TOSHIBA BiCD Digital Integrated Circuit Silicon Monolithic

TB62732FU

Step-up DC/DC Converter for White LED Driver

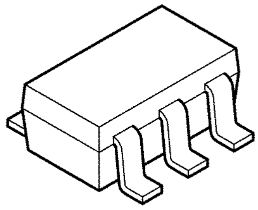
TB62732FU is the high efficiency Step-up type DC/DC converter that it is designed suitably in constant current lighting of white LED.

It is the most suitable for turning on 2 to 4 serial white LEDs with a Li-ion battery.

This IC builds in the N-ch MOS transistor which is necessary for switching of the coil.

And, LED current I_F is set up by a resistance with the outside.

This IC is the most suitable as a driver of white LED back light of the color LCD in the PDA, the cellular phone and the handy terminal machine.



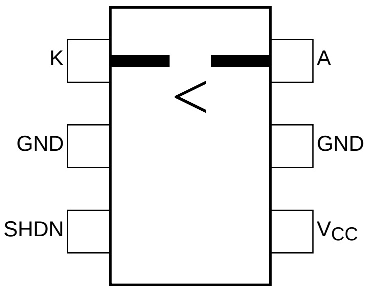
SSOP6-P-0.95B

Weight: 0.016 g (typ.)

Features

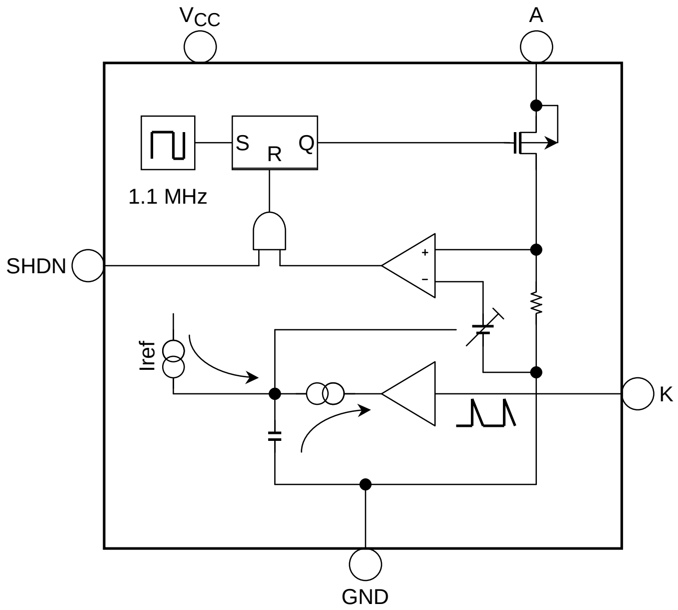
- LED current values can set according to external resistor
  - 15 mA (typ.) @R_sens = 3.3 Ω
  - 18.5 mA (typ.) @R_sens = 2.7 Ω
- 80% of the efficiency is realized. (LED serial 2 to 3, I_F = 20 mA)
- Maximum output voltage: Vo = 17 V
- Output power: Up to 320 mW supported
- Compact package: 6-pin SOT23 (SSOP6-P-0.95B)
- The N-ch MOS transistor building in low Ron.
  - Ron = 2.0 Ω (typ.) @V_{CC} = V_{IN} = 3.6 V
- Switching frequency: 1.1 MHz (typ.)
- Output capacitor
  - The small capacity of 0.47 µF
- Inductance: 2.2 µH to 10 µH

Pin assignment (top view)



Note 1: Be careful of handling because there is a terminal which is poor at ESD in this product.
This IC sometimes breaks when it is mounted at 180 degree for the reversal.
Mount a circuit board in the accurate direction.

Block Diagram



Pin Functions

No	Symbol	Function
1	K	Pin connecting LED cathode to resistor used to set current. Feedback pin for voltage waveforms for controlling LED constant current.
2, 5	GND	Ground pin for logic
3	SHDN	IC enable pin. When Low, Standby Mode and pin A turned off.
4	V_{CC}	Input pin for power supply for operating the IC. Operating voltage range: 3.0 to 5.5 V
6	A	DC-DC converter switch pin. The switch is an N-channel MOSFET transistor.

Note 2: Connect both GND pins to ground.

Absolute Maximum Ratings

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	−0.3 to +6.0	V
Input voltage	V_{IN}	−0.3 to $+V_{CC}$ + 0.3	V
Switching pin current	I_o (A)	380	mA
Switching pin voltage	V_o (A)	−0.3 to 17	V
Power dissipation	P_D	0.41 (IC only)	W
		0.47 (IC mounted on PCB) (Note 3)	
Saturation thermal resistance	$R_{th\ (j\text{-}a)}$	300 (IC only) 260 (IC mounted on PCB)	°C/W
Operating temperature range	T_{opr}	−40 to +85	°C
Storage temperature range	T_{stg}	−40 to +150	°C
Maximum junction temperature	T_j	125	°C

Note 3: Derate power dissipation by 3.8 mW/°C from the maximum rating for every 1°C exceeding the ambient temperature of 25°C (when IC is mounted on PCB).

Recommended Operating Conditions (unless otherwise specified, Ta = 25°C and V_{CC} = 3.6 V)

Characteristics	Symbol	Test circuit	Test condition	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	—	—	3.0	—	4.3	V
SHDN pin high-level input voltage	V_{IH}	—	V_{CC} = 3 to 4.3 V	2.6	—	V_{CC}	V
SHDN pin low-level input voltage	V_{IL}	—	V_{CC} = 3 to 4.3 V	0	—	0.5	V
SHDN pin input pulse width	tpw SHDN	—	SHDN = High and Low level	50	—	—	μs
Set LED current	I_o	—	V_{CC} = 3 V, turn on series LEDs of 2 to 4	5	—	20	mA

Electrical Characteristics
(unless otherwise specified, Ta = 25°C, V_{CC} = 3.6 V, V_{SHDN} = 3.6 V)

Characteristics	Symbol	Test circuit	Test condition	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	—	—	3.0	—	5.5	V
Current consumption at operation	I_{CC} (on)	—	SHDN = V_{CC}	—	0.52	0.8	mA
Current consumption at standby	I_{CC} (off)	—	SHDN = 0 V	—	0.5	1.0	μA
SHDN pin current	I_SHDN	—	SHDN = V_{CC}, Built-in pull-down resistor	—	4.2	7	μA
MOS transistor on-resistance	Ron	—	I_o = 300 mA, detection resistance value is contained	—	2.0	2.5	Ω
MOS transistor switching frequency	f_{OSC}	—	—	0.77	1.1	1.43	MHz
Pin A voltage	V_o (A)	—	—	17	—	—	V
Pin A current	I_o (A)	—	—	—	350	380	mA
Pin A leakage current	I_{oz} (A)	—	—	—	0.5	1	μA
Set up LED current I_F	I_o	—	R_sens = 2.7 Ω, L = 6.8 μH (Note 4)	—	18.5	—	mA
LED current V_{CC} dependence	dI_o	—		—	±8	±12	%

Note 4: The dissipation of the R_sens resistor isn't contained in the specification. Please, be careful.
The absolute value of I_o has the possibility to change not to correspond to the specification by inductance value and the relations of the load.

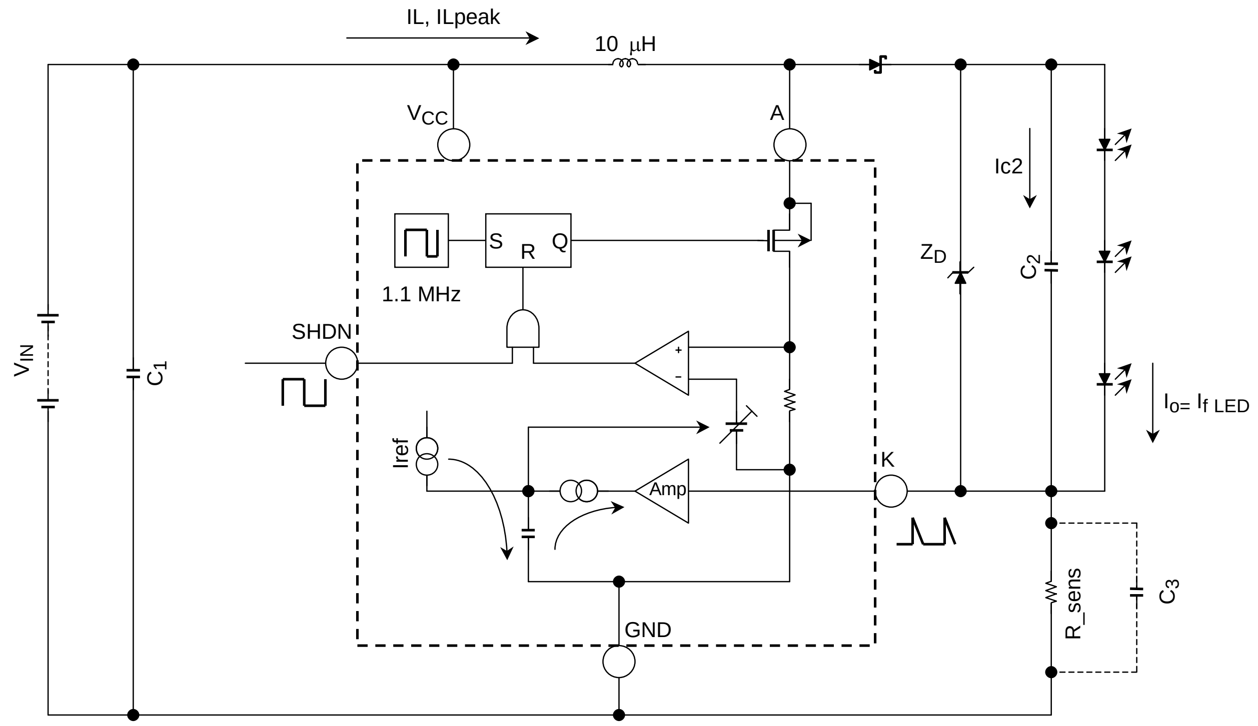


Figure 1 Application Circuit

Basic Operation

The step-up DC/DC converter is applied, and the basic circuit to the TB62732FU adopts peak control of the current pulse.

The internal MOS transistor NMOS is turned on in the fixed frequency f_{OSC} = 1 MHz, and the charge has the energy in the inductance.

Inductance electric current IL turns off NMOS when it reaches 80% of 1/1 MHz when it increased from IL = 0 and it reached IL = ILpeak = 350 (mA, typ.).

The shot key diode is turned on, and IL = Ic2 flows, because the coil may keep IL = ILpeak.

After that, Ic2 is decrease, and become IL = 0.

This operation is repeated, and Ic2 is fully done as to the charge, and it becomes I_O, and flows to LED.

The details of a basic pulse to use for the current control are shown in Figure 2.

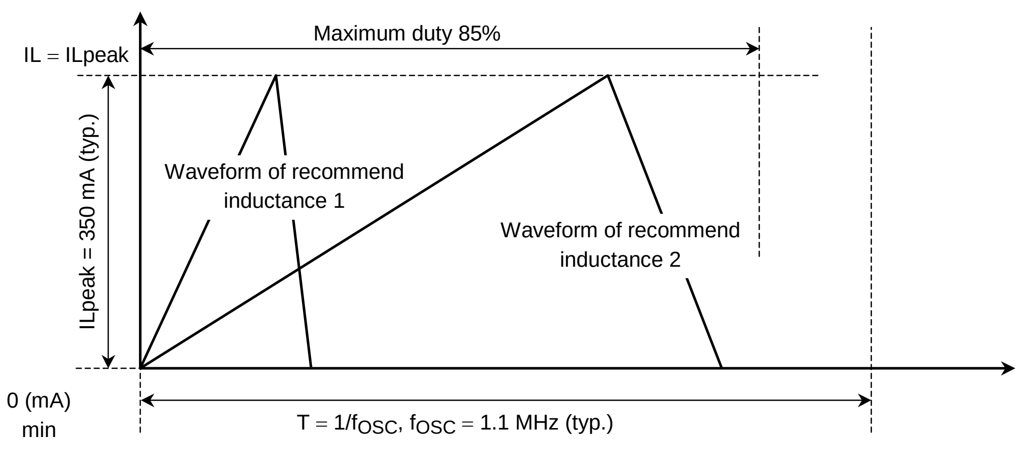


Figure 2 Switching Waveform of Inductance

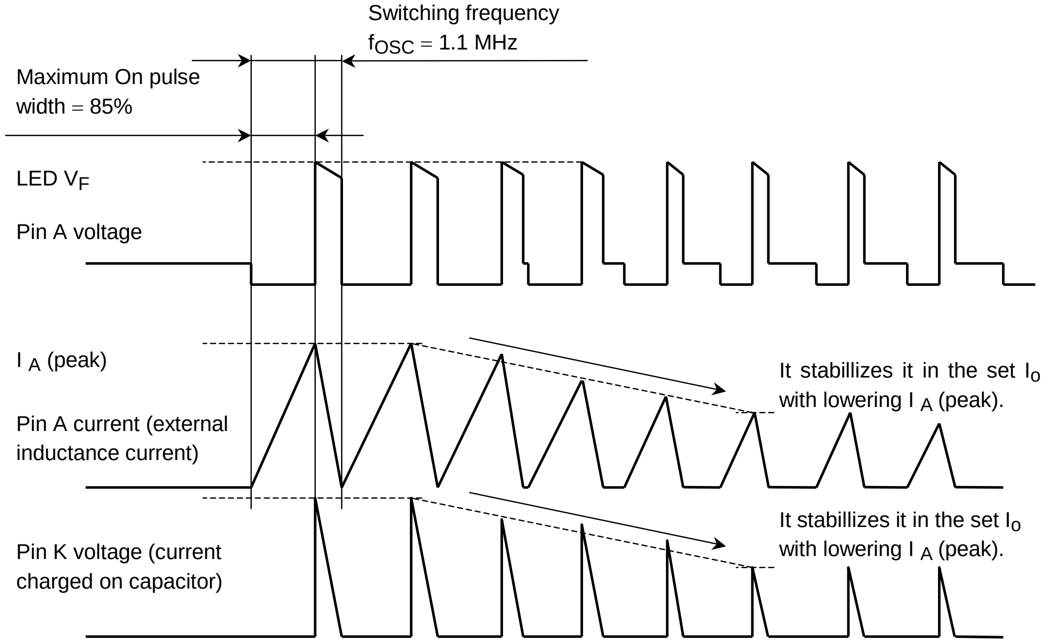


Figure 3 Burst Control Waveforms

The Stae of the Peak Current Control

Peak current control is the control that variability peak current pulse which shows in the figure 2 of the former page. The current pulse of the figure 4 is a charging current on the output side capacitor C_2.

It is supplied to LED as a discharge current on the C_2 and flows through the R_sens to GND.

And, as for the charging voltage wave form of the C_2, it feed back in the IC from the pin K.

Peak currents are decreased with the internal circuit which a pin K should be input from the AC voltage wave. It could may set at about 48 to 54 mV.

A constant current is controlled as an average current in LED as that result.

Therefore, when R_sens = 2.7 Ω is connected, it can get I_F of 19.6 mA at of 53 mV.

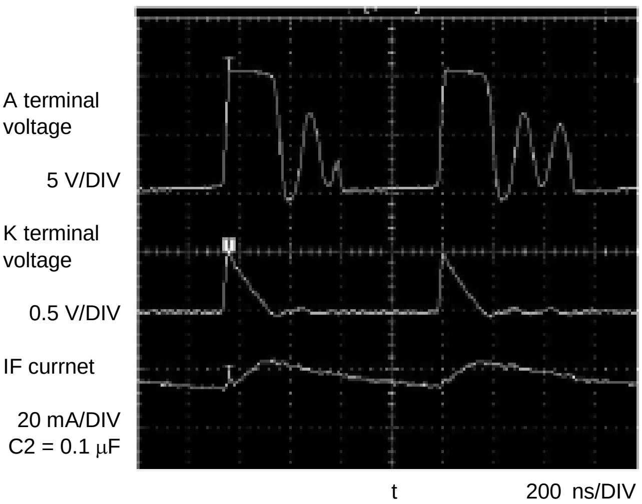
The most suitable design has a boost up inductance worn by inductance 4.7 to 10 μH to the load power 320 mW.

And, make an inductance small when load power is low.

Keep "V_{IN} (V_{CC}) < LED V_F total" strictly as a condition about the LED between the pin A and the pin K.

There are no relations with the control of the IC, and LED always comes to turn on.

Please, be careful.



Standby Operation

The SHDN pin is used to set normal or standby operation. When SHDN is set to Low, the operation is standby; when High, the LED is turned on. Current consumption in Standby Mode is 1 μA (max).

Drive Waveform

A left figure is an actual drive waveform.

From the top, the switching voltage waveform of the coil of the generator terminal, the feedback voltage wave form of the K terminal, and I_F of LED.

Output-side capacitor setting

The C_2 is upper 0.1 (μF) above is recommended from the consideration to the I_F peak.

Capacitor C_2 (μF)	Ripple Current (mA)	Note
0.01	15 to 25	
0.1	5 to 8	Recommend
0.47	2 to 4	
1	1 to 3	

External inductance setting

The minimum external inductance is calculated as follows:

L (μH) = ((K × P_o) − V_{IN} min × I_O) × (1/f_{OSC} min) × 2 × (1/Ip min × Ip min) . . . formula 2

The above parameters are described below:

P_O: output power (power required by LED load)
P_O (W) = V_F LED × I_F LED + Vf schottky × I_F LED + R_sens × I_F LED × I_F LED
LED forward current: I_F LED (mA) = Set current: I_O (mA), LED forward voltage: V_F LED (V),
Schottky diode forward voltage: Vf schottky (V),
Setting resistance: R_sens (Ω)

V_{IN} min (V): Minimum input voltage (battery voltage)

I_O (A): The average current value established with R_sens.

f_{OSC} (Hz): The switching frequency of the internal MOS transistor.

	Min	Typ.	Max	Unit
f_{OSC}	0.77	1.1	1.43	MHz

Ip (A): Peak current value to supply to the inductance.

	Min	Typ.	Max	Unit
Ip	320	350	380	MHz

For example, the following condition is substituted for the formula.
It is supposed under condition.
Input voltage V_{IN}: V_{IN} = 3 to 4.3 V,
V_F LED = 16 V, schottky diode Vf: schottky = 0.3 (V),
Setup resistance R_sens: R_sens = 2.7 (Ω),
Setup current I_O: I_O = 18.5 mA.
L (μH) = 5.6 (μH, V_{IN} = 4.3 V) and 6.3 (μH, V_{IN} = 3 V)
Therefore, 6.3 μH in V_{CC} = 3 V whose input voltage is low is chosen.
It is sufficient by the above calculation on the standard condition.

Selection of R_sens

Resistance between pin K and GND R_sens (Ω) is used for setting output current I_O. The mean output current I_O can be set according to the resistance.

The mean current I_O (mA) to be set is roughly calculated as follows:

I_O (mA) = 36 (mV) ÷ R_sens (Ω)

Number of LEDs	Pin K voltage V (K)	Note
2	48	
3	50	
4	52	

For example, when R_sens = 2.7 (Ω), I_O = 18.5 (mA) and current error of ±12%.

The IC has a minimum output P_O = 320 (mA).
At that time, if the product of current I_F LED and output voltage V_F LED exceeds P_O = 320 (mW), current I_F LED may become less than the desired value.

If the IC is not connected to the smoothing capacitor, set mean current I_F LED can be obtained.
At that time, because the current which flows to the LED is a sine-wave current with a maximum peak value of 380 mA, make sure that surge current I_{FP} (mA) does not flow to the LED.
Toshiba recommend use of components with low reactance (parasitic inductance) and minimized PCB wiring.

A zener diode in an application circuit example of the figure 1 is necessary for the over-voltage protection when LED becomes open.
It is recommended connecting a zener diode strongly because this driver doesn't have a voltage protection circuit.

A zener voltage is to satisfy the following condition.

i) Less than maximum output voltage of TB62732FU
ii) Upper total series LED V_F
iii) Less than maximum output capacitance C_2.

Moreover, it is possible by connecting the figure 4 like R_ZD to be able to control output current when LED becomes open, and to use small a zener diode of tolerance level.
The example of the IZD control by R_ZD connection.
(R_sens = 2.7 Ω)

R_DZ (Ω)	IZD (mA)
18	3
100	0.1

Since it may have a bad influence on the characteristic of a driver, Toshiba recommend 100 ohms or less.

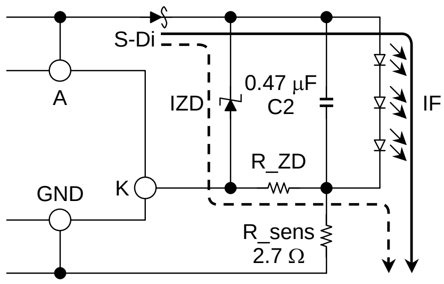
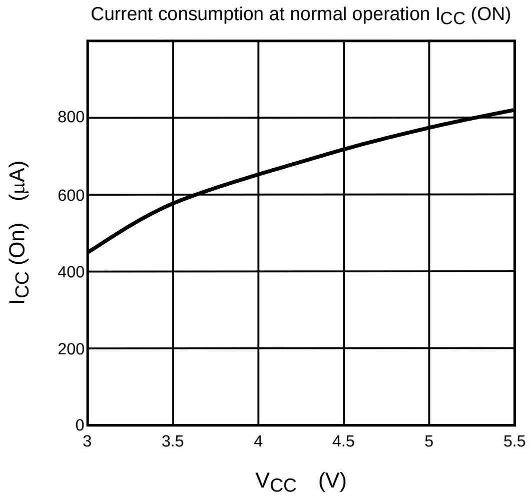
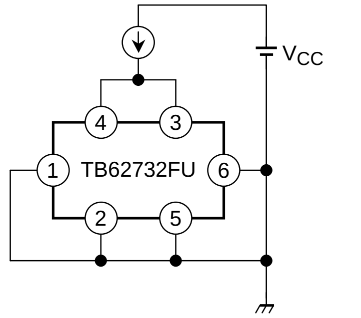
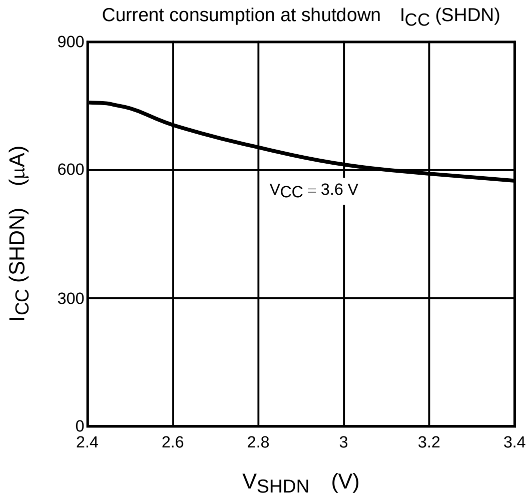
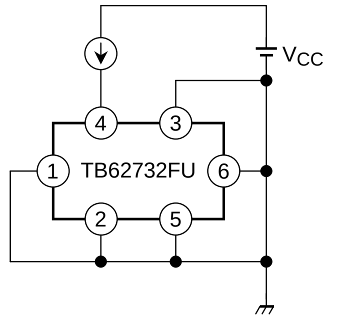


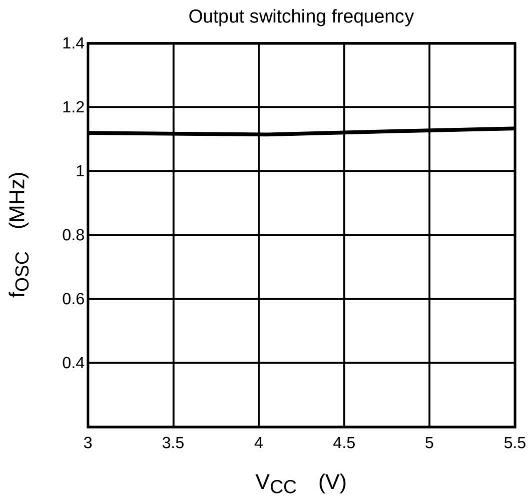
Figure 4 Application Circuit

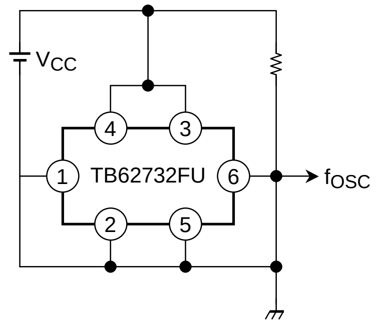

Current consumption at normal operation I_{CC} (ON)
I_{CC} (On) (μA)
800
600
400
200
0
3
3.5
4
4.5
5
5.5
V_{CC} (V)


V_{CC}
4
3
1
TB62732FU
6
2
5


Current consumption at shutdown I_{CC} (SHDN)
I_{CC} (SHDN) (μA)
900
600
300
0
V_{CC} = 3.6 V
2.4
2.6
2.8
3
3.2
3.4
V_{SHDN} (V)

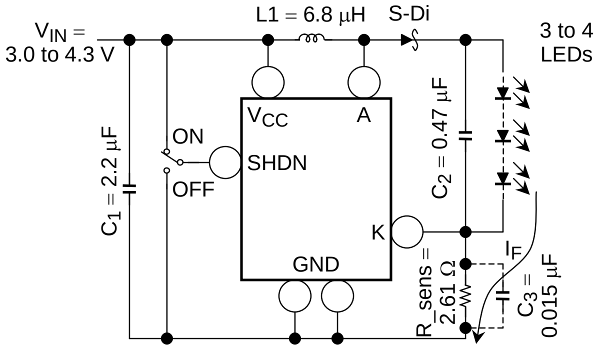

V_{CC}
4
3
1
TB62732FU
6
2
5


Output switching frequency
f_{OSC} (MHz)
1.4
1.2
1
0.8
0.6
0.4
3
3.5
4
4.5
5
5.5
V_{CC} (V)


V_{CC}
4
3
1
TB62732FU
6
f_{OSC}
2
5

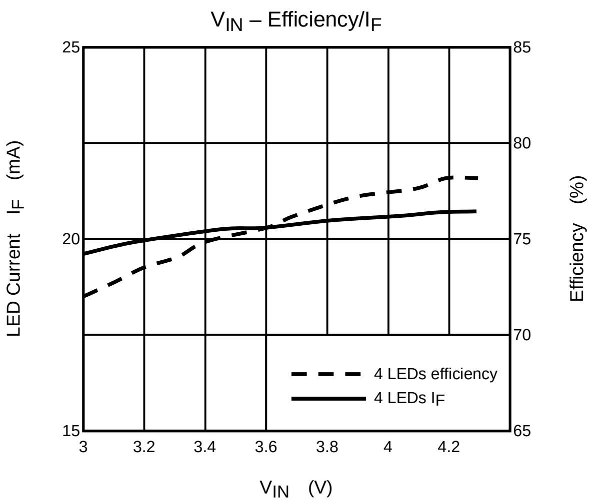
Application Evaluation Circuit Example 1
(the evaluation result example by the small coil: Coil = LDR304612T-6R8)

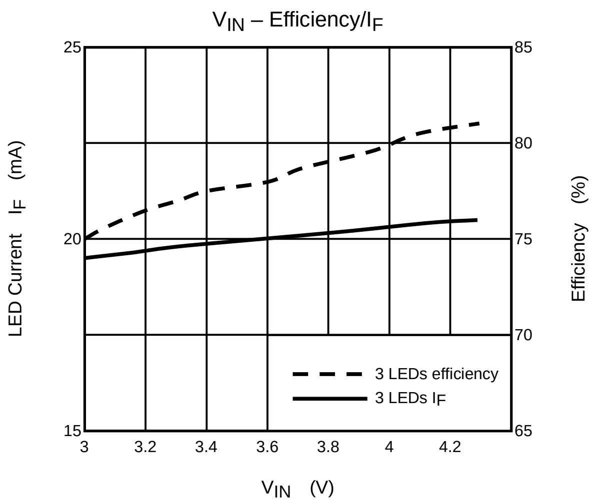
6.8 μH is the most suitable when serial 3 to 4 LEDs are turned on by I_F = 20 mA.
4.7 μH is recommended when serial 2 LEDs are turned on steadily in the range of V_{IN} > 4.5 V.

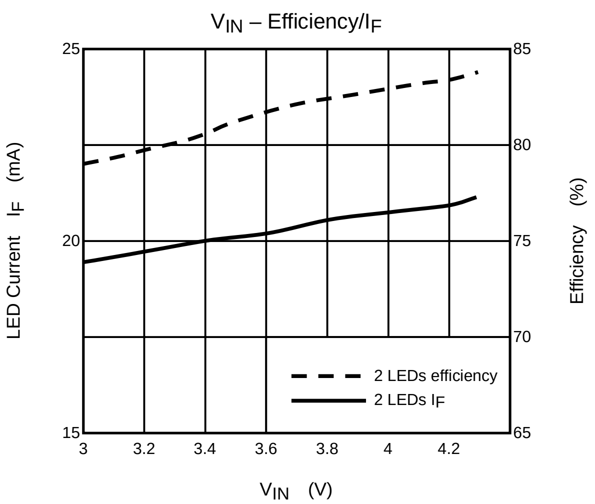


L1 : TDK LDR304612T-6R8
S-Di: TOSHIBA CUS02 30 V/1 A
LED: NICHIA NSCW215T

Note 5: It doesn't surely need to connect C_3.
The effect which becomes stable has I_F in the decrease voltage expected.







<Measurement>

The efficiency of the V_{IN} = 3.0 to 4.3 V range

Number of LED	Efficiency (%)	Average Efficiency (%)
2	79.0 to 83.8	81.6
3	75.1 to 80.9	78.3
4	72.0 to 78.3	75.7

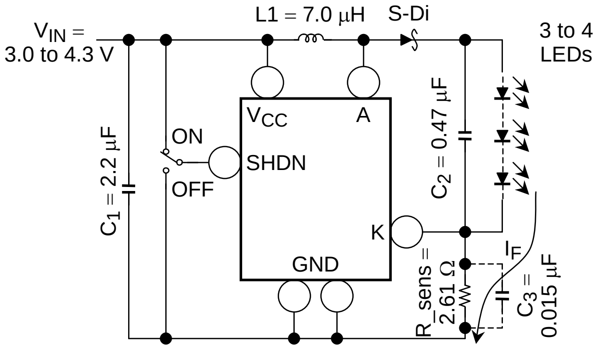
The I_F of the V_{IN} = 3.0 to 4.3 V range

Number of LED	I_F (mA)	V_{CC} Dependence (%)
2	19.5 to 21.1	7.8
3	19.5 to 20.5	4.9
4	19.6 to 20.7	5.3

Note 6: The value is our company actual measurement value. The result has the possibility to be different by the measurement environment.

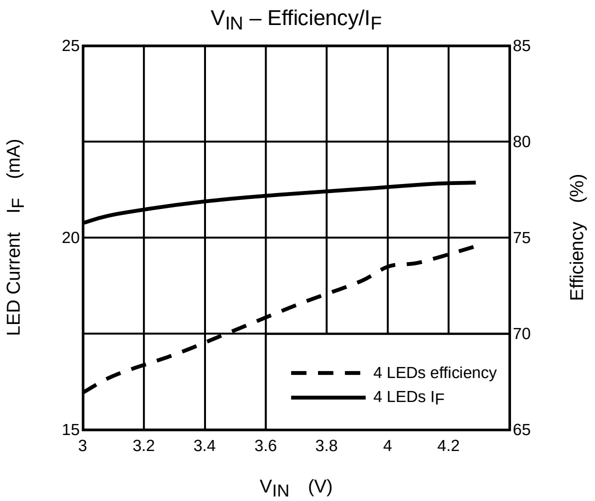
Application Evaluation Circuit Example 2
(the evaluation result example by the small coil: Coil = CXML321610-7R0)

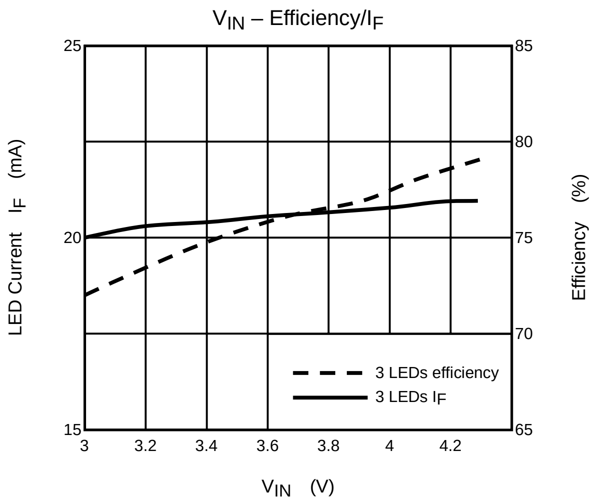
6.8 μH is the most suitable when serial 3 to 4 LEDs are turned on by I_F = 20 mA.
4.7 μH is recommended when serial 2 LEDs are turned on steadily in the range of V_{IN} > 4.5 V.

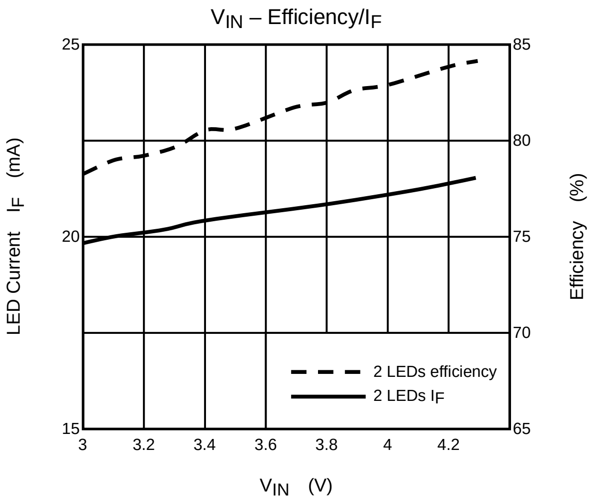


L1 : SUMITOMO CXML321610-7R0
S-Di: TOSHIBA CUS02 30 V/1 A
LED: NICHIA NSCW215T

Note 7: It doesn't surely need to connect C_3.
The effect which becomes stable has I_F in the decrease voltage expected.







<Measurement>

The efficiency of the V_{IN} = 3.0 to 4.3 V range

Number of LED	Efficiency (%)	Average Efficiency (%)
2	78.2 to 84.1	81.3
3	72.0 to 79.1	75.8
4	66.9 to 71.1	74.6

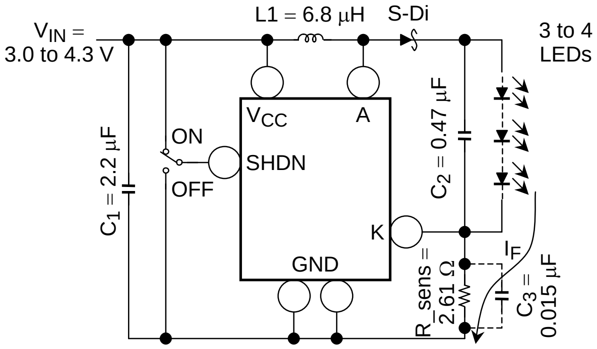
The I_F of the V_{IN} = 3.0 to 4.3 V range

Number of LED	I_F (mA)	V_{CC} Dependence (%)
2	19.8 to 21.6	8.1
3	20.0 to 21.0	4.8
4	20.4 to 21.5	4.9

Note 8: The value is our company actual measurement value. The result has the possibility to be different by the measurement environment.

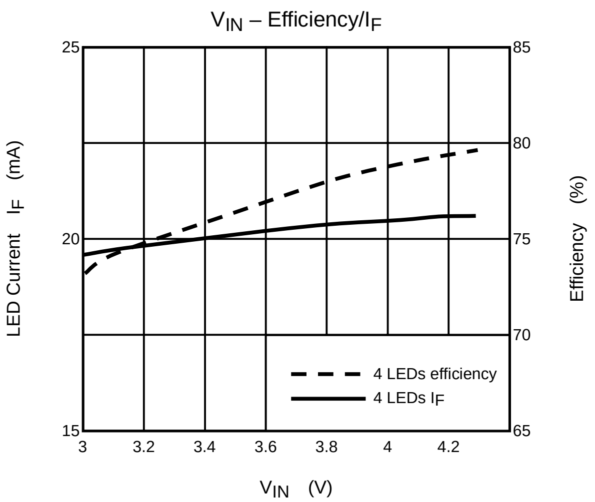
Application Evaluation Circuit Example 3
(the evaluation result example by the small coil: Coil = 976AS-6R8)

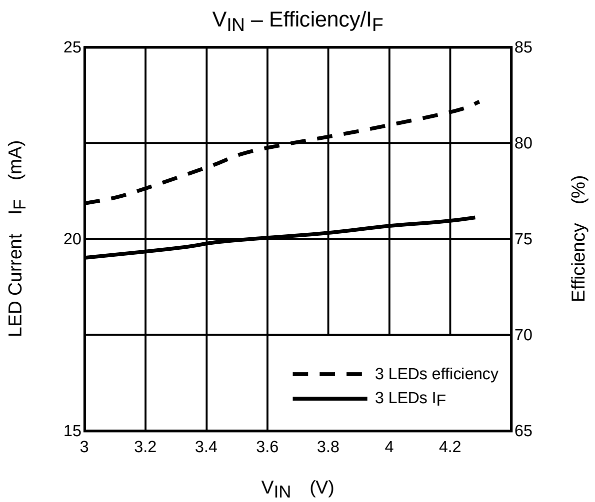
6.8 μH is the most suitable when serial 3 to 4 LEDs are turned on by I_F = 20 mA.
4.7 μH is recommended when serial 2 LEDs are turned on steadily in the range of V_{IN} > 4.5 V.

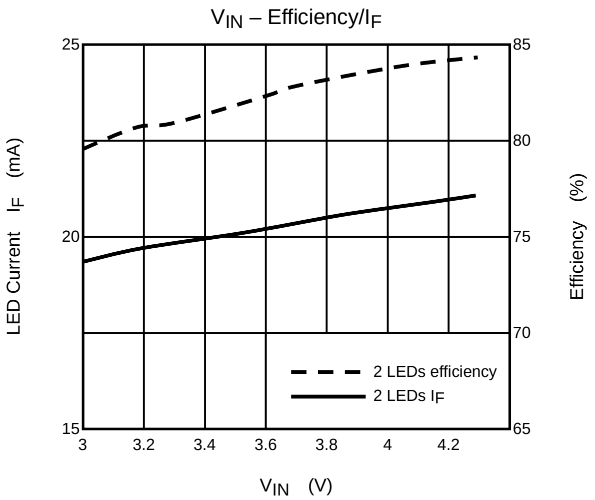


L1 : TOKO 976AS-6R8
S-Di: TOSHIBA CUS02 30 V/1 A
LED: NICHIA NSCW215T

Note 9: It doesn't surely need to connect C_3.
The effect which becomes stable has I_F in the decrease voltage expected.







<Measurement>

The efficiency of the V_{IN} = 3.0 to 4.3 V range

Number of LED	Efficiency (%)	Average Efficiency (%)
2	79.7 to 84.4	82.3
3	76.7 to 82.1	79.5
4	73.1 to 79.7	74.0

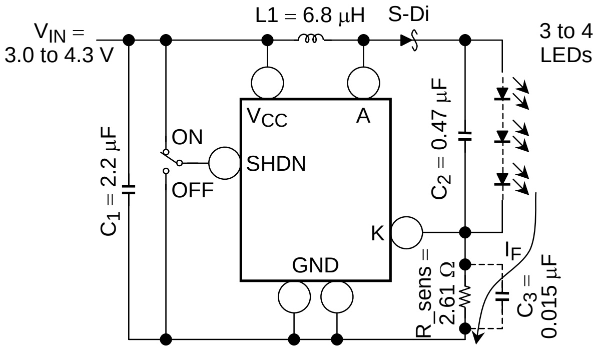
The I_F of the V_{IN} = 3.0 to 4.3 V range

Number of LED	I_F (mA)	V_{CC} Dependence (%)
2	19.4 to 21.1	8.1
3	19.5 to 20.5	5.1
4	19.6 to 20.7	5.3

Note 10: The value is our company actual measurement value. The result has the possibility to be different by the measurement environment.

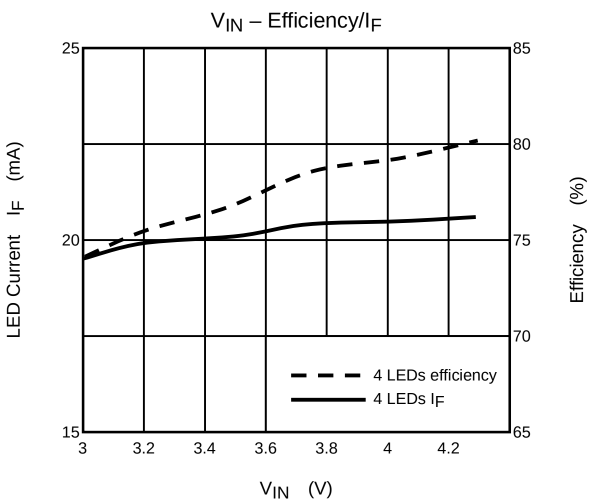
Application Evaluation Circuit Example 4
(the evaluation result example by the small coil: Coil = CXLD140-6R8)

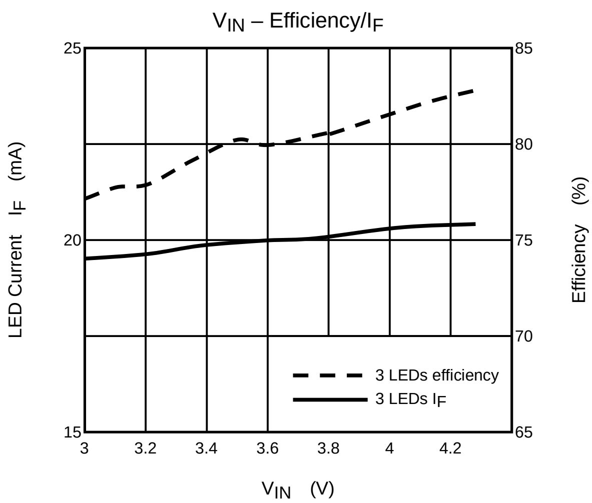
6.8 μH is the most suitable when serial 3 to 4 LEDs are turned on by I_F = 20 mA.
4.7 μH is recommended when serial 2 LEDs are turned on steadily in the range of V_{IN} > 4.5 V.

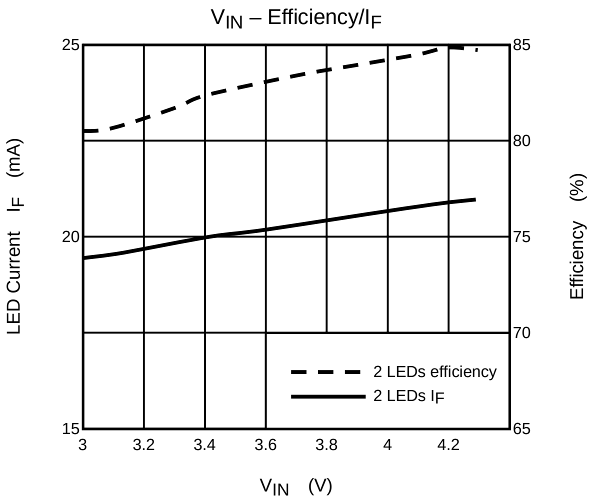


L1 : SUMITOMO CXLD140-6R8
S-Di: TOSHIBA CUS02 30 A/1 V
LED: NICHIA NSCW215T

Note11: It doesn't surely need to connect C_3.
The effect which becomes stable has I_F in the decrease voltage expected.







<Measurement>

The efficiency of the V_{IN} = 3.0 to 4.3 V range

Number of LED	Efficiency (%)	Average Efficiency (%)
2	80.3 to 84.9	82.9
3	77.2 to 82.8	80.2
4	74.1 to 80.4	77.6

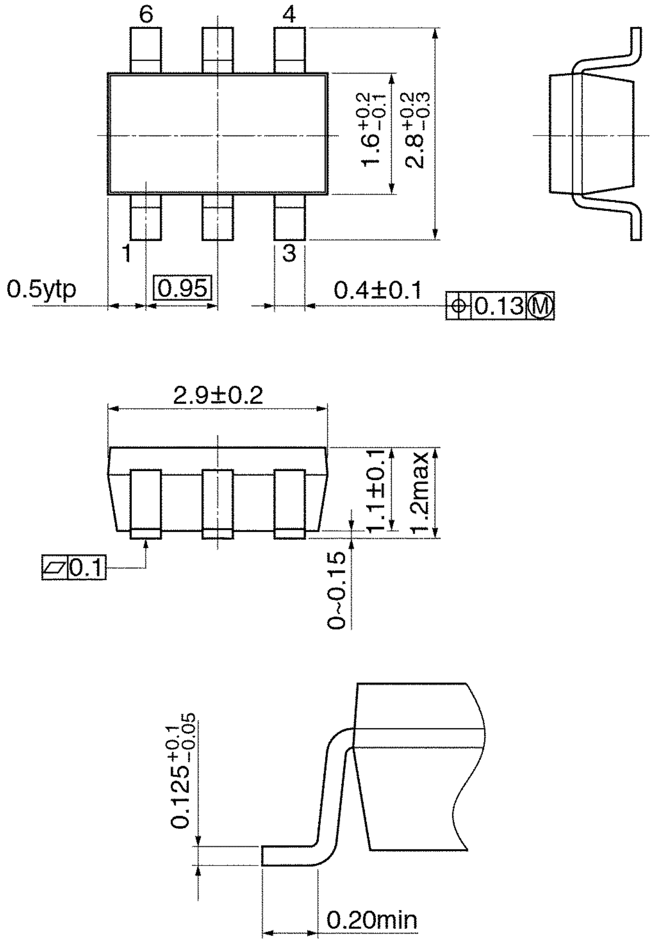
The I_F of the V_{IN} = 3.0 to 4.3 V range

Number of LED	I_F (mA)	V_{CC} Dependence (%)
2	19.4 to 21.0	7.6
3	19.5 to 20.5	5.1
4	19.6 to 20.7	5.3

Note 12: The value is our company actual measurement value. The result has the possibility to be different by the measurement environment.

Package Dimensions

SSOP6-P-0.95B Unit: mm



Weight: 0.016 g (typ.)

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