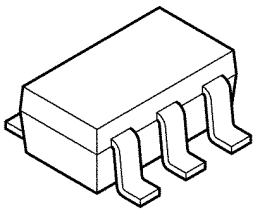
TOSHIBA BiCD Digital Integrated Circuit Silicon Monolithic

# TB62737FUG

Step Up Type DC/DC Converter for White LED

## Features

The TB62737FUG is a high efficient Step-Up Type DC/DC Converter specially designed for constant current driving of White LED.
This IC can drive 2-6 white LEDs connected series using a Li-ion battery.
This IC contains N-ch MOS-FET Transistor for Coil-Switching, and LED Current ($I_F$) is set with an external resistor.
This IC is especially for driving back light white LEDs in LCD of PDA, Cellular Phone, or Handy Terminal Equipment.



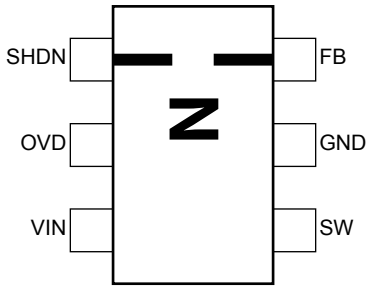
SSOP6-P-0.95B

Weight: 0.016 g (Typ.)

## Characteristics

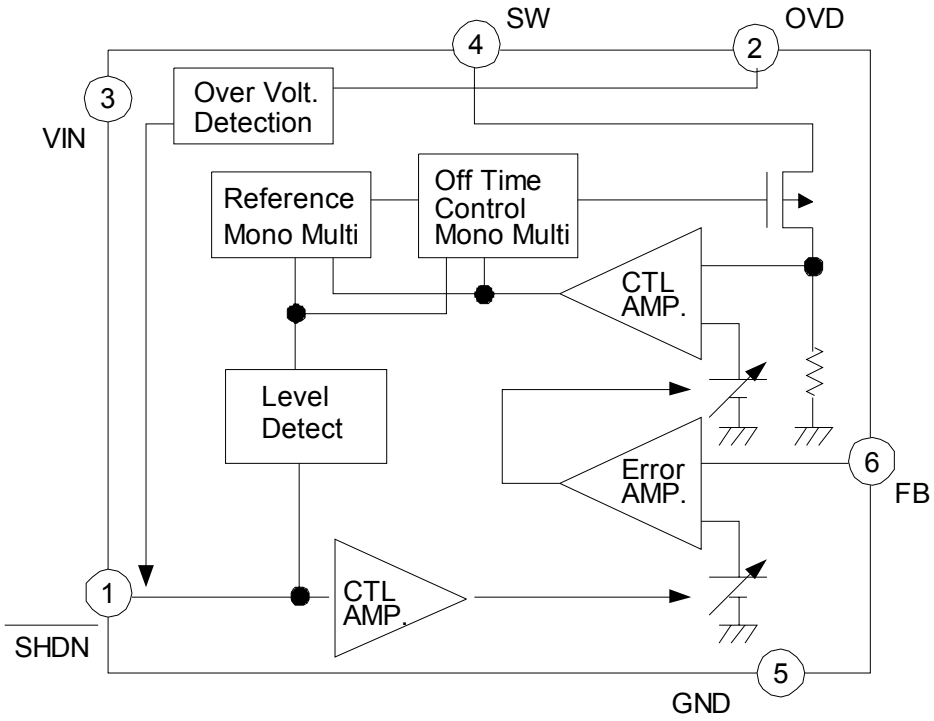
- Brightness Control Function with changing drive current :
  LED Current $I_F$ = 25% to 100% (Analog Input to $\overline{SHDN}$ terminal)
  For the control in range of 25% or less, refer 7-page.
- Maximum output voltage : $V_O$ = 24 V
  Can drive 2-6 white LEDs connected series (Typ. 4LEDs)
- Variable LED Current $I_F$ is set with a external resistor :
  20 mA (Typ.) @RSENS = 16 Ω
- Output Power : Available for 480mW LED loading
- High Efficiency : 87% @Maximum (Using recommended external parts: Typ. 4LEDs)
- Output Over Voltage Shutdown Function :
  Switching Operation is shut downed when OVD terminal Voltage is over 19 V (typ.).
- IC Package : SOT23-6
- Switching Frequency : 1.1 MHz (Typ.)

## Pin Assignment (Top view)




**Caution 1:** *This IC could be destroyed in some case if amounted in 180° inverse direction.*
*Please be careful about IC direction in mounting.*

## Block Diagram




## Pin Function

| Pin No. | Symbol | Function Description |
|---|---|---|
| 1 | $\overline{\text{SHDN}}$ | Voltage-Input Terminal for IC-Enable / Setting LED-$I_F$.<br>0V to 0.5V : Shutdown (PS) Mode, IC operation is disabled.<br>1.0V to 2.5V : $I_F$ = 25% to 100%<br>Over 2.5V : $I_F$ = 100%<br>$I_F$ adjustment with PWM input signal is also available. |
| 2 | OVD | Over Voltage Detection Terminal.<br>IC Switching Operation is disabled with detection over voltage.<br>If the voltage returns to detection level or less, Operation is enabled again. |
| 3 | VIN | Supply Voltage Input Terminal. ( 2.8V to 5.5V) |
| 4 | SW | Switch Terminal for DC/DC Converter. Nch MOSFET Built-In. |
| 5 | GND | Ground Terminal. |
| 6 | FB | LED $I_F$ Setting Resister Connecting Terminal. |

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

| Characteristics | Symbol | Ratings | Unit |
|---|---|---|---|
| Power Supply Voltage | $V_{IN}$ | −0.3 to +6.0 | V |
| Input Voltage | $V_{\overline{SHDN}}$ | −0.3 to $+V_{IN}$ + 0.3 | V |
| Switching Terminal Voltage | $V_o$ (SW) | -0.3 to 24 | V |
| Switching Terminal Current | $I_o$ (SW) | 380 | mA |
| Power Dissipation | $P_D$ | 0.41 (Device) | W |
| | | 0.47 (on PCB) Caution 2 | |
| Thermal Resistance | $R_{th\ (j-a)}$ | 300 (Device) | °C/W |
| | | 260 (on PCB) | |
| Operation Temperature Range | $T_{opr}$ | −40 to +85 | °C |
| Storage Temperature Range | $T_{stg}$ | −55 to +150 | °C |
| Maximum Junction Temperature | $T_j$ | 150 | °C |

Caution 2: Power Dissipation must be calculated with subtraction of 3.8 mW/°C from Maximum Rating with every 1°C if $T_{opr}$ is upper 25°C. (on PCB)

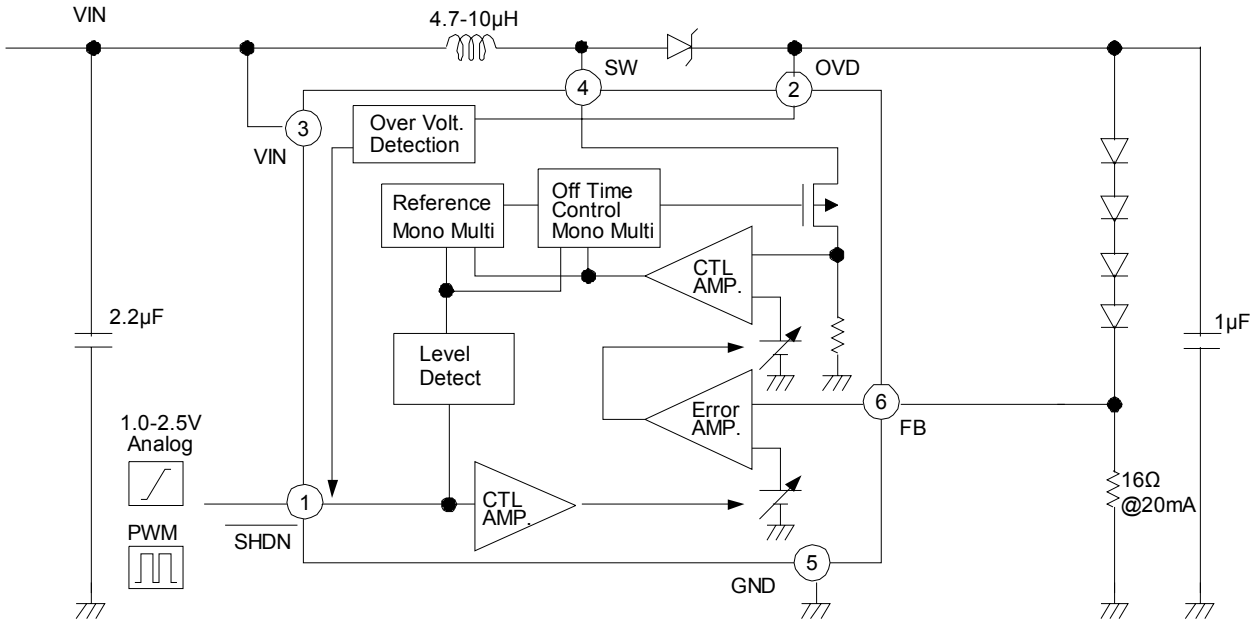
## Recommended Operating Condition (Ta = -40°C to 85°C if without notice)

| Characteristics | Symbol | Test Circuit | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| Power Supply Voltage | $V_{IN}$ | - | | 2.8 | - | 5.5 | V |
| $\overline{SHDN}$ terminal 'H' level input voltage | $V_{\overline{SHDN}H}$ | - | | 2.5 | - | $V_{IN}$ | V |
| $\overline{SHDN}$ terminal 'L' level input voltage | $V_{\overline{SHDN}L}$ | - | | 0 | - | 0.5 | V |
| $\overline{SHDN}$ terminal input Pulse Width | tpw | - | ON duty width<br>OFF duty width | 33 | - | - | μs |
| LED Current (Average Value) | $I_{o1}$ | - | $V_{IN}$ = 3.6 V, $R_{SENS}$=16Ω 4LEDs, $T_{opr}$ = 25°C | - | 20 | - | mA |

## Electrical Characteristics (Ta = -40°C to 85°C if without notice)

| Characteristics | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Voltage Range | $V_{IN}$ | | 2.8 | - | 5.5 | V |
| Operating Consumption Current | $I_{IN}$ (On) | VIN=3.6V, RSENS=16Ω | - | 0.9 | 1.5 | mA |
| Quiescent Consumption Current | $I_{IN}$ (Off) | VIN=3.6V,$V_{\overline{SHDN}}$=0V | - | 0.5 | 1.0 | μA |
| $\overline{SHDN}$ Terminal Current | $I_{\overline{SHDN}}$ | VIN=3.6V,$V_{\overline{SHDN}}$=3.6V | -10 | 0 | 10 | μA |
| Integrated MOS-Tr Switching Frequency | $f_{OSC}$ | VIN=3.6V,$V_{\overline{SHDN}}$=3.6V | 0.77 | 1.1 | 1.43 | MHz |
| SW Terminal Protection Voltage | $V_o$ (SW) | - | - | 25 | - | V |
| Switching Terminal Current | $I_{oZ}$ (SW) | - | - | 400 | - | mA |
| Switching Terminal Leakage Current | $I_{oz}$ (SW) | - | - | 0.5 | 1 | μA |
| FB Terminal Feedback Voltage (VFB) | $V_{FB}$ | $V_{IN}$=3.6V, RSENS=16Ω<br>$T_{opr}$=25°C, L=6.8μH | 308 | 325 | 342 | mV |
| FB Terminal Line Regulation | $\Delta V_{FB}$ | $V_{IN}$=3.6V center<br>$V_{IN}$=3.0 to 5.0V | -5 | - | 5 | % |
| OVD Terminal Voltage | $V_{OVD}$ | - | 19 | 22 | 23.5 | V |
| OVD Terminal Leakage Current | $I_{OVDZ}$ | $V_{OVD}$=16V | - | 0.5 | 1 | μA |

## Application Note




## Protection in LED opened condition

The operation with OVD terminal is available for the protection in case LED Circuit opened.
Please see the example of application circuit.
If load of LED is detached, Nch MOS switching operation is disabled with detection of boost circuit voltage.

### Setting of external Capacitor

In case not using PWM signal to $\overline{SHDN}$ terminal for brightness control, recommended values are
$C_1$ = Over 2.2 (μF), $C_2$ = Over 1.0 (μF)

In case with PWM signal to $\overline{SHDN}$ terminal for brightness control, recommended values are
$C_1$ = Over 4.7 (μF), $C_2$=Under 0.1 (μF) to reduce fluctuation of input current
and up accuracy of brightness.

The recommended capacitor values depend on the Brightness Control Method.
<Please see after page-8>
The capacitor value must be considered for gain enough accuracy of brightness with reduction of noise from Input current changing.

### Setting of external Inductor size

Please select the inductor size with referring this table corresponding to each number of LEDs.

Recommendation for the case that LED current $I_F$=20mA

| LEDs | Indictor size | Note |
|---|---|---|
| 2 | 4.7μH | LED Current $I_F$=20mA |
| 3 | | |
| 4 | 6.8μH | |
| 5 | 8.1μH | |
| 6 | 10μH | |

### Setting of $I_O$

Resistance connects between RSENS pin and GND.
The average current is set by this RSENS value and average current are obtained by the following equation.

$$I_F[mA] = \frac{325[mV]}{RSENS\ [\Omega]}$$

Current Value error is within ±5%.

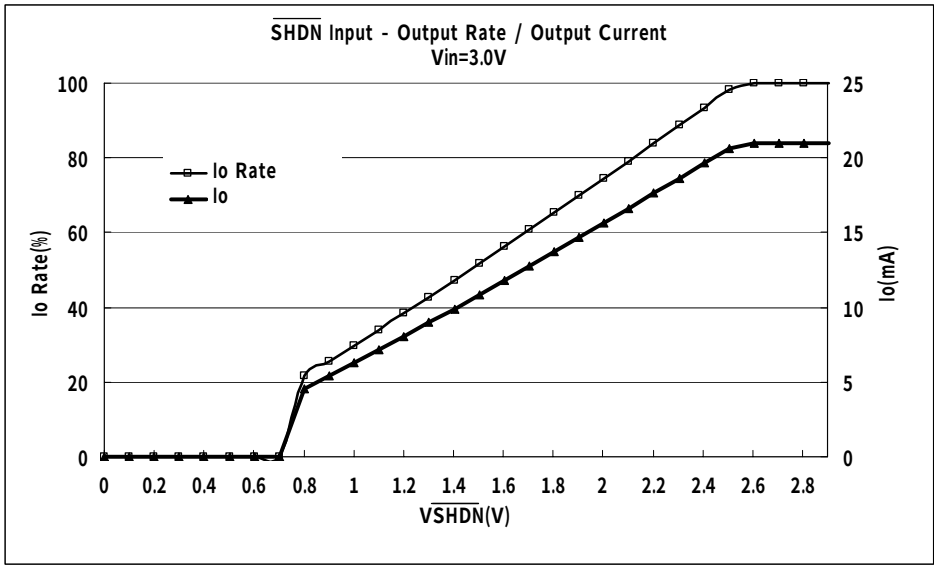
## Current Dimming Control

Recommended Brightness Control Circuits are 5 types.

1) Input analog voltage to $\overline{SHDN}$ terminal

$I_F$ can be adjusted in range of 25% to 100% after set with external resistor connected RSENS terminal.
Linearity error in V-A Conversion is within +/-10%.

| $\overline{SHDN}$ Voltage | $V_{\overline{SHDN}}$ = 0V～0.5V | $V_{\overline{SHDN}}$ = 1V～2.5V | $V_{\overline{SHDN}}$ > 2.5V | Note |
|---|---|---|---|---|
| Io Valuable Rate | 0 | 25 ～ 100 | 100 | Unit : % |



2) Input PWM signal to $\overline{SHDN}$ terminal

$I_F$ can be adjusted with PWM signal by inputting it to $\overline{SHDN}$ terminal.

**【Notice】**

**《 Minimum ON-time of PWM signal input 》**

- Set the minimum ON-time or OFF-time 33μs or more in inputting the PWM signal.
- Set the Duty ratio satisfying the condition above.

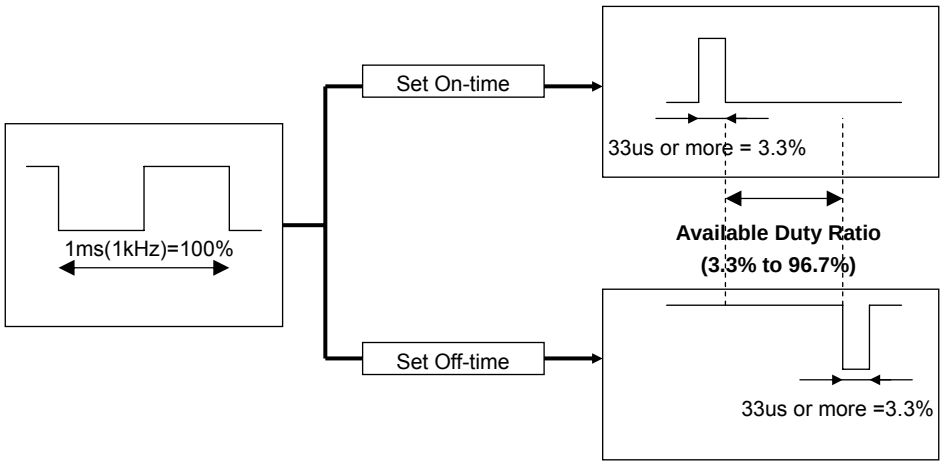
Ex) In case PWM Frequency is 1kHz,

1kHz is 1ms (PWM Width = 100%) and it takes 10μs per 1%.

To set the pulse width 33us or more, necessary ON-or-OFF-time is calculated below.

33μs÷10μs = 3.3%　( Under the condition that 10μs equals 1%. )

Finally, the Duty Ratio can be set in range of 3.3% to 96.7%.




**《 PWM signal frequency 》**

- The recommended PWM signal frequency is from 100Hz to 10kHz. There is a possibility to arise the audible frequency in mounting to the board because it is within the auditory area.

**《 Constant number of external condenser 》**

- To reduce the fluctuation of input current and increase the accuracy of brightness, the values that $C_1 = 4.7$ (μF) or more , $C_2 = 0.1$ (μF) or less are recommended.
- When the PWM signal is off, the time to drain $C_2$ of charge depends on the constant number. And so, the actual value is little different from the theoretical value.

**《 PWM input signal 》**

- Set the amplitude of PWM signal within the range of $\overline{SHDN}$ terminal specification.

**《 Rush current in inputting 》**

- In case dimming by inputting the PWM signal to the $\overline{SHDN}$ terminal, this IC turns on and off repeatedly. And the rush current, which provides the charge to $C_2$, arises in turning on. Take care in selecting the condenser.

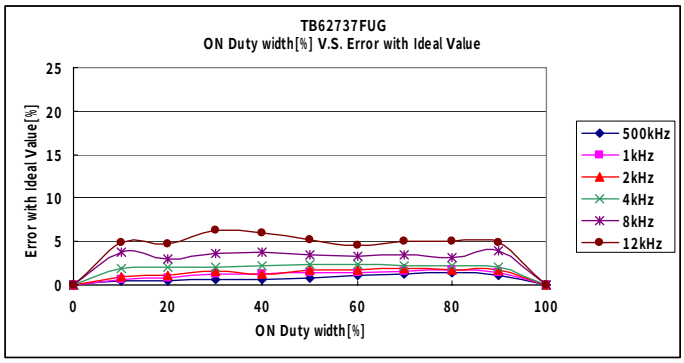
**《 Current value in Control with PWM : Ideal Equation 》**

$$I_F[mA] = \frac{325[mV] \times \text{ON Duty } [\%]}{RSENS\ [\Omega]}$$

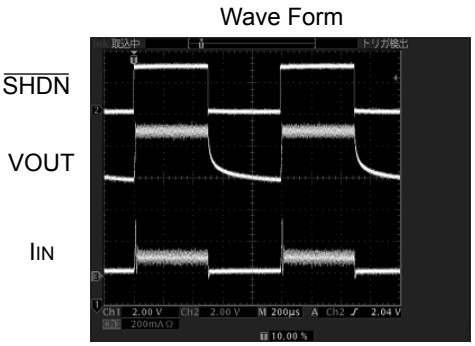
<Reference Data>

Condition: $V_{IN}$=3.6V, L=6.8μH, 4LEDs, RSENS=16mΩ@Io=20mA

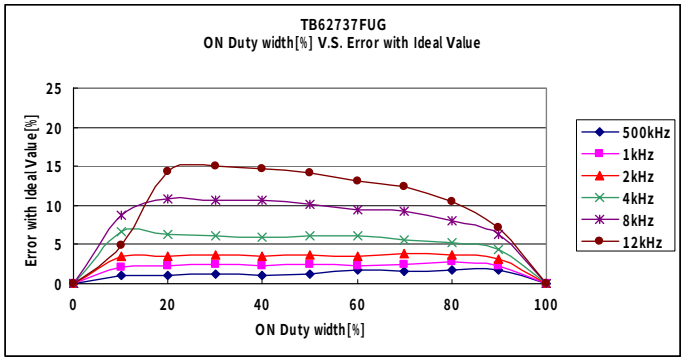
(1) C1=4.7μF, C2=0.1μF



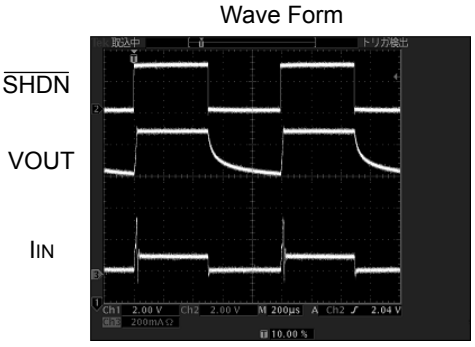

Wave Form



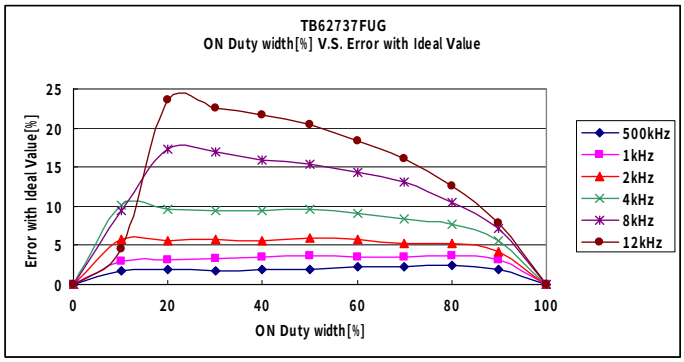

(2) C1=4.7μF, C2=0.47μF



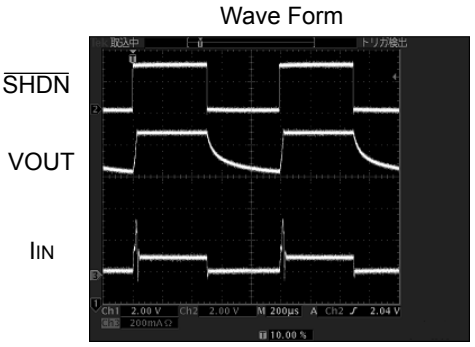

Wave Form



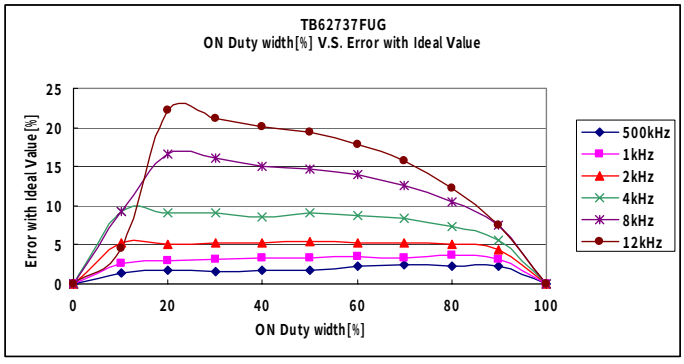

(3) C1=4.7μF, C2=1.0μF



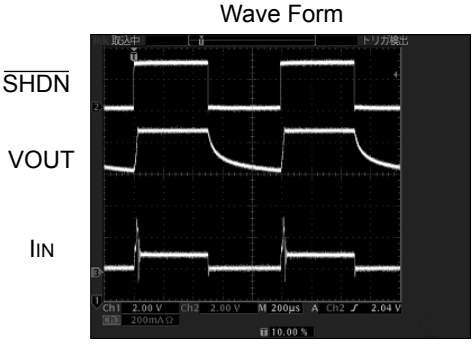

Wave Form



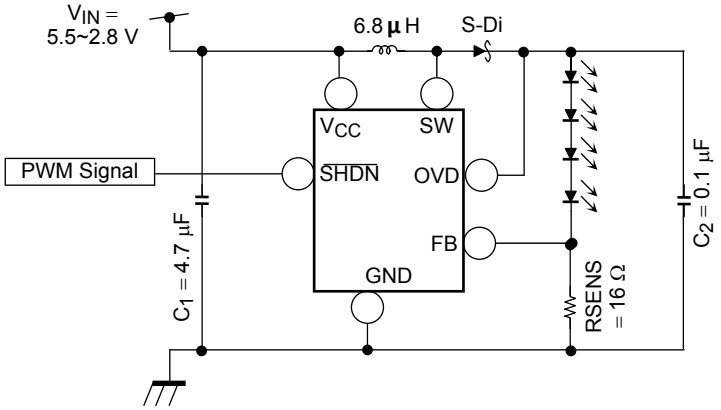

(4) C1=2.2μF, C2=1.0μF




Wave Form



**《Recommended application》**




3) Input analog voltage to FB terminal

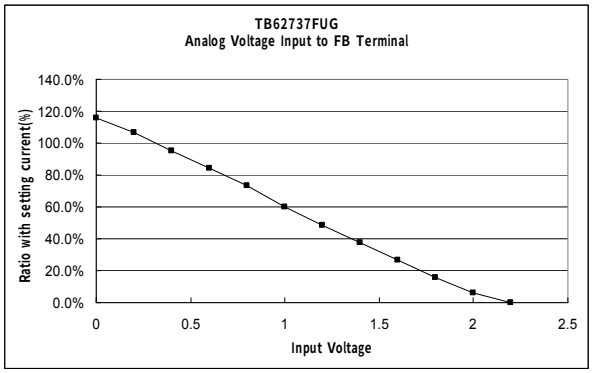
IF can be adjusted with Analog voltage input to FB terminal.
This method is without repeating IC ON/OFF, and no need to consider holding rash current.

**<< Notice >>**

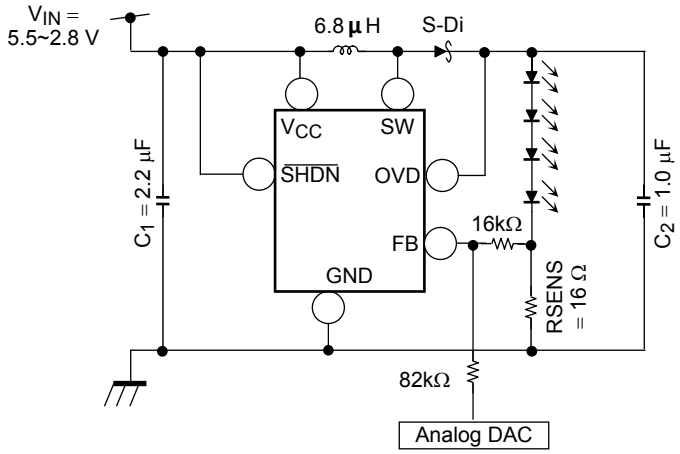
- LED current value goes over 100% of the current set with RSENS, if the input analog voltage is between 0V to 325mV(TYP.).

for ref.) Analog voltage = 0 to 2.2V
About external parts value, please see recommended circuit.

| Supply Voltage[V] | Ratio with Setting Current |
|---|---|
| No Connect(OFF) | 100% |
| 0 | 116.0% |
| 0.2 | 106.5% |
| 0.4 | 95.4% |
| 0.6 | 84.5% |
| 0.8 | 73.6% |
| 1 | 59.9% |
| 1.2 | 48.4% |
| 1.4 | 37.4% |
| 1.6 | 26.6% |
| 1.8 | 15.9% |
| 2 | 5.8% |
| 2.2 | 0.0% |




**《Recommended application》**



4) Input PWM signal with filtering to FB terminal

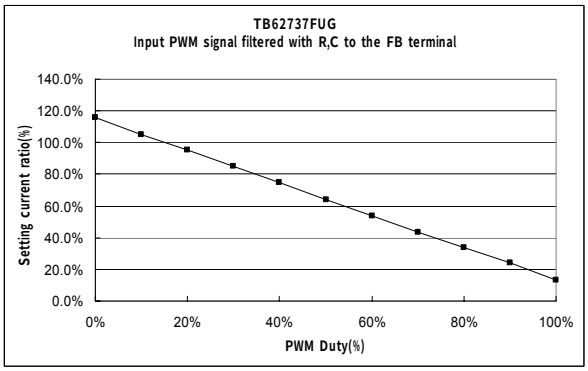
IF can be adjusted with filtering PWM signal using RC filter indicated in recommended circuit, because the PWM signal can be regard as analog voltage after filtering.
This method is without repeating IC ON/OFF, and no need to consider holding rash current.

**<< Notice >>**

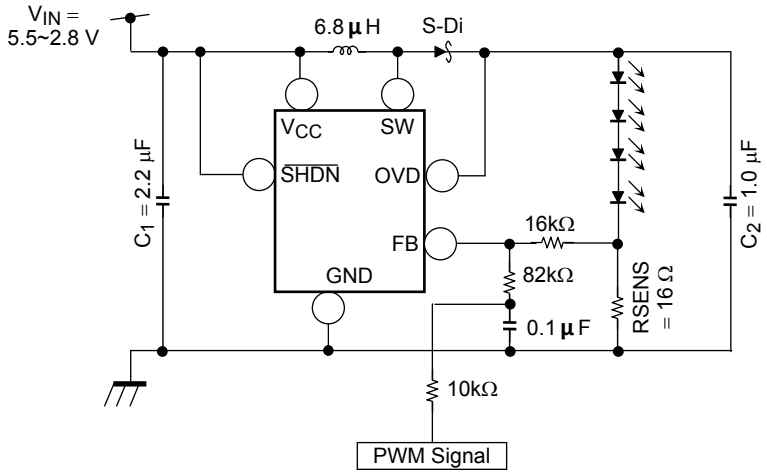
- LED current value goes over 100% of the current set with RSENS, if the input voltage after filtering is between 0V to 325mV(TYP.).

for ref.) Voltage during PWM Signal-ON = 2V
About external parts value, please see recommended circuit.

| Supply Voltage[V] | Ratio with Setting Current |
|---|---|
| No Connect(OFF) | 100% |
| 0 | 116.1% |
| 10% | 105.3% |
| 20% | 95.1% |
| 30% | 84.8% |
| 40% | 74.6% |
| 50% | 64.0% |
| 60% | 53.8% |
| 70% | 43.7% |
| 80% | 34.0% |
| 90% | 24.2% |
| 100% | 13.3% |




**《Recommended application》**



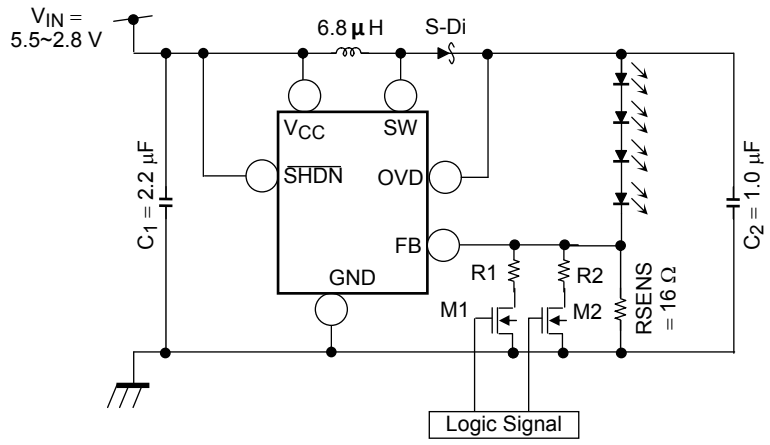
5) Input Logic signal

IF can be adjusted with Logic signal input as indicated in recommended circuit.
The Resistor connected the ON-State Nch MOS Drain and RSENS determines IF.

Average of Setting Current Io(mA) is next, approximately.

$I_F$ = ( 325[mV] / Sum of Resistor Value[Ω] )

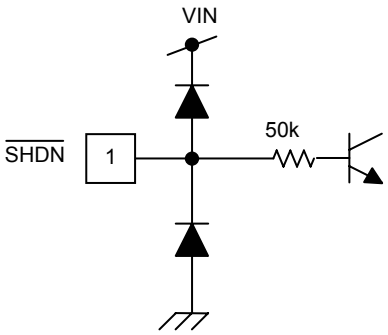
**《Recommended application》**



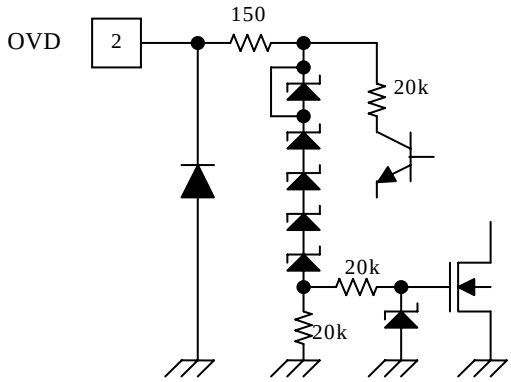

| M1 | M2 | LED Current |
|---|---|---|
| OFF | OFF | $\frac{325[mV]}{RSENS\ [\Omega]}$ |
| ON | OFF | $325\ [mV] \times \frac{RSENS\ [\Omega] \times R1\ [\Omega]}{RSENS\ [\Omega] + R1\ [\Omega]}$ |
| OFF | ON | $325\ [mV] \times \frac{RSENS\ [\Omega] \times R2\ [\Omega]}{RSENS\ [\Omega] + R2\ [\Omega]}$ |
| ON | ON | $325\ [mV] \times \frac{RSENS\ [\Omega] \times R1\ [\Omega] \times R2\ [\Omega]}{RSENS\ [\Omega] \times R1\ [\Omega] + RSENS\ [\Omega] \times R2\ [\Omega] + R1\ [\Omega] \times R2\ [\Omega]}$ |

### I/O Equivalent Pin Circuits

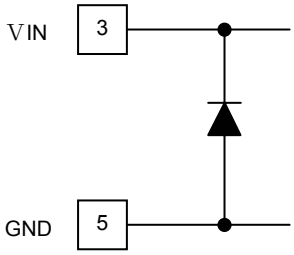
1. $\overline{\text{SHDN}}$ Terminal



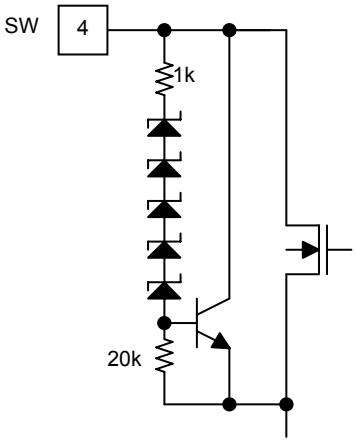

2. OVD Terminal



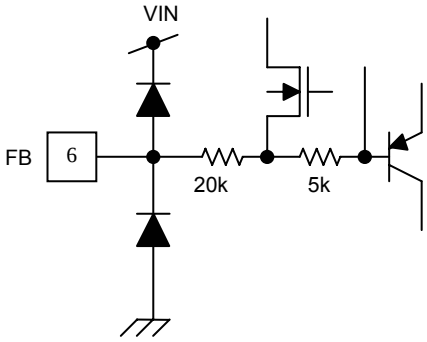

3. VIN terminal to GND terminal



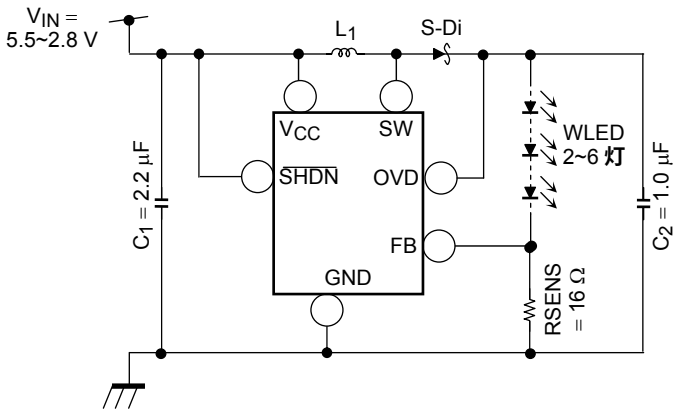

4. SW Terminal




5. FB Terminal

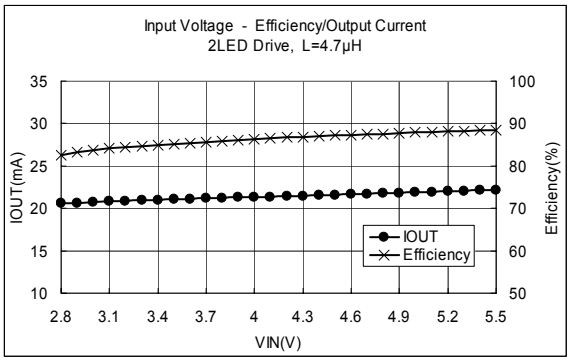


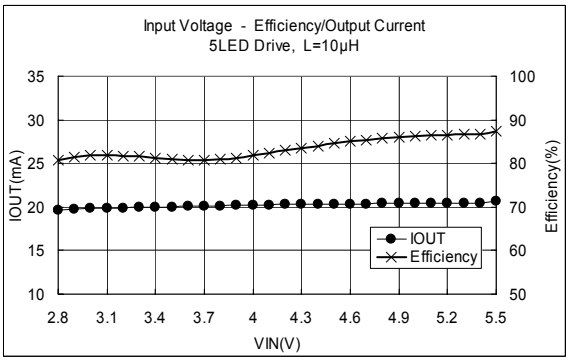
## 1. Application Circuit Example and Measurement Data (Reference data)

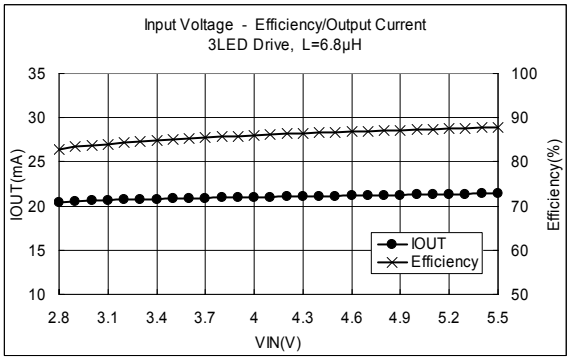


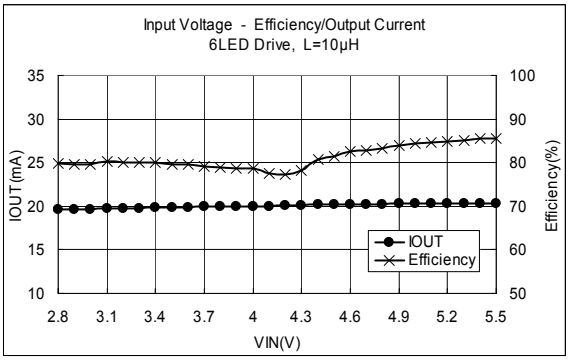

• Evaluation conditions

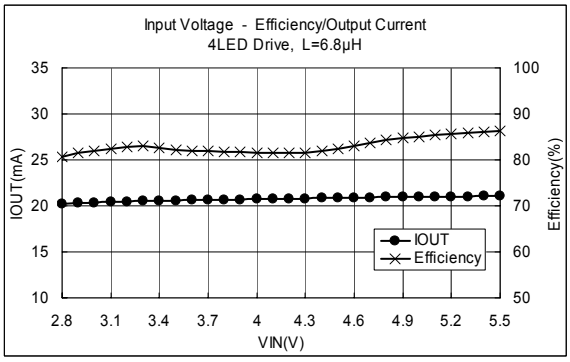
| | |
|---|---|
| L | : CXLD120 series (NEO MAX CO.,Ltd.) (Size 2.5 × 3.0 × 1.2 mm) |
| S-Di | : CUS02 1 A/30 V (TOSHIBA Corp.) |
| LED | : NSCW215T (NICHIA Corp.) |
| C1 | : C2012JB1E105K (TDK Corp.) |
| C2 | : C2012JB1E105K (TDK Corp.) |




### <Measurement Data>

Efficiency in the range of $V_{IN}$ = 2.8 to 5.5 V

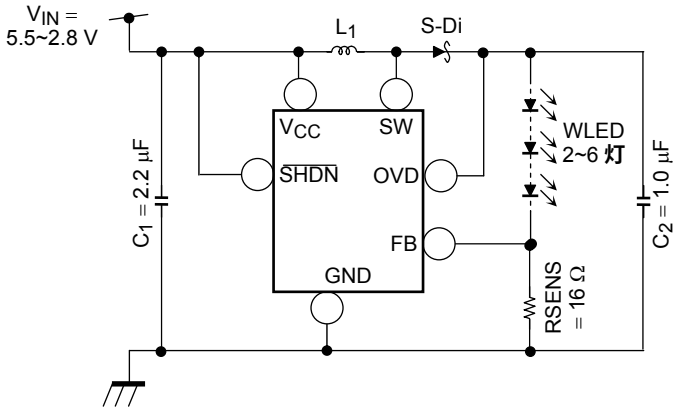
| | Efficiency (%) | Average Efficiency (%) |
|---|---|---|
| 2 LED | **82.60 to 88.46** | **86.29** |
| 3 LED | **82.69 to 87.78** | **85.95** |
| 4 LED | **80.73 to 86.22** | **83.05** |
| 5 LED | **80.73 to 87.28** | **83.45** |
| 6 LED | **79.78 to 85.55** | **81.15** |

Output current in the range of $V_{IN}$ = 3.0 to 5.0 V

| | Output Current (mA) $V_{IN}$ = 3.6 V center | Tolerance (%) | |
|---|---|---|---|
| | | MIN | MAX |
| 2 LED | **21.13** | **-3.50** | **1.77** |
| 3 LED | **20.60** | **-1.95** | **1.38** |
| 4 LED | **20.87** | **-1.75** | **1.11** |
| 5 LED | **20.06** | **-1.81** | **1.15** |
| 6 LED | **19.90** | **-1.95** | **1.28** |

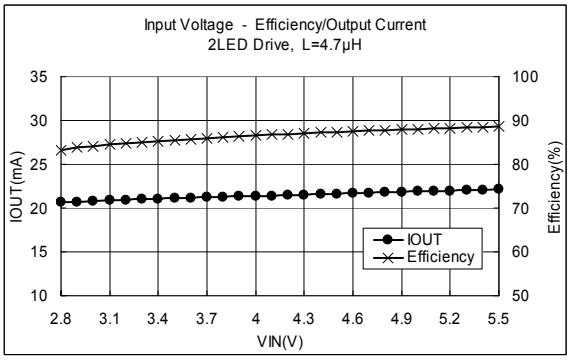
* $V_{OUT}$ voltage in driving 5 or 6 LEDs must be lower than OVD detection level.($V_{OUT}$<19V)

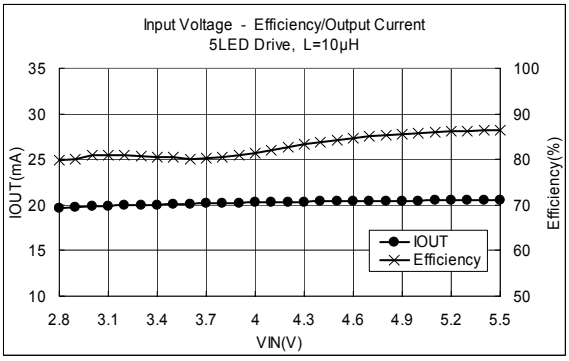
## 2. Application Circuit Example and Measurement Data (Reference data)

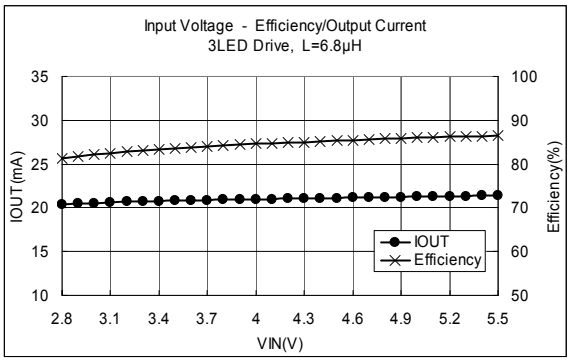


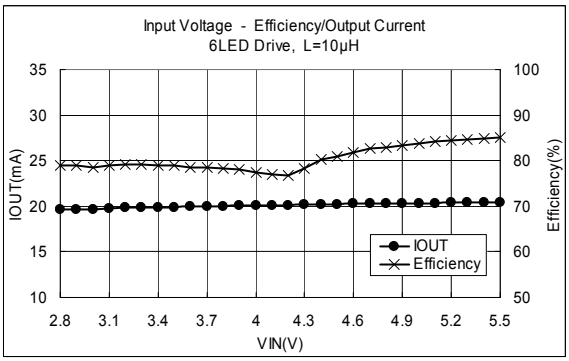

• Evaluation conditions

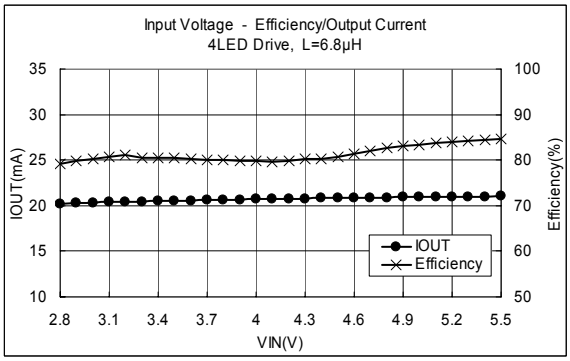
| | |
|---|---|
| L | : 1001AS series (TOKO, INC) (Size 3.6 × 3.6 × 1.2 mm) |
| S-Di | : CUS02 1 A/30 V (TOSHIBA Corp.) |
| LED | : NSCW215T (NICHIA Corp.) |
| C1 | : C2012JB1E105K (TDK Corp.) |
| C2 | : C2012JB1E105K (TDK Corp.) |




### <Measurement Data>

Efficiency in the range of $V_{IN}$ = 2.8 to 5.5 V

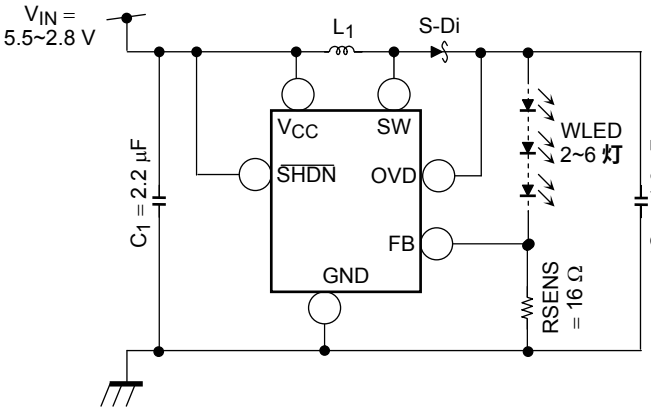
| | Efficiency (%) | Average Efficiency (%) |
|---|---|---|
| 2 LED | **83.10 to 88.60** | **86.55** |
| 3 LED | **81.32 to 86.47** | **84.54** |
| 4 LED | **79.15 to 84.63** | **81.30** |
| 5 LED | **79.72 to 86.39** | **82.87** |
| 6 LED | **78.91 to 85.10** | **80.47** |

Output current in the range of $V_{IN}$ = 3.0 to 5.0 V

| | Output Current (mA) $V_{IN}$ = 3.6 V center | Tolerance (%) | |
|---|---|---|---|
| | | MIN | MAX |
| 2 LED | **21.17** | **-3.32** | **1.73** |
| 3 LED | **20.85** | **-1.95** | **1.38** |
| 4 LED | **20.56** | **-1.79** | **1.15** |
| 5 LED | **20.10** | **-1.82** | **1.22** |
| 6 LED | **19.95** | **-1.94** | **1.26** |

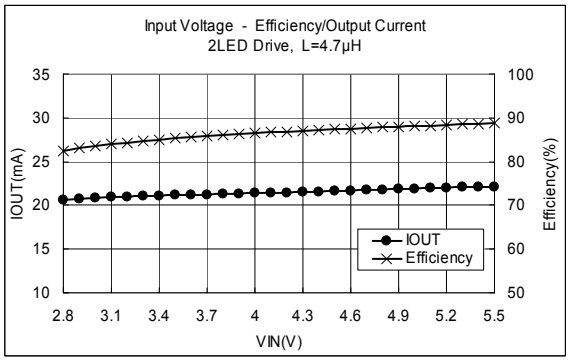
* $V_{OUT}$ voltage in driving 5 or 6 LEDs must be lower than OVD detection level.($V_{OUT}$<19V)

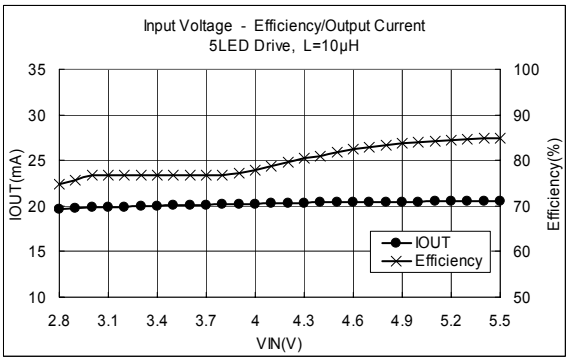
## 3. Application Circuit Example and Measurement Data (Reference data)

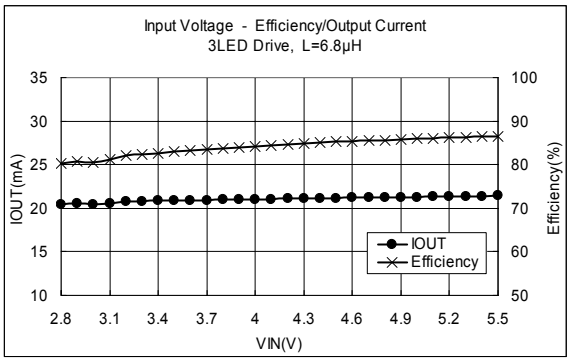


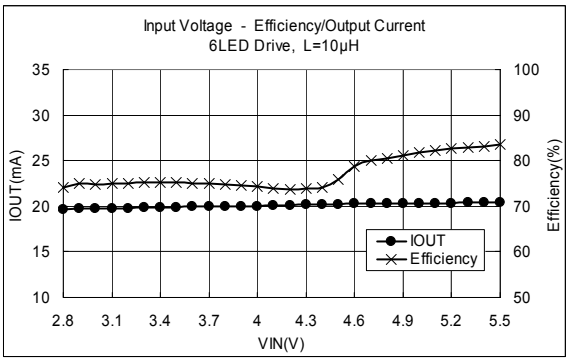

• Evaluation conditions

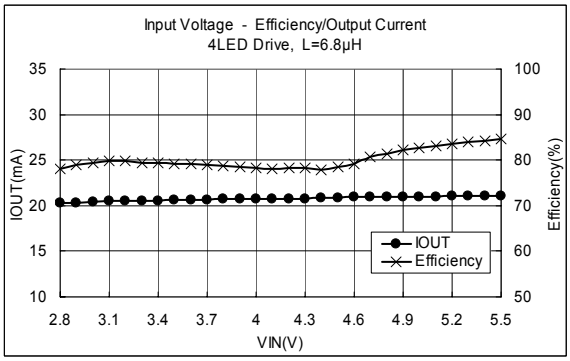
| | |
|---|---|
| L | : LQH2M series (Murata Manufacturing Co.,Ltd.) (Size 2.0 × 1.6 × 0.95 mm) |
| S-Di | : CUS02 1 A/30 V (TOSHIBA Corp.) |
| LED | : NSCW215T (NICHIA Corp.) |
| C1 | : C2012JB1E105K (TDK Corp.) |
| C2 | : C2012JB1E105K (TDK Corp.) |




### <Measurement Data>

Efficiency in the range of $V_{IN}$ = 2.8 to 5.5 V

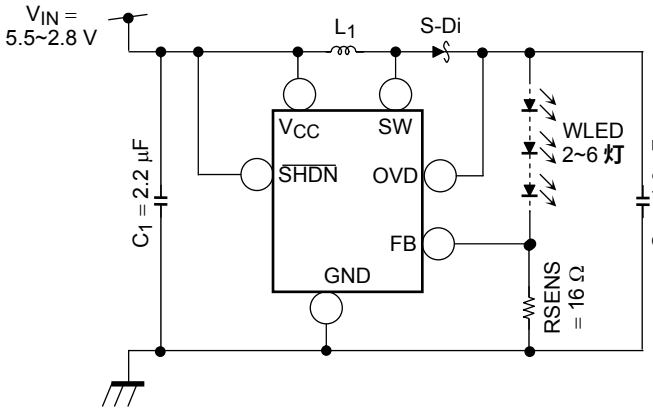
| | Efficiency (%) | Average Efficiency (%) |
|---|---|---|
| 2 LED | **82.37 to 88.70** | **86.38** |
| 3 LED | **80.19 to 86.55** | **84.12** |
| 4 LED | **78.11 to 84.54** | **80.16** |
| 5 LED | **74.79 to 84.94** | **79.94** |
| 6 LED | **74.14 to 83.47** | **77.17** |

Output current in the range of $V_{IN}$ = 3.0 to 5.0 V

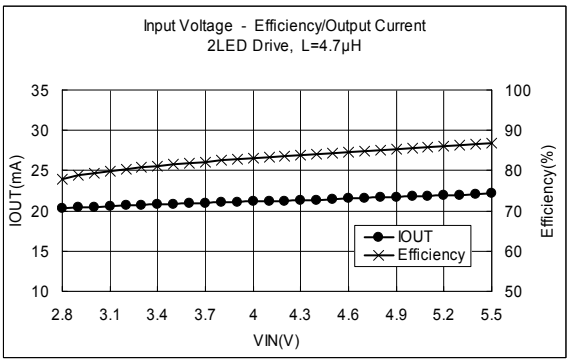
| | Output Current (mA) $V_{IN}$ = 3.6 V center | Tolerance (%) | |
|---|---|---|---|
| | | MIN | MAX |
| 2 LED | **21.19** | **-3.26** | **1.69** |
| 3 LED | **20.90** | **-1.87** | **2.17** |
| 4 LED | **20.63** | **-1.78** | **1.01** |
| 5 LED | **20.09** | **-1.88** | **1.25** |
| 6 LED | **19.93** | **-1.99** | **1.07** |

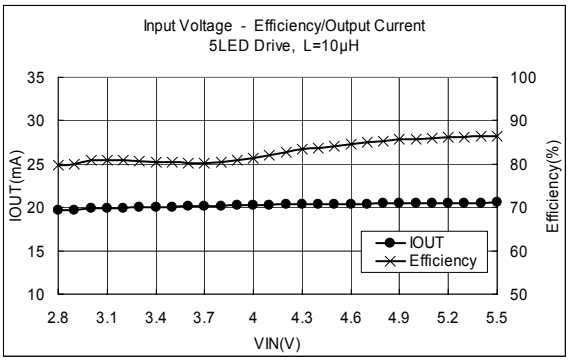
* $V_{OUT}$ voltage in driving 5 or 6 LEDs must be lower than OVD detection level.($V_{OUT}$<19V)

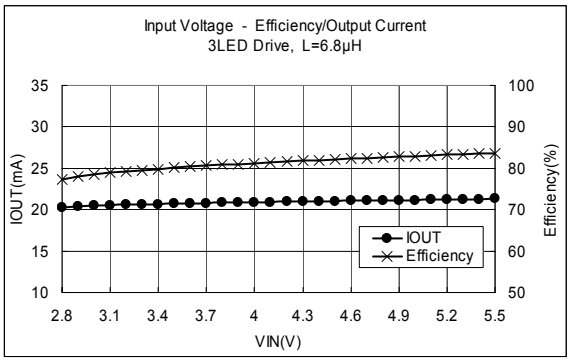
## 4. Application Circuit Example and Measurement Data (Reference data)

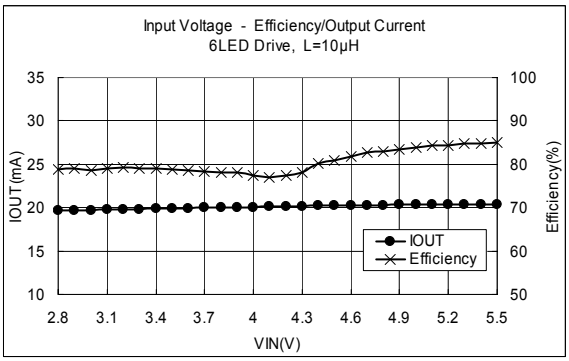


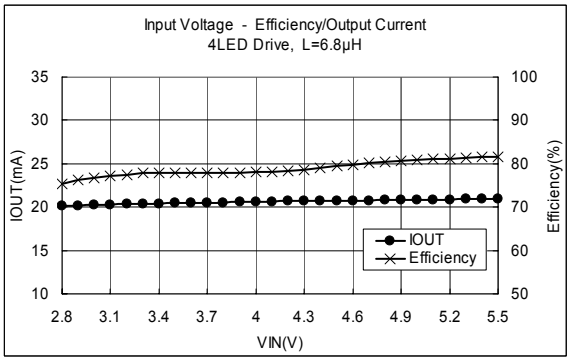

- Evaluation conditions
  - L : VLF3010A series (TDK Corp.) (Size 3.0 × 3.0 × 1.0 mm)
  - S-Di : CUS02 1 A/30 V (TOSHIBA Corp.)
  - LED : NSCW215T (NICHIA Corp.)
  - C1 : C2012JB1E105K (TDK Corp.)
  - C2 : C2012JB1E105K (TDK Corp.)




### <Measurement Data>

Efficiency in range of $V_{IN}$ = 2.8 to 5.5 V

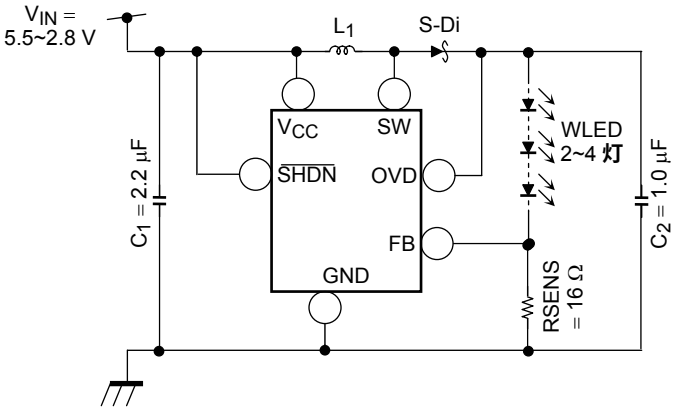
| | Efficiency (%) | Average Efficiency (%) |
|---|---|---|
| 2 LED | **79.85～86.97** | **84.02** |
| 3 LED | **80.19～85.32** | **83.39** |
| 4 LED | **78.77～83.60** | **80.69** |
| 5 LED | **79.72～86.39** | **82.87** |
| 6 LED | **78.91～85.10** | **80.49** |

Output current in range of $V_{IN}$ = 3.0 to 5.0 V

| | Output Current (mA) $V_{IN}$ = 3.6 V center | Tolerance (%) | |
|---|---|---|---|
| | | MIN | MAX |
| 2 LED | **21.19** | **-3.08** | **1.67** |
| 3 LED | **20.89** | **-1.86** | **1.33** |
| 4 LED | **20.64** | **-1.68** | **1.11** |
| 5 LED | **20.10** | **-1.82** | **1.22** |
| 6 LED | **19.95** | **-1.94** | **1.26** |

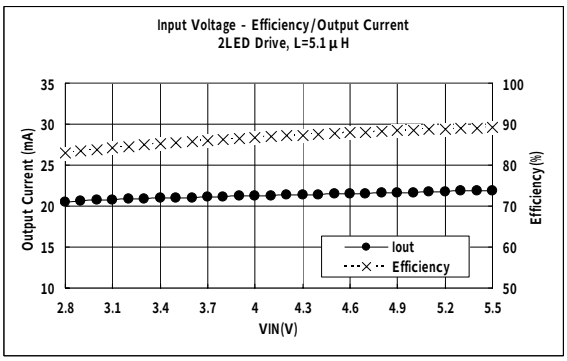
* $V_{OUT}$ voltage in driving 5 or 6 LEDs must be lower than OVD detection level.($V_{OUT}$<19V)

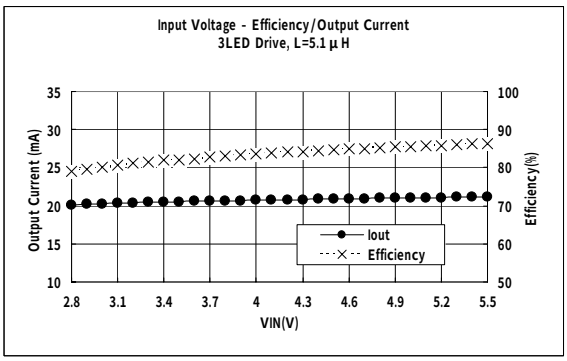
## 5. Application Circuit Example and Measurement Data (Reference data)

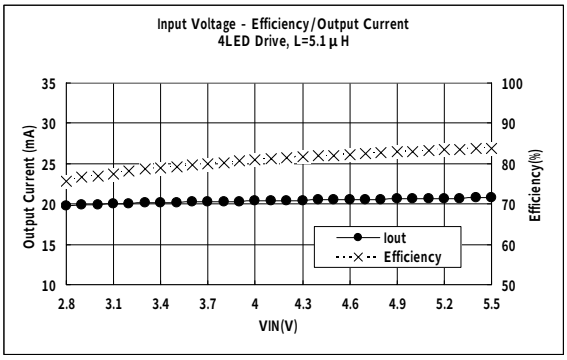



• Evaluation conditions

| | |
|---|---|
| L | : 32R51 (KOA Corp.) (Size 3.2 × 2.5 × 0.6 mm) |
| S-Di | : CUS02 1 A/30 V (TOSHIBA Corp.) |
| LED | : NSCW215T (NICHIA Corp.) |
| C1 | : C2012JB1E105K (TDK Corp.) |
| C2 | : C2012JB1E105K (TDK Corp.) |




### <Measurement Data>

Efficiency in the range of $V_{IN}$ = 2.8 to 5.5 V

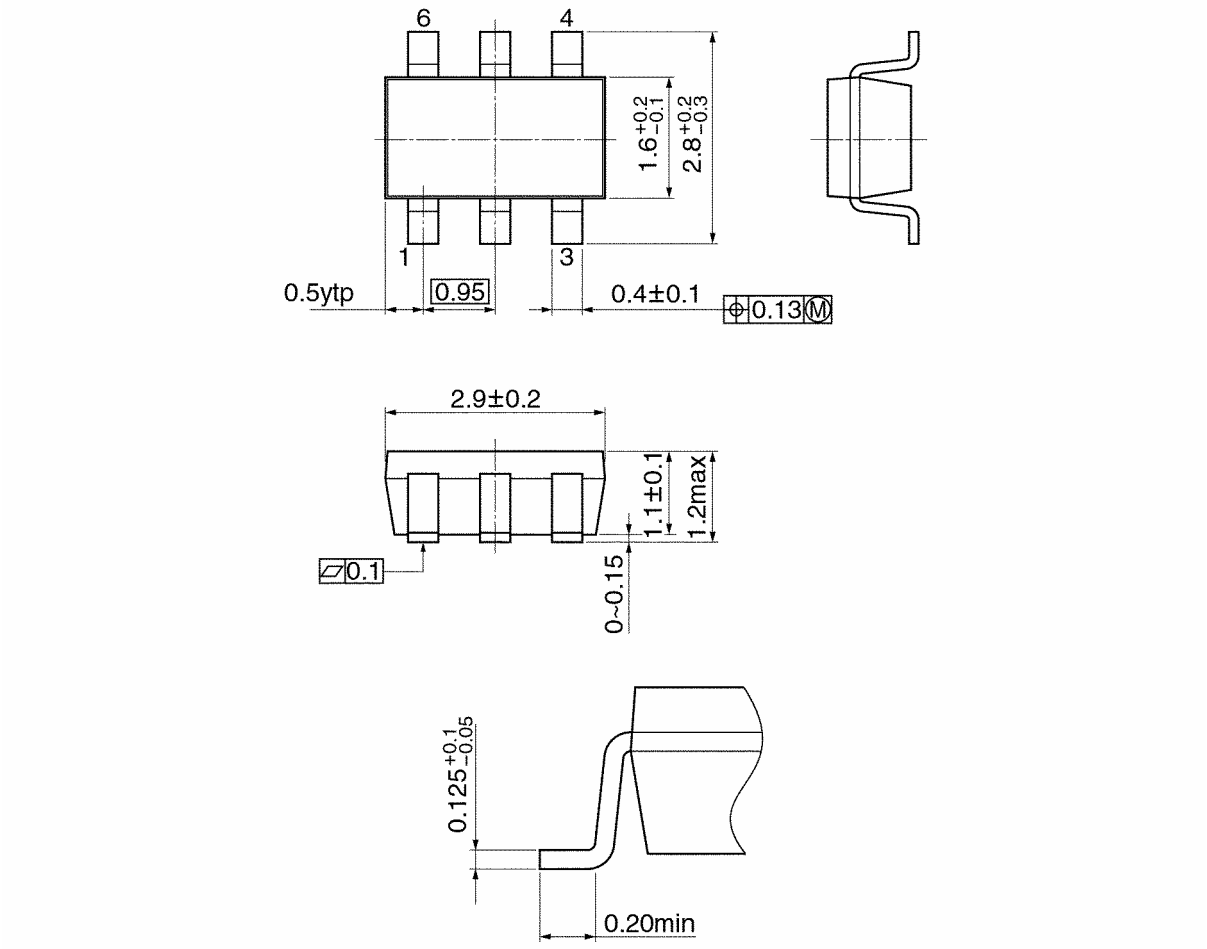
| | Efficiency (%) | Average Efficiency (%) |
|---|---|---|
| 2 LED | **83.08～89.23** | **86.73** |
| 3 LED | **79.02～86.30** | **83.52** |
| 4 LED | **75.75～83.83** | **80.78** |

Output current in the range of $V_{IN}$ = 3.0 to 5.0 V

| | Output Current (mA) $V_{IN}$ = 3.6 V center | Tolerance (%) | |
|---|---|---|---|
| | | MIN | MAX |
| 2 LED | **21.06** | **-2.46** | **4.02** |
| 3 LED | **20.57** | **-2.39** | **2.94** |
| 4 LED | **20.22** | **-2.28** | **2.65** |

## Package Dimensions

SSOP6-P-0.95B Unit: mm




Weight : 0.016 g (Typcal)

## Regarding solder ability

Regarding solder ability, the following conditions have been confirmed.

- Solder ability
  (1) Use of Sn-63Pb solder bath
    • solder bath temperature = 230°C, dipping time = 5 seconds, 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, number of times = once, use of R-type flux

## NOTES

- Utmost care is necessary in the design of the output line, VCC, COMMON and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.
- Do not insert devices in the wrong orientation. Make sure that the positive and negative terminals of power supplies are connected correctly. Otherwise, the rated maximum current of power dissipation may be exceeded and the device may break down or undergo performance degradation, causing it to catch fire or explode and resulting in injury.
- Please take care that IC might be destroyed in case external components were destroyed or not connected exactly.

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