
This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. PN junctions are formed at the intersection of these P layers with the N layers of other elements, creating parasitic diodes and/or transistors. For example (refer to the figure below):



Example of IC Structure

・When GND > Pin A and GND > Pin B, the PN junction operates as a parasitic diode
・When GND > Pin B, the PN junction operates as a parasitic transistor

Parasitic diodes occur inevitably in the structure of the IC, and the operation of these parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Accordingly, 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.

9) Over-current protection circuits
An over-current protection circuit (designed according to the output current) is integrated into the IC to prevent damage in the event of load shorting. This protection circuit is effective in preventing damage due to sudden and unexpected overloads on the output. However, the IC should not be used in applications where operation of the OCP function is anticipated or assumed

10) Thermal shutdown circuit (TSD)
This IC also incorporates a built-in TSD circuit for the protection from thermal destruction. The IC should be used within the specified power dissipation range. However, in the event that the IC continues to be operated in excess of its power dissipation limits, the rise in the chip's junction temperature T_j will trigger the TSD circuit, shutting off all output power elements. The circuit automatically resets itself once the junction temperature T_j drops down to normal operating temperatures. The TSD protection will only engage when the IC's absolute maximum ratings have been exceeded; therefore, application designs should never attempt to purposely make use of the TSD function.

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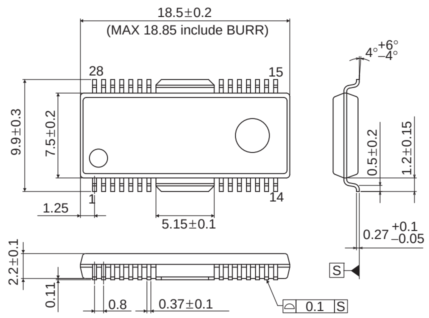
●Ordering part number

B	D		8	1	1	9		F	M	-	M		E	2

- BD: Part No.
- 8119: Part No.
- FM: Package — FM: HSOP-M28
- M: Type
- E2: Packaging and forming specification — E2: Embossed tape and reel

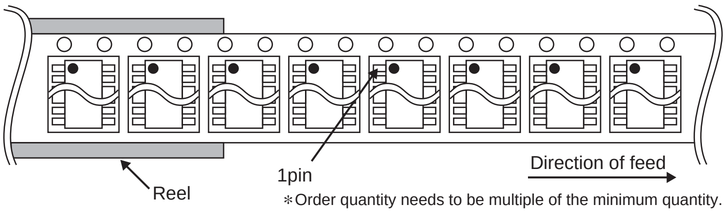
HSOP-M28



(Unit : mm)

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	1500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

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Notice

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2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment, 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.

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 (even if you use no-clean type fluxes, cleaning residue of flux is recommended); 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 (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient 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.

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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; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

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

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

Precaution for Electrostatic

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

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

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

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

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

Precaution for Product Label

QR code 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 our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

Precaution Regarding Intellectual Property Rights

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Other Precaution

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