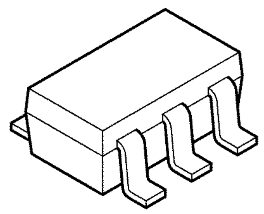
TOSHIBA BiCD Digital Integrated Circuit Silicon Monolithic

TB62736FUG

Step-up Type DC-DC Converter for White LEDs

The TB62736FUG is a high efficiency step-up type DC-DC converter that is designed especially for use as a constant current driver of white LEDs.
It is possible to drive 2 to 6 white LEDs connected in series using a lithium-ion battery.
This IC incorporates an N-ch-MOS FET transistor required for switching of an external inductor.
The forward current of the LEDs can be controlled by an external resistor.
This IC is best suited for use as a driver of white LED back lighting in color LCDs in PDAs, cellular phones and handy terminal devices.



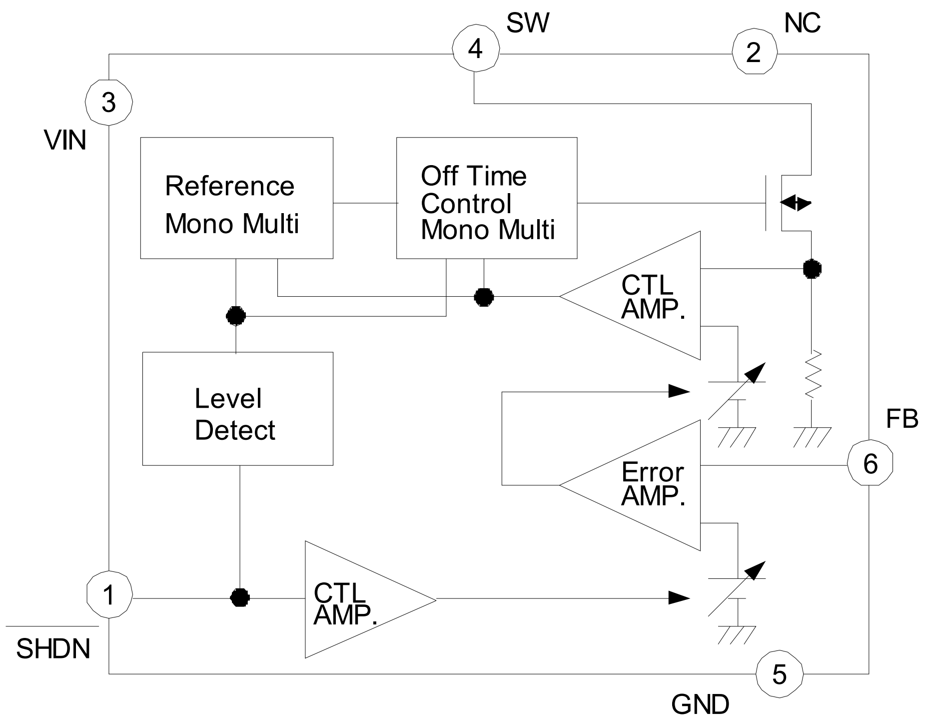
SSOP6-P-0.95B

Weight: 0.016 g (typ.)

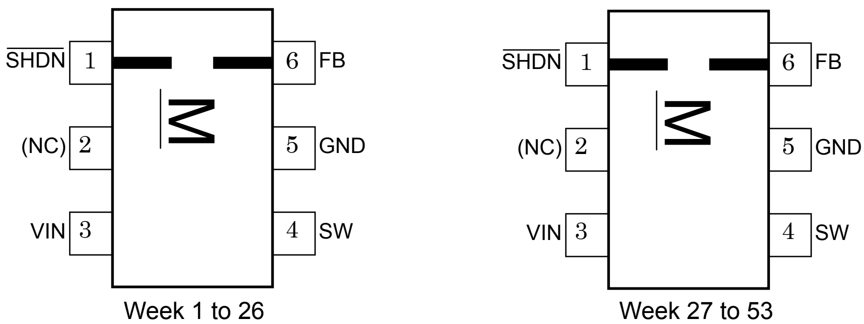
Features

- Brightness control function with changing drive current:
  LED current I_F = 25% to 100% (analog input)
- LED current values controlled by external resistance
  : 20 mA (typ.) @ RSENS=16 Ω
- Output power : 400 mW
- High efficiency : maximum 87% (when used with components as recommended herein)
- Switching Frequency : 1.1 MHz(Typ.)
- IC package: SSOP6-P-0.95B (SOT23-6)

Block Diagram



Pin Assignment (top view)



Note 1:The IC may break if mounted 180 degrees in reverse. Ensure the device is correctly orientated before assembly.

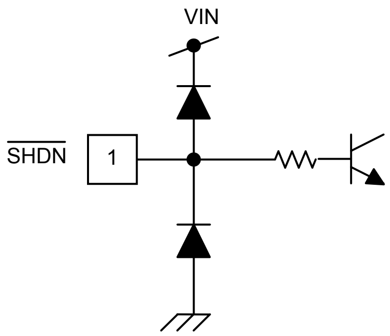
Pin Functions

No.	Symbol	Function
1	$\overline{\text{SHDN}}$	Input pin for IC ON/OFF control and variable LED I_F. 0 to 0.5 V : Shutdown Mode (IC shutdown) 1.0 V to 2.5 V : I_F = 25 to 100% Variable Over 2.5 V : I_F = 100% PWM signal input for I_F control (see p.5)
2	NC	No Connection or Connected to GND (Note 2)
3	VIN	Supply voltage pin. Supply voltage range : 2.8 V to 5.5 V
4	SW	DC-DC converter switching pin – switch incorporates N-ch MOSFET
5	GND	Ground pin
6	FB	LED I_F setting resistor connecting terminal.

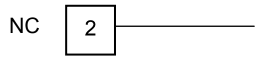
Note 2:The NC terminal is not connected to the internal circuit, so placing it on another terminal pattern does not represent a problem.

I/O Equivalent Pin Circuits

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

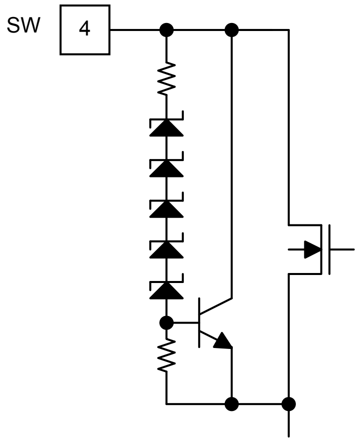


2. NC pin

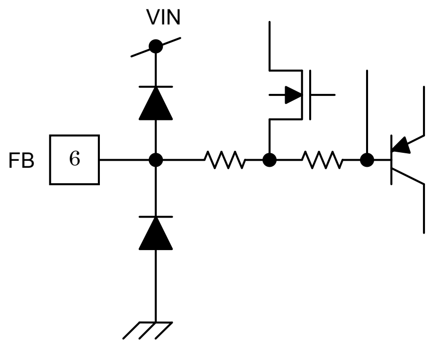


The NC pin is not connected to any internal circuit, so placing it on another terminal pattern does not present a problem.

3. SW pin



4. FB pin



Protection at the time of LED opening

The zener diode in the application circuit example is necessary for the provision of over-voltage protection in the event the LED becomes open. As the IC does not incorporate a voltage protection circuit, it is strongly advised that a zener diode be connected.

The zener diode should satisfy the following conditions:

i) Less than maximum output voltage of 24 V
ii) Greater than the total series LED V_F
iii) Less than the maximum output capacitance C_2.

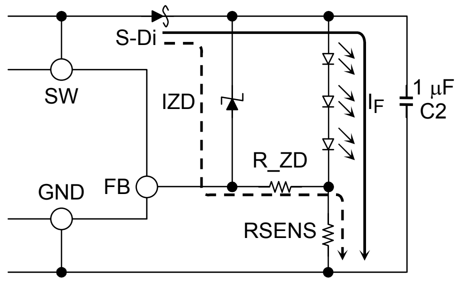
Moreover, by connecting a protection circuit such as R_ZD in the figure below, it is possible to control the output current when the LED becomes open, and to use a zener diode of lower tolerance.

An example of IZD control by R_ZD connection. (RSENS = 16 Ω)

R_ZD (Ω)	IZD (mA)
500	Around 0.6
100	Around 2.8

In order to avoid adverse effects on driver characteristics,

Toshiba recommends a resistance of 500 ohms or less.



Protection circuit application

Output-side Capacitor Setting

It is recommended that the value of C_2 be equal to, or greater than 1.0 (μF).

External Inductor Size Setting

For each number of LEDs, the selected inductance should be greater than the value indicated in the table below.

Number of LEDs	Inductance (Unit: μH)	Note
2	4.7	I_F = 20 mA
3	6.8	
4		
5	10	
6		

Control of I_F

The resistance RSENS is connected between the FB pin and the GND pin.
The average current is controlled by the RSENS value, and calculated using the following equation:

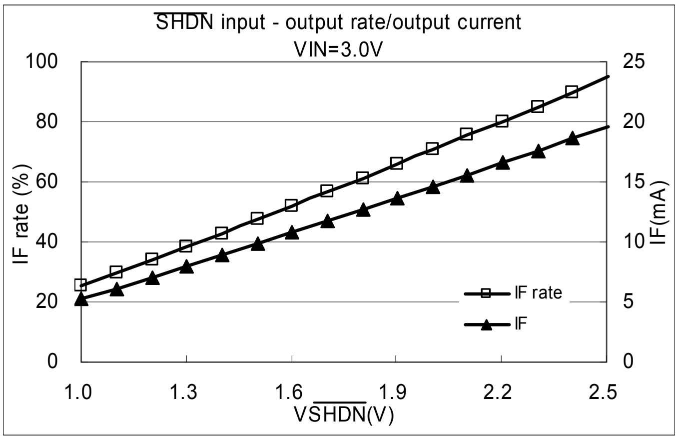
$$I_F\ (\text{mA}) = [\ 325\ \text{mV} / \text{RSENS}(\Omega)\ ]$$

Margin of error is ±5%.

Current control using $\overline{\text{SHDN}}$ pin

The IF current set by the RSENS pin resistance can be varied in the range of 25 to 100%.
Linearity error at VA conversion is ±10%.

$\overline{\text{SHDN}}$ Voltage	V$\overline{\text{SHDN}}$=0 V to 0.5 V	V$\overline{\text{SHDN}}$=1 V to 2.5 V	V$\overline{\text{SHDN}}$>2.5 V	Note
I_F Valuable Rate	0	25 - 100	100	UNIT : %



Dimming using PWM signal input

A dimming function can also by applied using a PWM signal.

[Notes]

- When using a PWM signal, the minimum pulse width of the PWM should be greater than 33μs.
- Duty ratio of PWM function should be set at 10% to 90%.
- The recommended PWM frequency should be 100 Hz to 10 kHz.

<<Output current is calculated using the following equation>>

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

Absolute Maximum Ratings (T_a = 25°C, unless otherwise specified)

Characteristics	Symbol	Ratings	Unit
Power supply voltage	V_{IN}	−0.3 to 6.0	V
Input voltage	V_{in}	−0.3 to V_{IN} + 0.3 (Note 3)	V
Switching pin voltage	$V_{O\ (SW)}$	−0.3 to 24	V
Power Dissipation	P_D	0.41 (IC only)	W
		0.47 (IC mounted on PCB)(Note 4)	
Thermal resistance	$R_{th\ (j\text{-}a)}$	300 (IC only)	°C/W
		260 (IC mounted on PCB)	
Operating temperature range	T_{opr}	−40 to 85	°C
Storage temperature	T_{stg}	−55 to 150	°C
Maximum junction temperature	T_j	150	°C

Note 3: However, do not exceed 6 V.

Note 4: Power dissipation is reduced by 3.8 mW/°C from the maximum rating for every 1°C exceeding the ambient temperature of 25°C (when the IC is mounted on a PCB).

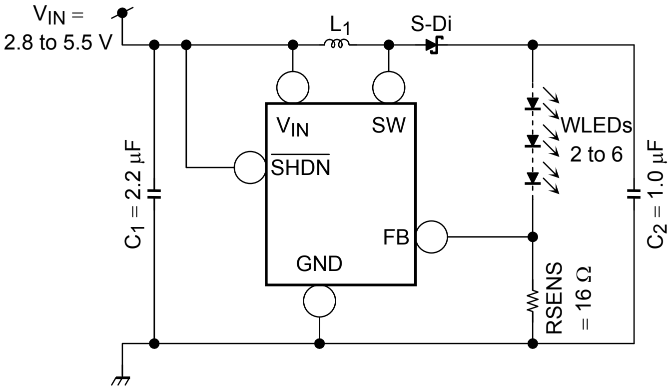
Recommended Operating Condition (T_a = −40 to 85°C, unless otherwise specified)

Characteristics	Symbol	Test Conditions	Min	Typ.	Max	Unit
Power supply voltage	V_{IN}	—	2.8	—	5.5	V
$\overline{\text{SHDN}}$ pin H level input voltage	$V_{\overline{SHDN}\ (H)}$	—	2.7	—	V_{IN}	V
$\overline{\text{SHDN}}$ pin L level input voltage	$V_{\overline{SHDN}\ (L)}$	—	0	—	0.5	V
$\overline{\text{SHDN}}$ pin input pulse width	tpw	ON/OFF duty width	33	—	—	μs
LED current (Average value)	I_{F1}	V_{IN} = 3.6 V, R_{SENS} = 16 Ω 4LEDs, T_a = 25°C	—	20	—	mA

Electrical Characteristics (T_a = 25°C V_{IN} = 2.8 to 5.5 V, unless otherwise specified)

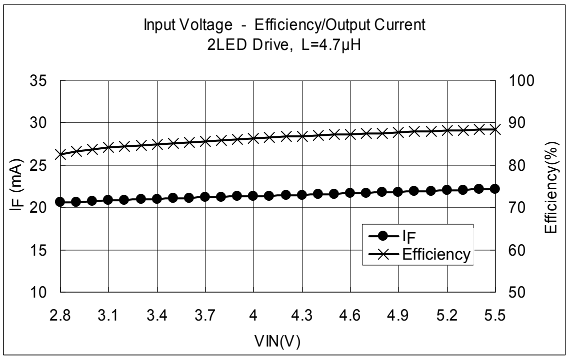
Characteristics	Symbol	Test Conditions	Min	Typ.	Max	Unit
Power supply voltage	V_{IN}	—	2.8	—	5.5	V
Operating consumption current	$I_{IN\ (ON)}$	V_{IN} =3.6 V, RSENS = 16 Ω	—	0.9	1.5	mA
Standby consumption current	$I_{IN\ (OFF)}$	V_{IN} = 3.6 V, $V_{\overline{SHDN}}$ = 0 V	—	0.5	1.0	μA
$\overline{\text{SHDN}}$ pin current	$I_{\overline{SHDN}}$	V_{IN} = 3.6 V, $V_{\overline{SHDN}}$ = 3.6 V or 0 V	−10	0	10	μA
Integrated MOS-FET switching frequency	f_{OSC}	V_{IN} = 3.6 V, $V_{\overline{SHDN}}$ = 3.6 V	0.77	1.1	1.43	MHz
$\overline{\text{SHDN}}$ pin H level input voltage	$V_{\overline{SHDN}\ (H)}$	—	2.7	—	V_{IN}	V
$\overline{\text{SHDN}}$ pin L level input voltage	$V_{\overline{SHDN}\ (L)}$	—	0	—	0.5	V
Switching pin protection voltage	$V_{O\ (SW)}$	—	—	25	—	V
Switching pin current	$I_{O\ (SW)}$	—	—	400	—	mA
Switching pin leakage current	$I_{OZ\ (SW)}$	—	—	0.5	1	μA
FB pin feedback voltage	V_{FB}	V_{IN} = 3.6 V, R_{SENS} = 16 Ω L = 4.7 μH	308	325	342	mV
FB pin line regulation	ΔV_{FB}	V_{IN} = 3.6 V center V_{IN} = 3.0 V to 5.0 V	−5	—	5	%

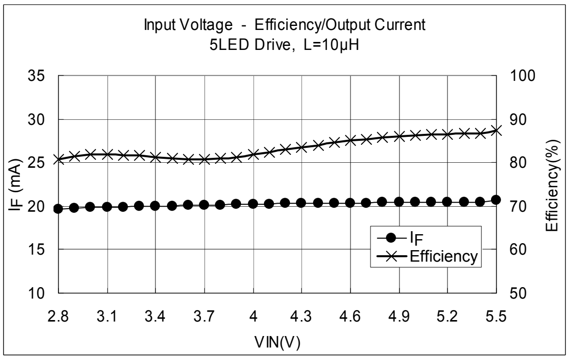
1. Application Circuit Example and Measurement Data (reference data)

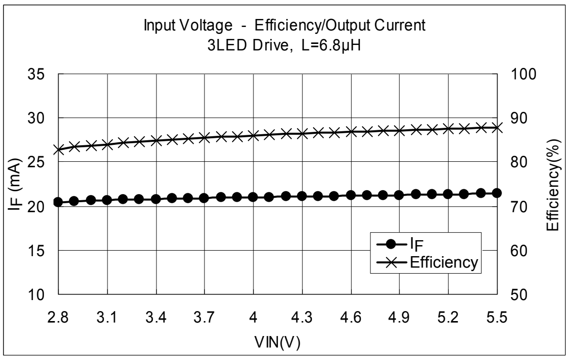


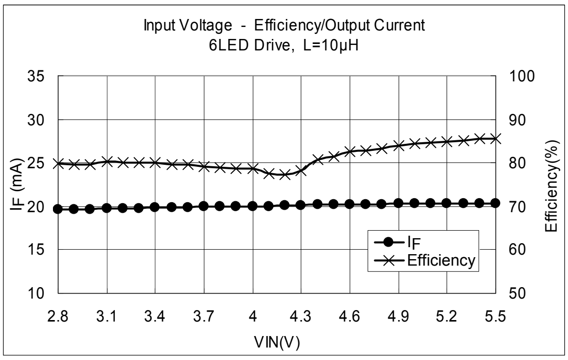
- Evaluation conditions

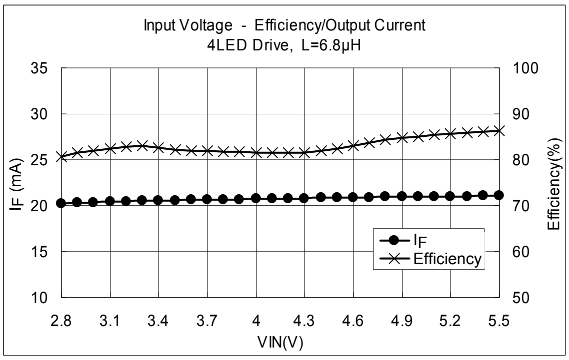
L_1	: CXLD120 series (NEO MAX CO., Ltd.) (Size: 2.5 mm × 3.0 mm × 1.2 mm)
C_1	: C2012JB1E225K (TDK Corp.)
C_2	: C2012JB1E105K (TDK Corp.)
S-Di	: CUS02 1 A/30 V (TOSHIBA Corp.)
WLEDs	: NSCW215T (NICHIA Corp.)











<Measurement Data>

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

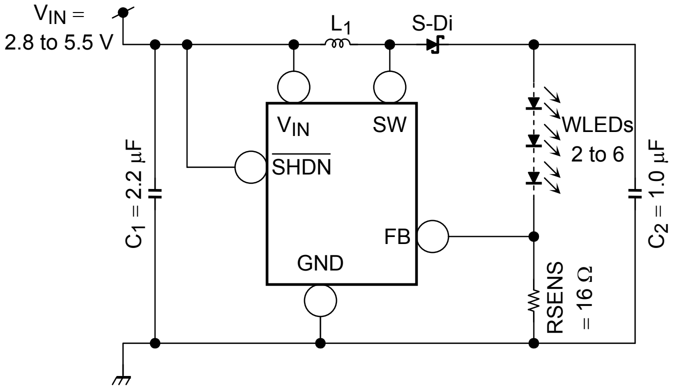
	Efficiency (%)	Average Efficiency (%)
2 LEDs	82.60 to 88.46	86.29
3 LEDs	82.69 to 87.78	85.95
4 LEDs	80.73 to 86.22	83.05
5 LEDs	80.73 to 87.28	83.45
6 LEDs	79.78 to 85.55	81.15

Output current in the range of V_{IN} = 3.0 to 5.0 V (V_{IN} = 3.6 V typ.)

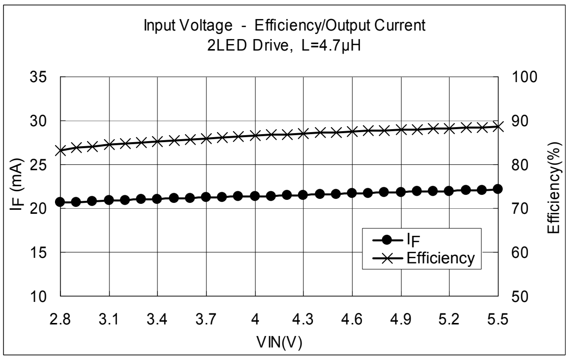
	Output Current (mA) V_{IN} = 3.6 V	Tolerance (%)	
		Min	Max
2 LEDs	21.13	−3.50	1.77
3 LEDs	20.60	−1.95	1.38
4 LEDs	20.87	−1.75	1.11
5 LEDs	20.06	−1.81	1.15
6 LEDs	19.90	−1.95	1.28

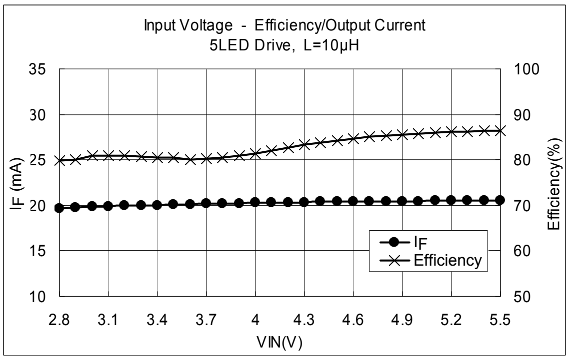
Note: These application examples are provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

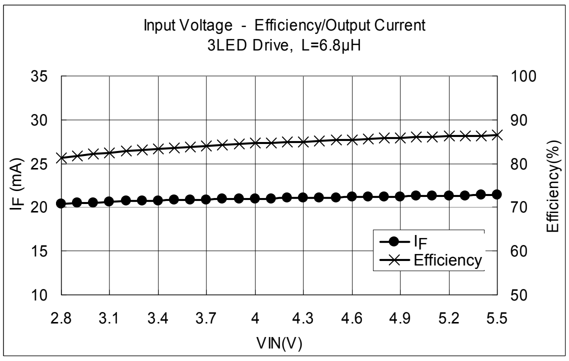
2. Application Circuit Example and Measurement Data (reference data)

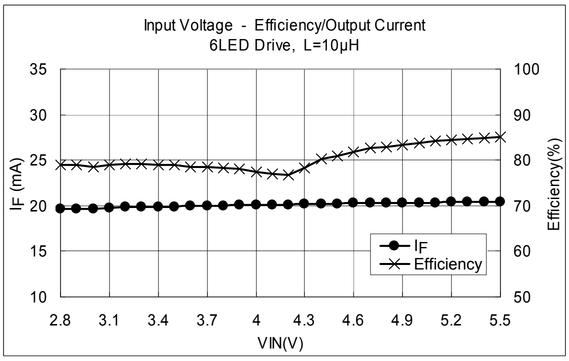


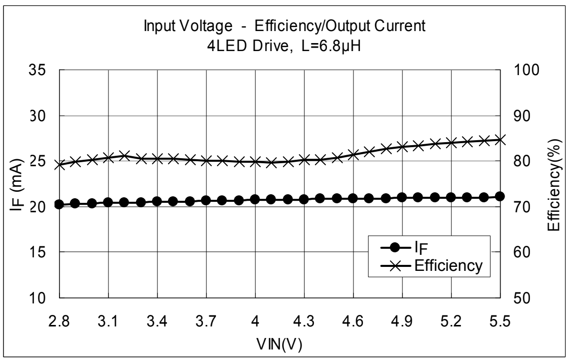
- Evaluation conditions
  - L_1 : 1001AS series (TOKO, INC) (Size: 3.6 mm × 3.6 mm × 1.2 mm)
  - C_1 : C2012JB1E225K (TDK Corp.)
  - C_2 : C2012JB1E105K (TDK Corp.)
  - S-Di : CUS02 1 A/30 V (TOSHIBA Corp.)
  - WLEDs: NSCW215T (NICHIA Corp.)











<Measurement Data>

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

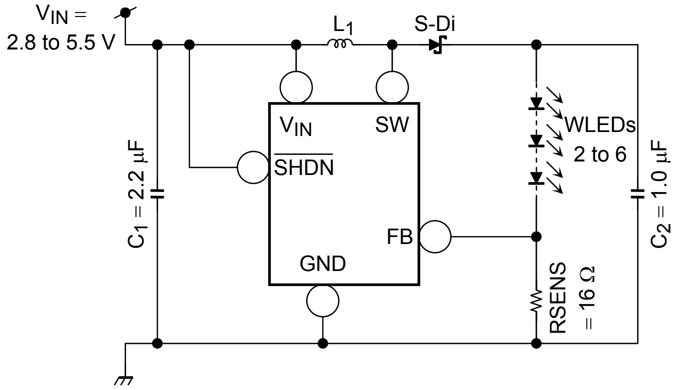
	Efficiency (%)	Average Efficiency (%)
2 LEDs	83.10 to 88.60	86.55
3 LEDs	81.32 to 86.47	84.54
4 LEDs	79.15 to 84.63	81.30
5 LEDs	79.72 to 86.39	82.87
6 LEDs	78.91 to 85.10	80.47

Output current in the range of V_{IN} = 3.0 to 5.0 V (V_{IN} = 3.6 V typ.)

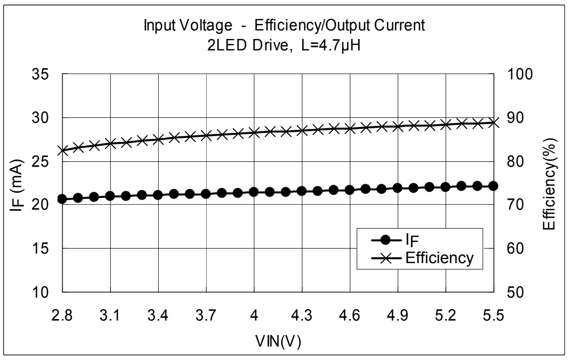
	Output Current (mA) V_{IN} = 3.6 V	Tolerance (%)	
		Min	Max
2 LEDs	21.17	−3.32	1.73
3 LEDs	20.85	−1.95	1.38
4 LEDs	20.56	−1.79	1.15
5 LEDs	20.10	−1.82	1.22
6 LEDs	19.95	−1.94	1.26

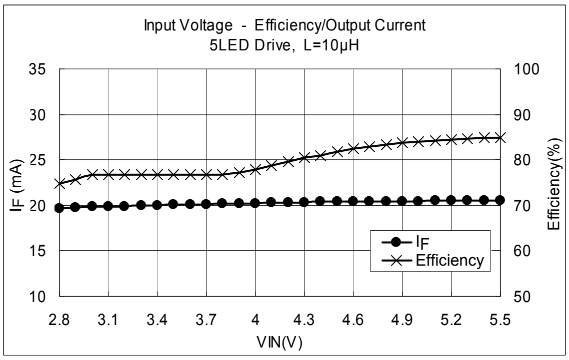
Note: These application examples are provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

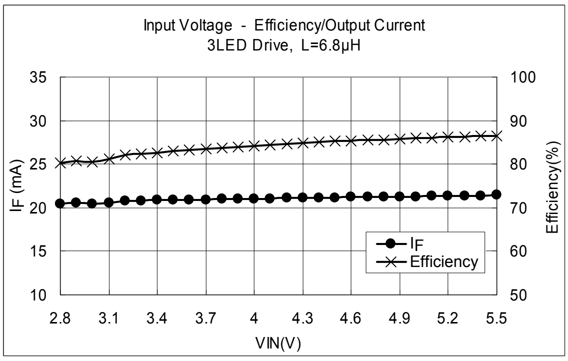
3. Application Circuit Example and Measurement Data (reference data)

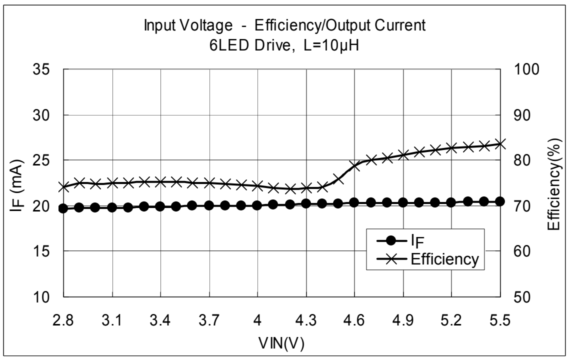


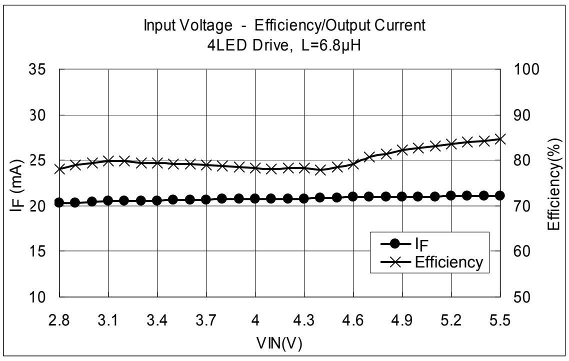
- Evaluation conditions
  - L_1 : LQH2M series (Murata Manufacturing Co.,Ltd.) (Size: 2.0 mm × 1.6 mm × 0.95 mm)
  - C_1 : C2012JB1E225K (TDK Corp.)
  - C_2 : C2012JB1E105K (TDK Corp.)
  - S-Di : CUS02 1 A/30 V (TOSHIBA Corp.)
  - WLEDs: NSCW215T (NICHIA Corp.)











<Measurement Data>

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

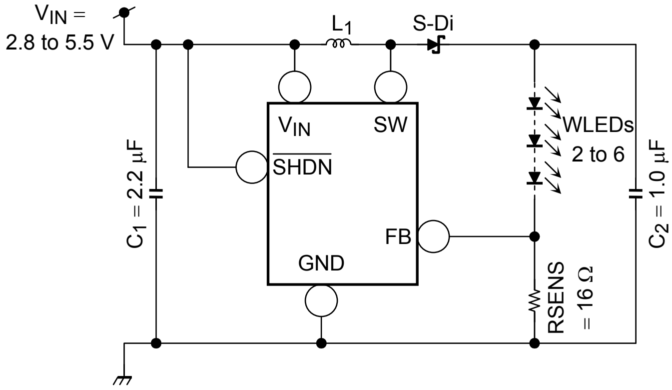
	Efficiency (%)	Average Efficiency (%)
2 LEDs	82.37 to 88.70	86.38
3 LEDs	80.19 to 86.55	84.12
4 LEDs	78.11 to 84.54	80.16
5 LEDs	74.79 to 84.94	79.94
6 LEDs	74.14 to 83.47	77.17

Output current in the range of V_{IN} = 3.0 to 5.0 V (V_{IN} = 3.6 V typ.)

	Output Current (mA) V_{IN} = 3.6 V	Tolerance (%)	
		Min	Max
2 LEDs	21.19	−3.26	1.69
3 LEDs	20.90	−1.87	2.17
4 LEDs	20.63	−1.78	1.01
5 LEDs	20.09	−1.88	1.25
6 LEDs	19.93	−1.99	1.07

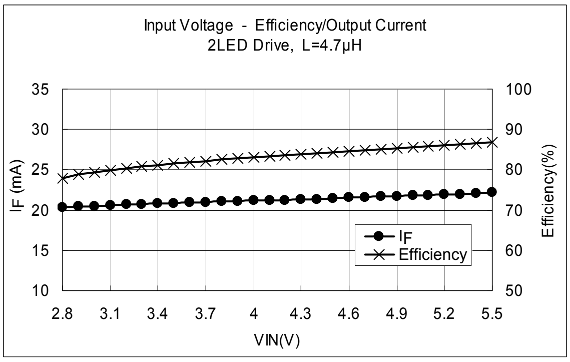
Note: These application examples are provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

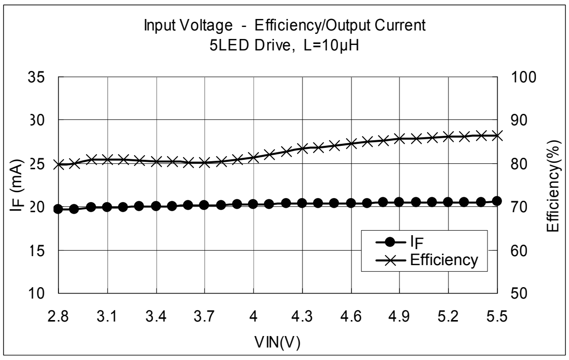
4. Application Circuit Example and Measurement Data (reference data)

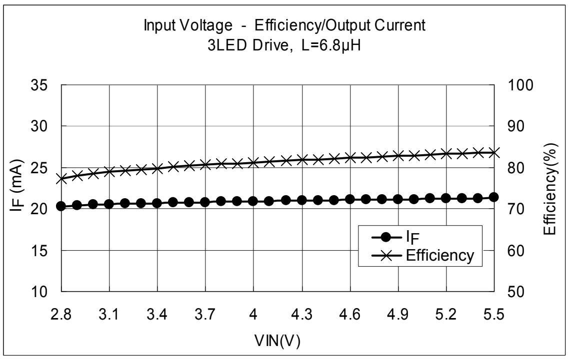


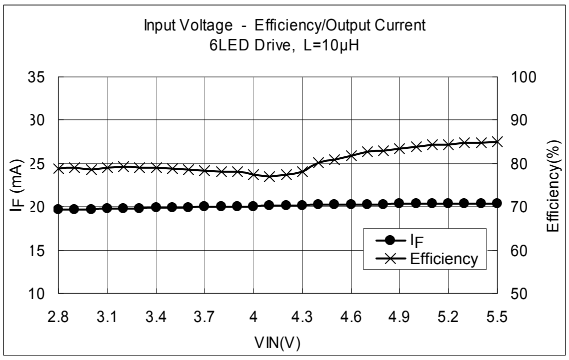
- Evaluation conditions

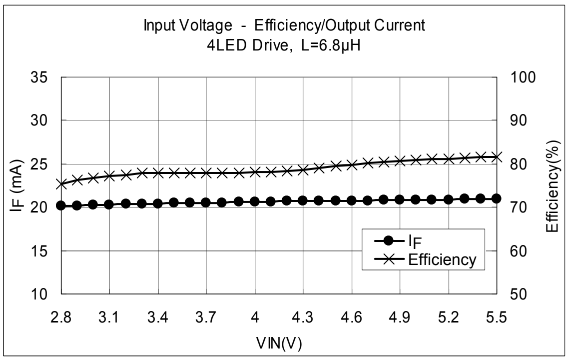
  L_1 : VLF3010A series (TDK Corp.)
  (Size: 3.0 mm × 3.0 mm × 1.0 mm)
  C_1 : C2012JB1E225K (TDK Corp.)
  C_2 : C2012JB1E105K (TDK Corp.)
  S-Di : CUS02 1 A/30 V (TOSHIBA Corp.)
  WLEDs: NSCW215T (NICHIA Corp.)











<Measurement Data>

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

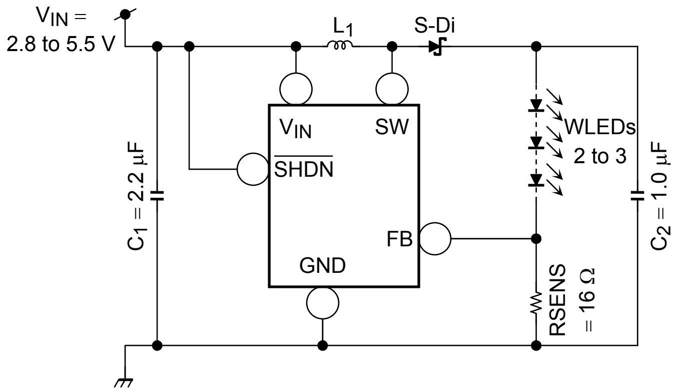
	Efficiency (%)	Average Efficiency (%)
2 LEDs	79.85 to 86.97	84.02
3 LEDs	80.19 to 85.32	83.39
4 LEDs	78.77 to 83.60	80.69
5 LEDs	79.72 to 86.39	82.87
6 LEDs	78.91 to 85.10	80.49

Output current in the range of V_{IN} = 3.0 to 5.0 V (V_{IN} = 3.6 V typ.)

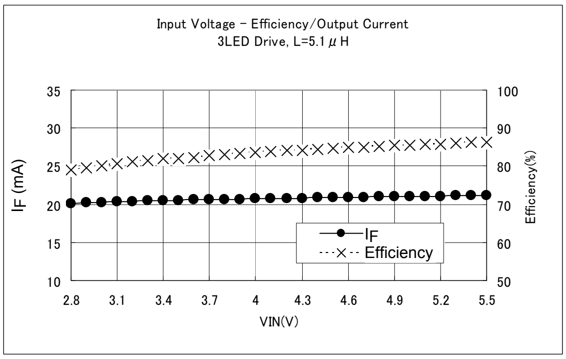
	Output Current (mA) V_{IN} = 3.6 V	Tolerance (%)	
		Min	Max
2 LEDs	21.19	−3.08	1.67
3 LEDs	20.89	−1.86	1.33
4 LEDs	20.64	−1.68	1.11
5 LEDs	20.10	−1.82	1.22
6 LEDs	19.95	−1.94	1.26

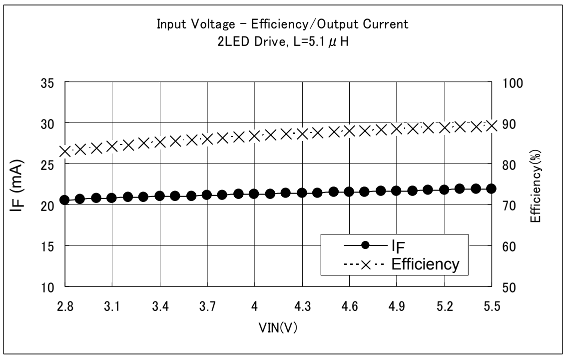
Note: These application examples are provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

5. Application Circuit Example and Measurement Data (reference data)



- Evaluation conditions
  - L_1 : 32R51 (KOA Corp.) (Size: 3.2 mm × 2.5 mm × 0.6 mm)
  - C_1 : C2012JB1E225K (TDK Corp.)
  - C_2 : C2012JB1E105K (TDK Corp.)
  - S-Di : CUS02 1 A/30 V (TOSHIBA Corp.)
  - WLEDs: NSCW215T (NICHIA Corp.)



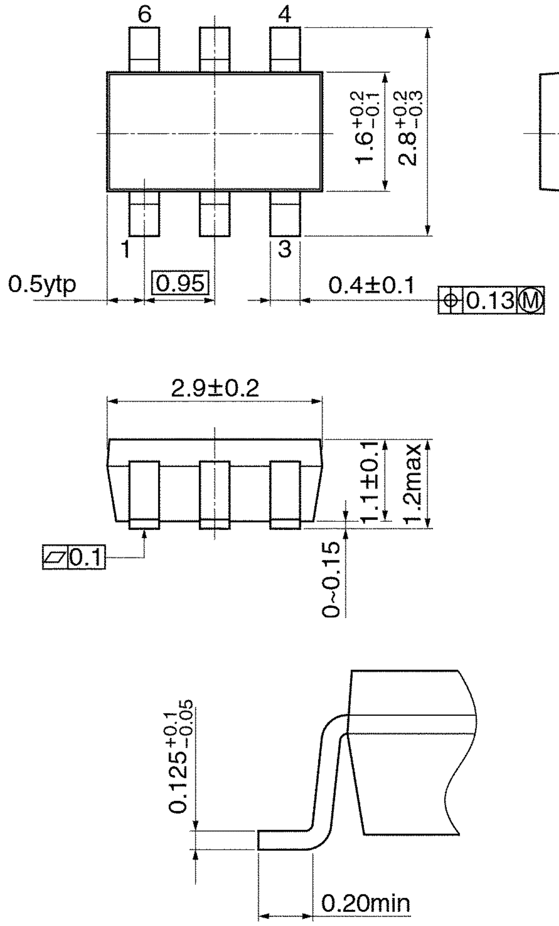


Note: These application examples are provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

Package Dimensions

SSOP6-P-0.95B

Unit: mm



Weight: 0.016 g (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] 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) 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.

(2) 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 pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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
use of R-type flux

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