

LED Drivers for LCD Backlights

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



BD6586MUV

No.11040ECT35

●Description

BD6586MUV is white LED driver IC with PWM step-up DC/DC converter that can boost max 24V and current driver that can drive max 25mA. The wide and precision brightness can be controlled by external PWM pulse.

BD6586MUV has very accurate current drivers, and it has few current errors between each strings. So, it will be helpful to reduce brightness spots on the LCD. Small package type is suited for saving space.

●Features

- 1) High efficiency PWM step-up DC/DC converter (fsw=1MHz)
- 2) High accuracy & good matching ($\pm 3.0\%$) current drivers 4ch (MAX.25mA/ch)
- 3) 28V power Nch MOSFET
- 4) Soft Start
- 5) Drive up to 6 in series, 4 strings in parallel
- 6) Rich safety functions
 - Over-voltage protection
 - Output Short protection
 - External SBD open detect
 - Over current limit
 - Thermal shutdown
 - UVLO
- 7) Small & thin package (VQFN024V4040) 4.0 × 4.0 × 1.0mm

●Applications

All middle size LCD equipments backlight of Notebook PC, portable DVD player, car navigation systems, etc.

●Absolute maximum ratings (Ta=25 °C)

| Parameter | Symbol | Ratings | Unit | Condition |
|-----------------------------|--------|--------------------|------|--|
| Maximum applied voltage 1 | VMAX1 | 7 | V | VBAT, EN1, EN2, TRSW, PWM, TESTO, ISET, TEST |
| Maximum applied voltage 2 | VMAX2 | 25 | V | LED1, LED2, LED3, LED4, |
| Maximum applied voltage 3 | VMAX3 | 30.5 | V | SW |
| Maximum applied voltage 4 | VMAX4 | 50.5 | V | VDET |
| Power dissipation 1 | Pd1 | 500 ^{*1} | mW | |
| Power dissipation 2 | Pd2 | 780 ^{*2} | mW | |
| Power dissipation 3 | Pd3 | 1510 ^{*3} | mW | |
| Operating temperature range | Topr | -40 ~ +85 | °C | |
| Storage temperature range | Tstg | -55 ~ +150 | °C | |

*1 Reduced 4.0mW/ °C With Ta>25 °C when not mounted on a heat radiation Board.

*2 1 layer (ROHM Standard board) has been mounted. Copper foil area 0mm², When it's used by more than Ta=25 °C, it's reduced by 6.2mW/ °C.

*3 4 layer (JEDEC Compliant board) has been mounted.

Copper foil area 1layer 6.28mm², Copper foil area 2~4layers 5655.04mm², When it's used by more than Ta=25 °C, it's reduced by 12.1mW/ °C.

●Recommended operating range (Ta=-40 °C ~ +85 °C)

| Parameter | Symbol | Ratings | | | Unit | Condition |
|----------------------|--------|---------|------|------|------|-----------|
| | | Min. | Typ. | Max. | | |
| Power supply voltage | VBAT | 2.7 | 3.6 | 5.5 | V | |

●Electrical characteristic (Unless otherwise specified, VBAT=3.6V, Ta = +25 °C)

| Parameter | Symbol | Limits | | | Unit | Condition |
|-----------------------------------|--------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| [EN1, EN2, PWM Terminal] | | | | | | |
| EN threshold voltage (Low) | VthL | 0 | - | 0.4 | V | |
| EN threshold voltage (High) | VthH | 1.4 | - | 5.5 | V | |
| EN terminal input current | Iin | - | 8.3 | 16.0 | μA | Input=2.5V |
| [Under Voltage Lock Out] | | | | | | |
| Under Voltage Lock Out | UVLO | 2.05 | 2.35 | 2.65 | V | VBAT falling edge |
| [Switching Regulator] | | | | | | |
| Quiescent Current | Iq | - | 0.1 | 2.0 | μA | EN1=EN2=PWM=0V |
| Current Consumption | Idd | - | 2.2 | 4.6 | mA | VDET=0V, ISET=24kΩ |
| LED Control voltage | VLED | 0.4 | 0.5 | 0.6 | V | |
| Over Current Limit | Ocp | 1.1 | 1.5 | 2.5 | A | *1 |
| SBD Open Protect | Sop | - | - | 0.1 | V | Detect voltage of VDET pin |
| Switching frequency | fSW | 0.7 | 1.0 | 1.3 | MHz | |
| Duty cycle limit | Duty | 91 | 95 | 99 | % | LED1-4=0.3V |
| Over voltage limit | Ovl | 25.0 | 25.5 | 26.0 | V | LED1-4=0.3V |
| SW Transistor On Resistance | RSW | - | 0.24 | 0.32 | Ω | Isw=100mA |
| [Current driver] | | | | | | |
| LED maximum current | ILMAX | - | - | 25 | mA | |
| LED current accuracy | ILACCU | - | - | ±5 | % | ILED=20mA |
| LED current matching | ILMAT | - | - | ±3 | % | •Each LED current/Average (LED1- 4) •ILED=20mA |
| ISET voltage | Iset | 0.5 | 0.6 | 0.7 | V | |
| LED current limiter | ILOCP | 35 | 60 | 90 | mA | Current limit value at ISET resistance 4.7kΩ setting LED1, 2, 3, 4=0.5V |
| LED Terminal Over Voltage Protect | LEDOVP | 10.0 | 11.5 | 13.0 | V | EN1=EN2=PWM=2.5V |

*1 This parameter is tested with DC measurement.

●Block diagram, I/O equivalent circuit diagram

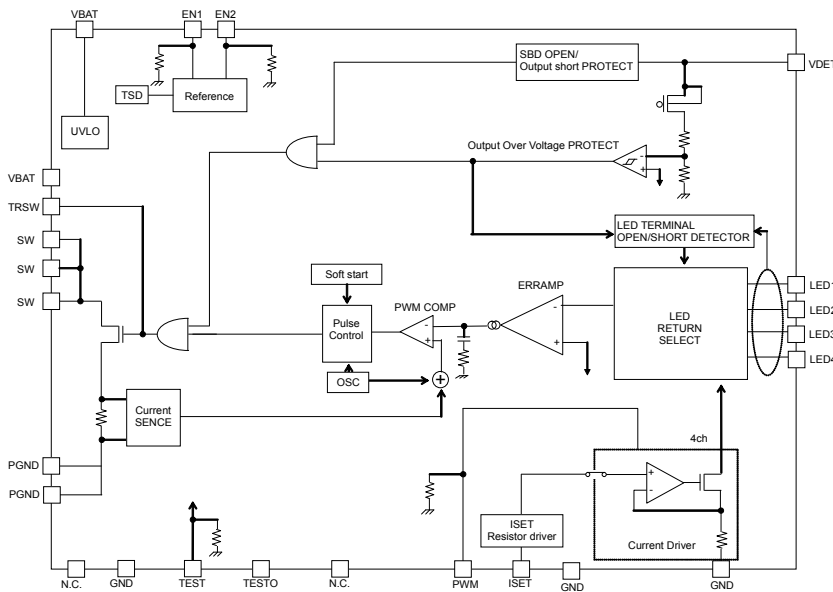


Fig.1 Block diagram

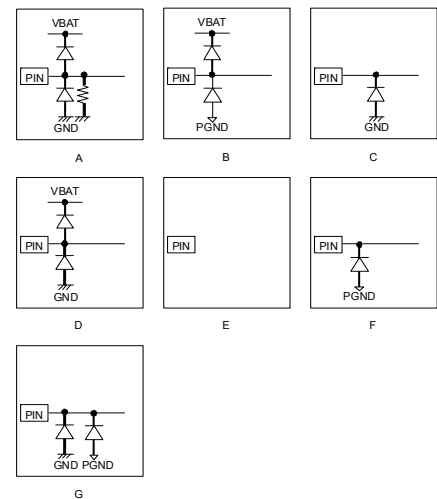


Fig.2 I/O equivalent circuit diagram

●Pin assignment table

| PIN Name | In/Out | PIN number | Function | Terminal equivalent circuit diagram |
|----------|--------|------------|---|-------------------------------------|
| 1 | VBAT | In | Battery input | G |
| 2 | EN1 | In | Power control pin | A |
| 3 | EN2 | In | Power control pin | A |
| 4 | GND | - | GND for DC/DC | B |
| 5 | PWM | In | PWM input pin for power ON/OFF only driver | A |
| 6 | ISET | In | Register connection for LED current setting | D |
| 7 | GND | - | GND for ISET Register | B |
| 8 | LED1 | In | Current sink for LED1 | C |
| 9 | LED2 | In | Current sink for LED2 | C |
| 10 | GND | - | GND for Current Driver | B |
| 11 | LED3 | In | Current sink for LED3 | C |
| 12 | LED4 | In | Current sink for LED4 | C |
| 13 | TEST | In | TEST input (Pull down 100kΩ to GND) | A |
| 14 | TESTO | Out | TEST output | D |
| 15 | N.C. | - | No connect pin | E |
| 16 | SW | Out | Switching Tr drive Pin | F |
| 17 | SW | Out | Switching Tr drive Pin | F |
| 18 | SW | Out | Switching Tr drive Pin | F |
| 19 | VDET | In | Detect input for SBD open and OVP | C |
| 20 | N.C. | - | No connect pin | E |
| 21 | PGND | - | PGND for switching transistor | D |
| 22 | PGND | - | PGND for switching transistor | D |
| 23 | N.C. | - | No connect pin | E |
| 24 | TRSW | Out | The gate of Switching Tr | D |

●Description of Functions

1) PWM current mode DC/DC converter

While BD6586MUV is power ON, the lowest voltage of LED1, 2, 3, 4 is detected, PWM duty is decided to be 0.5V and output voltage is kept invariably. As for the inputs of the PWM comparator as the feature of the PWM current mode, one is overlapped with error components from the error amplifier, and the other is overlapped with a current sense signal that controls the inductor current into Slope waveform to prevent sub harmonic oscillation. This output controls internal Nch Tr via the RS latch. In the period where internal Nch Tr gate is ON, energy is accumulated in the external inductor, and in the period where internal Nch Tr gate is OFF, energy is transferred to the output capacitor via external SBD. BD6586MUV has many safety functions, and their detection signals stop switching operation at once.

2) Soft start

BD6586MUV has soft start function.

The soft start function prevents large coil current.

Rush current at turning on is prevented by the soft start function.

After EN1, EN2 are changed L → H, soft start becomes effective for within 1ms and soft start doesn't become effective even if EN1, EN2 are changed L → H after that.

And, when the H section of PWM is within 1ms, soft start becomes invalid when PWM is input to H more than three times.

The invalid of the soft start can be canceled by making EN1, EN2, PWM → L.

And, a soft start function doesn't work after a protection function release.

3) External SBD open detect and over voltage protection

BD6586MUV has over boost protection by external SBD open and over voltage protection. It detects VDET voltage and is stopped output Tr in abnormal condition. Details are as shown below.

▪ External SBD open detect

In the case of external SBD is not connected to IC, the coil or internal Tr may be destructed. Therefore, at such an error as VOUT becoming 0.1V or below, the Under Detector shown in the figure works, and turns off the output Tr, and prevents the coil and the IC from being destructed.

And the IC changes from activation into non-activation, and current does not flow to the coil (0mA).

▪ Over voltage protection

At such an error of output open as the output DC/DC and the LED is not connected to IC, the DC/DC will boost too much and the VDET terminal exceed the absolute maximum ratings, and may destruct the IC. Therefore, when VDET becomes sensing voltage or higher, the over voltage limit works, and turns off the output Tr, and the pressure up made stop.

At this moment, the IC changes from activation into non-activation, and the output voltage goes down slowly. And, when the output voltage becomes the hysteresis of the over voltage limit or below, the output voltage pressure up to sensing voltage once again and unless the application error is recovered, this operation is repeated.

4) Thermal shut down

BD6586MUV has thermal shut down function.

The thermal shut down works at 175°C or higher, and while holding the setting of EN1, EN2 control from the outside, turns into non operation condition from operation condition. And at 175°C or below, the IC gets back to its normal operation.

5) Over Current Limit

Over current flows the current detection resistor between switching transistor source and PGND, then the voltage of that resistor turns more than detection voltage. Over current protection is operating and it is prevented from flowing more than detection current by reducing ON duty of switching Tr without stopping boost.

As over current detector of BD6586MUV is detected peak current, current more than over current setting value does not flow.

6) Under Voltage Lock Out(UVLO)

When VBAT declines in 2.35V (Typ.) from the condition of the power-on, DC/DC and a current driver are changed from a state of movement to the condition at the time of the non-movement. And, it is returned in a state of movement when VBAT is raised beyond 2.55V (Typ.).

●Operating of the application deficiency

- 1) When 1 LED or 1 parallel OPEN during the operating the LED parallel which became OPEN isn't lighting, but other LED parallel is lighting.
Then, Output boosts up to the over voltage protection voltage 25.5V because LED terminal can be 0V.
After the over voltage protection is detected, LED terminal of 0V isn't cut from feedback loop.
Then, Output voltage will become normal voltage automatically.
- 2) When LED short-circuited in the plural
All LED continue to be turned on, unless LED terminal voltage become more than "LED terminal over voltage protection (11.5V)".
When it was more than 11.5V, the line which short-circuited is only turned on, and LED current of other lines decrease or turn off.
- 3) When Schottky diode came off
All LED aren't turned on.
Also, IC isn't destroyed because boost operating stops by the Schottky diode coming off protected function.
- 4) When an output capacitor short.
All LED aren't turned on.
And, an IC isn't destroyed because boost stops by the SBD open protection function.
But, big electric current occurs, and a coil or SBD is likely to destroy it because the route of the GND short circuit of the power supply → coil → output capacitor occurs.
- 5) When the resistance to connect it to the ISET terminal short.
All LED aren't turned on.
Because LED current limit works, all current drivers stop, and DC/DC maintains boost under the state without load.
And, it is returned in a state of normality by canceling a state of short.

●Start control and select constant current driver

BD6586MUV can control the start conditions by EN1, 2 and PWM terminals, and sets 0.4V or below EN1, 2 terminals, so IC can power off. EN1,2 and PWM power on at more than 1.4V, constant current can select ON/OFF by the combination of EN as shown below table.

When there is unused constant current driver, unused LED terminal is set "OPEN".

| Enable | | | Constant current driver | | | | IC POWER |
|--------|-----|-----|-------------------------|------|------|------|----------|
| EN1 | EN2 | PWM | LED1 | LED2 | LED3 | LED4 | |
| H | H | H | OFF | ON | ON | OFF | ON |
| L | H | H | OFF | ON | ON | ON | ON |
| H | L | H | ON | ON | ON | ON | ON |
| L | L | H | OFF | OFF | OFF | OFF | OFF |
| H | H | L | OFF | OFF | OFF | OFF | ON |
| L | H | L | OFF | OFF | OFF | OFF | ON |
| H | L | L | OFF | OFF | OFF | OFF | ON |
| L | L | L | OFF | OFF | OFF | OFF | OFF |

●Control Signal input timing

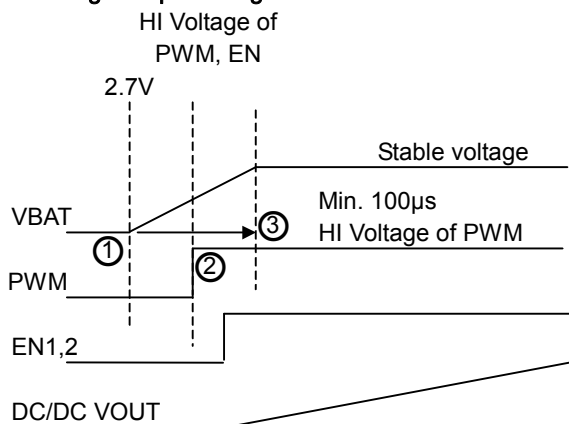


Fig.3 control Signal timing

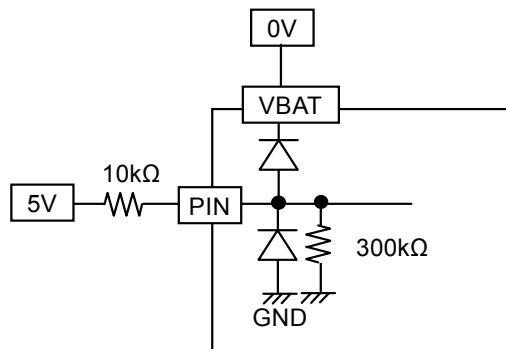


Fig.4 Voltage with a control sign higher than VBAT
Example corresponding to application of conditions

In case you input control signs, such as EN1, EN2 and PWM in the condition that the standup of supply voltage (VBAT) is not completed, be careful of the following point.

- ①Input each control signal after VBAT exceeds 2.7V.
- ②Please do not input each control sign until VBAT exceeds HI voltage of EN1, EN2 and PWM.
- ③When you input HI voltage to EN1, EN2 and PWM during the standup of VBAT, please give Min.100µs as the standup time of VBAT from stable voltage to 2.7V.

There is no timing limitation at each input signal of EN1, EN2 and PWM.

If each control sign changes into a condition lower than VBAT in (1) and (2), it goes via the ESD custody diode by the side of VBAT of each terminal. A power supply is supplied to VBAT and there is a possibility of malfunctioning. Moreover, when the entrance current to the terminal exceeds 50mA, it has possibility to damage the LSI. In order to avoid this condition, as shown in the above figure, please insert about 10kΩ in a signal line, and apply current qualification.

●LED current setting range

LED current can set up Normal current by resistance value (RISET) connecting to ISET voltage. Setting of each LED current is given as shown below.

$$\text{Normal current} = 20\text{mA}(24\text{k}\Omega/\text{RISET})$$

Also, Normal current setting range is 10mA~25mA.
LED current becomes a leak current MAX 2µA at OFF setting.

ISET Normal current setting example

| RISETH | LED current |
|---------------|-------------|
| 24kΩ (E24) | 20mA |
| 25.5 kΩ (E96) | 18.8mA |
| 27 kΩ (E12) | 17.8mA |
| 28kΩ (E96) | 17.1mA |
| 30kΩ (E24) | 16.0mA |
| 33kΩ (E6) | 14.5mA |

●Brightness control

There are two dimming method is available, first method is analog dimming that apply analog voltage to ISETH terminal, and second method is PWM control via digital dimming of EN1, EN2 PWM terminals or PWM. Because each method has the different merit, please choose a suitable method for the application of use.

Refer to Fig.23 for the analog dimming.

Two techniques can be used as digital dimming by the PWM control. One is PWM control of current driver, the other is PWM control of power control.

As these two characteristics are shown in the below, selects to PWM control process comply with application.

- Efficiency emphasis in the low brightness which has an influence with the battery life → 2) Power control PWM control
- LED current dispersion emphasis in the PWM brightness control → 1) Current driver PWM control

(Reference)

| PWM regulation process | Efficiency of LED current 0.2mA (PWM Duty=1%) | PWM frequency 200Hz Low Duty |
|------------------------|---|------------------------------|
| Current driver | 60% | 0.1% |
| Power control | 94% | 0.6% |

1)Current driver PWM control is controlled by providing PWM signal to PWM terminal, as it is shown Fig.5.

The current set up with ISET is chosen as the H section of PWM and the current is off as the L section. Therefore, the average LED current is increasing in proportion to duty cycle of PWM signal. This method that it lets internal circuit and DC/DC to work, because it becomes to switch the driver, the current tolerance is a few when the PWM brightness is adjusted, it makes it possible to brightness control until 20μs (MIN0.4% at 200Hz). And, don't use for the brightness control, because effect of ISET changeover is big under 20μs ON time and under 20μs OFF time. There is no effect of ON/OFF changeover at 0% and 100%, so there is no problem on use. Typical PWM frequency is 100Hz~10kHz.

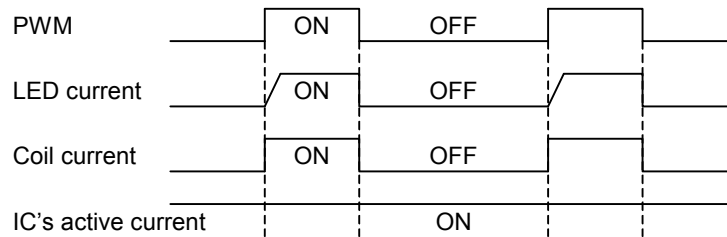


Fig.5 Current driver PWM control

2)Power control PWM control is controlled by providing PWM signal to EN1, EN2 as it is shown Fig.6. The current setting set up with PWM logic is chosen as the H section and the current is off as the L section. Therefore, the average LED current is increasing in proportion to duty cycle of EN1, EN2 signal. This method is, because IC can be power-off at off-time, the consumption current can be suppress, and the high efficiency can be available, so it makes it possible to brightness control until 50μs (MIN1% at 200Hz). And, don't use for the brightness control, because effect of power ON/OFF time changeover is big under 50μs ON time and under 50μs OFF time. There is no effect of ON/OFF changeover at 0% and 100%, so there is no problem on use. Typical PWM frequency is 100Hz~1kHz.

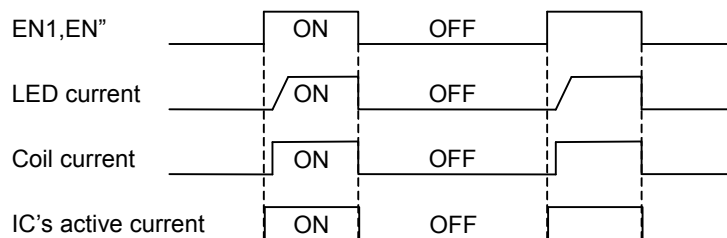


Fig.6 Power control PWM control

●The separations of the IC Power supply and coil Power supply

This IC can work in separating the power source in both IC power supply and coil power supply. With this application, it can obtain that decrease of IC power consumption, and the applied voltage exceeds IC rating 5.5V.

That application is shown in below Fig.7. The higher voltage source is applied to the power source of coil that is connected from an adapter etc. Next, the IC power supply is connected with a different coil power supply.

When the coil power supply is applied, it is no any problem even though IC power supply is the state of 0V. Although IC power supply is set to 0V, pull-down resistance is arranged for the power off which cuts off the leak route from coil power supply in IC inside, the leak route is cut off. And, there is no power on-off sequence of coil power supply and IC power supply.

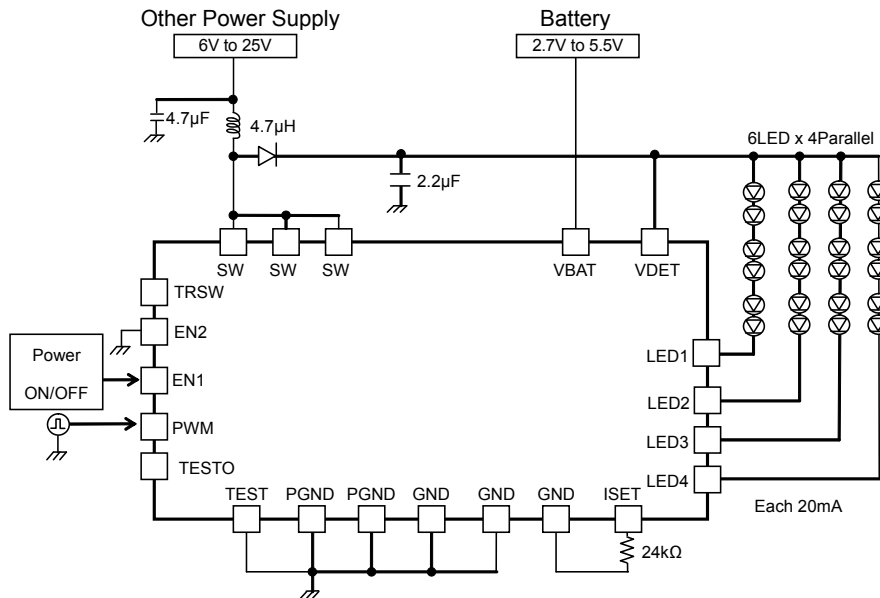


Fig.7 Each battery and coil power supply

●The coil selection

The DC/DC is designed by more than 4.7µH. When L value sets to a lower value, it is possibility that the specific sub-harmonic oscillation of current mode DC / DC will be happened.

Please do not let L value to 3.3µH or below.

And, L value increases, the phase margin of DC / DC becomes to zero. Please enlarge the output capacitor value when you increase L value.

Example)

| | | | | |
|-------|---|------------------|-----------|------|
| 4.7µH | = | output capacitor | 2.2µF/50V | 1pcs |
| 6.8µH | = | output capacitor | 2.2µF/50V | 2pcs |
| 10µH | = | output capacitor | 2.2µF/50V | 3pcs |

This value is just examples, please made sure the final judgment is under an enough evaluation.

●The adjustment of the switching wave form

A switching wave form between the coil and the switch terminal can be adjusted by connecting a capacitor to TRSW. Switching noise can be restrained though efficiency is made to decrease by connecting a capacitor.

Decide capacity value after the enough evaluation when you adjust switching noise.

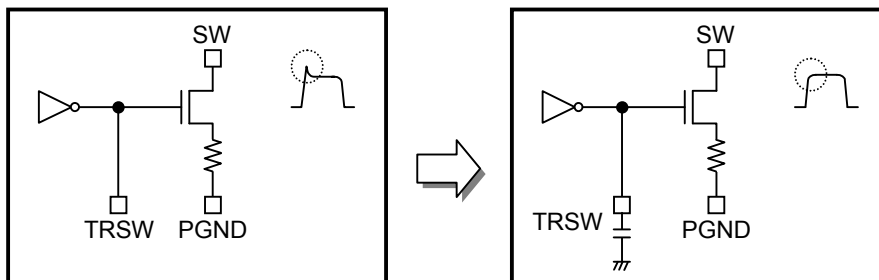


Fig.8 The adjustment of the switching wave form

●PCB Layout

In order to make the most of the performance of this IC, its layout pattern is very important. Characteristics such as efficiency and ripple and the likes change greatly with layout patterns, which please note carefully.

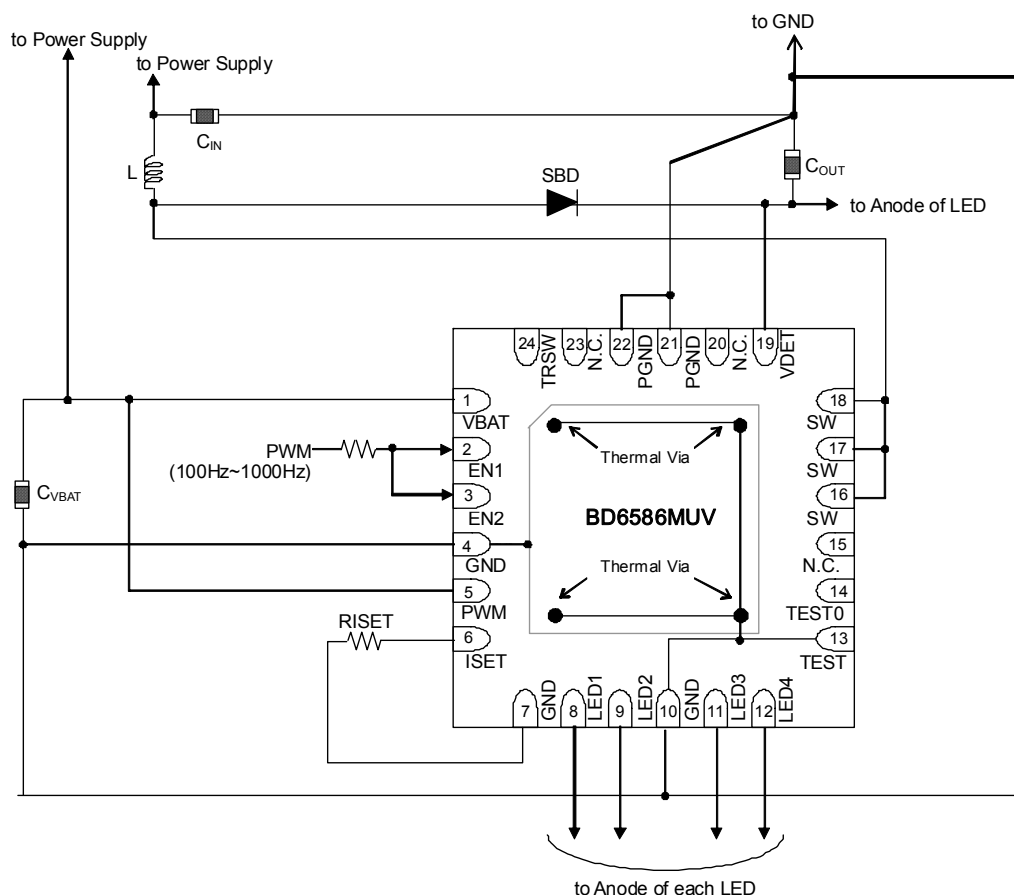


Fig.9 PCB Layout

Connect the input bypass capacitor C_{IN} nearest to coil L and $PGND$, as shown in the upper diagram.

Ripple of a power supply is smoothed by C_{IN} and connect stable voltage to $VBAT$ terminal by the low resistance. Thereby, the input voltage ripple of the IC can be reduced.

Connect C_{VBAT} nearest to between the $VBAT$ terminal and GND (4 pin) as shown in the upper diagram when you can't be wired by the low resistance from C_{IN} to $VBAT$ pin

Connect schottky barrier diode SBD of the regulator nearest to between coil L and SW terminal.

And connect output capacitor C_{OUT} nearest to between C_{IN} and GND pin. Thereby, the output voltage ripple of the IC can be reduced.

GND terminal (4,7,10 pin) is connected inside the IC, and it is GND of the block except switching and a transistor.

A current drive performance may be restricted by influence of a noise, if $PGND$ which is not smooth connected to GND .

A GND terminal is connected to the stable GND plane. And connect it to a GND plane after smoothing $PGND$ by C_{IN} and C_{OUT} . GND and $PGND$ are separated inside IC.

And connect it to a GND plane after smoothing $PGND$ by C_{IN} and C_{OUT} .

Connect the heat sink of IC to a GND plane through Thermal Via. And Connect with the largest possible pattern.

It is satisfactory even if it connects with the GND terminal of IC.

Connect LED current setting resistor $RISET$ nearest to $ISET$ pin. **There is possibility to oscillate when capacity is added to ISET terminal, so pay attention that capacity isn't added. And, RISET of GND side must be wired directly to GND(7pin) pin.**

When those pins are not connected directly near the chip, influence is given to the performance of $BD6586MUV$, and may limit the current drive performance. As for the wire to the inductor, make its resistance component small so as to reduce electric power consumption and increase the entire efficiency.

A layout pattern in consideration of these is shown in p.12.

●Recommended PCB layout pattern

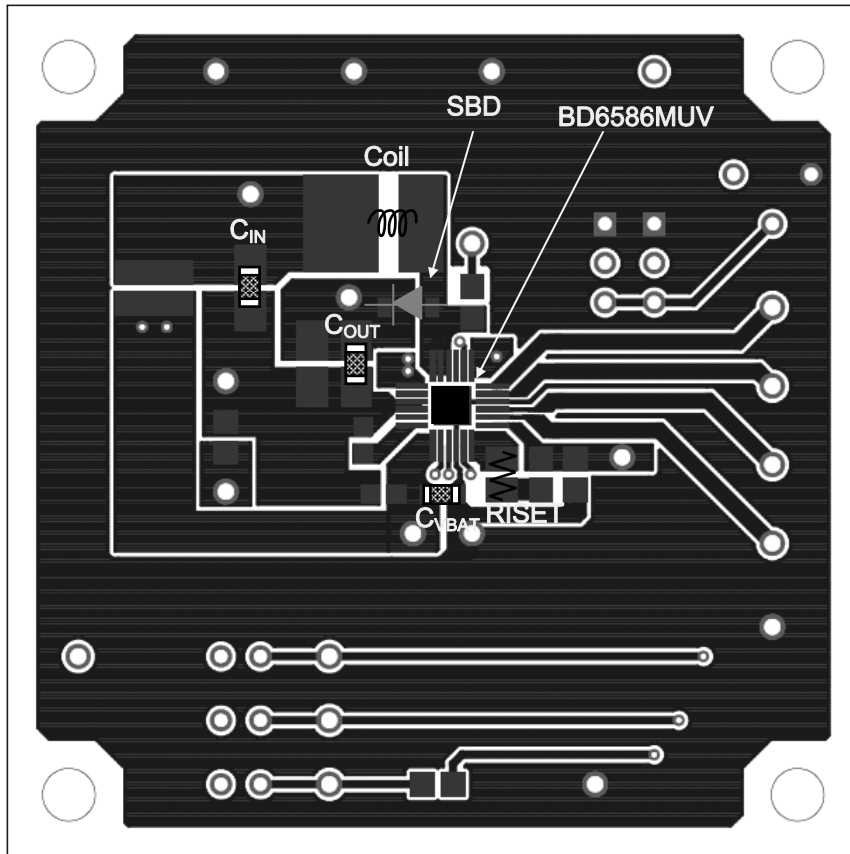


Fig.10 Frontal surface <Top view>

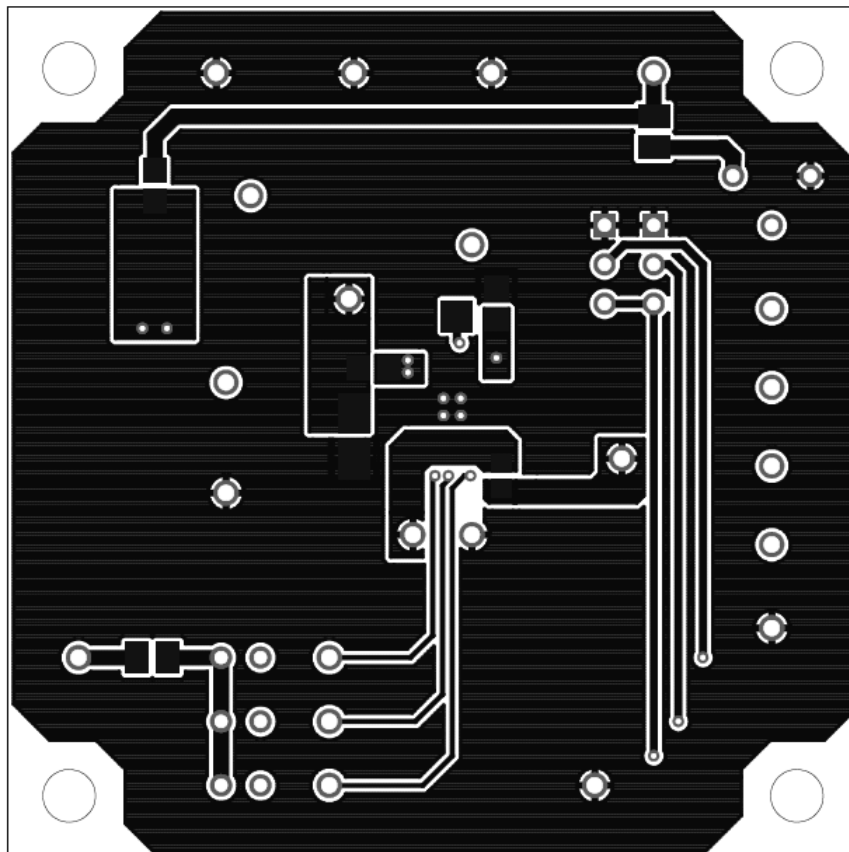


Fig.11 Rear surface <Top view>

● Selection of external parts

Recommended external parts are as shown below.

When to use other parts than these, select the following equivalent parts.

•Coil

| Value | Manufacturer | Product number | Size | | | DC current (mA) | DCR (Ω) |
|-------------|--------------|------------------|----------|------------|--------------|-----------------|------------------|
| | | | Vertical | Horizontal | Height (MAX) | | |
| 4.7 μ H | TOKO | A915AY-4R7M | 5.2 | 5.2 | 3.0 | 1870 | 0.045 |
| 4.7 μ H | TOKO | B1015AS-4R7M | 8.4 | 8.3 | 4.0 | 3300 | 0.038 |
| 4.7 μ H | TOKO | A1101AS-4R7M | 4.1 | 4.1 | 1.2 | 1400 | 0.115 |
| 4.7 μ H | TDK | LTF5022T-4R7N2R0 | 5.0 | 5.2 | 2.2 | 2000 | 0.073 |
| 10 μ H | TDK | LTF5022T-100M1R4 | 5.0 | 5.2 | 2.2 | 1400 | 0.140 |
| 4.7 μ H | TDK | VLP6810T-4R7M1R6 | 6.3 | 6.8 | 1.0 | 1600 | 0.167 |
| 10 μ H | TDK | VLP6810T-100M1R1 | 6.3 | 6.8 | 1.0 | 1100 | 0.350 |

•Capacitor

| Value | Pressure | Manufacturer | Product number | Size | | | TC | Cap Tolerance |
|-----------------------------------|----------|--------------|----------------|----------|------------|----------------|-----|---------------|
| | | | | Vertical | Horizontal | Height | | |
| [Power supply capacitor] | | | | | | | | |
| 4.7 μ F | 25V | MURATA | GRM319B31E475K | 3.2 | 1.6 | 0.85 \pm 0.1 | B | +/-10% |
| 4.7 μ F | 25V | MURATA | GRM21BR61E475K | 2.0 | 1.25 | 1.25 \pm 0.1 | X5R | +/-10% |
| 1 μ F | 10V | MURATA | GRM188B11A105K | 1.6 | 0.8 | 0.8 \pm 0.1 | B | +/-10% |
| 4.7 μ F | 10V | MURATA | GRM219B31A475K | 2.0 | 1.25 | 0.85 \pm 0.1 | B | +/-10% |
| [Output capacitor] | | | | | | | | |
| 1 μ F | 35V | MURATA | GRM219B3YA105K | 2.0 | 1.25 | 0.85 \pm 0.1 | B | +/-10% |
| 1 μ F | 50V | MURATA | GRM31MB31H105K | 3.2 | 1.6 | 1.15 \pm 0.1 | B | +/-10% |
| 1 μ F | 50V | MURATA | GRM21BB31H105K | 2.0 | 1.25 | 1.25 \pm 0.1 | B | +/-10% |
| 2.2 μ F | 50V | MURATA | GRM31CB31H225K | 3.2 | 1.6 | 1.6 \pm 0.2 | B | +/-10% |

•Resistor

| Value | Tolerance | Manufacturer | Product number | Size | | |
|---|------------|--------------|----------------|----------|------------|-----------------|
| | | | | Vertical | Horizontal | Height |
| [Resistor for LED current decision <ISET pin>] | | | | | | |
| 24k Ω | \pm 0.5% | ROHM | MCR006YZPD243 | 0.6 | 0.3 | 0.23 \pm 0.03 |

•SBD

| Pressure | Manufacturer | Product number | Size | | |
|----------|--------------|----------------|----------|------------|---------------|
| | | | Vertical | Horizontal | Height |
| 60V | ROHM | RB160M-60 | 3.5 | 1.6 | 0.8 \pm 0.1 |

The coil is the part that is most influential to efficiency. Select the coil whose direct current resistor (DCR) and current - inductance characteristic is excellent. BD6586MUV is designed for the inductance value of 4.7 μ H. Don't use the inductance value less than 2.2 μ H. Select a capacitor of ceramic type with excellent frequency and temperature characteristics.

Further, select Capacitor to be used with small direct current resistance, and pay sufficient attention to the layout pattern shown in P.10.

● Attention point of PCB layout

In PCB layout design, the wiring of power supply line should be low Impedance, and put the bypass capacitor if necessary. Especially the wiring impedance must be lower around the DC/DC converter.

● About heat loss

In heat design, operate the DC/DC converter in the following condition.

(The following temperature is a guarantee temperature, so consider the margin.)

1. Periphery temperature Ta must be less than 85 $^{\circ}$ C.
2. The loss of IC must be less than dissipation Pd.

●Application example

- LED current setting controlled ISET resistor.
 $24\text{k}\Omega$: 20mA
 $30\text{k}\Omega$: 16mA
 $19.6\text{k}\Omega$: 24.5mA
 $33\text{k}\Omega$: 14.5mA
- Brightness control
 Please input PWM pulse from EN1, EN2 or PWM terminal.
 Please refer electrical function p.7.

7 inch panel

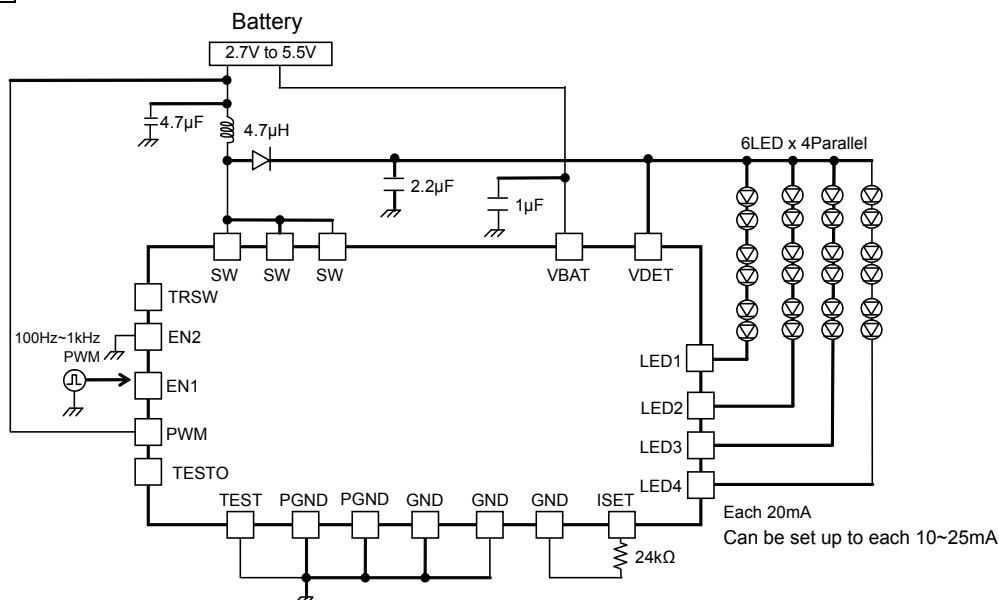


Fig.12 6 series×4 parallel, LED current 20mA setting
Power control PWM application

5inch panel

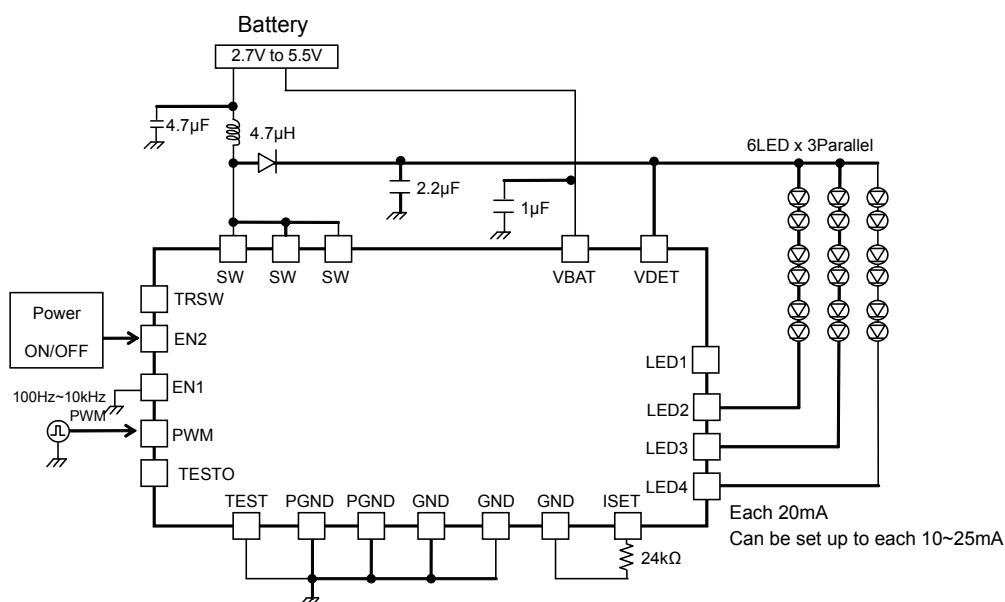


Fig.13 6 series×3 parallel, LED current 20mA setting
Current driver PWM application

●Application example

- LED current setting controlled ISET resistor.
 24kΩ : 20mA
 30kΩ : 16mA
 19.6kΩ : 24.5mA
 33kΩ : 14.5mA
- Brightness control
 Please input PWM pulse from EN1, EN2 or PWM terminal.
 Please refer electrical function p.7.

5 inch panel

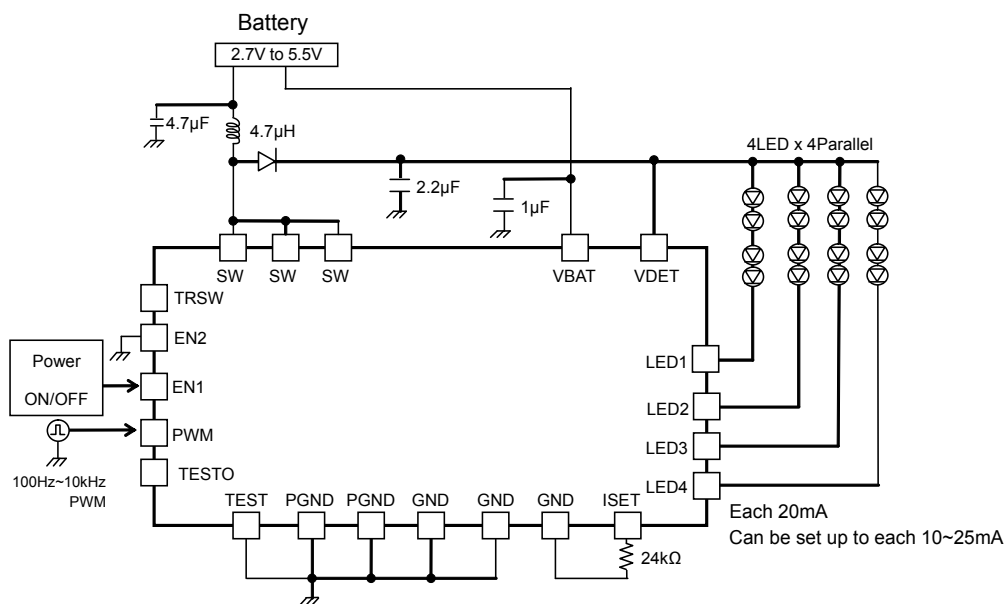


Fig.14 4 series×4 parallel, LED current 20mA setting
 Current driver PWM application

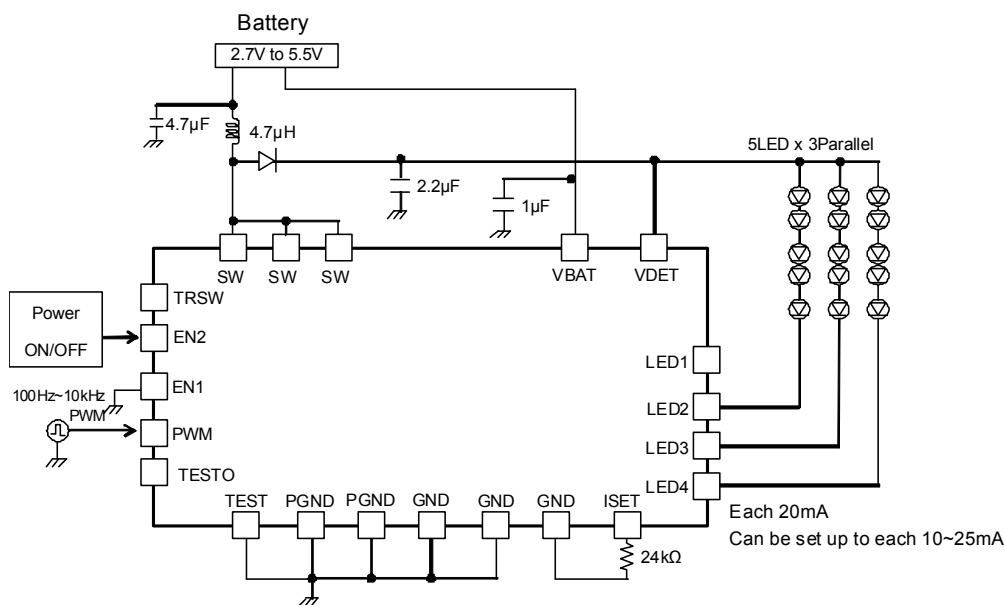


Fig.15 5 series×3 parallel, LED current 20mA setting
 Current driver PWM application

●Application example

- LED current setting controlled ISET resistor.
 $24\text{k}\Omega$: 20mA
 $30\text{k}\Omega$: 16mA
 $19.6\text{k}\Omega$: 24.5mA
 $33\text{k}\Omega$: 14.5mA
- Brightness control
 Please input PWM pulse from EN1, EN2 or PWM terminal.
 Please refer electrical function p.7.

Less than 5 inch panel

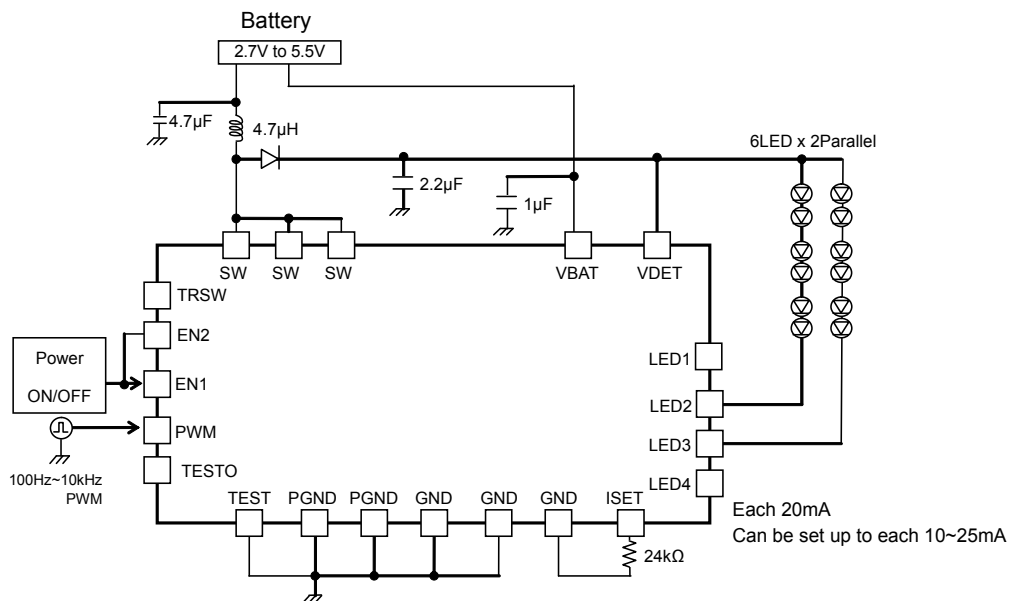


Fig.16 6 series×2 parallel, LED current 20mA setting
Current driver PWM application

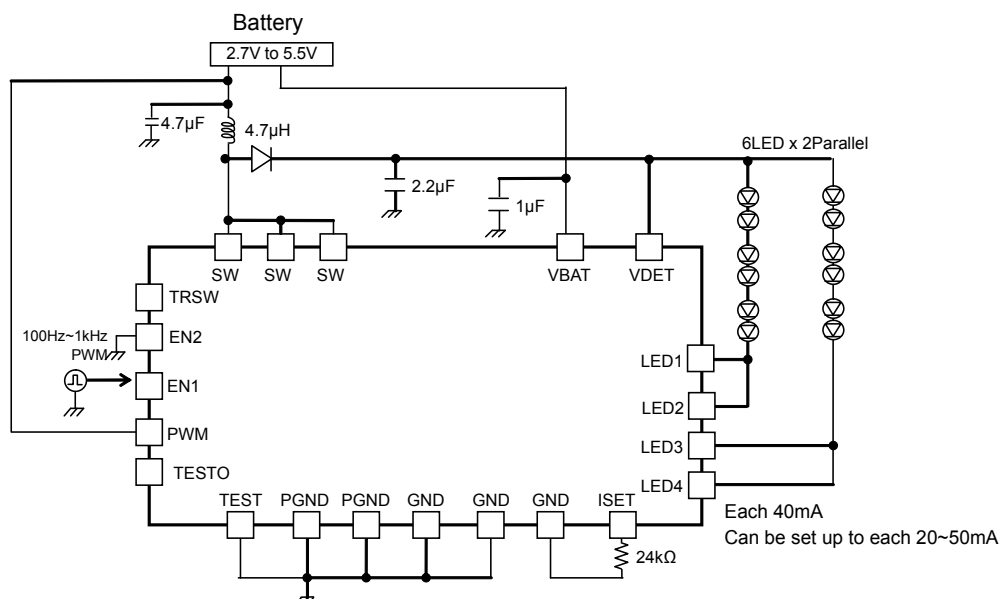


Fig.17 6 series×2 parallel, LED current 40mA setting
Power control PWM application

●Application example

- LED current setting controlled ISET resistor.
 24kΩ : 20mA
 30kΩ : 16mA
 19.6kΩ : 24.5mA
 33kΩ : 14.5mA
- Brightness control
 Please input PWM pulse from EN1, EN2 or PWM terminal.
 Please refer electrical function p.7.

For big current LED

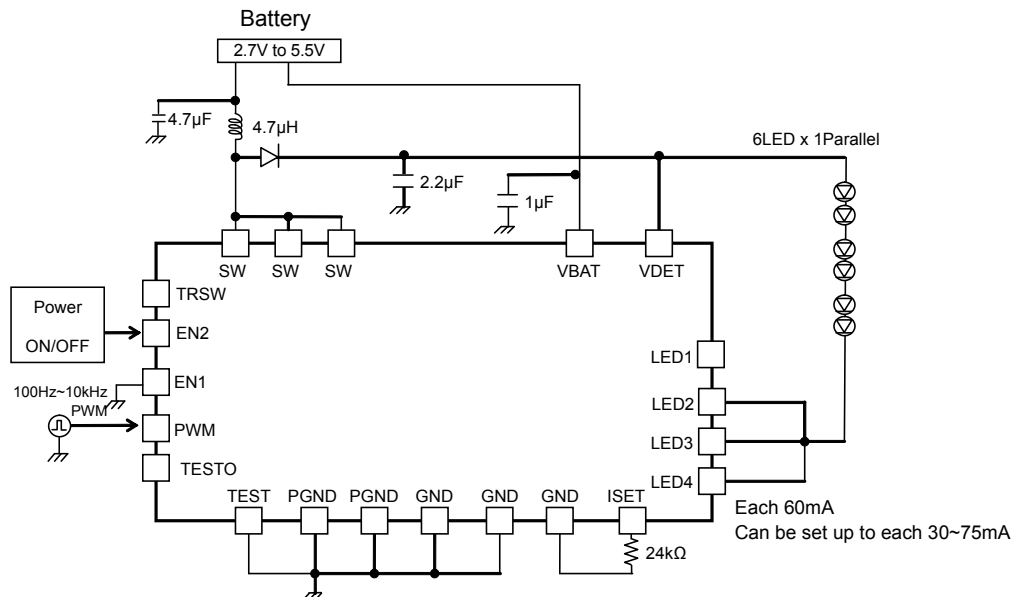


Fig.20 6 series×1 parallel, LED current 60mA setting
Current driver PWM application

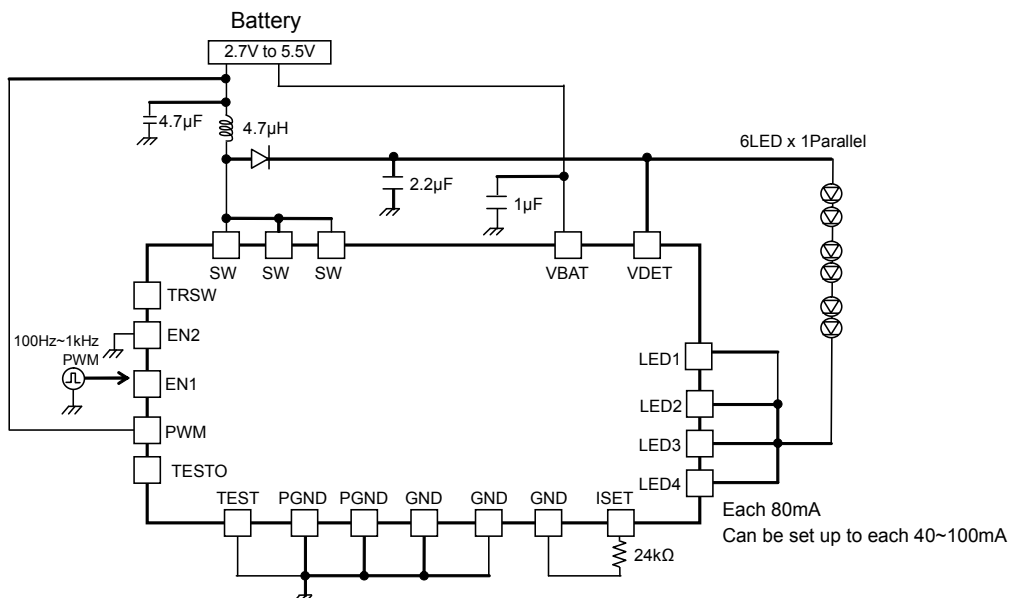


Fig.21 6 series×1 parallel, LED current 80mA setting
Power control PWM application

●Application example

- LED current setting controlled ISET resistor.
 24kΩ : 20mA
 30kΩ : 16mA
 19.6kΩ : 24.5mA
 33kΩ : 14.5mA
- Brightness control
 Please input PWM pulse from EN1, EN2 or PWM terminal.
 Please refer electrical function p.7.

For the application of 7V and more

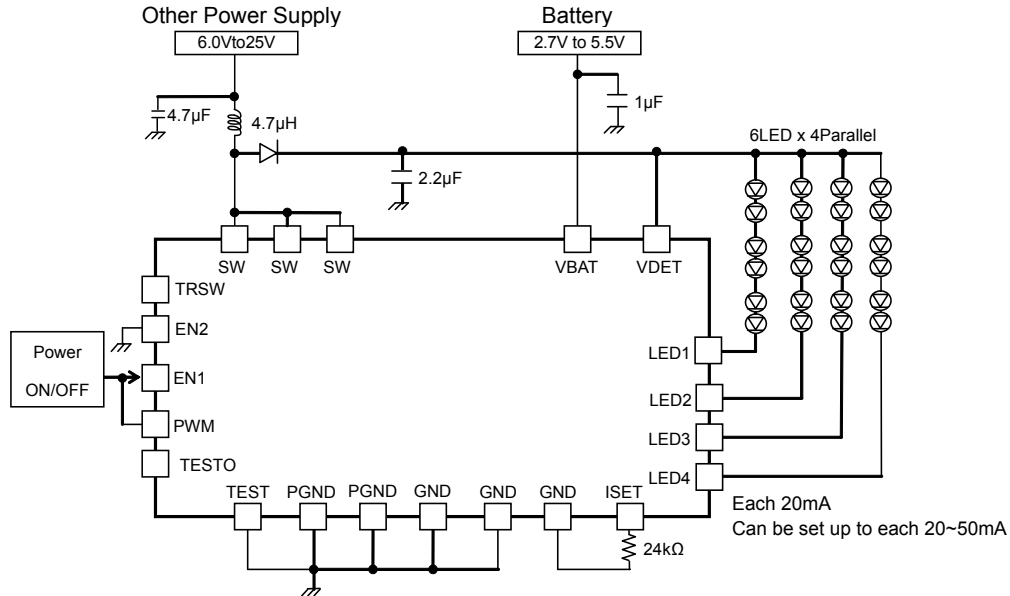
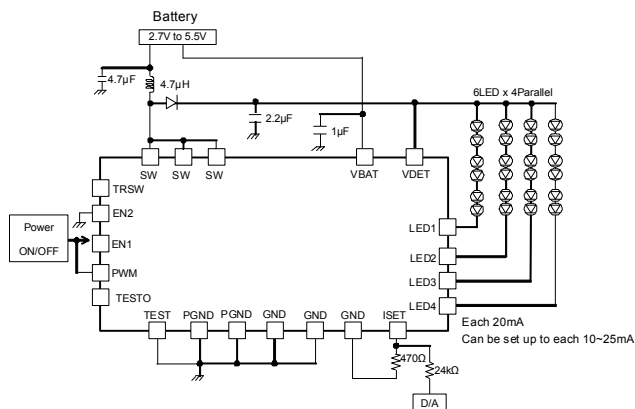


Fig.22 6 series×4 parallel, LED current 20mA setting Power control PWM application

●Analog style optical application

- Control LED current to charged D/A voltage.
- Show application example and typ control.
- Please decide final value after you evaluated application, characteristic.



| D/A | LED current |
|-------|-------------|
| 0.05V | 19.4mA |
| 0.2V | 14.4mA |
| 0.4V | 7.7mA |
| 0.5V | 4.4mA |
| 0.6V | 1.0mA |
| 0.7V | 0mA |

$$\text{LED current} = \left(\frac{\text{ISET voltage}}{470\text{k}\Omega} + \frac{\text{ISET voltage} - \text{D/A}}{24\text{k}\Omega} \right) \times 800$$

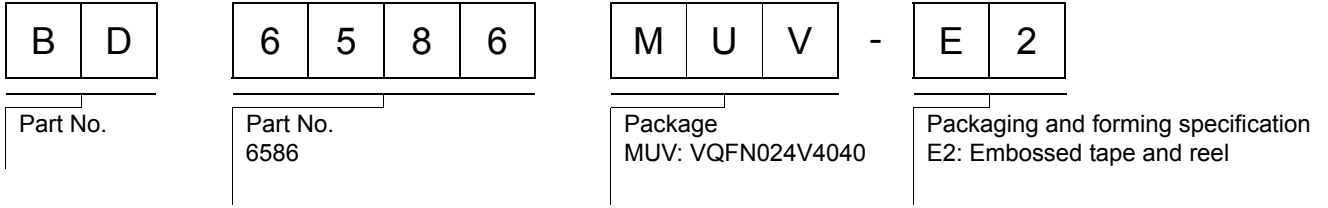
$$\text{typ LED current} = \left(\frac{0.6\text{V}}{470\text{k}\Omega} + \frac{0.6\text{V} - \text{D/A}}{24\text{k}\Omega} \right) \times 800$$

Fig.23 Analog style optical application

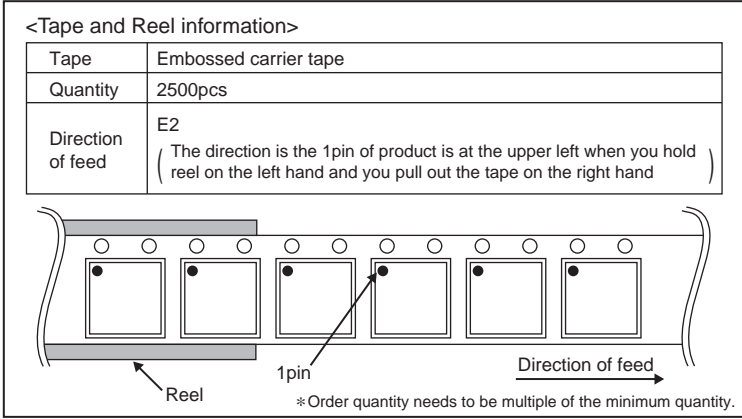
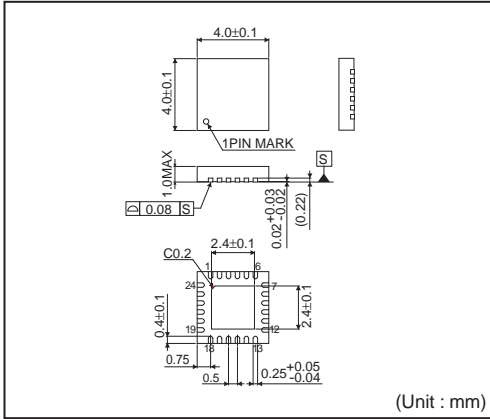
●Notes for use

- (1) Absolute Maximum Ratings
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given to take physical safety measures including the use of fuses, etc.
- (2) Operating conditions
These conditions represent a range within which characteristics can be provided approximately as expected. The electrical characteristics are guaranteed under the conditions of each parameter.
- (3) Reverse connection of power supply connector
The reverse connection of power supply connector can break down ICs. Take protective measures against the breakdown due to the reverse connection, such as mounting an external diode between the power supply and the IC's power supply terminal.
- (4) Power supply line
Design PCB pattern to provide low impedance for the wiring between the power supply and the GND lines. In this regard, for the digital block power supply and the analog block power supply, even though these power supplies has the same level of potential, separate the power supply pattern for the digital block from that for the analog block, thus suppressing the diffraction of digital noises to the analog block power supply resulting from impedance common to the wiring patterns. For the GND line, give consideration to design the patterns in a similar manner.
Furthermore, for all power supply terminals to ICs, mount a capacitor between the power supply and the GND terminal. At the same time, in order to use an electrolytic capacitor, thoroughly check to be sure the characteristics of the capacitor to be used present no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.
- (5) GND voltage
Make setting of the potential of the GND terminal so that it will be maintained at the minimum in any operating state. Furthermore, check to be sure no terminals are at a potential lower than the GND voltage including an actual electric transient.
- (6) Short circuit between terminals and erroneous mounting
In order to mount ICs on a set PCB, pay thorough attention to the direction and offset of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign matters entering between terminals or between the terminal and the power supply or the GND terminal, the ICs can break down.
- (7) Operation in strong electromagnetic field
Be noted that using ICs in the strong electromagnetic field can malfunction them.
- (8) Inspection with set PCB
On the inspection with the set PCB, if a capacitor is connected to a low-impedance IC terminal, the IC can suffer stress. Therefore, be sure to discharge from the set PCB by each process. Furthermore, in order to mount or dismount the set PCB to/from the jig for the inspection process, be sure to turn OFF the power supply and then mount the set PCB to the jig. After the completion of the inspection, be sure to turn OFF the power supply and then dismount it from the jig. In addition, for protection against static electricity, establish a ground for the assembly process and pay thorough attention to the transportation and the storage of the set PCB.
- (9) Input terminals
In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input terminal. Therefore, pay thorough attention not to handle the input terminals, such as to apply to the input terminals a voltage lower than the GND respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input terminals when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input terminals a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.
- (10) Ground wiring pattern
If small-signal GND and large-current GND are provided, It will be recommended to separate the large-current GND pattern from the small-signal GND pattern and establish a single ground at the reference point of the set PCB so that resistance to the wiring pattern and voltage fluctuations due to a large current will cause no fluctuations in voltages of the small-signal GND. Pay attention not to cause fluctuations in the GND wiring pattern of external parts as well.
- (11) External capacitor
In order to use a ceramic capacitor as the external capacitor, determine the constant with consideration given to a degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.
- (12) Thermal shutdown circuit (TSD)
When junction temperatures become 175°C (typ) or higher, the thermal shutdown circuit operates and turns a switch OFF. The thermal shutdown circuit, which is aimed at isolating the LSI from thermal runaway as much as possible, is not aimed at the protection or guarantee of the LSI. Therefore, do not continuously use the LSI with this circuit operating or use the LSI assuming its operation.
- (13) Thermal design
Perform thermal design in which there are adequate margins by taking into account the permissible dissipation (Pd) in actual states of use.
- (14) Selection of coil
Select the low DCR inductors to decrease power loss for DC/DC converter.

●Ordering part number



VQFN024V4040



Notes

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