TOSHIBA BiCD Integrated Circuit Silicon Monolithic

TB62758FTG

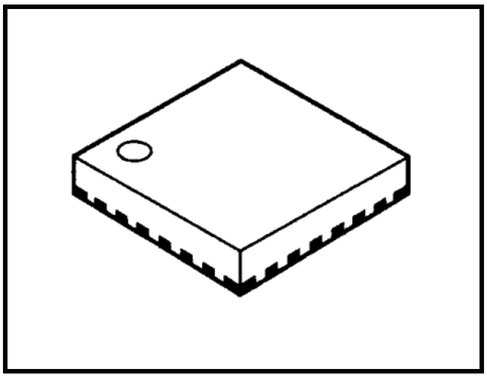
Step up type DC/DC converter built in 6 ch sync driver for White LED

TB62758FTG is a high efficient step-up type DC/DC controller specially designed for constant current drive of white LED.

This IC can drive white LEDs with constant current by dividing white LEDs, which are serial connected with lots of LEDs, into 6 lines.

LED current (I_F) is set with an external resistor and dimming control is available by PWM signal.

This IC is especially for driving back light white LEDs in large LCD which is 10 inches or more.

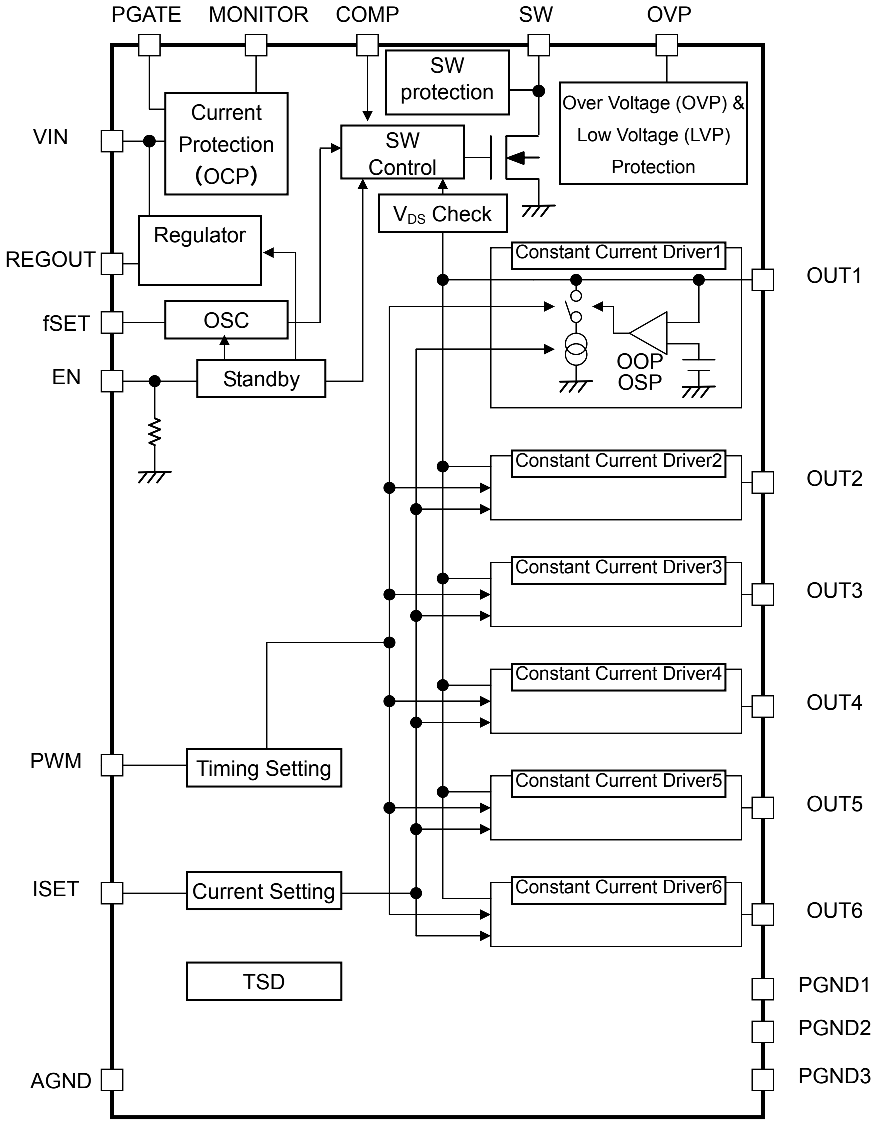


Weight :0.021g (TYP)

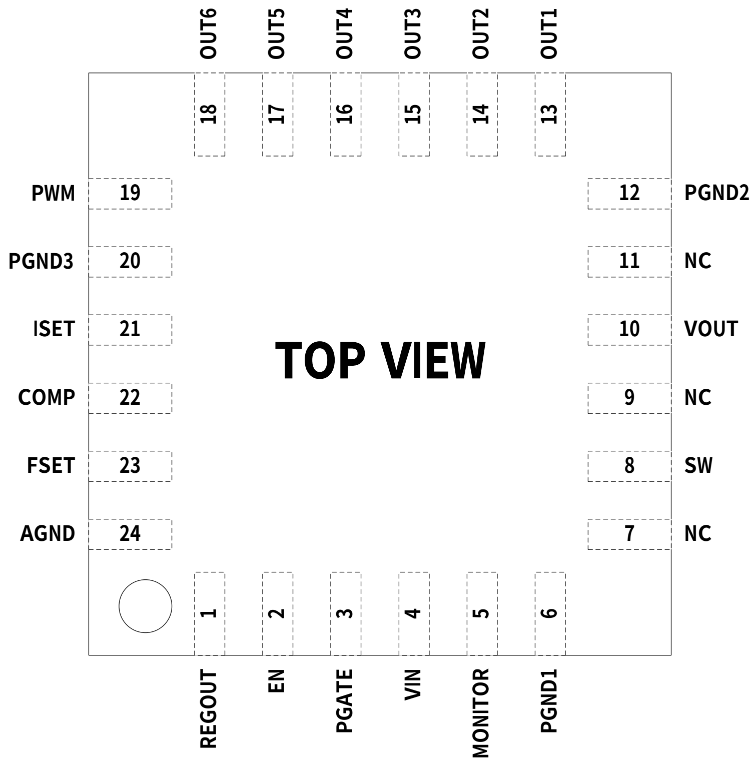
Characteristics

- Variable LED current (I_F) is 20mA @R_{ISET} = 11kΩ
- IC package：VQON24
- Input Voltage range : 7.5V to 22V
  6.8V to 22V（VOUT<38V，I_F：20mA）
- Switching frequency：200kHz to 1.5 MHz
  Set by the resistance connected to fSET terminal
- Constant current driver Built in open detection
  Built in short-circuit detection
- Built in thermal shutdown circuit 150℃(MIN)
- Built in output over voltage protecting circuit：42V(MIN)
- Built in output reduced voltage protection
- Built in input over current protection
- Built in SW terminal protection

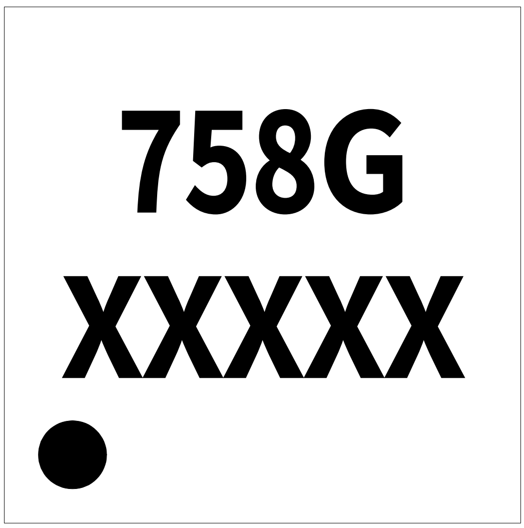
Block Diagram



Pin Assignment (top view)



Marking

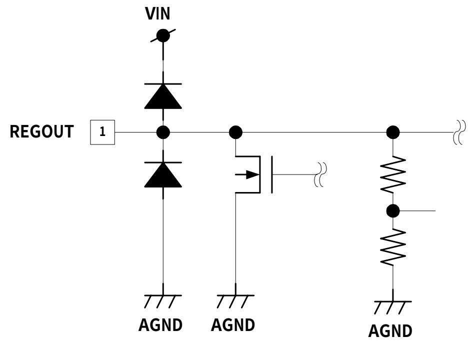


Pin Description

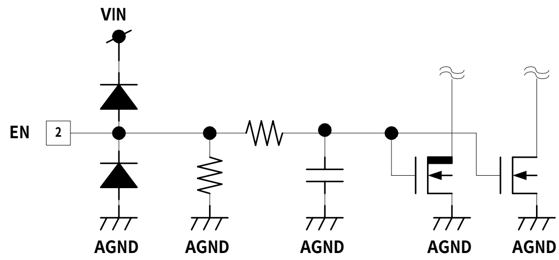
No.	Pin name	I/O	A/D	Functional description
1	REGOUT	O	A	Output of regulator (5V) for driving internal circuit Bypass to ground near REGOUT with the capacitor (1.0μF).
2	EN	I	D	Input chip enable signal. EN= High: Standby mode, EN= Low: Shutdown mode. Pull down to GND with the resistance of 100kΩ.
3	PGATE	P	-	Output terminal to drive the gate of PchMOS for shutdown supply line.
4	VIN	P	-	Power supply input.
5	MONITOR	I	A	Input terminal to monitor the input current on different voltage with VIN.
6	PGND1	P	-	Power ground
7	NC	-	-	No connect. No connect or connect to ground.
8	SW	O	A	Switching terminal for voltage booster.
9	NC	-	-	No connect. No connect or connect to ground.
10	VOUT	I	A	Input terminal to monitor output voltage.
11	NC	-	-	No connect. No connect or connect to ground.
12	PGND2	P	-	Power ground
13	OUT1	O	A	Constant current SINK terminals to drive LED.
14	OUT2	O	A	
15	OUT3	O	A	
16	OUT4	O	A	
17	OUT5	O	A	
18	OUT6	O	A	
19	PWM	I	D	Input terminal to control LED constant current drive. PWM= High: Operation mode. PWM= Low: Standby mode.
20	PGND3	P	-	Power ground
21	ISET	O	A	Connect to SINK current setup resistance.
22	COMP	O	A	Terminal for controlling compensation point of AMP which controls output voltage. Connect RC between COMP and GND.
23	FSET	O	A	Connect to resistance for internal frequency setup.
24	AGND	P	-	Ground for analog circuit.

Equivalent circuits around terminals

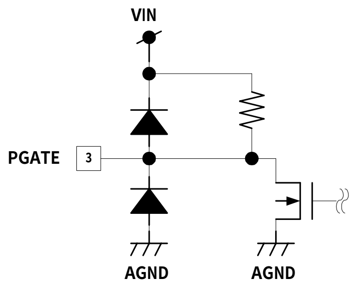
1. REGOUT



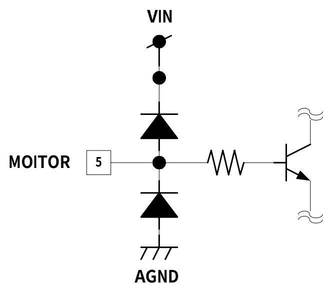
2. EN



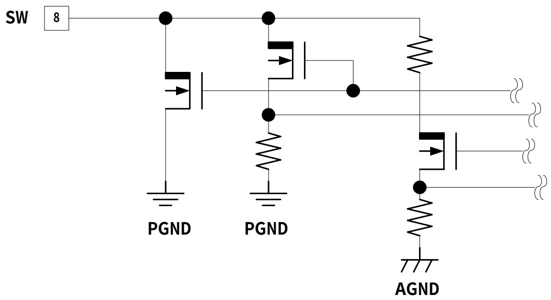
3. PGATE



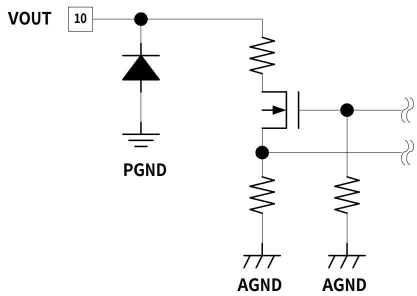
4. MONITOR



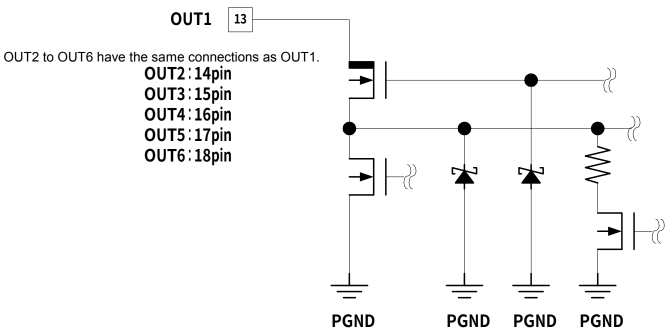
5. SW



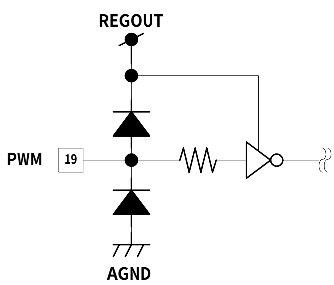
6.VOUT



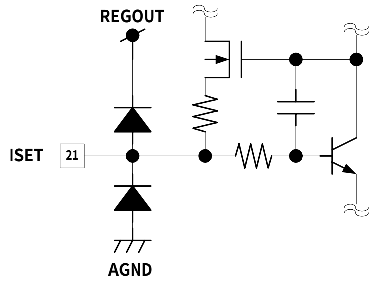
7. OUT1 to 6



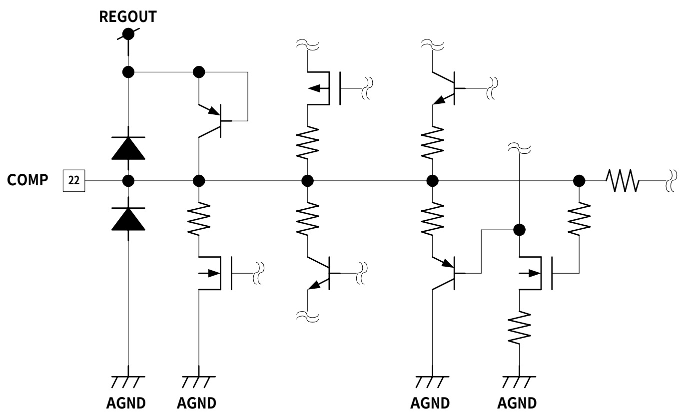
8.PWM



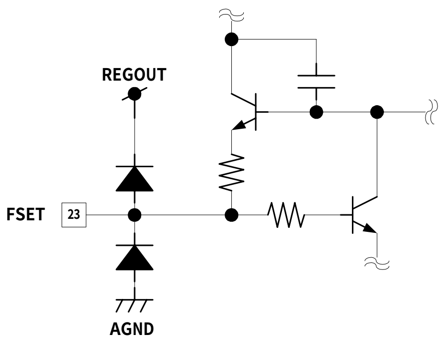
9. ISET



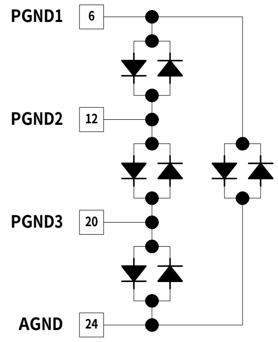
10. COMP



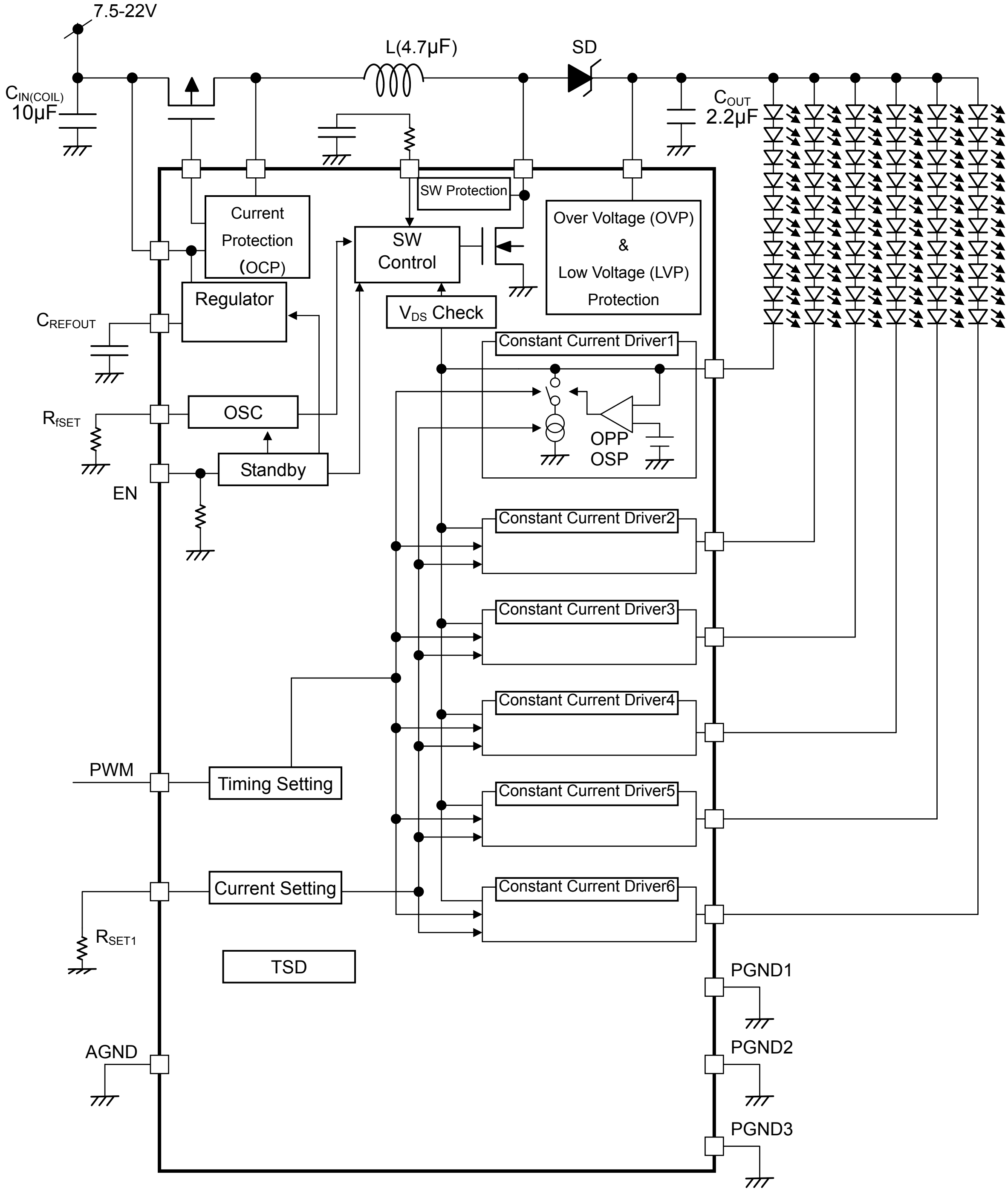
11.FSET



12. AGND,PGND1 to 3



Application Circuit



Explanation of Operation

Modes are selectable by 2 input signals.

EN terminal : High---Standby mode or Operation mode
Low --- OFF mode

PWM terminal : High--- Operation mode
Low --- Standby mode

The operation transfers to the operation mode by inputting high to EN terminal. Voltage boosting of VOUT and LED constant current driving are controlled by input signal of PWM terminal.

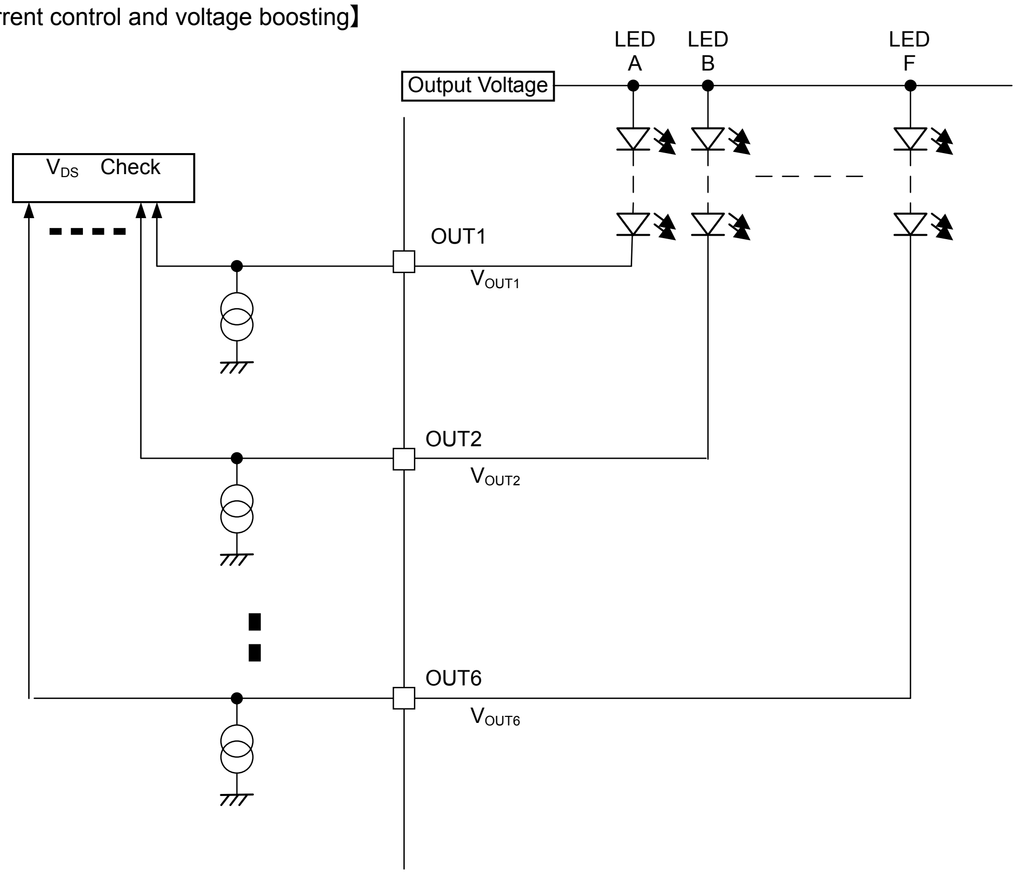
This IC has variable abnormal detecting circuits and controls the operation depending on the abnormal state.

1. OFF mode (EN=”L”)
   Power is supplied. IC operation halts.
   Pch driver for over current protection is outputting high. The power for the inductor is not supplied.

2. Standby mode (EN=”H”, PWM=”L”)
   The operation of the regulator in the IC starts. Operations of the constant current block and the voltage booster block halt. In this case, a part of the protection operates and it shifts to the abnormal stop mode when some abnormal situations occur. (The descriptions of protection are written in P.13 or more)

3. Operation mode
   Both of the voltage booster block and the constant current block are in operation mode. The voltage booster block controls the boosted voltage by monitoring the OUT voltage.

【Constant current control and voltage boosting】



Applied voltage to each OUT terminal (OUT1 to OUT6) changes depending on the variation of Vf of white LED.

The lowest voltage among V_{OUT1}, V_{OUT2}, V_{OUT3}, V_{OUT4}, V_{OUT5}, and V_{OUT6} in figure1 is determined as a reference voltage. And VOUT is controlled to set this reference voltage 0.6V (TYP.).

(Ex.)

LED A: TOTAL Vf＝25V
LED B: TOTAL Vf＝24.5V
LED F: TOTAL Vf＝25.5V

In this case, the output voltage is determined by referring V_{OUT6}.

Output voltage＝25.5V＋0.6V＝26.1V

In this case, V_{OUT1} is 1.1V, V_{OUT2} is 1.6V, and V_{OUT6} is 0.6V.

Each Voltage which is applied to OUT1 to OUT6 changes depending on the variation of Vf of the connected LED.

When the difference of the voltage which is applied to each OUT terminal (OUT1 to OUT6), take care in determining the current quantity per 1ch.

When the power consumption exceeds the power dissipation, IC may be destroyed.

The power dissipation is 1.3W when the ambient temperature is 25℃. (Condition: Exposed Pad is mounted.)

(1.3W – 24.39mW×Ta) – (Applied voltage per channel × LED set current＋IC applied voltage × IC consumption current) ＞0

Take care in designing by noticing the above formula.

※ Board condition of power dissipation : JEDEC4 layers (Size : 76.4×114.3×1.6mm)

4. Transition from OFF mode to standby mode

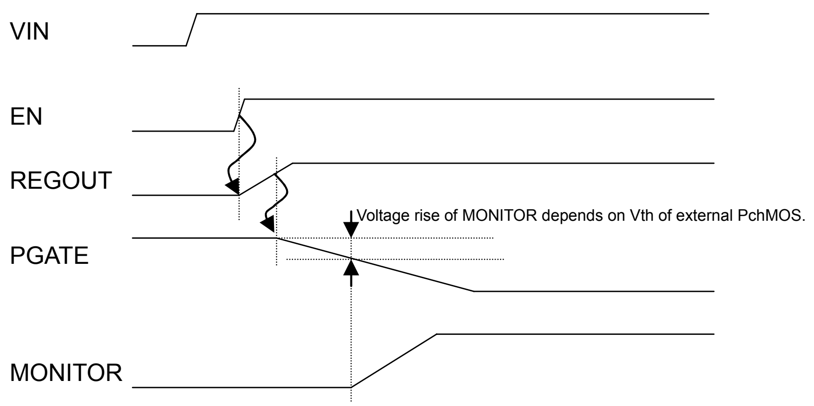
First, the operation of the regulator in the IC starts. Then, over current protection starts driving after the output voltage of the regulator reaches a certain value or more. And the voltage supply to the inductor starts

Over current protection has a soft start function to suppress the rush current which is generated just after the power supply.

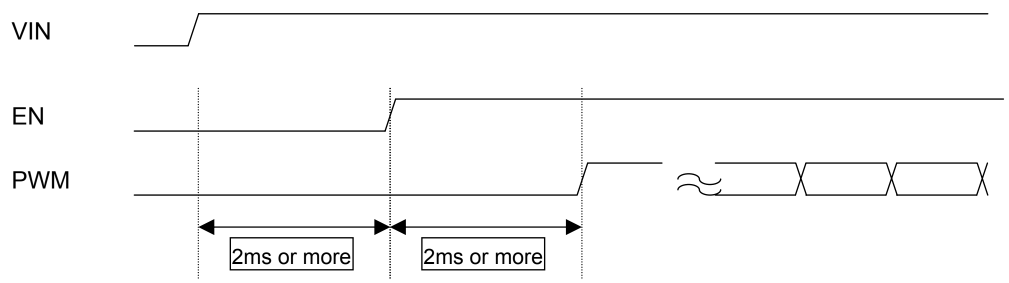
Be sure to input high to EN terminal before inputting high to PWM signal because the soft start function works when PWM signal is low.

Time lag between these two inputs is recommended to set 2ms or more.

【Timing chart】



【Recommended timing of input】



5. Transition from standby mode to operation mode

It transits from standby mode to operation mode by inputting high to PWM while EN is inputted high.

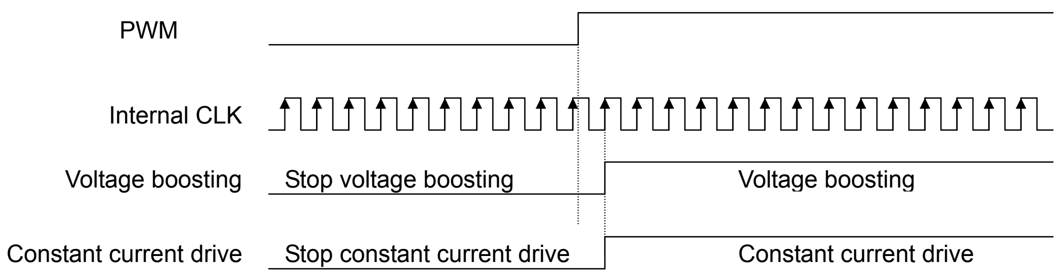
In this case, the constant current circuit starts driving in synchronizing with internal clocks when PWM is inputted high. However, LED open detection and LED short-circuit detection are not provided until VOUT reaches the specified voltage (total of Vf which depends on the number of LED lights + voltage of the constant current circuit). (Masking time of detection)

They start detecting after VOUT reaches the specified voltage.

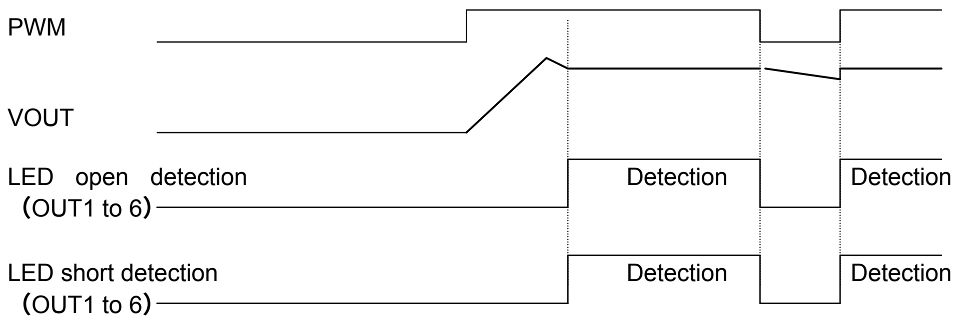
When LED has already been in open state from the time of the shutdown mode, the specified voltage of VOUT can not be detected. And VOUT is boosted up to OVP without any detection. In this case, open LED is detected by OVP and the normal operation is recovered after the open channel is set OFF.

This masking time of detection starts working from the time of the shutdown mode and it continues till VOUT reaches the specified voltage at first time. However, the masking time does not generate in case that the mode transits from standby to operation after VOUT reaches the specified voltage.

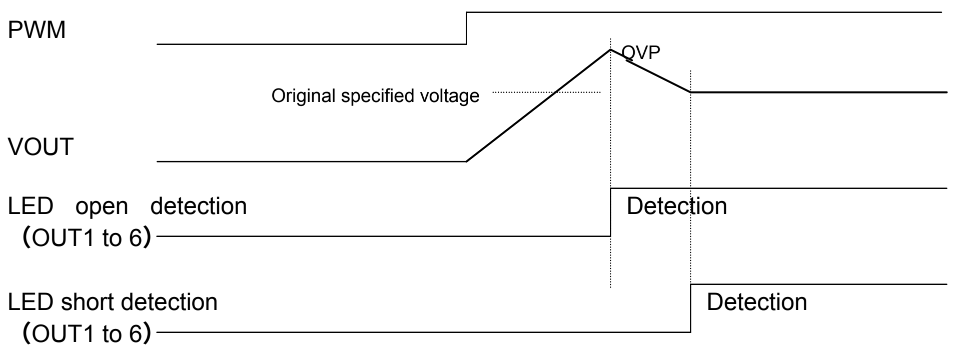
【Normal rise（Synchronized with internal CLK）】



【Normal sequence】



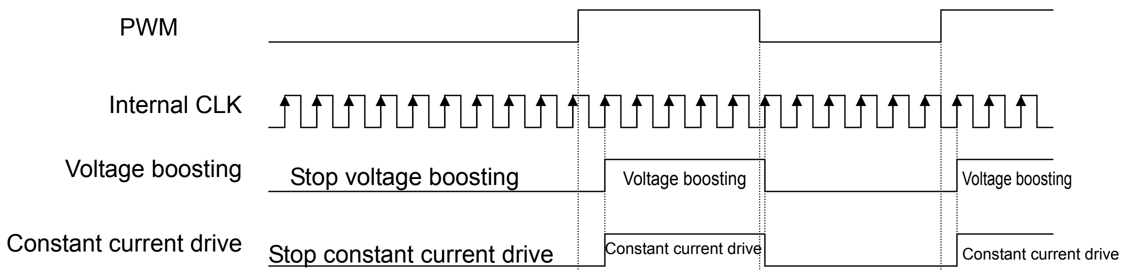
【When the open LED terminal exists from the beginning】



6. PWM dimming

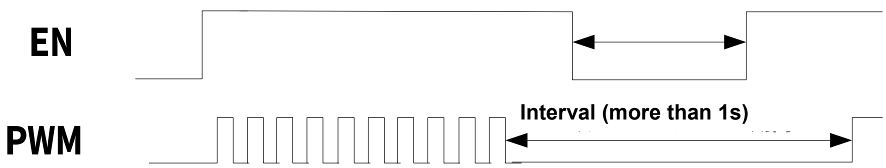
It transits from standby mode to operation mode by changing PWM signal from low to high while EN is high.
It transits from operation mode to standby mode by changing PWM signal from high to low while EN is high.
To switch the mode while the PWM is high, control the signal in synchronizing with internal clock.

【PWM dimming】



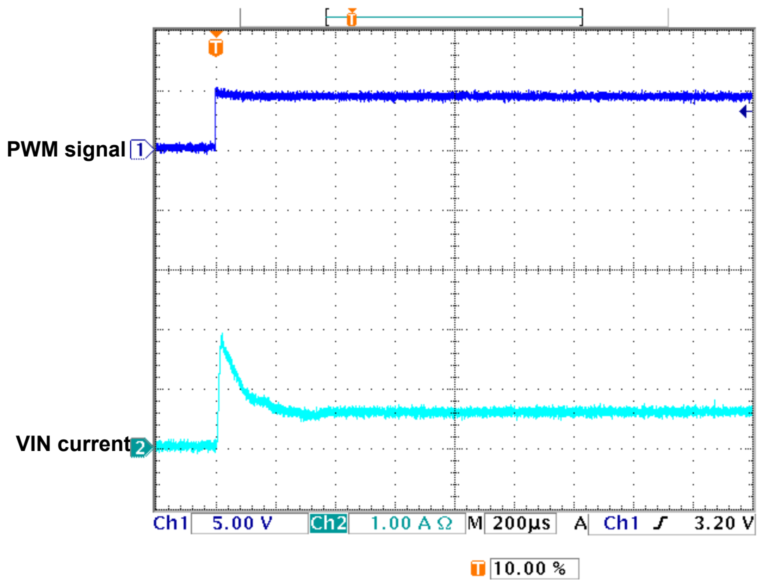
Notes)

Soft start function does not work when PWM is kept low after PWM dimming and PWM dimming is implemented again. In this case, there is a possibility that VIN has a rush current.
Maximum of the rush current is about 3A under the worst condition. (Constant number of application circuit)
To avoid this rush current, EN signal should be inputted again during PWM operation.



【Waveform of rush current】

Condition: VIN=7V,10LEDs×6ch,20mA

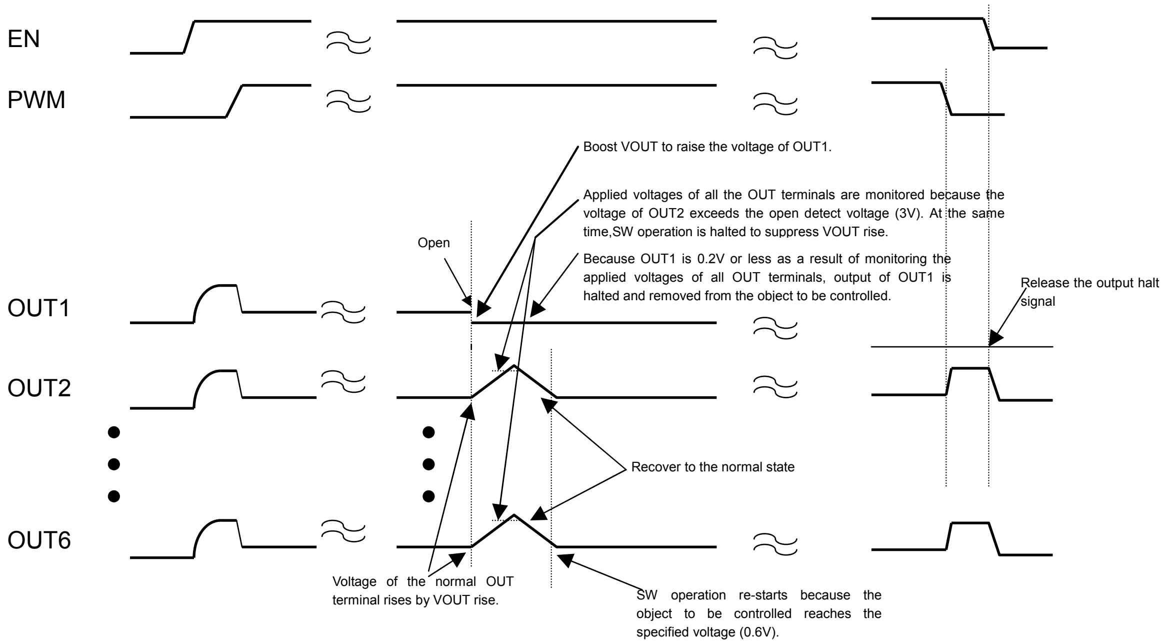


7. Abnormal detection in operation mode

7-1. LED open detection

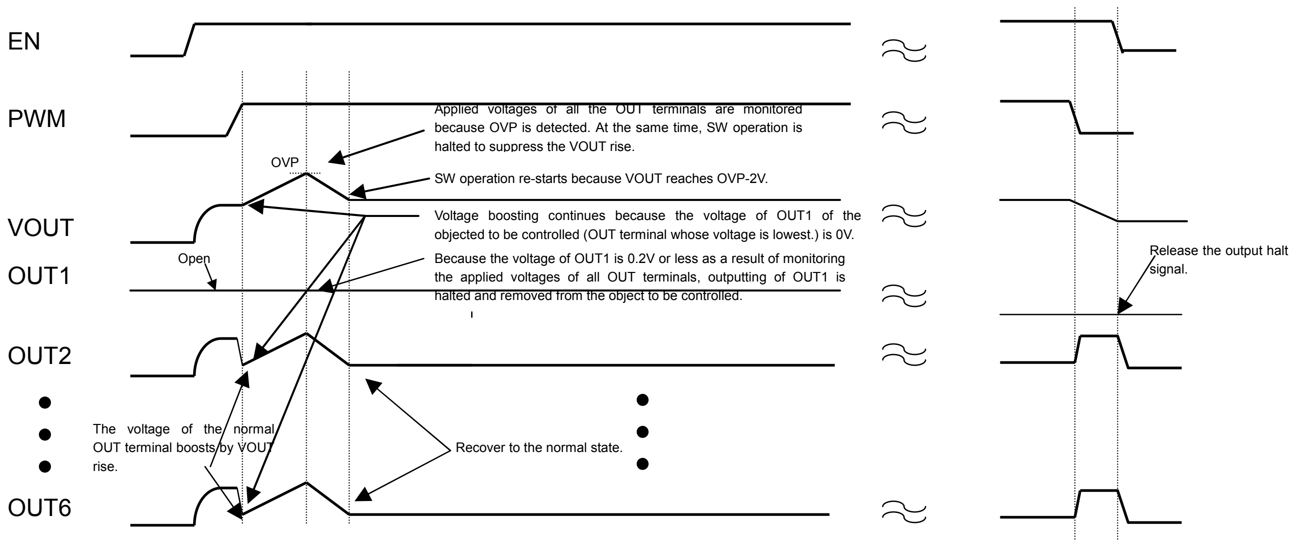
When LED becomes open in the operation mode, IC provides higher power to boost VOUT because the applied voltage of the pertinent OUT terminal is high impedance (0). So, the applied voltages of the normal OUT terminals (not open) are boosted. When the applied voltage of the OUT terminal exceeds 3V (Typ.), it starts detecting the open OUT terminals by halting SW operation. When the open terminal (the voltage of OUT terminal is 0.2 V or less.) is detected, the pertinent OUT terminal is removed from the object to be controlled.
And it recovers to the normal state after stopping the current drawing.
SW operation re-starts when any of the voltages of the OUT terminals recover to 0.60V.
To release the halt of the open OUT terminal, the signal should be inputted to EN again.
When the open terminal (the voltage of the OUT terminal is 0.2V or less.) is not detected, it recovers to the normal operation.

(In case OUT1 is open in the operation mode)



When LED is open from the time of the shutdown mode, the specified voltage of VOUT can not be detected in the beginning of the operation mode. So, VOUT rises because the open state can not be detected though the applied voltage of OUT terminal exceeds 3 V. When VOUT reaches OVP, SW operation halts and the open detection starts.
When open terminal (the voltage of the OUT terminal is 0.2 V or less.) is detected, the pertinent OUT terminal is removed from the object to be controlled. And it recovers to the normal state after stopping the current drawing.
SW operation re-starts when any of the voltages of the OUT terminals recover to 0.6V.
To release the halt of the open OUT terminal, the signal should be inputted to EN again.
When the open terminal (the voltage of the OUT terminal is 0.2V or less.) is not detected, it recovers to the normal operation.

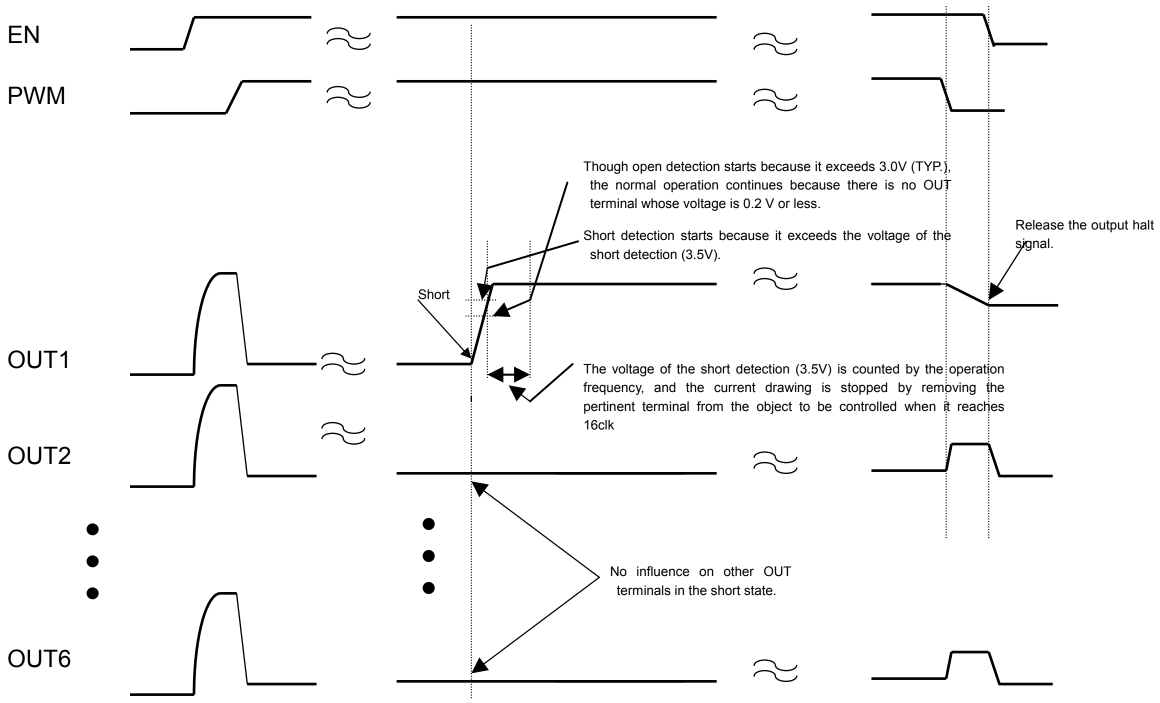
(In case OUT1 is open from the time of the shutdown mode.)



7-2. LED short-circuit detection

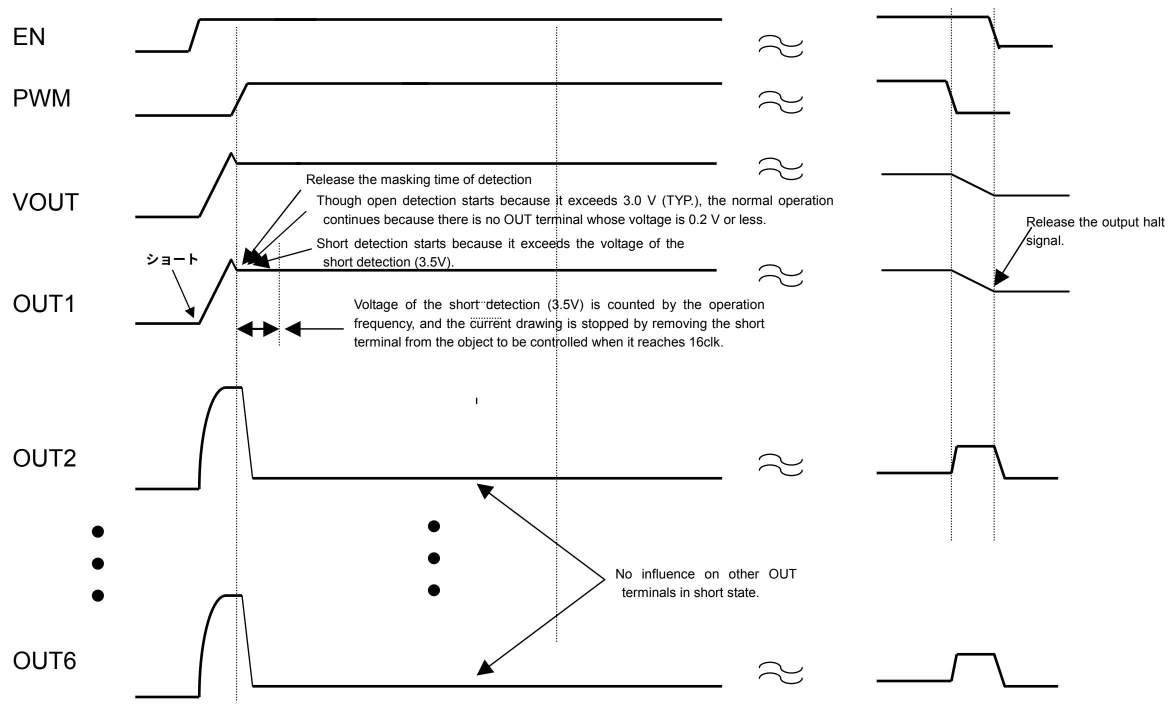
In case one of OUT terminals (OUT1 to OUT6) is short-circuited to high voltage in the operation mode, the applied voltage of the pertinent OUT terminal becomes higher than the control voltage.
Open detection starts when the applied voltage for OUT terminal exceeds 3 V (Typ.). But in the short-circuit mode, the normal operation continues though the applied voltage exceeds the open detection voltage because there is no OUT terminal whose applied voltage is 0.2V or less.
Short-circuit detection starts when it exceeds 3.5 V (Typ.).
When short-circuit terminal (the voltage of the OUT terminal is 3.5 V or more.) is detected, the pertinent OUT terminal is removed from the object to be controlled. And the operation recovers to the normal state after stopping the current drawing.
To release the halt of the open OUT terminal which detects short-circuit, the signal should be inputted to EN again.

(In case OUT1 is open in the operation mode.)



In case LED is in short-circuit state from the time of the OFF mode, the short-circuit detection is not provided until the specified voltage of VOUT is detected because the masking time of detection is available in the beginning of the operation mode.
Short-circuit detection starts after VOUT reaches the specified voltage. When the short-circuit terminal (the voltage of the OUT terminal is 3.5 V or more.) is detected, the pertinent OUT terminal is removed from the object to be controlled. And it recovers to the normal state after stopping the current drawing.
To release the halt of the OUT terminal which is short circuit, the signal should be inputted to EN again.

(In case OUT1 is short circuit since shutdown mode.)



7-3. In case all the OUT terminals are out of the object to be controlled in the open detection and the short-circuit detection.

When all of the OUT terminals are out of the object to be controlled, it shifts to the abnormal stop mode, and all the IC functions except regulator operation stop.
To recover from the abnormal stop mode, the signal should be inputted to EN again.

However, under the conditions below, constant current operation keeps without transferring to the abnormal stop mode.
1. All OUT terminals (OUT1 to OUT6) are in the short-circuit state when the IC operation transfers from OFF mode to abnormal stop mode.
2. Some OUT terminals are out of the object to be controlled because they are abnormal, and the rest normal OUT terminals show that they are in the short-circuit mode at the same timing.

7-4. Output over voltage protection (OVP)

It monitors VOUT output.

When OVP is provided in the operation mode, open OUT terminal is detected by stopping SW operation. When open terminal (Voltage of OUT terminal is 0.2V or less.) is detected, the pertinent terminal is removed from the object to be controlled. And it recovers to the normal state after halting the current drawing.

SW operation re-starts when VOUT reaches OVP minus 2 V.

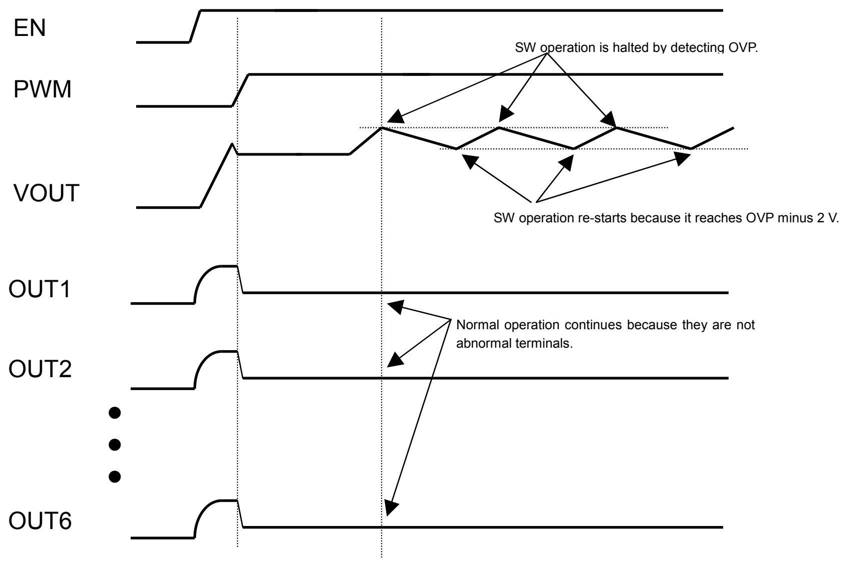
To release the halt of OUT terminal, the signal should be inputted to EN again.

When any open terminal (Voltage of OUT terminal is 0.2V or less.) is not detected by OVP detection, it recovers to the normal operation.

Open terminal is usually detected by OVP detection, but OVP may be also detected in the normal operation in case that the setup VOUT is high (it means the number of direct lines of LED is large.) and the variation of LED_Vf between parallel lines is large. In this case, VOUT oscillates between OVP and OVP minus 2 V.

This terminal should be connected near output capacitor and far from SW terminal because this terminal is influenced by noise easily.

(In case OVP is detected without short-circuit terminal and open terminal.)



8. Abnormal stop mode

When any of the abnormal state below is detected in the standby mode or the operation mode, it shifts to the abnormal stop mode immediately.
All the operations except regulator (voltage boosting and constant current drive) are halted. To recover to the ormal operation, the signal should be inputted to EN again.

Each abnormal state is detected by…

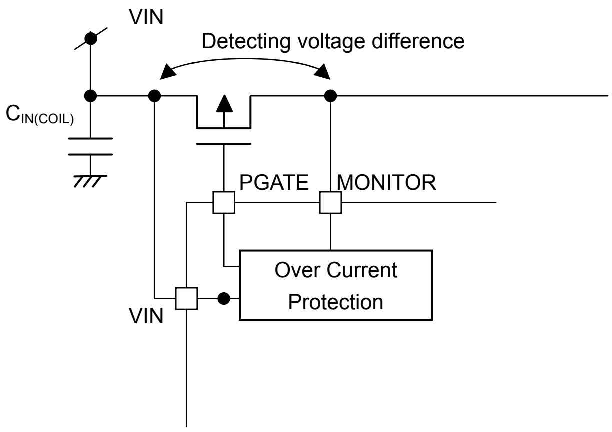
1. Temperature monitoring (TSD)
2. Over current protection (OCP)
3. Low voltage protection (LVP)

8-1. Temperature monitoring (TSD)

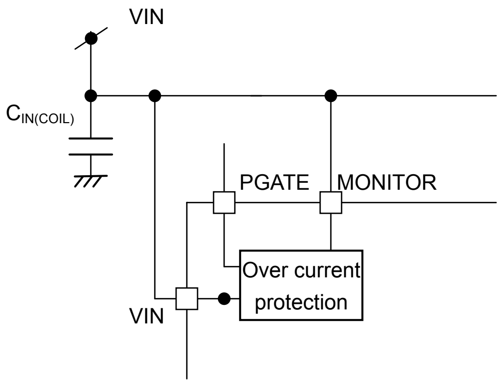
It monitors the temperature of the internal IC. The setting range is 150°C to 180°C.

8-2. Input over current protection (OCP)

The voltage between VIN and MONITOR is measured when EN is high.
It outputs low to PGATE when the voltage difference becomes 100mV(TYP) or more for 8 bit or more.



In case this function is not used, connect VIN and MONITOR directly. PGATE should be no connection.



8-3. Output low voltage protection (LVP)

It monitors VOUT output. It is detected when VOUT becomes 2 V or less. This terminal should be connected near to output capacitor and far from SW terminal because it is influenced by noise easily.

8-4. SW protection

When SBD is not connected, the applied voltage of SW terminal increases rapidly by the voltage boosting of SW terminal. In this case, SW protection prevents the voltage from exceeding the tolerant voltage of SW.

9. Transition from standby mode to shutdown mode

Outputting high to PGATE terminal after EN is low. This internal regulator is not integrated the sink source. So, Output voltage of REGOUT terminal is decreased by self-discharge.

10. Others

10-1. ON/OFF setup time of PWM

Frequency set of PWM signal is100 to 10 kHz.

However, take care in setting PWM frequency because the minimum ON/OFF time is defined as 10 μs.

Ex.) When PWM signal frequency is set 10kHz, duty width has 0, 10 to 90, and 100%.
When PWM signal frequency is set 1 kHz, duty width has 0, 1 to 99, and 100%.

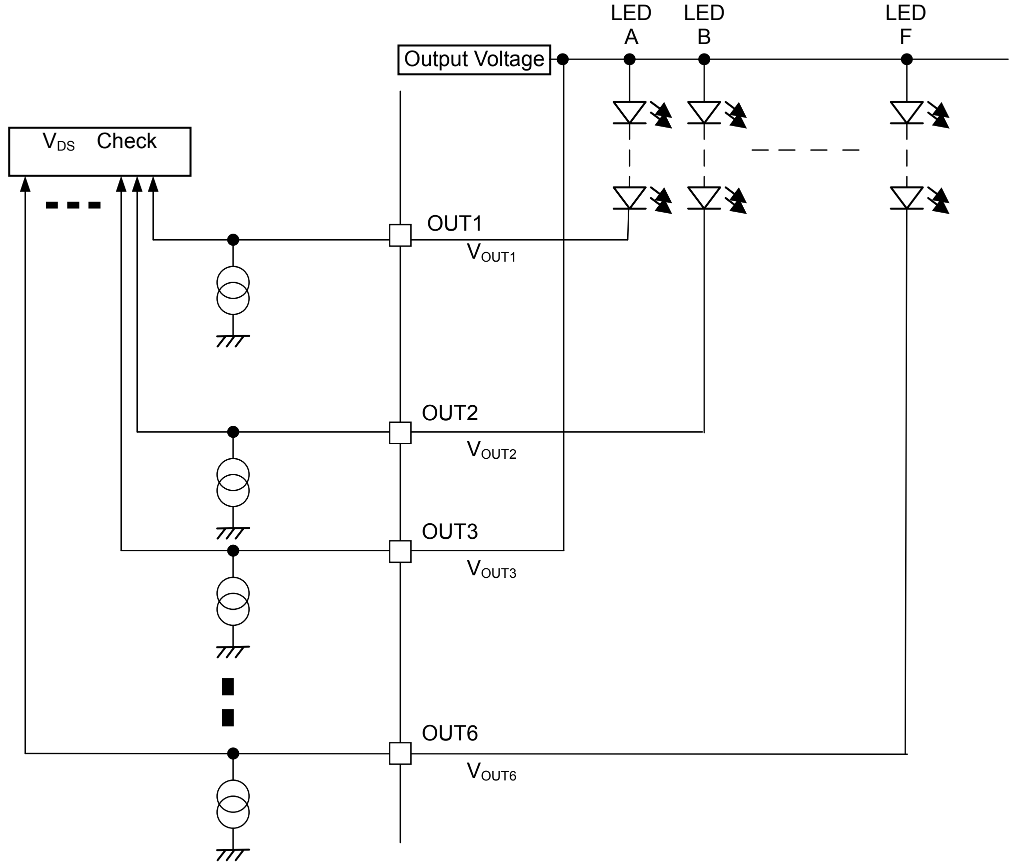
10-2. Treatment of the unused channel

When unused channel is used in the open state, the over voltage detection (OVP) works in the initial operation.

If this detection has any problems, please treat as follows,

• Connect OUT terminal of unused channel to VIN or VOUT.

Ex.) In case Ch3 is unused.



10-3. Operation in open mode and short-circuit mode of external shotkey diode

When shotkey diode is in open or short-circuit mode, IC may be destroyed because over current flows in SW terminal. In this case, power supply is stopped by input over current protection and never recovers.

Notes on handling of ICs

Setting capacitor

Recommended values: $C_{IN\ (COIL)}$; 10 or more (μF), COUT ; 2.2 or more (μF).
Generally, ceramic capacitor tends to decrease its capacitor when voltage is applied.
So, select the capacitor depending on LED's characteristics (size, withstand pressure, and so on).

Setting LED current (IF)

Average set current (IF) can be set by RISET resistance which is connected between ISET terminal and GND.
Average set current is provided by formula below.

$$\text{Average output current IF (mA)} = \frac{1.14\ \text{(V)}}{\text{RISET (K}\Omega\text{)}} \times 193$$

Setting oscillation frequency

Oscillation frequency can be set by RFSET resistance which is connected between FSET terminal and GND.
Oscillation frequency is provided by formula below.

$$\text{Oscillation frequency (MHz)} = \frac{1.14\ \text{(V)}}{\text{RFSET (K}\Omega\text{)}} \times 80$$

Setting external inductor

The value of 4.7 (μH) is recommended for the standard application.
In case standard oscillation frequency (1MHz) is changed, the value of inductor should be changed.

Setting COMP terminal

The values of resistance (RCOMP) and capacitor (CCOMP) which are connected to COMP terminal are recommended as follows;

RCOMP＝510 (Ω)
CCOMP＝0.1 (μF) (For standard applications.)

CCOMP should not be changed because this capacitor has a soft start function to avoid rush current which generates just after startup.
In case inductor is changed because of changing the oscillation frequency, RCOMP may need to be adjusted to stabilize the switching operation.

Absolute Maximum Ratings (Ta = 25°C if without notice)

Characteristics	Symbol	Condition	Rating	Unit
Power supply voltage	V_{IN}		–0.3 to +30	V
Input voltage1	V_{IN1}	EN, PWM	–0.3 to +6V	V
Input voltage2	V_{IN2}	SW, VOUT	–0.3 to +48V	V
Power dissipation	P_D	Exposed Pad not mounting*Note2,3	1.3	W
		Exposed Pad mounting*Note2,3	3.0	
Thermal resistance	$R_{th\ (j\text{-}a)}$	Exposed Pad not mounting*Note2,3	96	°C/W
		Exposed Pad mounting*Note2,3	41	
Operation temperature range	T_{opr}		–10 to +85	°C
Storage temperature range	T_{stg}		–55 to +150	°C
Maximum junction temperature	T_j		150	°C

Note1: The power dissipation of 12.5mW/℃must be deducted from the maximum rating, whenever the ambient temperature of 1 ℃ exceeds 25 ℃. (Condition; Mounted state.)
Note 2 : The power dissipation of 10.42mW/℃ (without pad mounting) and of 24.39 mW/℃ (with pad mounting) must be deducted from the maximum rating, whenever the ambient temperature of 1 ℃ exceeds 25 ℃.
Note 3 : PCB Condition : 76.4×114.3×1.6mm, JEDEC (4 layers)

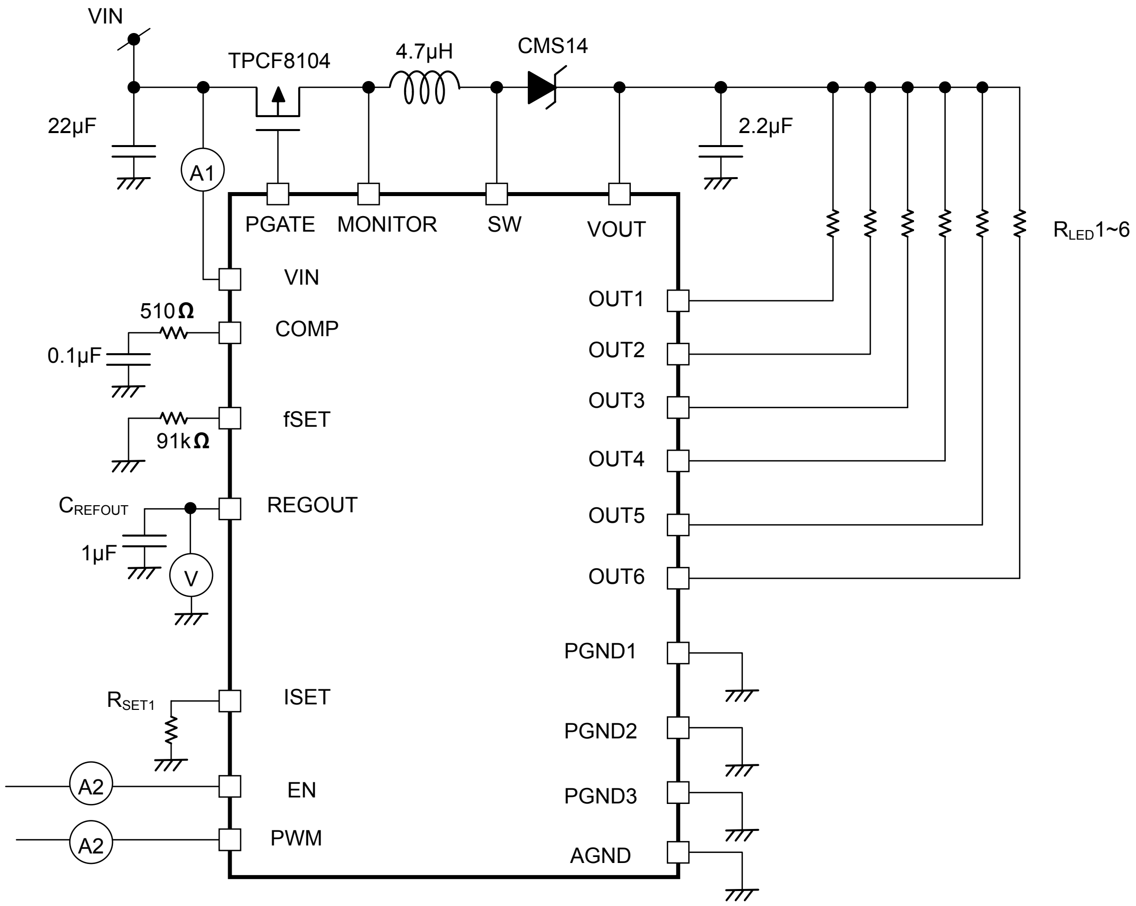
Operating Condition (Ta = -10~ to 85°C if without notice)

Characteristics	Symbol	Condition	Min	Typ.	Max	Unit
Power supply voltage	V_{IN}	VOUT is 42 V or less. ILED : 30mA	7.5	-	22	V
		VOUT is 38 V or less. ILED : 20mA	6.8	-	22	V
Signal frequency of PWM input	f_{PWM}		0.1	-	10	kHz
LED setup current	$I_{F(RANGE)}$	OUT1 to OUT6	10	-	30	mA
Oscillating setup	I_F		0.2	-	1.5	MHz
PWM : Minimum ON/OFF time	tON(tOFF)		10	-	-	μs

Electrical Characteristics (Ta = 25°C, V_{IN} = 7.5 to 22 V if without notice)

Characteristics	Circuit	Symbol	Test Condition	Min	Typ.	Max	Unit
Operating consumption current	1	I_{IN} (On)	EN＝H, PWM＝H, VIN＝22V, R_{ISET}＝11kΩ	―	8.7	12.0	mA
	1	I_{IN} (OVP)	EN＝H, PWM＝H, VIN＝22V, R_{ISET}＝11kΩ,V_{OVP}＝46V	―	7.5	10.0	mA
	1	I_{IN} (SHUT)	Abnormal stop mode	―	2.1	4.0	mA
Off consumption current	1	I_{IN} (Off)	VIN=22V, EN=L	―	0.5	1.0	μA
Output voltage of REGOUT terminal	1	V_{REGOUT}		4.80	5.05	5.30	V
High voltage to logic terminal	―	$V_{(LOGIC)H1}$	EN terminal	1.3	―	5.5	V
		$V_{(LOGIC)H2}$	PWM terminal	1.3	―	REGOUT	V
Low voltage to logic terminal	―	$V_{(LOGIC)L}$	EN terminal, PWM terminal	0	―	0.4	V
Input current of logic terminal	1	I_{EN}	V_{EN}=3.3V	―	33	50	μA
	1	I_{PWM}	V_{PWM}=3.3V	―	0	1.0	μA
Pull down resistance of EN terminal	1	R_{EN}		70	100	130	kΩ
Switching frequency	2	f_{OSC}	R_{FSET}=91kΩ	0.9	1.0	1.1	MHz
Peak current of switching terminal	3	I_o (SW)	EN="H", PWM="H", Vin=7.5V	―	2.0	―	A
Leakage current of switching terminal	4	I_{OZ}(SW)	EN="L", PWM="L", V_{SW}=42V	―	―	0.5	μA
OVP protection voltage	5	V_{OVP}		42	44.5	46	V
OCP protection voltage	6	V_{OCP}		80	100	120	mV
LVP protection voltage	5	V_{LVP}		1.8	2.0	2.3	V
Input current to OVP terminal	5	I_{OVP}	EN＝H，PWM＝H， V_{OVP}=42V	―	42	60	μA
Leakage current of OVP terminal	7	I_{OVPLK}	EN＝L		0.5	1	μA
Thermal shutdown temperature	―	T_{TSD}		150	―	190	℃
ISET terminal output voltage	8	V_{ISET}		1.10	1.14	1.18	V
FSET terminal output voltage		V_{FSET}		1.10	1.14	1.18	V
OUT terminal output voltage	8	V_{OUT1-6}	ISET=11kΩ	0.55	0.60	0.68	V
Gain	―	gain	-	―	193	―	A/A
Constant Current Accuracy	9	$\|\Delta I_{LED(IC)}\|$		―	2	―	%
Constant current operation			VIN＝7.5V to 22V, ISET＝11kΩ	19.6	20	20.4	mA
Leakage current of OUT terminal	10	$I_{OUTLEAK1\ to\ 6}$	EN＝H，PWM＝L	―	―	1	μA
Output current ON time	―	tON		―	1.0	―	μs
Output current OFF time	―	tOFF		―	0.15	―	μs

TEST CIRCUIT1 (Consumption current measurement)



A1：Consumption current measurement

	EN	PWM	VIN	ILED	VOUT	R_{LED}1 to 6
IIN(On)	H	H	22V	20mA	―	2kΩ
IIN(OVP)　(※1)	H	H	22V	20mA	46V	―
IIN(SHUT)	H	L	22V	―	―	―
IIN(Off)	L	L	22V	―	―	―

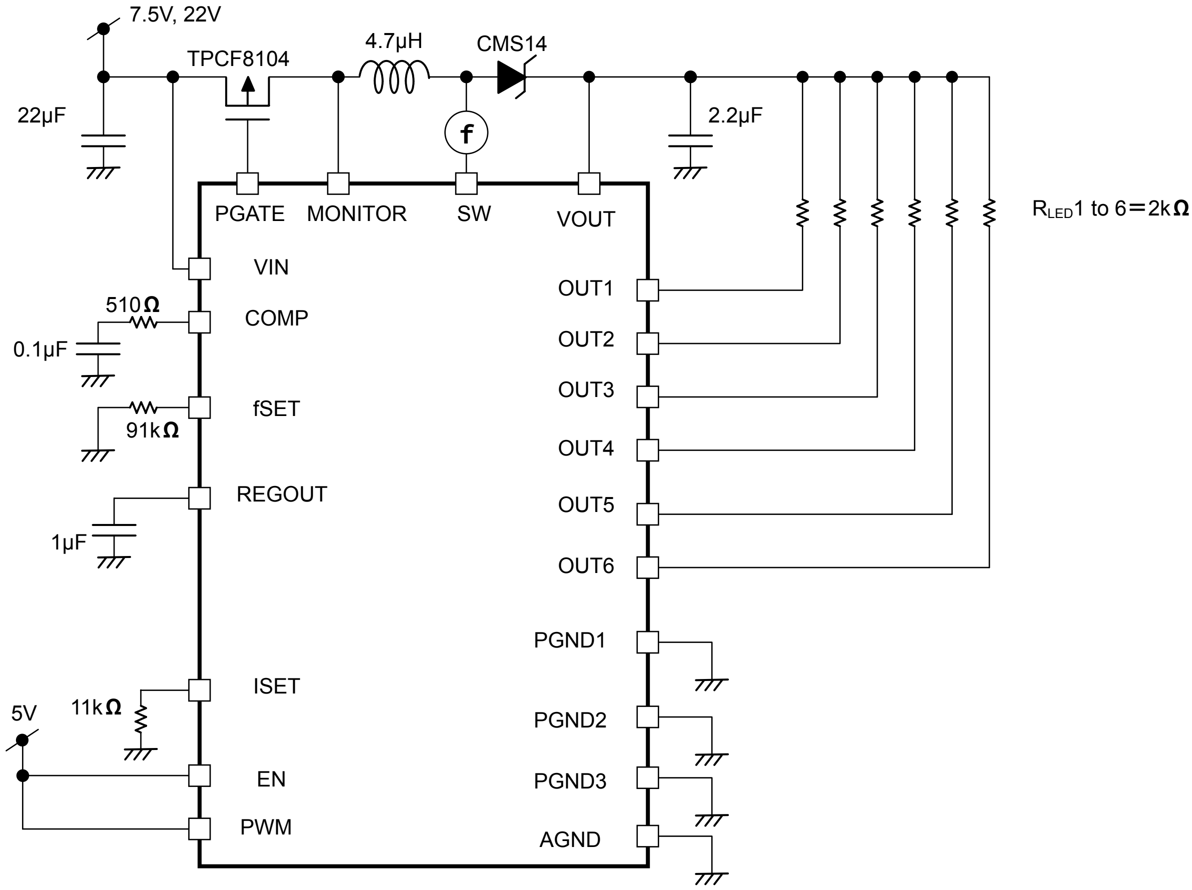
※1： Supplying power to OVP terminal from another supply.

A2：Measure input current of logic terminal. (Applied voltage: 3.3V)

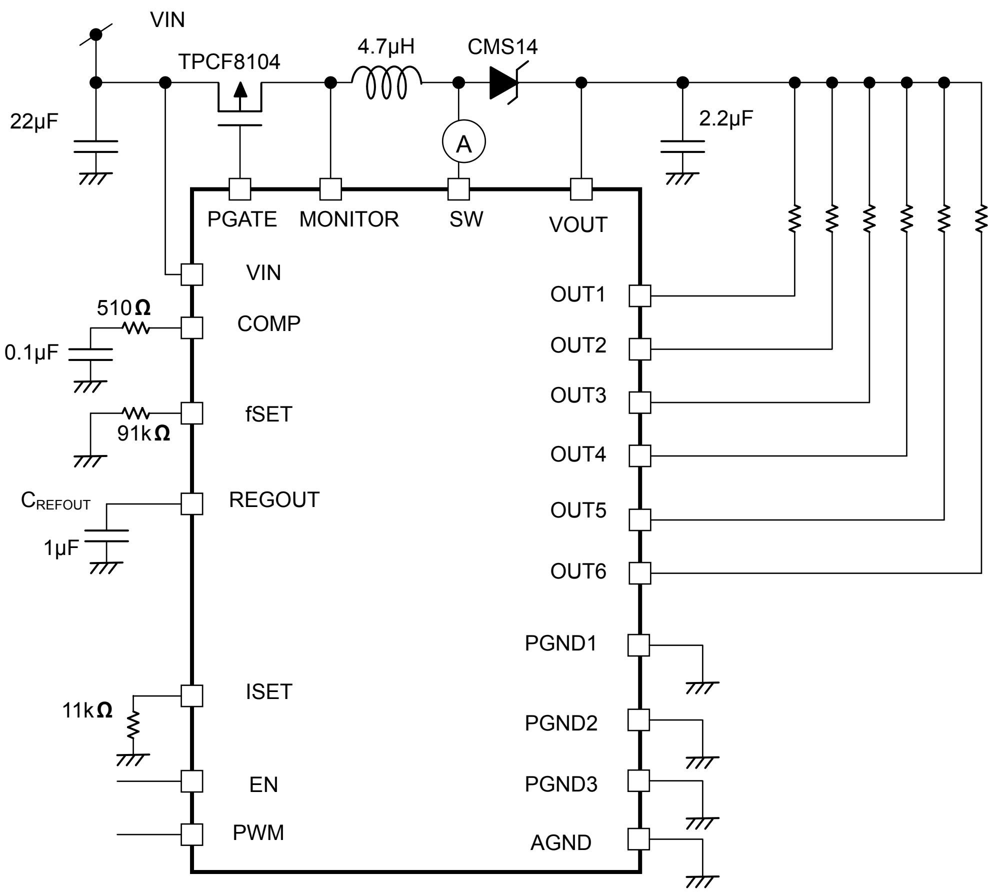
R_{EN}：3.3V÷$I_{\_EN}$

V　：V_{REGOUT} measurement

TEST CIRCUIT2 (Frequency measurement)



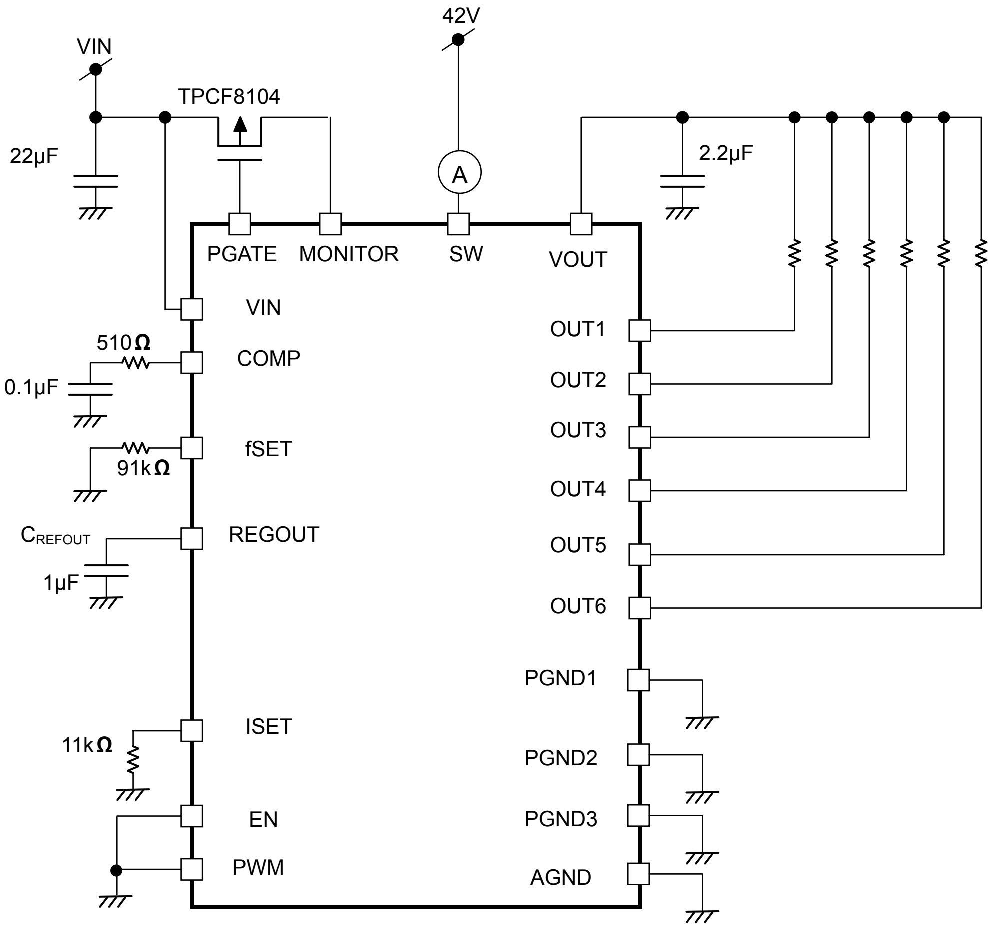
TEST CIRCUIT3 (Current measurement of SW terminal)



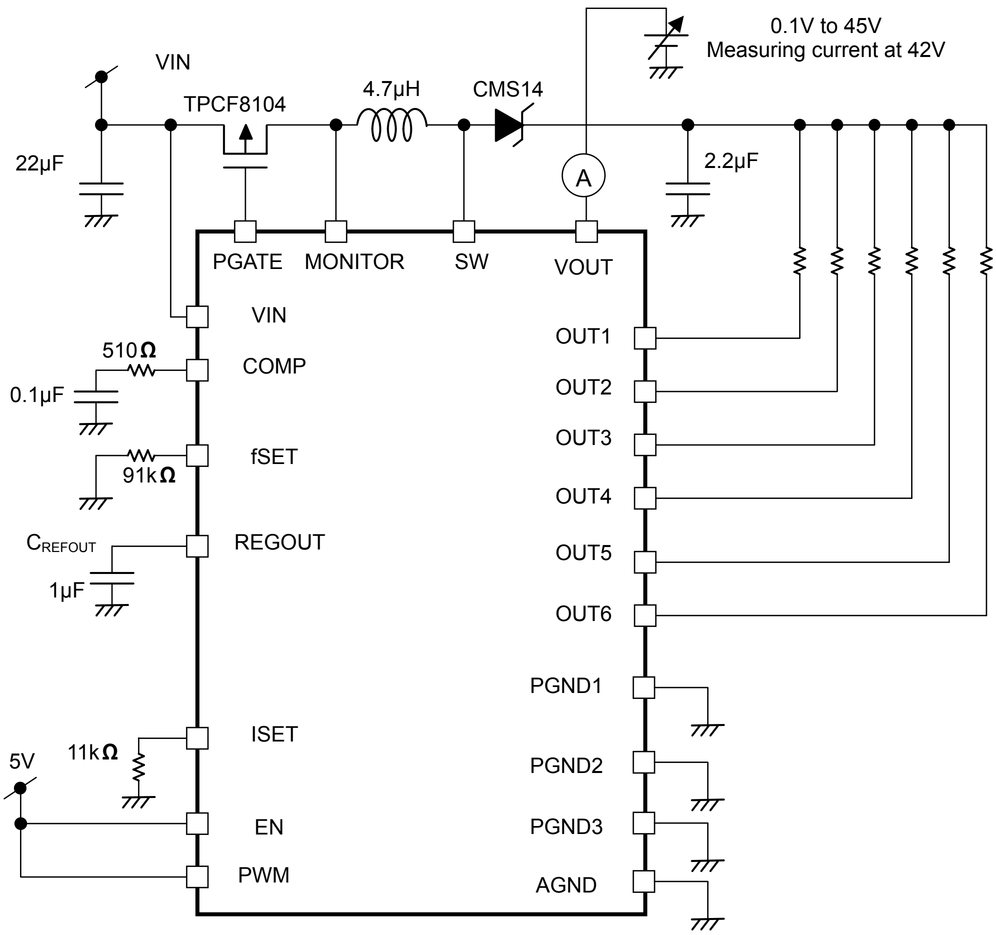
Peak current measurement of SW terminal

	EN	PWM	VIN	ILED	VOUT	R_{LED}1 to 6
Peak current measurement of SW terminal	H	H	7.5V	25mA	40V	1.5kΩ

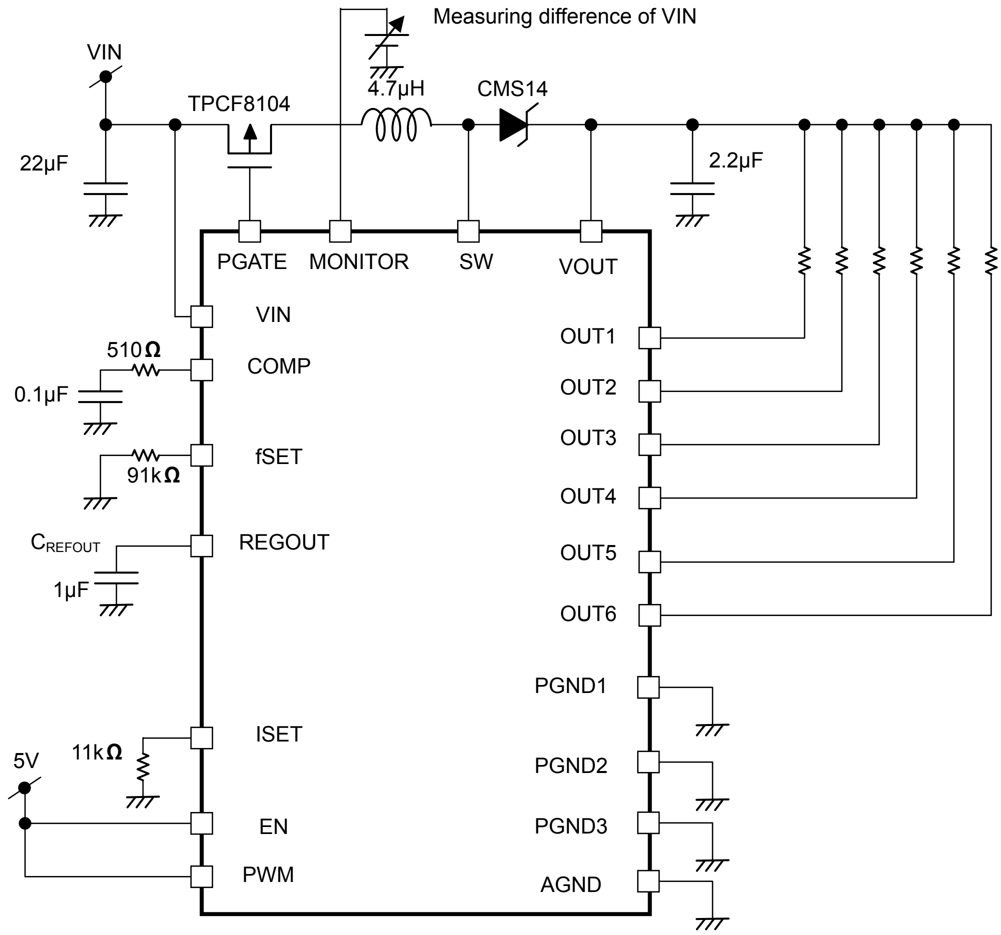
TEST CIRCUIT4 (Leakage current measurement of SW terminal)



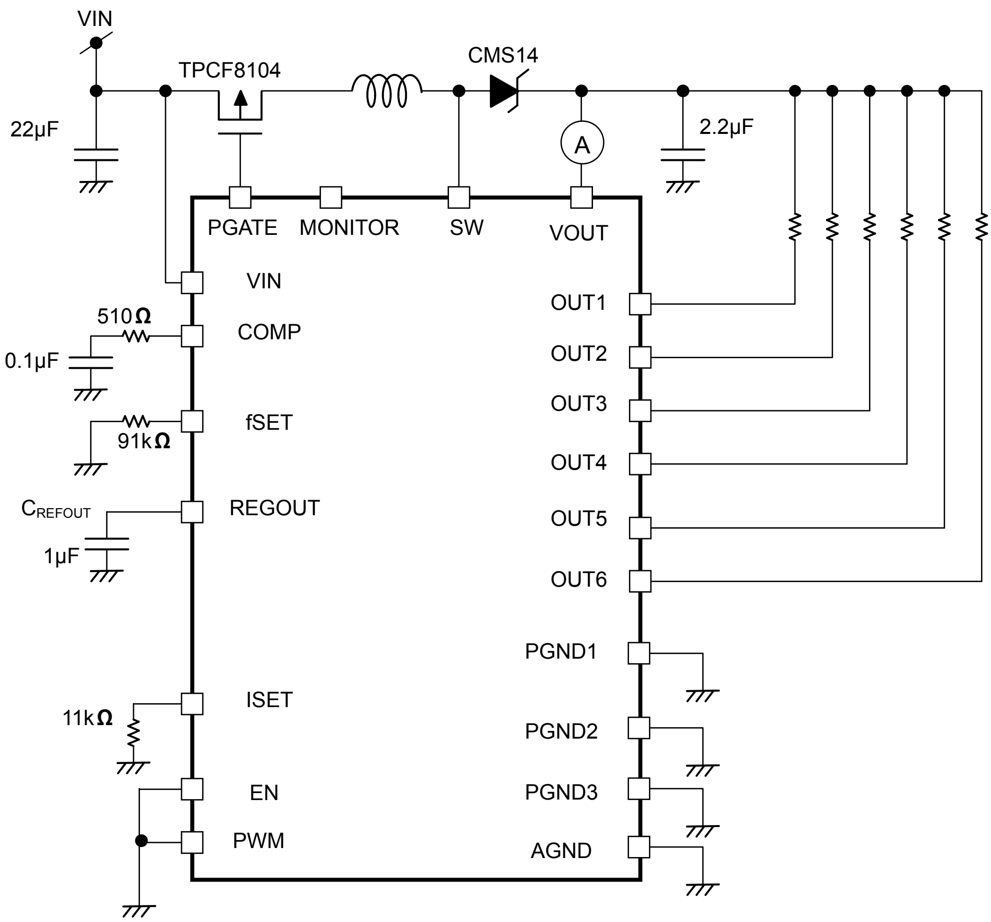
TEST CIRCUIT5



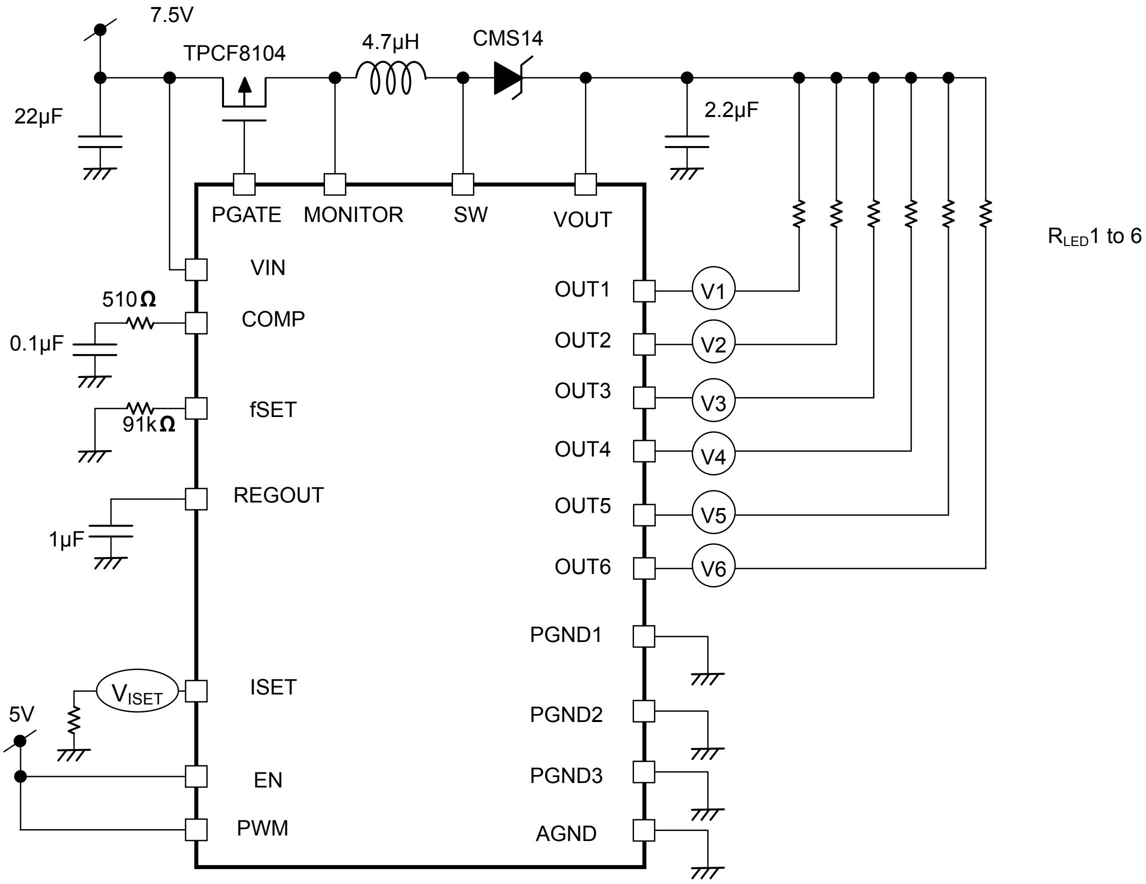
TEST CIRCUIT6



TEST CIRCUIT7

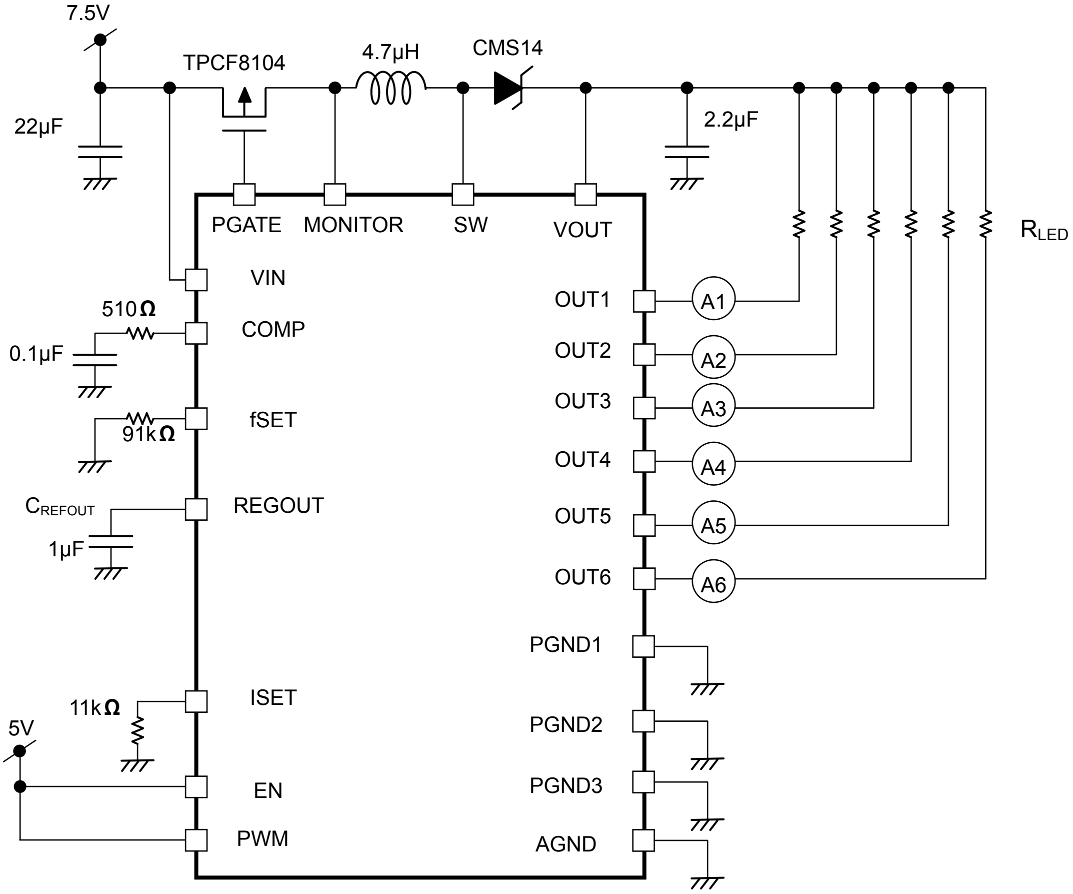


TEST CURCUIT8



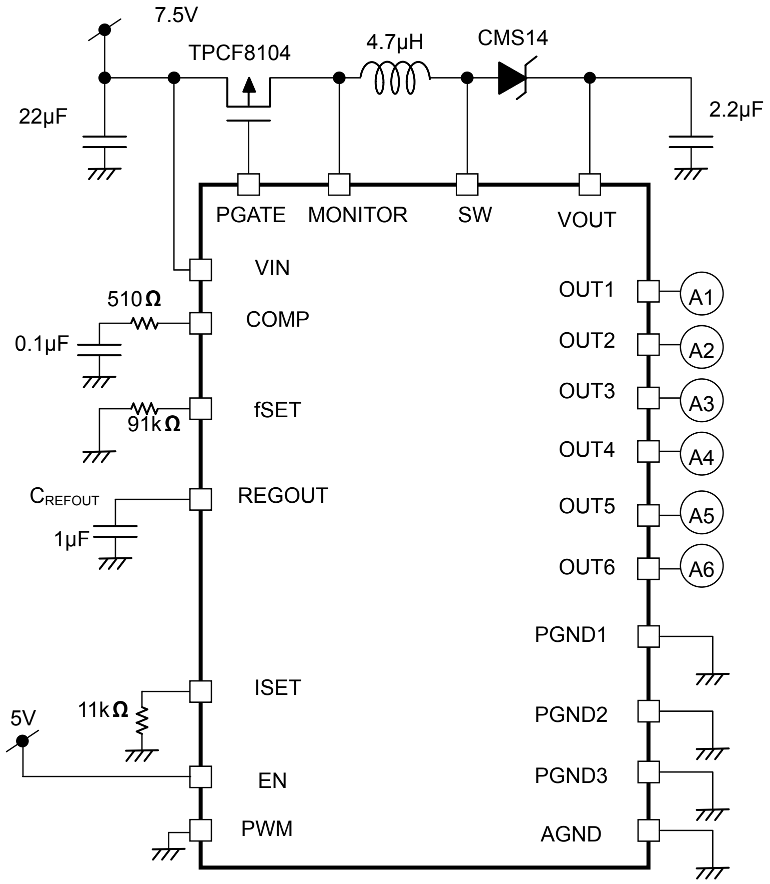
	R_{LED}1	R_{LED}2	R_{LED}3	R_{LED}4	R_{LED}5	R_{LED}6
V1 measure	2.0kΩ	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ
V2 measure	1.9kΩ	2.0kΩ	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ
V3 measure	1.9kΩ	1.9kΩ	2.0kΩ	1.9kΩ	1.9kΩ	1.9kΩ
V4 measure	1.9kΩ	1.9kΩ	1.9kΩ	2.0kΩ	1.9kΩ	1.9kΩ
V5 measure	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ	2.0kΩ	1.9kΩ
V6 measure	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ	1.9kΩ	2.0kΩ

TEST CURCUIT9

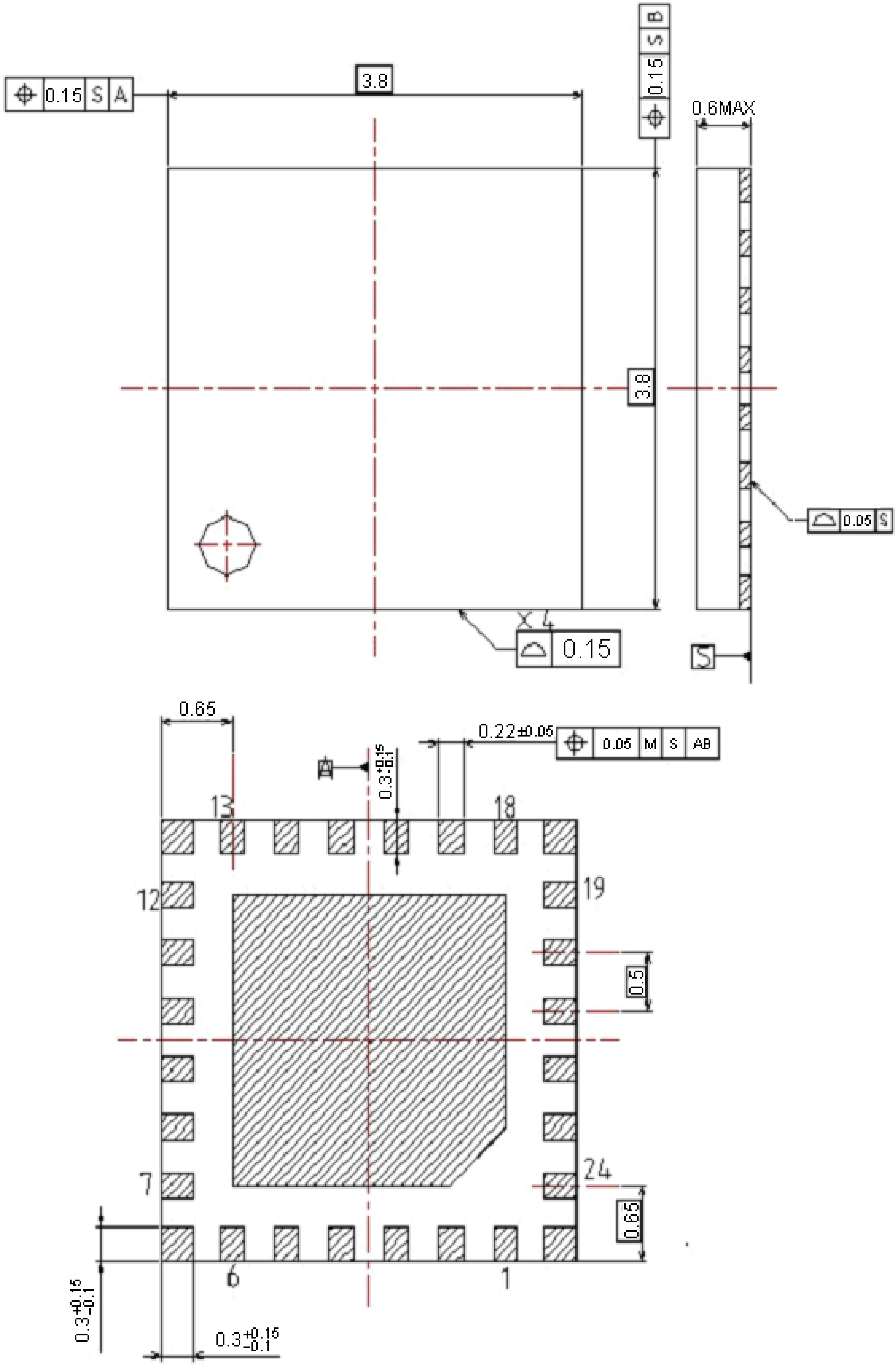


	Condition		R_{LED} condition
A1 measure	1	A1÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A1÷(Ave. of A1 to A6)×100	R_{LED}1＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}1)
A2 measure	1	A2÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A2÷(Ave. of A1 to A6)×100	R_{LED}2＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}2)
A3 measure	1	A3÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A3÷(Ave. of A1 to A6)×100	R_{LED}3＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}3)
A4 measure	1	A4÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A4÷(Ave. of A1 to A6)×100	R_{LED}4＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}4)
A5 measure	1	A5÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A5÷(Ave. of A1 to A6)×100	R_{LED}5＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}5)
A6 measure	1	A6÷(Ave. of A1 to A6)×100	R_{LED}1 to 6＝2kΩ
	2	A6÷(Ave. of A1 to A6)×100	R_{LED}6＝1.9kΩ, R_{LED}＝2kΩ(Except R_{LED}6)

TEST CURCUIT10



Package Dimensions



Weight: 0.021g (TYP)

Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.
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5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on handling of ICs

(1) [1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

(2) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

(3) If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

(4) Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

(5) Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator.
If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure can cause smoke or ignition. (The over current can cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.

Points to remember on handling of ICs

(1) Over current Protection Circuit

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

(2) Thermal Shutdown Circuit

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(3) Heat Radiation Design

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (T_J) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(4) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output terminals might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

The following conditions apply to solderability:

About solderability, following conditions were confirmed

- Solderability

  (1) Use of Sn-37Pb solder Bath
  - solder bath temperature: 230°C
  - dipping time: 5 seconds
  - the number of times: once
  - use of R-type flux

  (2) Use of Sn-3.0Ag-0.5Cu solder Bath
  - solder bath temperature: 245°C
  - dipping time: 5 seconds
  - the number of times: once

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